Eskom Holdings SOC Ltd

ESKOM MINIMUM EMISSION STANDARDS EXEMPTION

Eskom Fleet Report



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Eskom Holdings SOC Ltd

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ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	Definition
AEL	Atmospheric Emissions Licence
AOA	Annual Operational Analyses
AP-HRA	Air pollution health risk assessments
APHR-BCA	Air Pollution Health Risk Benefit Cost Analysis
AQMP	Air Quality Management Plan
AQO	Air Quality Offsets
ARM	Air Resource Management
BAT	Best Available Technology
BCA	Benefit-cost analysis
BPFS	Biodiversity Plan Free State Province
BU	Business Units
CAPEX	Capital Expenditure
CRA	Concept Release Approval
CV	Calorific value
DEA	Department of Environmental Affairs
DFFE	Department of Forestry, Fisheries and the Environment
DHP	Dust Handling Plant
DSI	Dry Sorbent Injection
DWS	Department of Water and Sanitation
EAF	Energy Availability Factors
EIA	Environmental Impact Assessment
ERF	Exposure-response functions
ERI	Eskom Rotek Industries
ERP	Emission Reduction Plan
ESA	Ecological Support Area
EWE	Extreme Weather Events
FDDM	Fezile Dabi District Municipality
FEPA	Freshwater Ecosystem Priority Areas
FGD	Flue Gas Desulphurisation
GBV	Gender-Based Violence
GCD	Group Capital Department
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GHGP	Greenhouse Gas Protocol

Acronym/Abbreviation	Definition
GVA	Gross Value Added
HFPS	High Frequency Power Supplies
I&AP	Interested and Affected Parties
IDP	Integrated Development Plan
IPCC	Intergovernmental Panel on Climate Change
IPPs	Independent Power Producers
IRP	Integrated Resource Plan
IVRSv	Integrated Vaal River System
LCOE	Levelised cost of electricity
JET	Just Energy Transition
LNB	Low NO_X burner
LPG	Liquid Petroleum Gas
MES	Minimum Emission Standards
MLM	Metsimaholo Local Municipality
Mt	Megatonnes
NAAQS	National Ambient Air Quality Standards
NAQO	National Air Quality Officer
NCCAS	National Climate Change Adaptation Strategy
NCCRP	National Policies such as the Climate Change Response
NDC	Nationally Determined Contribution
NDP	National Development Plan
NECA	National Environmental Consultative and Advisory
NECOM	National Energy Crisis Committee of Ministers
NEMAQUA	National Environmental Management: Air Quality Act
NERSA	National Energy Regulator of South Africa
NGER	National Greenhouse Gas Emission Reporting
NO_X	Nitrogen Oxides
NPV	Net Present Value
NWA	National Water Act (No. 36 of 1998)
OEMs	Original Equipment Manufacturers
OFA	Over-fire Air
OIP	Offset Intervention Plan
Opex	Operating Expenditure
PCD	Pollution Control Dam
PF	Pulverised fuel
PJFF	Pulse Jet Fabric Filter

Acronym/Abbreviation	Definition
PM	Particulate Matter
PMV	Planning, Monitoring and Verification
PPE	Personal Protective Equipment
PV	Photovoltaic
RR	Relative Risk
R&R	Repowering and Repurposing
ROI	Return on investment
SAPS	South African Police Service
SAWS	South African Weather Services
SCR	Selective Catalytic Reduction
SO_2	Sulphur dioxide
SPF	Spray Polyurethane Foam
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
VOC	Volatile Organic Compounds
VRESS	Vaal River Eastern Sub-system
VSL	Value of a statistical life
VTAPA	Vaal Triangle Airshed Priority Area
WBCSD	World Business Council for Sustainable Development
WCWDM	Water Conservation and Water Demand Measures
WHO	World Health Organisation
WMO	World Meteorological Organisation
WRI	World Resources Institute
WTP	Willingness to Pay

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EXECUTIVE SUMMARY

Eskom Holdings SOC Ltd (Eskom) is South Africa's public electricity utility, supplying about 95% of the country's electricity with a generation capacity exceeding 35,000 MW. Around 90% of its power comes from coal-fired stations, primarily located in the Mpumalanga Highveld, with others in the Free State and Limpopo provinces.

Coal-fired power stations must comply with strict environmental regulations under the National Environmental Management: Air Quality Act (NEM:AQA). Eskom sought postponements and alternative limits to the Minimum Emission Standards (MES) for oxides of nitrogen (NO_X), sulphur dioxide (SO_2) and particulate matter (PM) between 2018 and 2020. These applications were necessary due to several factors, such as the restrictive legal framework, the advanced age of Eskom's power plant fleet, and the technical challenges of reducing emissions. The high costs of emission reduction technologies, which could significantly impact electricity tariffs and the financial stability of the utility, further underscored the need for a phased approach to compliance.

In October 2021, the Department of Forestry, Fisheries, and the Environment (DFFE) granted conditional postponements for some power stations (Grootvlei, Arnot, Komati, Camden, Hendrina, Acacia, and Port Rex Power Stations), provided partial refusals for others (Majuba, Tutuka, Kendal, and Kriel), and rejected the applications for Lethabo, Matla, Medupi, Matimba, and Duvha.

In December 2021 Eskom initiated an appeal process, engaging with the DFFE, and other governmental departments, on the basis that immediate compliance would lead to the shutdown of about 16,000 MW of coal-fired capacity. Eskom emphasised that this would negatively impact the national grid and delay South Africa's energy transition, that flu gas desulphurisation (FGD) retrofit on "six-pack" power stations was not proven to be technically feasible and would be a world first, and that if funding was available to execute the required compliance projects in time to meet the MES, this would result in an approximate increase of 10% on existing electricity tariffs (Eskom, 2020).

In May 2024, the Minister approved the MES suspensions for the power stations set to shut down by 31 March 2030 (Hendrina, Grootvlei, Arnot, Camden, and Kriel) and, under Section 59 of the NEM:AQA, instructed Eskom to apply for MES exemptions for the remaining stations (Lethabo, Kendal, Tutuka, Matla, Duvha, Majuba, Matimba, and Medupi). The Minister would then assess each application based on its merits and supporting information.

This report presents the Eskom Fleet exemption application, comprising Lethabo, Tutuka, Matla, Duvha, Majuba, Kendal, Medupi, and Matimba, highlighting the specific environmental and operational challenges each face. While the primary focus is on the Eskom Fleet, aspects of the Highveld and Vaal Triangle Fleet and Waterberg Fleet are discussed separately. This holistic approach is necessary as a particular station's circumstances cannot be considered in isolation of the entire Eskom Fleet as station performance, emissions impacts, and financial impacts need to be considered cumulatively. By considering the entire Eskom fleet, the report aims to provide a cohesive strategy for reducing emissions and achieving compliance while addressing the unique challenges of each power station.

To address emission reductions in the Eskom Fleet, Eskom developed an Emission Reduction Plan (ERP) in 2015, with this being updated in 2019 (EERP 2019), 2020 and 2022. In May 2024, as part of the Minister's decision, Eskom were required to review the 2022 ERP, with this having been revised by Eskom in 2024.

Eskom currently has abatement technologies to mitigate PM at all power stations since this is historically the pollutant of most concern considering health impacts, and boilers with low NO_X design at Medupi, Kendal, Kusile, and Camden, with SO_2 abatement technology in the form of flue-gas desulphurisation (FGD) installed at Kusile. Further, Eskom is currently taking steps to further reduce PM emissions at the stations, with several abatement equipment upgrades and refurbishments completed, and currently being undertaken, focusing on projects such as electrostatic precipitator (ESP) refurbishments, high frequency power supply (HFPS) installations, sulphur trioxide (SO_3) plant upgrades, and Dust Handling Plant (DHP) upgrades. In addition to these projects, and ensuring Eskom's commitment to emission reductions, as part of the 2024 ERP, Eskom are also planning and/or evaluating the following to reduce emissions:

- Wet FGD at Medupi (included in previous ERPs)
- Kendal (semi-dry FGD) and Majuba (Duct Sorbent Injection (DSI FGD)) SO_2 reduction projects have been identified as potential alternatives, although are being evaluated as part of this process.
- Low NO_X Burner (LNB) technology at Majuba, Tutuka and Lethabo to mitigate NO_X emissions.
- Despatch Prioritisation Strategy at specific power stations, initiated to reduce SO_2 emissions, however also positively impacting PM and NO_X emissions.
- Efficiency improvement projects under the Generation Recovery Programme to optimise the air-to-fuel ratio which should abate some SO_2 emissions and maximise combustion efficiency.
- The progressive shutdown of coal-fired stations will reduce overall Eskom Fleet emissions.
- Although not a method of reducing emissions at source (i.e. the power stations), the cumulative impact on neighbouring communities is reduced through the air quality offset (addressing emission sources within the community) projects already implemented by Eskom, therefore Eskom are looking to expand this beyond the 35,000 households originally planned.

Key emissions of concern, and regulated by the NEM:AQA, are PM, SO_2, and NO_X. The following discussions provide key highlights for each pollutant, considering details such as current performance, planned projects, Eskom Fleet emission reductions and trajectories, and Eskom's exemption request, where applicable. The Eskom Fleet emission reduction trajectories consider four scenario projections:

- ERP 2024 A (PM and NO_X reduction, Despatch Prioritisation strategy, efficiency improvements, and SO_2 abatement at Medupi and Kusile), representing Eskom's planned projection.
- ERP 2024 B (As per ERP 2024 A plus SO_2 reduction technology installed at Majuba and Kendal), representing a projection, that with additional guarantees and strategic decisions, could be achieved.
- ERP 2024 C (As per ERP 2024 A and B, plus SO_2 reduction technology at Matimba, Lethabo and Tutuka), representing a projection that would require substantial guarantees and considerations of the significant financial impacts, such as on electricity tariffs.
- Eskom's Security of Supply Projection developed using conservative assumptions such as higher electricity demands due to a growing economy, a delay in IPP projects, and a delay in Kusile U6 generating unit coming online.

The following sections focus on the key aspects assessed in this report, namely ambient concentrations, dispersion modelling, Eskom's Fleet emissions trajectory, financial considerations, and conclusions from the health benefit cost analysis. While not specifically discussed in the executive summary, other aspects considered in this report include water, waste, climate change, and socioeconomic impacts. Further, a comprehensive stakeholder engagement process was followed, aligned with the NEMA regulations, detailed in this report.

PARTICULATE MATTER

Presently ambient air quality monitoring shows PM to be non-compliant in the Highveld, Vaal Triangle and Waterberg, with this impacted by multiple sources, such as Eskom power stations, mining, industrial activities, uncontrolled waste burning, veld fires, and domestic fuel burning; importantly, the non-compliant ambient concentrations are not only due to Eskom emissions. Cumulatively the Eskom Fleet shows a significant reduction in PM stack emissions in the coming years due to the various abatement projects being implemented. Eskom's emission trajectories for the options of ERP 2024 A, ERP 2024 B, and ERP 2024 C, show identical trajectories as the same PM abatement projects are planned for each. By FY2030, these show a 65-kilo tonne (kt) reduction from FY2025, representing a 74% decrease, due to PM abatement projects implemented in the fleet and stations entering shutdown phase.

Despite the significant PM emission reduction, and the dispersion modelling indicating compliant PM_{10} annual average concentrations, non-compliant 24-hour PM_{10} concentrations are predicted, as well as non-compliant annual and 24-hour average $PM_{2.5}$ concentrations; although, the conservative approach to the PM simulations providing an absolute worst-case scenario must be considered. The predicted ambient PM concentrations are predominantly due to the low-level fugitive sources (windblown ash from the ashing facilities), rather than the stack emissions themselves; the benefit of the stack emissions reductions, as evident in the trajectories, is over-shadowed by the impacts associated with fugitive emissions. This conclusion is supported by the additional dispersion modelling undertaken to assess particulate matter emissions only from the stacks, which showed full compliance with the annual and 24-hour average PM_{10} and $PM_{2.5}$ National Ambient Air Quality Standards (NAAQS), with no exceedances predicted. This was evident for the Highveld and Vaal Triangle Fleet, as well as the Waterberg Fleet, indicating ground-level impacts associated with stack emissions are well below the NAAQS.

While the abovementioned emission trajectories show significant improvements in the next few years, to offset Eskom PM emissions further, Eskom has introduced an air quality offset (AQO) program, a key component of Eskom's ERP. This program aims to offset PM emissions by implementing interventions that deliver net ambient air quality benefits within communities impacted by Eskom's stations, focusing on PM_{10} and $PM_{2.5}$. In the Highveld and Vaal Triangle, key interventions include the distribution of hybrid stoves, ceilings, electrical rewiring, and LPG heaters to households, as well as clean-up campaigns to remove illegally dumped waste. The program has been implemented in phases, with Phase 1 targeting Kwazamokuhle, Ezamokuhle, and Sharpeville. Preliminary results show significant reductions in PM_{10} and $PM_{2.5}$ concentrations and improvements in indoor air quality in participating households. Eskom plans to expand its AQO program to additional communities and explore new interventions, such as dust suppression on unpaved roads and veld fire management.

In the Waterberg area interventions to date have focussed on educational initiatives, with further options being considered including introducing cleaner household energy sources, managing waste burning, reforestation, and surfacing bare public grounds. Research into Eskom's potential AQO initiatives is ongoing, focusing on interventions that reduce emissions to create the greatest positive impact in specific communities.

Considering each power stations performance, Duvha Unit (U)1 and U2, Majuba, Medupi, and Matimba currently comply with the new plant PM MES. The remaining stations are unable to comply with the new plant MES until completion of their respective PM abatement projects, detailed in this

report. While Eskom recognises the currently non-compliant PM ambient concentrations in the Waterberg, Highveld, and Vaal Triangle, to which Eskom is not the sole contributor, Eskom's PM emission trajectory shows substantial reductions in the next few years, driven by the commissioning of the PM abatement projects, as well as the assumed shutdowns of Arnot, Kriel, Hendrina, Grootvlei, and Camden. Further reductions will be achieved by the plant efficiency improvements and the Despatch Prioritisation strategy.

In light of the above, Eskom is requesting exemption from the new plant PM MES at Duvha (U4 and U6), Lethabo (U1, U2, U3, U4, and U5), Matla (U4, U5, and U6), Kendal, and Tutuka until completion of the abatement projects, after which these stations will comply with the new plant MES, as presented in Table 0-1. The total nominal Capex to complete the PM abatement projects is estimated at R9.4 billion.

Table 0-1 – Particulate matter requested emission limits and timeframes

STATION	GENERATING UNIT	MAXIMUM RELEASE RATE*			DURATION OF EMISSIONS
		mg/Nm^3	Average	Date To Be Achieved	
LETHABO	U6	100 mg/Nm^3	Daily	Immediate	Continuous
		50 mg/Nm^3	Daily	1 April 2025	Continuous
	U2, U3	100 mg/Nm^3	Daily	Immediate	Continuous
		50 mg/Nm^3	Daily	1 April 2026	Continuous
	U5	100 mg/Nm^3	Daily	Immediate	Continuous
		50 mg/Nm^3	Daily	1 October 2026	Continuous
	U4	100 mg/Nm^3	Daily	Immediate	Continuous
		50 mg/Nm^3	Daily	1 April 2027	Continuous
	U1	100 mg/Nm^3	Daily	Immediate	Continuous
		50 mg/Nm^3	Daily	1 October 2027	Continuous
DUVHA	U1, U2, U5	50 mg/Nm^3	Daily	Immediate	Continuous
	U4, U6	100 mg/Nm^3	Daily	Immediate	Continuous
		50 mg/Nm^3	Daily	1 October 2026	Continuous
MATLA	U1, U2, U3	100 mg/Nm^3	Daily	Immediate	Continuous
		50 mg/Nm^3	Daily	1 April 2025	Continuous
	U4, U5, U6	100 mg/Nm^3	Daily	Immediate	Continuous
		50 mg/Nm^3	Daily	1 April 2026	Continuous
TUTUKA	All Units	300 mg/Nm^3	Daily	Immediate	Continuous
		50 mg/Nm^3	Daily	1 April 2027	Continuous
KENDAL	U3, U4, U6	100 mg/Nm^3	Daily	Immediate	Continuous
		50 mg/Nm^3	Daily	1 October 2025	Continuous
	U1, U2, U5	100 mg/Nm^3	Daily	Immediate	Continuous
		50 mg/Nm^3	Daily	1 April 2026	Continuous
MAJUBA	All Units	50 mg/Nm^3	Daily	Immediate	Continuous
MEDUPI	All Units	50 mg/Nm^3	Daily	Immediate	Continuous
MATIMBA	All Units	50 mg/Nm^3	Daily	Immediate	Continuous

*Emission limits requested are for normal operations, so excludes upset, startup, shutdown, or maintenance conditions.

OXIDES OF NITROGEN

For the period 2021 – 2023, measured ambient NO_2 concentrations in the Highveld and Vaal Triangle are compliant with the National Ambient Air Quality Standards (NAAQS). While Eskom is not the sole contributor to these concentrations, Eskom emissions still do contribute, recognising these contributions are made at Eskom's current emission rates i.e. without NO_X abatement at Matla, Duvha, Tutuka, Majuba, and Lethabo. Despite these stations not having NO_X abatement, ambient concentrations are compliant with the NAAQS. Considering the cumulative Eskom Fleet NO_X emissions trajectory, by FY2030 (compared to 2025), NO_X emissions are estimated to reduce by 292kt (40%) due to assumed shutdowns of Arnot, Kriel, Hendrina, Camden, and Grootvlei. Between FY2025 and FY2050, total NO_X emissions are estimated to reduce by 78%.

Considering the cumulative Highveld and Vaal Triangle dispersion model and maximum sensitive receptor predictions, all modelling scenarios predicted compliant NO_2 concentrations, with annual averages well below the NAAQS, and no hourly exceedances predicted. This included the current scenarios (modelling Scenario 1 and Scenario A), which assumed no NO_X abatement at Matla, Duvha, Tutuka, Majuba, and Lethabo.

Although ambient concentrations and the dispersion modelling indicate compliance with the NAAQS, Eskom is still planning to install LNB at Majuba, Lethabo, and Tutuka, after which all three stations will comply with the new plant NO_X MES. Currently, Kendal, Matimba, and Medupi comply with the new plant NO_X MES. LNB installation at Tutuka is planned to commence in 2025 on the first generating unit, with installation complete by 2029; Majuba's installation commences 2026, with the last unit in 2030; and Lethabo's LNB installation commences in 2027, with the last unit complete by 2031. As noted, once LNB installations are complete, the stations will comply with the new plant MES.

Considering Duvha and Matla, with assumed shutdown due to commence in 2030, and optimistic LNB commencement dates of 2028, with LNB installations only complete well into the station's shutdown phases, it is not economically feasible to install LNB at Matla and Duvha. Consideration also needs to be given to the National Environmental Consultative and Advisory (NECA) Panel, which commented that it would not be economically feasible to install LNB at Matla due to its assumed shutdown; this same consideration can be given to the Duvha station. Currently, both stations comply with the existing plant MES, and with the initiation of Despatch Prioritisation to address SO_2 emissions, NO_X emissions will reduce further, although not to compliance with the new plant MES.

In light of the above, and the currently compliant ambient NO_X concentrations in the Highveld and Vaal Triangle, the dispersion modelling predictions indicating NAAQS compliance, the NO_X emission reductions anticipated in the Eskom Fleet over the next few years, and that once LNB installations are complete all Eskom stations operating post 2035 will comply with the new plant MES, Eskom is requesting exemption from the new plant MES. This exemption request is for Tutuka, Majuba, and Lethabo until completion of the LNB installations, and for Matla and Duvha until their assumed shutdowns (Table 0-2). The total nominal Capex to install LNB at Lethabo, Tutuka, and Majuba is estimated at R7 billion (-15% to +20%).

Table 0-2 – Oxides of nitrogen requested emission limits and timeframes

STATION	GENERATING UNIT	MAXIMUM RELEASE RATE*			DURATION OF EMISSIONS
		mg/Nm^3	Average	Date To Be Achieved	
DUVHA	All Units	1,100 mg/Nm^3	Daily	Immediate - Shutdown	Continuous
MATLA	All Units	1,100 mg/Nm^3	Daily	Immediate - Shutdown	Continuous
LETHABO	All Units	1,100 mg/Nm^3	Daily	Immediate	Continuous
		750 mg/Nm^3	Daily	1 April 2031	Continuous
TUTUKA	All Units	1,100 mg/Nm^3	Daily	Immediate	Continuous
		750 mg/Nm^3	Daily	1 April 2029	Continuous
MAJUBA	All Units	1,100 mg/Nm^3	Daily	Immediate	Continuous
		750 mg/Nm^3	Daily	1 April 2030	Continuous
KENDAL	All Units	1,100 mg/Nm^3	Daily	Immediate	Continuous
		750 mg/Nm^3	Daily	1 April 2025	Continuous
MEDUPI	All Units	750 mg/Nm^3	Daily	Immediate	Continuous
MATIMBA	All Units	750 mg/Nm^3	Daily	Immediate	Continuous

*Emission limits requested are for normal operations, so excludes upset, startup, shutdown, or maintenance conditions.

SULPHUR DIOXIDE

Measured ambient SO_2 concentrations in the Highveld, Vaal Triangle and Waterberg for the period 2021 – 2023 show compliance with the NAAQS. While Eskom is not the sole contributor to these concentrations, Eskom emissions are a key contributor, recognising these contributions are made at Eskom's current emission rates i.e. without SO_2 abatement at Duvha, Matla, Lethabo, Tutuka, Medupi, Matimba, Kendal and Majuba, with ambient concentrations remaining compliant with the NAAQS. Considering the cumulative Eskom Fleet SO_2 reductions under ERP 2024 A (which excludes SO_2 abatement at Lethabo, Tutuka, Matimba, Majuba and Kendal), by FY2030 a reduction of 555kt (32%) is anticipated, with a further 165kt (14%) by FY2035 due to completion of the wet FGD at Medupi, Despatch Prioritisation, efficiency improvement projects, and assumed shutdown of Arnot, Kriel, Camden, Hendrina, Grootvlei, Duvha, and Matla.

The cumulative Highveld and Vaal dispersion modelling indicated compliance with the NAAQS under all modelling scenarios, including those where Lethabo, Majuba, Kendal, and Tutuka were simulated at current emission rates, without SO_2 abatement. The cumulative Waterberg dispersion model showed compliance with the hourly and annual average NAAQS, however predicted non-compliance with the 24-hour NAAQS until completion of the wet FGD at Medupi. Following Medupi's FGD completion, modelling predictions showed compliance with the NAAQS, despite Matimba not having FGD technology installed i.e. emitting at current rates.

While all stations comply with their respective current emission limits, the stations cannot comply with the new plant MES without SO_2 abatement technology. Following the completion of the wet FGD at Medupi, Medupi will comply with the new plant MES. The Medupi installations are due to commence in FY2028, taking five-years to complete on all generating units, with a completion date of FY2032.

Considering Matla and Duvha, no SO_2 abatement technologies were assessed in the ERP scenarios due to the costs associated with the technology, time to install the technology, and that Matla and

Duvha commence their assumed shutdowns in 2030. Further, based on the commentary provided by the NECA Panel regarding the LNB installation at Matla not being economically feasible due to its shutdown schedule, the same consideration can be given to the SO_2 abatement technologies at Matla and Duvha.

SO_2 abatement technologies at Majuba and Kendal were evaluated as part of this application, assessed under ERP 2024 B (a scenario, that with additional guarantees and considerations, could be achieved), with semi-dry FGD identified as the most appropriate at Kendal, while DSI FGD was identified for Majuba. The semi-dry FGD would bring Kendal into compliance with the new plant MES, while the Majuba DSI FGD would reduce SO_2 emissions, however not to compliance with the new plant MES.

Regarding Kendal, should the new plant MES be enforced, an optimistic installation start date of FY2031 could be achieved as concept and design has not commenced, with full installation complete by FY2035. This installation has an estimated nominal Capex of R44.4 billion (-15% to +20%), with an annual real Opex of approximately R1 billion. Considering the full FGD impact would only be realised approximately four-years before the assumed Kendal shutdown, and the cost of installation, it is not deemed economically feasible to install.

At Majuba, installation of the DSI would commence in FY2029 due to the pilot project being commissioned, and concept and design not yet commenced, with full completion by FY2033. This installation has an estimated nominal Capex of R13.1 billion (-15% to +20%), with an annual real Opex of approximately R1 billion. Assumed Majuba shutdown is due to commence in FY2047, with complete shutdown by FY2052. While Majuba has a longer remaining life, and DSI FGD is lower in cost compared to alternatives, Majuba's high operating cost, in addition to the DSI FGD Capex and high annual Opex, challenges the economic and financial viability of installing DSI at Majuba. Further to this, the DSI FGD will not achieve compliance with the new plant MES, with alternatives (wet or semi-dry FGD) not being technically feasible at Majuba.

Considering ERP 2024 C, which represents a scenario that would require substantial guarantees, with significant financial implications, SO_2 technologies were evaluated for Tutuka, Lethabo, and Matimba. In previous applications, Eskom's position has been that installation of SO_2 technologies at Lethabo, Tutuka, and Matimba are not economically feasible and are at high risk of not even being technically feasible for implementation; this position is maintained in this application.

Should new plant SO_2 MES compliance be enforced at Tutuka, Lethabo, and Matimba, and since concept and design have not commenced, followed by procurement and construction, an optimistic start date of FY2031 is estimated. Since installation is five years for all generating units, estimated completion dates would be optimistically FY2035. Tutuka starts shutdown in FY2036, one year after completion of the FGD, Lethabo starts shutdown FY2037, two years of completion of FGD, and Matimba starts shutdown FY2039, four years of completion of the FGD. Considering the nominal Capex (-15% to +20%) to install FGD at Tutuka (R38.4 billion), Lethabo (R40 billion), and Matimba (R42 billion), as well as the approximate annual real Opex of R1 billion for each station, return on investment would not be realised and is therefore not economically feasible to install this equipment.

The total nominal Capex to implement ERP 2024 C, inclusive of ERP 2024 A (planned) and ERP 2024 B (with additional guarantees and considerations) is R256.9 billion, with an estimated real Opex of R6.3 billion per year. No detailed energy system modelling has been completed for this study due to timing constraints but previous work has shown that attempts to install FGD at multiple stations

simultaneously to bring about rapid MES compliance will result in significant capacity shortages and unprecedented levels of load shedding which will have catastrophic impacts on the economy and the country broadly.

In light of the above, and the currently compliant ambient SO_2 concentrations in the Waterberg, Highveld and Vaal Triangle, the dispersion modelling predictions indicating NAAQS compliance, and the SO_2 emission reductions anticipated in the Eskom Fleet over the next few years, Eskom is requesting exemption from the new plant SO_2 MES. This exemption request is for Medupi until completion of the FGD installations, and Lethabo, Matimba, Majuba, Tutuka, Kendal, Matla and Duvha until their assumed shutdowns (Table 0-3). To reduce SO_2 emissions, the Despatch Prioritisation Strategy will be initiated, while efficiency improvement projects, addressing combustion efficiencies, will be implemented.

While extension of a station's life may provide improved economic viability for SO_2 reduction at certain stations, this would mean an extension of South Africa's reliance on coal generation, potentially impacting South Africa's greenhouse gas (GHG) commitments. A possible alternative to consider, would be that if funding is made available Eskom increases its investments in renewables and grid connection by the same amounts that would have been invested in such SO_2 retrofits; this would result in larger economic value add than FGD retrofits, and would progress South Africa's transition to renewables quicker.

Table 0-3 – Sulphur dioxide requested emission limits and timeframes

STATION	GENERATING UNIT	MAXIMUM RELEASE RATE*			DURATION OF EMISSIONS
		mg/Nm^3	Average	Date To Be Achieved	
DUVHA	All Units	2,600 mg/Nm^3	Daily	Immediate - Shutdown	Continuous
MATLA	All Units	2,600 mg/Nm^3	Daily	Immediate - Shutdown	Continuous
LETHABO	All Units	2,600 mg/Nm^3	Daily	Immediate - Shutdown	Continuous
TUTUKA	All Units	3,000 mg/Nm^3	Daily	Immediate - Shutdown	Continuous
MATIMBA	All Units	3,500 mg/Nm^3	Monthly	Immediate - Shutdown	Continuous
KENDAL	All Units	3,000 mg/Nm^3	Daily	Immediate	Continuous
		1,000 mg/Nm^3	Daily	1 April 2036**	Continuous
MAJUBA	All Units	3,000 mg/Nm^3	Daily	Immediate	Continuous
		2,100 mg/Nm^3	Daily	1 April 2034**	Continuous
MEDUPI	All Units	3,500 mg/Nm^3	Monthly	Immediate	Continuous
		800 mg/Nm^3	Monthly	1 April 2032	Continuous

*Emission limits requested are for normal operations, so excludes upset, startup, shutdown, or maintenance conditions.
**Should semi-dry FGD be installed at Kendal, and DSI FGD at Majuba.

SUMMARY

In addition to the above motivations, is consideration of the Health Cost Benefit Analysis (CBA) undertaken for the Highveld and Vaal Triangle, and Waterberg regions. This analysis evaluated the health benefits and costs associated with ERP 2024 A, ERP 2024 B, and ERP 2024 C. The benefit:cost ratios (BCR) need to be interpreted with care. They are meant only to provide a perspective on and inform the decision-making process underlying the scenarios. They are not meant

to be interpreted as a definitive answer to making abatement decisions. Decisions involving human health have to be informed by non-economic criteria as well. In addition, with uncertainty inherent in the analysis, the cost benefit ratio should thus not be viewed as absolute, but rather as a relative value from which to compare scenarios (Prime Africa Consult, 2024).

In the Highveld and Vaal, the CBA concludes that greatest health benefits relative to costs would be realised in ERP 2024 A, with a BCR above 1. While ERP 2024 B approaches 1 in the most optimistic scenarios, it generally shows that costs of installations outweigh the health benefits that will be realised. Implementation of ERP 2024 C is shown that costs of installations far outweigh the health benefits that will be realised, with the BCR well below one. Considering the Waterberg CBA, the BCR's for all scenarios are significantly low, well below 1, concluding that under all scenarios the costs of installation far outweigh the health benefits that will be realised.

Over the past decade, South Africa's electricity system has struggled to meet demand due to frequent breakdowns and reduced capacity, leading to recurrent loadshedding. This crisis has severely impacted the economy, particularly the mining and industrial sectors, causing reduced outputs and a loss of investor confidence and government revenue. Power outages have also affected medical care, food storage, sanitation, water, and sewerage facilities, while citizens faced daily challenges such as extended commutes, increased crime, and difficulties in food preparation. The exemptions applied for aim to ensure that security of supply is maintained and the impacts described above are avoided while minimising the environmental impact of the stations operations.

Eskom is mindful that any exemption application should be limited in extent and believes that the alternative emission limits requested above, and this application in general, complies with this approach. Specifically, Eskom has:

- In respect of PM limits only requested exemption where it is necessary for the time to complete the emission reduction projects to bring the stations into new plant MES compliance. Further, the exemption requested alternate limits is no worse than the MES existing plant limits which the stations have operated at historically.
- In respect of NO_X limits for Lethabo, Tutuka and Majuba, exemptions are requested where it is necessary for the time to complete the emission reduction projects to bring the stations into compliance with the new plant MES. Further, there is compliance to NAAQS ambient air quality limits for NO_2 and the exemption requested alternate limits is no worse than the MES existing plant limits which the stations have operated at historically.
  - In the case of NO_X limits for Duvha and Matla the exemption request is supported by a clear motivation, there is compliance to NAAQS ambient air quality limits for NO_2, and the requested alternate limits are no worse than the MES existing plant limits which the stations have operated at historically.
- In terms of SO_2 the exemption request has provided clear motivation above of the appropriateness of the alternate limits specifically illustrating that there is compliance to NAAQS ambient air quality limits for SO_2. In addition, Eskom is not seeking a blanket exemption as it intends to operate at alternate SO_2 limits generally below the existing plant limits and it will obtain MES compliance for two out of the three priority pollutants at all stations operating post 2035.

In conclusion, Eskom believes that based on the analysis completed for this application the exemptions requested are appropriate and balance the environmental and health impact of its emissions with the national requirement for security of supply and sustainable growth and development.

The public participation phase is complete, which commenced on 6 November 2024 and ended 6 December 2024. The comments received during this process have been responded to, as contained within the Stakeholder Engagement Report. The final Exemption Application reports will be submitted to the Minister of the DFFE to consider the applications. Any further comments can be directed to the Minister.

1 INTRODUCTION

Eskom Holdings SOC Ltd (Eskom) is South Africa's public electricity utility, supplying about 95% of the country's electricity with a generation capacity exceeding 35,000 MW. Around 90% of its power comes from coal-fired stations, primarily located in the Mpumalanga Highveld, with others in the Free State and Limpopo provinces.

Coal-fired power stations must comply with strict environmental regulations under the National Environmental Management: Air Quality Act (NEM:AQA). Eskom sought postponements and alternative limits to the Minimum Emission Standards (MES) for oxides of nitrogen (NO_X), sulphur dioxide (SO_2) and particulate matter (PM) between 2018 and 2020. These applications were necessary due to several factors, such as the restrictive legal framework, the advanced age of Eskom's power plant fleet, and the technical challenges of reducing emissions. The high costs of emission reduction technologies, which could significantly impact electricity tariffs and the financial stability of the utility, further underscored the need for a phased approach to compliance.

In October 2021, the Department of Forestry, Fisheries, and the Environment (DFFE) granted conditional postponements for some power stations (Grootvlei, Arnot, Komati, Camden, Hendrina, Acacia, and Port Rex Power Stations), provided partial refusals for others (Majuba, Tutuka, Kendal, and Kriel), and rejected the applications for Lethabo, Matla, Medupi, Matimba, and Duvha.

In December 2021 Eskom initiated an appeal process, engaging with the DFFE, and other governmental departments, on the basis that immediate compliance would lead to the shutdown of about 16,000 MW of coal-fired capacity. Eskom emphasised that this would negatively impact the national grid and delay South Africa's energy transition, that flu gas desulphurisation (FGD) retrofit on "six-pack" power stations was not proven to be technically feasible and would be a world first, and that if funding was available to execute the required compliance projects in time to meet the MES, this would result in an approximate increase of 10% on existing electricity tariffs (Eskom, 2020).

In May 2024, the Minister approved the MES suspensions for the power stations set to shut down by 31 March 2030 (Hendrina, Grootvlei, Arnot, Camden, and Kriel) and, under Section 59 of NEM:AQA, instructed Eskom to apply for MES exemptions for the remaining stations (Lethabo, Kendal, Tutuka, Matla, Duvha, Majuba, Matimba, and Medupi). The Minister would then assess each application based on its merits and supporting information.

This report presents a summary for the Eskom Fleet exemption application, highlighting the specific environmental and operational challenges it faces. While the primary focus is on the Eskom Fleet, aspects of the Highveld and Vaal Triangle Fleet and Waterberg Fleet are discussed separately. This holistic approach is necessary as a particular station's circumstances cannot be considered in isolation of the entire Eskom Fleet as station performance, emissions impacts, and financial impacts need to be considered cumulatively. By considering the entire Eskom fleet, the report aims to provide a cohesive strategy for reducing emissions and achieving compliance while addressing the unique challenges of each power station. Station specific and cumulative reports are contained in Annexures of this report, as follows:

- Annexure A: Cumulative airshed Atmospheric Impact Report
- Annexure B: Cumulative stack emissions only dispersion modelling
- Annexure C: Airshed specific Health Cost Benefit Analysis

2 LEGAL OVERVIEW

In terms of Section 21 of the NEM:AQA a list of activities which result in atmospheric emissions and which the Minister or Member of the Executive Council (MEC) reasonably believes, have or may have a significant detrimental effect on the environment, must be promulgated. Sections 22, 36 to 49, 61 and 62 provide additional information regarding the Atmospheric Emissions Licence (AEL) requirements and processes to be followed. GNR 893 (22 November 2013), as amended, promulgated in terms of the NEM:AQA, contains a list of activities that would require licensing

2.1 THE MINIMUM EMISSION STANDARDS

In March 2010, the MES was published in terms of the NEM:AQA. The intent is that by setting these emission limits (known as point source limits), overall air quality at the local or ambient level, as defined by the National Ambient Air Quality Standards (NAAQS), will be maintained. In terms of the NEM:AQA, all of Eskom's coal- and liquid fuel-fired power stations are required to meet the MES contained in GNR 893, and as amended in GNR 1207. The MES also provides transitional arrangements in respect of the requirement for existing plants to meet the MES and provided that less stringent limits had to be achieved by existing plants by 1 April 2015, and more stringent “new plant” limits had to be achieved by existing plants by 1 April 2020.

2.1.1 POSTPONEMENT OR SUSPENSION OF COMPLIANCE TIMEFRAMES

Section 12 of GNR 893 (as amended by GNR 1207) provides for the postponement or suspension of compliance timeframes with the MES under specific conditions. This means that facilities may apply to the NAQO for a postponement or suspension, for a maximum of 5 years, if they are unable to comply with the set standards by the required date.

The applicant must demonstrate current or future projects aimed at ensuring eventual compliance. They should also include an air quality impact assessment detailing the implications of continued emissions on the environment and health and evidence of consultation with I&APs.

2.1.2 EXEMPTION FROM MINIMUM EMISSION STANDARDS

Section 59 of the NEM:AQA grants any person, or organ of state, the right to apply for exemption from a provision of the NEM:AQA. These exemptions are typically made where compliance with a provision is economically or technically unfeasible and are generally time-bound and subject to review.

Section 59 of the NEM:AQA provides Eskom the opportunity to apply for exemption from certain provisions of the NEM:AQA. In terms of Section 59, Eskom is required to advertise the application in at least two newspapers circulating nationally and give reasons for the application. The approval of an MES exemption application could potentially limit the constitutional rights of South Africans by leading to environmental degradation, posing health risks, and creating economic and social challenges. As such, an approval would likely be issued subject to a range of conditions to limit potential negative impacts.

2.2 NATIONAL AMBIENT AIR QUALITY STANDARDS

In terms of Section 9 of the NEM:AQA the Minister identified substances in the ambient air that are believed to present a threat to the health, well-being or the environment and has in respect of those substances, established national standards for ambient air quality. These standards provide the permissible amount or concentration of each of the substances in ambient air. The standards contain

the averaging periods, concentrations, frequencies of exceedance, compliance dates and reference methods for select substances.

In 2004, the National Ambient Air Quality Standards (NAAQS) were promulgated to better regulate local air quality. The NAAQS define the acceptable levels of environmental risk associated with human exposure to air pollutants. If an area meets the NAAQS, it is considered to have an air quality that poses a legally acceptable level of risk to the environment and human health in South Africa.

The NAAQS relevant to the Eskom Power Stations and this exemption application are sulphur dioxide (SO_2), nitrogen dioxide (NO_2), and particulate matter (PM_{10} and $PM_{2.5}$). The NEM:AQA defines ambient air to exclude air regulated by the Occupational Health and Safety Act (No. 85 of 1993).

2.3 ENFORCEMENT OF PRIORITY AREA MANAGEMENT PLANS

The Regulation for Implementing and Enforcing Priority Air Quality Management Plans of 26 August 2024 (GNR 5153) is a framework established by the South African government to provide for the implementation and enforcement of a priority area's air quality management plans, in terms of sections 19(1)(b) and 19(5) of the NEM:AQA, to strengthen air quality management in identified priority areas with high levels of air pollution. It was published for public comment, allowing stakeholders and the public to provide input before it is finalised.

GNR 5153 is aimed at ensuring that designated priority areas meet national ambient air quality standards. The regulations also establish the mandatory steps for implementing emission reduction and management measures, with the government empowered to monitor their effectiveness and enforce compliance where necessary. They apply to various proponents, including those involved in activities like mining, reclamation, or operating controlled emitters such as power stations. These proponents are required to submit emission reduction and management plans, in terms of the Regulations, within six months of the publication of a priority area AQMP. Once these emission reduction and management plans are approved, they must be implemented within specified timeframes. Additionally, any existing priority area AQMPs, published prior to the commencement of these regulations, must be reviewed by the DFFE within two years to include updated emission reduction targets. These measures ensure that compliance is regularly evaluated and enforced across sectors.

The priority areas defined in South Africa, and applicable to Eskom's exemption application, are the Vaal Triangle Airshed Priority Area (VTAPA), Highveld Priority Area (HPA) and the Waterberg Priority Area (WPA). The Eskom power stations that fall within each of these are:

- Vaal Triangle PA: Lethabo
- Highveld PA: Kusile, Tutuka, Matla, Duvha, Kendal, Majuba, Arnot, Kriel, Grootvlei, Hendrina, and Camden
- Waterberg PA: Medupi and Matimba

Each priority area includes industrial activities, such as power stations, refineries, and other significant emission sources that contribute to poor air quality in the region, such as mining, domestic fuel burning and uncontrolled waste burning. The priority area AQMP's seek to reduce emissions from industries such as power stations and petrochemical plants, with specific focus on reducing SO_2, NO_x, and PM. Specific emission limits, including those tied to MES for industries, are a cornerstone of each AQMP, although the implementation of regulations relevant to priority areas by authorities must also be done under the consideration and indulgence of any MES postponements, suspensions and exemptions

granted to emitters. The AQMP's require industries to meet strict MES values and incorporate Best Available Technology (BAT) for emission reduction. These measures include continuous monitoring and improvements, such as reducing fugitive emissions (unintended releases of pollutants, such as dust or gases from industrial activities). The AQMP's also calls for offsets to reduce pollution in other areas as compensation when targets are not immediately achievable. In addition, industries are encouraged to regularly review and update their emission reduction strategies to align with evolving environmental policies.

Adherence to the priority area AQMP's, as it currently stands, is not a legal requirement. The AQMP's outline guidelines and recommended actions for stakeholders in the region to help meet air quality standards. However, while it sets MES and encourages BAT use, its enforcement has been somewhat limited. Non-compliance primarily results in reputational risks or administrative sanctions but is not uniformly enforced across sectors. In terms of the recently published Priority Area Regulations (GNR 5153) the AQMP's must be reviewed within two years of publication of the regulations to include emission reduction targets. Once reviewed, stakeholders (such as industries, municipalities, and other entities operating within a priority area) will be required to develop emission reduction and management plans indicating how they will comply with the agreed emission reduction targets. The regulation also provides enforcement mechanisms, including fines or penalties for non-compliance, making adherence to such air quality management plans legally enforceable. Thus, with the new regulation, failure to comply would result in legal consequences, strengthening the overall governance and impact of air quality management in priority areas.

2.4 ESKOM POWER STATION LEGAL STATUS

Table 2-1 presents the status of Eskom's Atmospheric Emission Licenses (AELs) and which stations are requesting exemption for which pollutant, as part of this application. Considering the stations due for complete shutdown by 2030 (Arnot, Hendrina, Camden, Grootvlei, and Kriel), their suspension applications have been approved by the Minister, and therefore no exemption applications are made in this submission.

Currently, with the exception of Matimba, all Eskom AELs have expired at those stations requesting exemption in this submission. Eskom has submitted AEL renewal applications for all its applicable power stations but the renewal process is on hold until the exemption applications are finalised and decisions made. AELs will be renewed once the exemption process is complete.

Table 2-1 – Eskom Fleet AEL, Suspension, and Exemptions Status

	AEL REFERENCE	EXPIRY	EXEMPTION APPLICATIONS (THIS APPLICATION)		
			PM	NO_X	SO_2
Arnot	17/4/AEL/MP312/11/15	10 June 2029	Suspension applications approved; therefore, no exemption request being made in this application		
Camden	Msukaligwa/Eskom H SOC Ltd/CPS/0012/2024/F04	31 March 2030			
Kriel	17/AEL/MP312/11/09	05 August 2029			
Grootvlei	Dipaleseng/Eskom H SOC Ltd/GPS/0015/2024/F04	31 March 2030			
Hendrina	17/4/AEL/MP312/11/16	10 June 2029			
Duvha	17/04/AEL/MP312/11/07	30 June 2022	Y[1]	Y	Y
Matla	17/4/AEL/MP312/11/14	30 June 2022	Y[1]	Y	Y
Kendal	17/4/AEL/MP312/11/15	30 September 2024	Y	N	Y
Lethabo	FDDM-MET-2011-08-P1	31 March 2020	Y[1]	Y	Y
Majuba	R PKI Seme/Eskom H SOC Ltd MPS/0014/2021/F04	25 April 2024	N	Y	Y
Tutuka	Lekwa/Eskom H SOC Ltd TPS/0013/2019/F03	25 April 2024	Y	Y	Y
Matimba	H16/1/13-WDM05	27 September 2027	N	N	Y
Medupi	H16/1/13-AEL/M1/R1	01 December 2025	N	N	Y
Y: Exemption application being made as part of this submission. N: No exemption application being made as part of this submission i.e. parameter compliant with new plant MES Y[1]: Limited exemption from MES requested for parameter i.e. certain generating units will comply from 1 April 2025.					

3 CURRENT PERFORMANCE SUMMARY

3.1 CURRENTLY INSTALLED ABATEMENT EQUIPMENT

Currently installed emission abatement equipment at each station within the Eskom Fleet are presented in Table 3-1.

Table 3-1 – Current installed abatement on Eskom Fleet

STATION	CURRENT INSTALLED ABATEMENT
Lethabo	Electrostatic precipitators (ESPs), sulphur trioxide (SO_3) plant, and high frequency power supplies (HFPS) to mitigate PM emissions.
Medupi	Pulse Jet Fabric Filter (PJFF) to mitigate PM emissions Low NO_X Burner (LNB) to mitigate NO_X emissions
Matla	ESPs, HFPS (Unit (U) 1, U2, U4 and U6), and SO_3 plant to mitigate PM emissions
Duvha	ESPs and SO_3 Plants (U4, U5, U6), fabric filters (U1, U2), HFPS (U5) to mitigate PM emissions
Tutuka	ESPs, HFPS (U4, U5, U6) to mitigate PM emissions
Kendal	ESPs, HFPS and SO_3 plant to mitigate PM emissions. Low NO_X boilers designed to mitigate NO_X emissions
Majuba	PJFF to mitigate PM emissions
Matimba	ESPs and SO_3 plant to mitigate PM emissions Low NO_X boilers designed to mitigate NO_X emissions
Kusile	Wet FGD, PJFFP to mitigate PM emissions Low NO_X Burner (LNB) to mitigate NO_X emissions
Arnot	PJFFP to mitigate PM emissions
Kriel	ESP Upgrade, HFPS installation (in progress) and SO_3 plant to mitigate PM emissions
Camden	PJFFP to mitigate PM emissions, LNB to mitigate NO_X emissions
Hendrina	PJFFP to mitigate PM emissions
Grootvlei	PJFFP to mitigate PM emissions, 4-units offline

3.2 CURRENT AND NEW PLANT EMISSION LIMITS

As per each station AEL and/or aligned to each station's 2015 and 2021 postponement applications in which extensions of the current limits were provided until 31 March 2025 for SO_2 and NO_X at some stations, Table 3-2 presents the current and new plant emission limits applicable to those stations applying for exemptions. New plant limits are due to come into effect on 1 April 2025, if not already in effect at a particular station. The exemption requests, as presented in Chapter 7 of this report, are being made in terms of the new plant MES, due to come into effect 1 April 2025.

Table 3-2 – Current and future emission limits applicable to the Eskom Fleet

	PM (mg/Nm^3)		NO_X (mg/Nm^3)		SO_2 (mg/Nm^3)	
	Current	**1 April 2025**	**Current**	**1 April 2025**	**Current**	**1 April 2025**
Duvha	100	50	1,100	750	2,300	1,000
Matla – U5, U6	100	50	750	750	2,600	1,000
Matla – South Stack, U4	200	50				
Kendal	100	50	1,100	750	3,500	1,000
Lethabo	100	50	1,100	750	2,600	1,000
Majuba	100	50	1,500	750	3,200	1,000
Tutuka	300	50	1,100	750	3,400	1,000
Matimba	50	50	750	750	3,500*	1,000
Medupi	50	50	750	750	3,500*	1,000
*Approval received for monthly average						

3.3 STATION EMISSIONS PERFORMANCE

Table 3-3 presents average emissions for each station for the period April 2019 – October 2024; importantly, these averages include upset conditions which are not regulated by the emission limits, and therefore the averages presented should be considered as worst-case. As evident, all stations complied with their applicable (current) emission limits for SO_2, with no exceedances of the limit during FY2023/24 (during normal operations). However, as is evident from the averages, no stations will comply with the new plant SO_2 MES (1,000mg/Nm^3) without abatement technology.

Regarding NO_X emissions between April 2019 – October 2024, emission averages have complied with current emission limits at all stations, except for Lethabo, where although the average remains compliant, exceedances of the limit did occur in FY2023/24. While Medupi, Kusile, Matimba, and Kendal will comply with the new plant NO_X MES (750 mg/Nm^3), the remaining stations will not be able to comply without NO_X abatement technology.

During April 2019 – October 2019, and as presented, PM emissions remain the greatest challenge at most stations, except for Duvha Unit (U)1 and U2, Majuba, and Medupi, all of which have pulse jet fabric filters (PJFF). Although the average emission at Matimba complies with the new plant MES, exceedances of this have recently occurred. While Medupi, Matimba, Majuba, and Duvha U1 and U2 will comply with the new plant PM MES (50 mg/Nm^3) by 1 April 2025, the remaining stations cannot comply until the necessary PM abatement projects are complete.

Table 3-3 – Average station emissions between 2019 – 2024 (mg/Nm^3)

	PM (mg/Nm^3)*	NO_X (mg/Nm^3)*	SO^2 (mg/Nm^3)*
Duvha U1, U2	28	796	1,663
Duvha U4, U5, U6	100		
Matla	184	765	1,936
Kendal	341	785	2,055
Lethabo	101	837	1,856
Majuba	20	1,004	1,934
Tutuka	239	818	2,141
Matimba	36	441	2,522
Medupi	27	379	2,689

Red text indicates the average is non-compliant with the current limit.
Orange text indicates that although the average complied with the current limit, exceedances of this limit occurred.
*Emission averages include upset conditions, which are not regulated by the emission limits, and therefore averages presented are worst-case, and not representative of normal operations as regulated by the emission limits.

4 EMISSION REDUCTION PLAN

Coal-fired power stations are subject to strict environmental regulations and monitoring due to their emissions. All coal-fired power stations are required to meet the MES contained in GNR 893 that was issued on 22 November 2013 (as updated by GNR 1207 on 31 October 2018) and promulgated in terms of Section 21 of the NEM: AQA.

Between 2018 and 2020, Eskom submitted applications for postponement, suspension and/or alternative limits to the MES for several of its power stations to the DFFE as the power utility sought more time to implement necessary pollution control technologies for NO_X, SO_2 and PM emissions.

To address emission reductions, Eskom developed an Emission Reduction Plan (ERP) in 2015, with this being updated in 2019 (EERP 2019), 2020 and 2022. In May 2024, as part of the Minister's decision, Eskom were required to review the 2022 ERP, with this having been revised by Eskom in 2024.

Eskom's focus has been on PM emission reductions, which is aligned with the ambient monitoring data from the various stations located through the Waterberg, Highveld and Vaal; importantly these stations represent cumulative ambient concentrations with Eskom not being the sole contributor to measured concentrations. Of the Highveld and Vaal monitoring stations reviewed for this exemption application, for the period 2021 – 2023, all monitoring stations indicated non-compliance with the PM_{10} and $PM_{2.5}$ annual average NAAQS at some point, with numerous exceedances of the NAAQS 24-hour standards also recorded. The Waterberg monitoring stations indicate non-compliance with the PM_{10} and $PM_{2.5}$ NAAQS, with annual exceedances at Marapong, while 24-hr exceedances also occurred more than the permitted frequency of exceedances at Marapong and Medupi.

While PM has been the critical focus, NO_X and SO_2 emission reduction projects have also been considered. However, unlike PM, ambient NO_2 and SO_2 concentrations in the Highveld, Waterberg, and Vaal Triangle for 2021 – 2023 remain below the annual SO_2 and NO_2 NAAQS; although exceedances of the short-term averaging periods (10-minute, hourly, 24-hour, as applicable) of the NAAQS were measured at certain monitoring stations, their frequency of occurrence remained below the permitted frequency of exceedance, remaining compliant with relevant standards.

Following Eskom's review of the 2022 ERP, and to ensure continued focus on emission reductions, Eskom developed the 2024 ERP. In addition to the various abatement equipment upgrades and refurbishments currently being undertaken at each station, predominantly addressing PM emissions through electrostatic precipitator (ESP) refurbishments, high frequency power supply (HFPS) upgrades, SO_3 plant upgrades, and Dust Handling Plant (DHP) upgrades, many of which are already complete, Eskom are also planning and/or evaluating the following to reduce emissions:

- Wet flue gas desulphurisation (FGD) at Medupi (included in previous ERPs)
- Kendal (semi-dry FGD) and Majuba (Duct Sorbent Injection (DSI FGD)) SO_2 reduction projects have been identified as potential alternatives, although are being evaluated as part of this process.
- Low NO_X Burner (LNB) technology at Majuba, Tutuka and Lethabo to mitigate NO_X emissions.
- Despatch Prioritisation Strategy at specific power stations, initiated to reduce SO_2 emissions, however also positively impacting PM and NO_X emissions.
- Efficiency improvement projects under the Generation Recovery Programme to optimise the air-to-fuel ratio which should abate some SO_2 emissions and maximise combustion efficiency.
- The progressive shutdown of coal-fired stations will reduce overall Eskom Fleet emissions.

- Although not a method of reducing emissions at source (i.e. the power stations), the cumulative impact on neighbouring communities is reduced through the air quality offset (addressing emission sources within the community) projects already implemented by Eskom, therefore Eskom are looking to expand this beyond the 35,000 households originally planned.

Figure 4-1 illustrates Eskom's planned or estimated installation dates, linked to the 2024 ERP, for abatement equipment upgrades, retrofits, and new installations. This installation schedule considers:

- Time required to secure funding for each project.
- Lead time required to procure, design, manufacture, and begin installations.
- The outage schedule to allow generating units to be taken offline for upgrades / retrofitting while maintaining security of supply i.e. ensuring sufficient generating capacity remains across the stations to avoid loadshedding.
- To ensure security of supply, generally only a single generating unit at a station can be taken offline at a time, particularly with regards to the long installation timelines of the equipment.

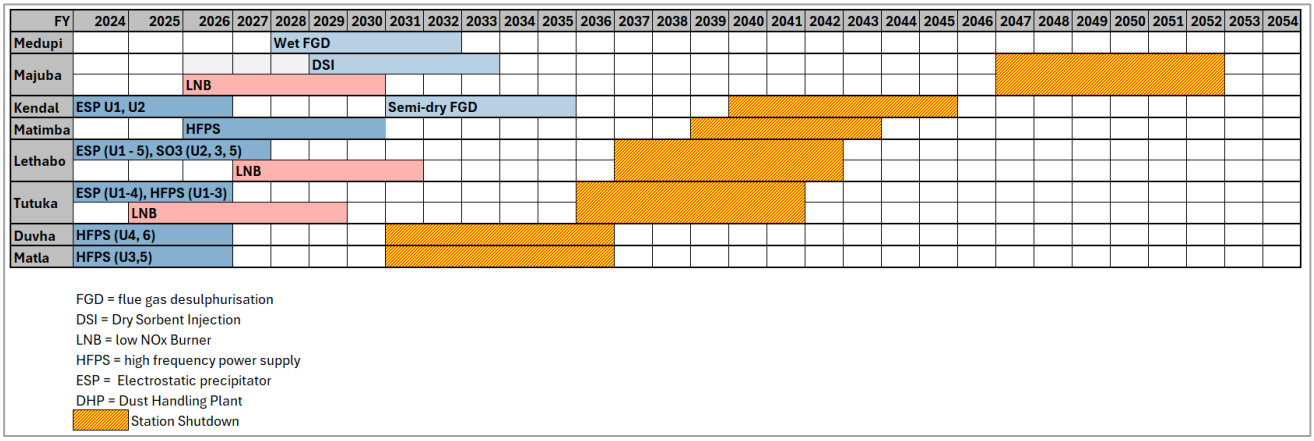


Figure 4-1 - Eskom's abatement equipment installation schedule

Coal beneficiation as a method of reducing SO_2 emissions has been investigated by Eskom and research continues. Investigations to date illustrate the potential for sulphur reduction but various complexities in terms of implementation need to be confirmed and managed such as the energy intensive nature of the process, increased coal mined, and the generation of additional wastewater and coal discards/solid waste. The financial and contractual implications of beneficiation also need to be assessed and shown to be positive for Eskom. Given these uncertainties Eskom has not included any benefit associated with coal beneficiation in the ERP and emission reduction calculations. Any emission reduction identified in this area in future will be considered additional to the 5% improvement in emissions associated with efficiency improvement projects.

Similarly, investigations completed to assess emission reductions using coal with a lower sulphur content confirm that for Eskom to obtain coal with low(er) sulphur content will, in most cases, require sourcing a washed product. This will result in Eskom acquiring coal from the same source pool that services the export market. Purchasing export market coal will result in a significant cost increase for Eskom and this filter though as an increase in electricity prices.

4.1 DESPATCH PRIORITISATION STRATEGY

With the addition of alternate energy sources (wind and solar) on to the national grid planned in the draft IRP, the existing coal fired power stations are expected to provide additional flexibility to the system through increased variability in a load following mode of operation, as well as providing back-up to the variable intermittent non-dispatchable renewable technologies, as well as providing ancillary services, inertia etc. which are not provided by the inverter-based renewable technologies. This essentially results in lower running load factors for these stations as the renewable energy sources will be given priority dispatch over the fossil fuelled stations. Furthermore, South Africa's commitments under the Paris Agreement (with the upcoming revision of the NDC) is expected to result in a new GHG emissions target for 2035. Considering an indicative limit of 125-140 Mt CO_2 per annum from fossil fuel generation from 2031, this equates to average load factors of 40-45% for stations operating in 2031 and between 48% to 55% for stations operating beyond 2035, i.e. after Matla and Duvha shutdown. While the MES and climate change regulatory process are legally separate it is useful to note both ERP 2024 A and the security of supply projection are aligned with Eskom's current pollution prevention plan running to December 2025. Future CO_2 trajectories will be based on the updated pollution prevention plan and IRP, NDC, and Sectorial Emission Targets (SET).

Despatch Prioritisation of renewables reduces SO_2 emissions given the costs associated with SO_2 abatement equipment, complexities of installation, and the age of most stations within the Eskom fleet where return on investment may not be realised. The recent improvement in the reliability of the fleet, allowing Eskom to adopt increased use of Despatch Prioritisation to reduce emissions, is due to a variety of reasons, although most critically the successful implementation of the Generation Recovery Programme. This programme was initiated in March 2023 focusing on specific projects targeting major and minor breakdowns and has improved the generating capacity at stations, allowing improved load management.

To limit emission loads Eskom will not run coal stations at maximum loads but will rather aim to limit the loads to only what is required for system adequacy making maximum use of other available energy sources for generation, resulting in less coal burnt. This reduction in load will result in a reduction in the levels of total emissions from Eskom into the atmosphere. Although the objective is to reduce SO_2 emissions, given the reduced coal burnt, NO_X and PM emissions will also be positively impacted.

Although Despatch Prioritisation will lead to reduced emissions, it is noted this is based on other power generation sources being added to the grid, allowing Eskom to reduce loads overtime. The addition of these alternative generation sources is outside of Eskom's control, and therefore should these not materialise within anticipated timeframes or there is an increase in economic growth, to avoid constraining the economy and ensure continued grid stability and security of supply, in terms of national energy planning Eskom may be required to operate stations at higher loads with increased emissions.

4.2 FLEET EMISSIONS TRAJECTORY AND ABATEMENT PROJECTS

Eskom considered various emission reduction scenarios (ERP alternatives) based on present planning assumptions considering the various abatement initiatives undertaken, planned or being evaluated, energy demand, station shutdowns, and the positive impact of Despatch Prioritisation. No detailed stochastic energy systems analysis, such as is done for the Integrated Resource Plan (IRP), was completed for this exemption application process given time constraints. The energy projections used for the ERP alternatives were based on presently available planning assumptions and Eskom

internal projections. Considering security of supply, a fourth emission projection was included, representing an upper emission limit projection based on more conservative assumptions than the original ERP alternatives with the aim to ensure security of electricity supply in the absence of any stochastic energy system analysis is provided. The trajectories considered comprised:

- ERP 2024 A (PM and NO_X reduction, Despatch Prioritisation strategy, and SO_2 abatement at Medupi and Kusile), representing Eskom's planned projection.
- ERP 2024 B (As per ERP 2024 A plus SO_2 reduction technology installed at Majuba and Kendal), representing a projection, that with additional guarantees and strategic decisions, could be achieved.
- ERP 2024 C (As per ERP 2024 A and B, plus SO_2 reduction technology at Lethabo and Tutuka), representing a projection that would require substantial guarantees and considerations of the significant financial impacts, such as on electricity tariffs.
- Eskom's Security of Supply Projection developed using conservative assumptions such as higher electricity demands due to a growing economy, a delay in IPP projects, and a delay in Kusile U6 generating unit coming online.

Each ERP alternative emission trajectory considered, as well as the Security of Supply trajectory, and abatement projects linked to each are illustrated and discussed in the following sections. These sections consider a 2025 baseline for comparative purposes which better represents Eskom's current performance in meeting national demand as opposed to 2019, when loadshedding was in place, constraining the economy and reducing demand. While the below sections refer to requested exemptions, the motivations for these exemptions are provided in Chapter 7 of this report. For the following sections, it is assumed that the proposed FGD retrofit type (where applicable) on a 'six-pack' power station has proven to be technically feasible, notwithstanding that it would be a world-first.

4.2.1 PARTICULATE MATTER

PM emissions at most power stations remain a challenge, and without the necessary abatement projects will not achieve MES compliance, except for those already in compliance. Table 4-1 presents complete and planned PM related projects, and the date of when the last abatement project will be complete. Given the ambient levels of PM it is important for the Eskom Fleet to comply with the new plant PM MES, and therefore all projects presented below are included in ERP 2024 A, ERP 2024 B, ERP 2024 C, and the Security of Supply trajectory. Eskom is committed to and will be commissioning these projects, if not already commissioned. The following highlights are noted:

- Duvha U1 and U2, Medupi, and Majuba have no PM projects planned as these stations have PJFF and comply with the new plant MES.
- Although Matimba has recently experienced elevated PM emissions, these are being addressed which will ensure compliance with the new plant MES from 1 April 2025; despite this compliance, HFPS installations are planned for Matimba to reduce emissions further. Since emissions will comply by 1 April 2025 with the new plant MES, priority has been given to other station's abatement projects to bring them into compliance, after which Matimba projects will commence.
- Regarding Duvha U4, U5, and U6, Matla, Kendal, Lethabo, and Tutuka, compliance with the new plant MES can only be achieved once these abatement projects are complete.

Considering the timeframes to complete these projects, some of which will not be complete by 1 April 2025, exemptions from the new plant PM MES are being requested, specifically for Duvha (U4, U5,

U6), Kendal, Lethabo (U1, U2, U3, U4, U5), Matla (U4, U5, U6), and Tutuka. Critically, once these projects are complete, the Eskom Fleet will comply with the new plant MES.

Table 4-1 – Status of particulate matter abatement projects

	ERP Alternative	Complete	Planned	Timeframe to Full Completion
Duvha U1, U2	ERP 2024 A; ERP 2024 B; ERP 2024 C	Not required	None	N/A
Duvha U4, U5, U6		U5 HFPS	U4 and U6 HFPS	1 April 2026 (U4, U6)
Matla		All Unit ESP upgrades; HFPS on U1, U2, U4, U6	HFPS on U3, U5	1 April 2026 (U4, U5, U6)
Kendal		HFPS on all units; ESP upgrades on U3, U4, U5, U6; SO_3 plant refurbishment on all units; DHP overhauls on U2, U3, U4, U5, U6	ESP upgrade U2; DHP overhaul U1	1 October 2025 (U1, U4, U6); 1 April 2026 (U1, U2, U5)
Lethabo		ESP upgrade U6; HFPS on all units; SO_3 plant upgrades on U1, U4, U6	ESP upgrade U1, U2, U3, U4, U5; SO_3 plant upgrades U2, U3, U5	1 April 2026 (U2, U3) 1 October 2026 (U5) 1 April 2027 (U4) 1 October 2027 (U1)
Majuba		Not required	None	N/A
Tutuka		ESP upgrades U6, U5; HFPS U4, U6	ESP upgrades U1, U2, U3, U4; DHP refurb U1, U2, U3, U4; HFPS U1, U2, U3, U5; SO_3 flue gas conditioning	1 January 2027
Kusile		Not required	None	N/A
Matimba		Not required	HFPS on U1, U2, U3, U4, U5, U6	31 March 2030
Medupi		Not required	None	N/A
*Includes required optimisation periods of new equipment				

PM emission trajectories associated with ERP 2024 A, ERP 2024 B, ERP 2024 C and the Security of Supply are illustrated in Figure 4-2. As noted, all alternatives considered the same PM abatement installed at Tutuka, Matla, Duvha, Kendal, Lethabo, and Matimba, so have the same trajectories, while the Security of Supply trajectory includes these projects as well as increased generation to meet demand assumptions.

From FY2025, emissions are anticipated to reduce sharply until FY2028 due to the PM abatement projects at Tutuka, Matla, Duvha, Kendal and Lethabo, as well as the progression of the assumed shutdown phases at Grootvlei, Hendrina, Arnot, Kriel, and Camden. From FY2030, PM emissions remain consistently low, showing further reductions from FY2040 due to stations assumed to be entering shutdown phases. By FY2030, compared to FY2025 (actuals), Eskom Fleet PM emissions are anticipated to have reduced by 65kt, representing a 74% reduction, after which emissions will gradually reduce as stations enter shutdown. Between FY2025 and FY2050, a total PM emissions reduction of 94% (82kt) is estimated.

Considering Eskom's Security of Supply projection, representing an upper emissions limit, emissions show a similar trend to the ERP projections, although are marginally higher between FY2026 to FY2030 due to the conservativeness of this projection. By FY2030, a PM reduction of 64kt (71%) is

estimated, with a further reduction by FY2035 of 6.5kt (25%). As noted, this is an upper emissions projection, the same trend of emission reductions year on year is evident from FY2026.

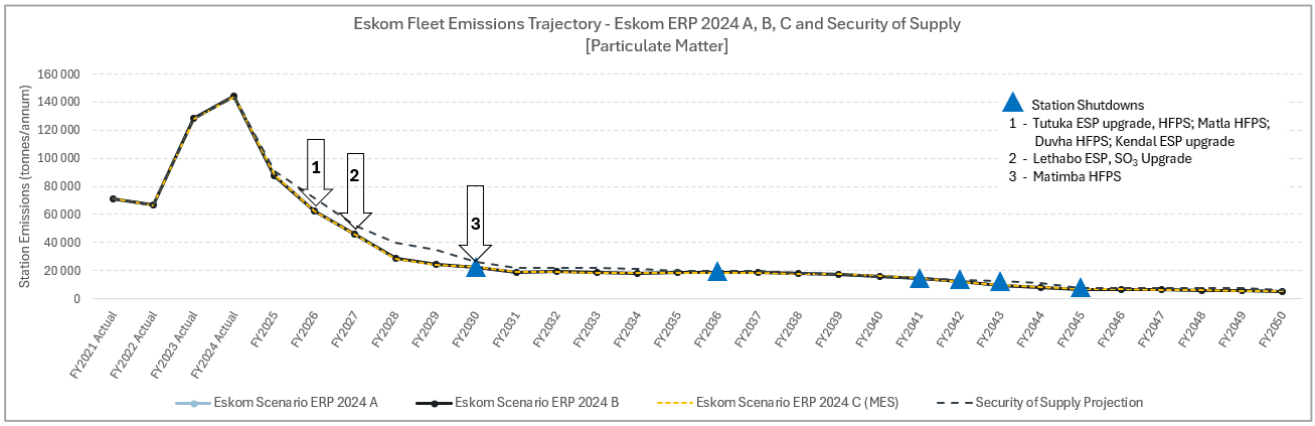


Figure 4-2 - Eskom Fleet particulate matter trajectories

While the abovementioned emission trajectories show significant improvements in the next few years due to the planned projects and station shutdowns, to offset Eskom PM emissions further, Eskom has introduced an air quality offset (AQO) program, a key component of Eskom's ERP. This program aims to offset PM emissions by implementing interventions that deliver net ambient air quality benefits, focusing on PM_{10} and $PM_{2.5}$. While the focus is on PM emitting activities in the communities, addressing low-level and indoor pollution, through these initiatives other pollutants are also impacted positively, as illustrated below. These improvements have direct impacts on concentrations communities are exposed to.

In the Highveld and Vaal Triangle, key interventions include the distribution of hybrid stoves, ceilings, electrical rewiring, and LPG heaters to households, as well as cleanup campaigns to remove illegally dumped waste. The program has been implemented in phases, with Phase 1 targeting Kwazamokuhle, Ezamokuhle, and Sharpeville. Preliminary results show significant reductions in PM_{10} and $PM_{2.5}$ concentrations and improvements in indoor air quality in participating households. Eskom plans to expand its AQO program to additional communities and explore new interventions, such as dust suppression on unpaved roads, and veld fire management. Air Resource Management (Pty) Ltd (ARM) have been appointed by Eskom to undertake planning, monitoring, and verification of Phase 1 of Eskom's AQO Plan at Kwazamokuhle, Ezamokuhle, and Sharpeville. In Kwazamokuhle and Ezamokuhle ARM have calculated a net reduction in emissions, with reductions in PM_{10} (132t), $PM_{2.5}$ (123t), as well as carbon monoxide (CO), SO_2, NO_2, and volatile organic compounds (VOCs). These emission reductions occur at ground-level and within households, so have real improvements on public health.

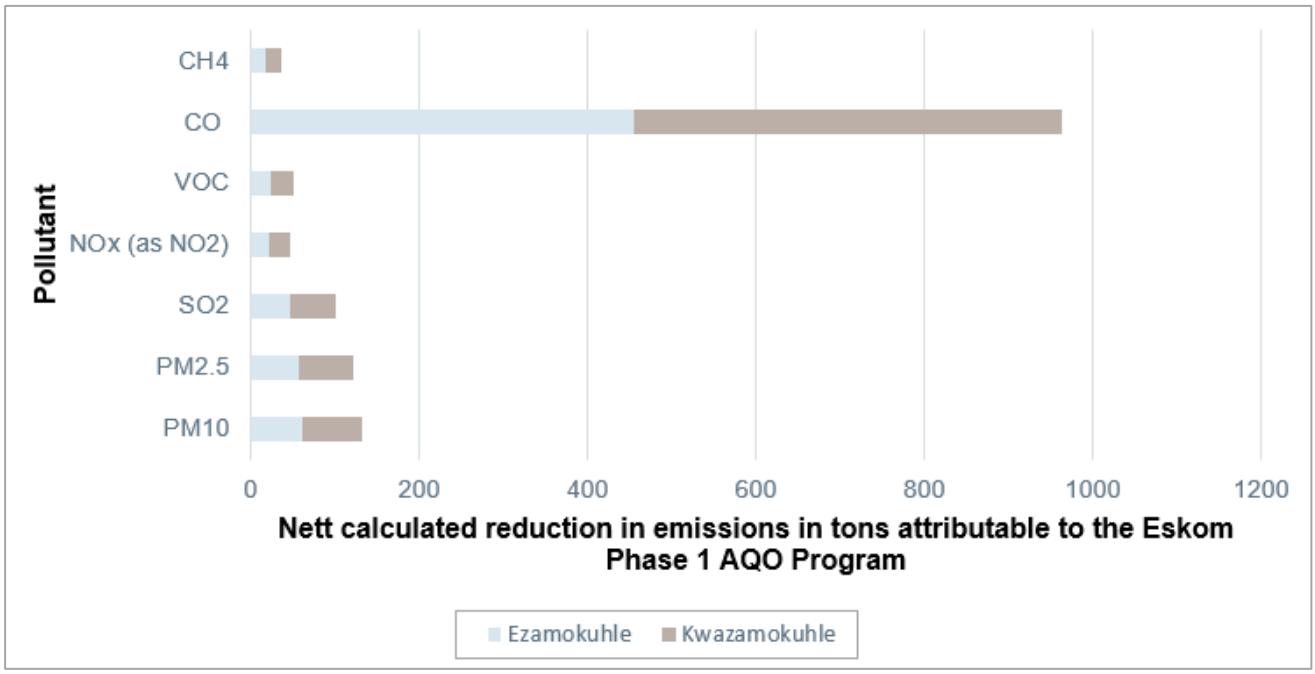


Figure 4-3 - Total net reduction in emissions attributable to Eskom's Phase 1 AQO Project (tonnes) for Ezamokuhle and Kwazamokuhle (Air Resource Management, 2024)

In the Waterberg area key interventions include introducing cleaner household energy sources, managing waste burning, reforestation, and surfacing bare public grounds. Research into Eskom's potential AQO initiatives is ongoing, focusing on interventions that reduce PM and SO_2 emissions to create the greatest positive impact in specific communities. Biomass fuel burning in Marapong has been identified as a significant contributor to emissions. While no direct offset solution for SO_2 emissions has been identified, the focus remains on PM reduction, with AQO initiatives running concurrently with onsite emissions reduction projects.

4.2.2 OXIDES OF NITROGEN

As noted previously, NO_X emissions at Kendal, Matimba, and Medupi will comply with the new plant MES from 1 April 2025, and therefore no NO_X abatement projects are planned at these stations. The remaining stations will require NO_X abatement technologies to achieve compliance with the new plant MES. Of these, LNB installations are planned for Majuba, Tutuka and Lethabo, although given the timeframes to complete, will not comply with the new plant MES by 1 April 2025. Given the assumed shutdown phases of Matla and Duvha (both assumed to be commencing in 2030), NO_X abatement technologies at these stations are not planned as the stations would be shutting down at the same time as the NO_X upgrades was underway.

Considering the timeframes of the LNB installations, and that abatement is not planned at Matla and Duvha, exemptions from the new plant NO_X MES are being requested for Majuba, Tutuka, and Lethabo until completion of the LNB installations, and at Duvha and Matla until shutdown.

Table 4-2 – Status of NO_X abatement projects

	ERP Alternative	Complete	Planned	Timeframe to Full Completion
Duvha	ERP 2024 A; ERP 2024 B; ERP 2024 C	None	None	N/A
Matla		None	None	N/A
Kendal		Not Required	None	N/A
Lethabo		None	LNB	1 April 2031
Majuba		None	LNB	1 April 2030
Tutuka		None	LNB	1 January 2028
Kusile		LNB	None	N/A
Matimba		Not Required	None	N/A
Medupi		LNB	None	N/A
*Includes required optimisation periods of new equipment				

NO_X emission trajectories associated with ERP 2024 A, ERP 2024 B, ERP 2024 C and the Security of Supply are illustrated in Figure 4-4. All Scenario's ERP 2024 A, ERP 2024 B, and ERP 2024 C assume the same NO_X abatement installed; that is LNBs at Tutuka, Majuba, and Lethabo, therefore the emission trajectory for each is the same, while the Security of Supply includes this abatement this is based on an increased electricity demand.

From FY2025, emissions are anticipated to reduce in the coming years due to the burner efficiency improvement projects, Despatch Prioritisation initiated to address SO_2 emissions, station shutdowns assumed to be complete by FY2030 (Grootvlei, Camden, Hendrina, Arnot, and Kriel), Duvha and Matla assumed to be entering shutdown phase in FY2031, and the completion of the LNB abatement on Tutuka (FY2029), Majuba (FY2030), and Lethabo (FY2031). By FY2030, compared to FY2025 (actuals), Eskom Fleet NO_X emissions are anticipated to have reduced by 292kt, representing a 40% reduction. Emissions remain stable until FY2041, after which further reductions will occur due to stations entering shutdown. Between FY2025 and FY2050, a total NO_X emissions reduction of 78% (574kt) is estimated.

Considering Eskom's Security of Supply projection, representing an upper emissions limit, emissions increase to FY2026, remaining above the ERP 2024 A, B, and C projections, given the conservativeness of the Security of Supply projection, although by FY2030 shows a 256kt (33%) reduction and is more closely aligned with the ERP projections. By FY2035, a further 151kt (29%) reduction is estimated and aligns more closely with the ERP projections and shows closer alignment until FY2041. As noted, although this is an upper emissions projection, the same trend of emission reductions year on year is evident from FY2026.

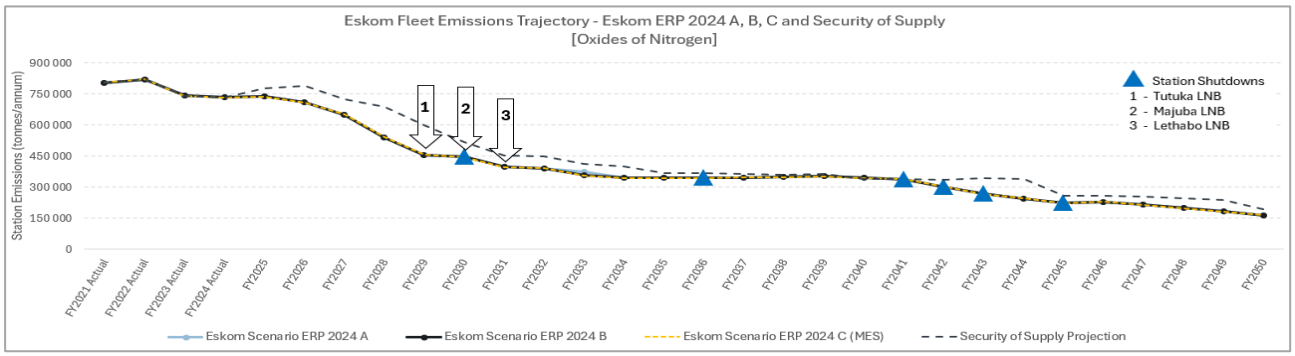


Figure 4-4 - Eskom Fleet oxides of nitrogen emission trajectories

4.2.3 SULPHUR DIOXIDE

The Eskom Fleet complies with each stations current plant SO_2 MES, with the Highveld and Vaal Fleet measuring an average emission between 2019 – 2024 of 1,930mg/Nm^3, and the Waterberg an average emission of 2,606mg/Nm^3, although without abatement technologies will not comply with the new plant MES (1,000mg/Nm^3). Table 4-3 presents planned and/or evaluated SO_2 abatement projects. To achieve SO_2 MES new plant limits, Medupi will install a wet FGD, due to commence in FY2028, with completion in FY2032, while Kusile has FGD installed, both are included as part of ERP 2024 A. The Majuba DSI FGD and Kendal semi-dry FGD are assessed in the ERP 2024 B alternative and presented in Table 4-3, although their commissioning requires various considerations and is not the recommended option ,as presented in Chapter 7 of this report. Should the semi-dry FGD be commissioned at Kendal, new plant MES compliance will be achieved. Regarding the DSI FGD being evaluated for Majuba, although this would reduce SO_2 emissions, this would not achieve MES compliance.

Considering the commissioning timeframes of the SO_2 abatement technologies, exemptions from the new plant MES are requested for Medupi until completion of the installations. Should installations proceed at Majuba and Kendal, despite the recommendations of this report, and assuming it is technically feasible, exemptions are requested until completion of these installations. For Matla, Duvha, Lethabo, Tutuka, and Matimba, since SO_2 abatement is not being evaluated for these stations, exemption from the new plant SO_2 MES is requested until shutdown; motivations for each are provided in Chapter 7 of this report. Alternate SO_2 emission limits below the existing plant limits are being requested for all stations (except Matimba).

Table 4-3 – Status of SO_2 abatement projects

	ERP Alternative	Complete	Planned	Evaluation[1]	Exemption Request[2]	Timeframe to Full Completion
Duvha	-	-	-	-	-	N/A
Matla	-	-	-	-	-	N/A
Kusile	ERP 2024 A	Wet FGD	-	-	-	N/A
Medupi	ERP 2024 A	-	Wet FGD	-	-	1 April 2032
Kendal	ERP 2024 B	-	-	Semi-Dry FGD[2]	-	1 April 2036
Majuba	ERP 2024 B	-	-	DSI FGD[2]	-	1 April 2034
Lethabo	ERP 2024 C	-	-	-	Semi-Dry FGD	N/A
Tutuka	ERP 2024 C	-	-	-	Semi-Dry FGD	N/A
Matimba	ERP 2024 C	-	-	-	Semi-Dry FGD	N/A

[1]Considered an alternative and is being evaluated as part of this application
[2]While technologies are included in this table, exemption for these is being requested, with this position maintained by Eskom from previous applications, and therefore no completion dates are provided as concept and design has not commenced.

As noted previously, scenario ERP 2024 A assumed only the FGD installation at Kusile and Medupi (completion in 2032), with no other stations receiving SO_2 abatement technology. Scenario ERP 2024 B assumed SO_2 abatement installations at Kusile, Medupi, Kendal, and Majuba, representing a potentially practical option with certain considerations, if proven to be technically feasible. Scenario ERP 2024 C assumed SO_2 abatement installed at Kusile, Matimba, Medupi, Kendal, Majuba, Lethabo,

and Tutuka (Matla and Duvha were not given FGD as it cannot be practically installed given their shutdown before 2035).

As illustrated in Figure 4-5, all three scenarios remain similar until FY2032, when the Majuba DSI FGD takes effect, followed by the Kendal FGD, resulting in ERP 2024 B and ERP 2024 C having lower emissions than ERP 2024 A. In FY2036, ERP 2024 C reduces further due to a combination of SO_2 abatement technology at Matimba, Lethabo and Tutuka, and completion of the Duvha and Matla shutdowns. While actual emissions show a reduction from ERP 2024 A to ERP 2024 B and C, considering the cumulative Highveld and Vaal dispersion modelling predictions at receptors, ERP 2024 A, which only assumes SO_2 abatement at Kusile, still shows full MES compliance, without abatement at Kendal and Majuba. The modelling predictions show ERP 2024 B, which assumes Kendal and Majuba abatement, have slightly lower ambient concentrations than ERP 2024 A, while these reduce further for ERP 2024 C, although crucially all modelling scenarios predict full MES compliance (discussed further in Chapter 5).

Considering ERP 2024 A, by FY2030, compared to FY2025 (actuals), Eskom Fleet SO_2 emissions are anticipated to have reduced by 555kt, representing a 32% reduction in emissions. In FY2035, compared to FY2030, a further reduction of 165kt (14%) is anticipated, and by FY2040 a further 6% reduction is anticipated. Between FY2025 and FY2050, a total SO_2 emissions reduction of 85% (1.45Mt) is estimated.

Regarding Eskom's Security of Supply projection, representing an upper emissions limit, emissions increase to FY2026, remaining above the ERP 2024 A, B, and C projections, although by FY2030 shows a 482kt (27%) reduction and is more closely aligned with the ERP projections. By FY2035, the Security of Supply projection shows a further reduction of 294kt (23%) and aligns more closely with the ERP projections, and from FY2036 shows closer alignment until FY2050. Crucially, although this is an upper emissions projection, the same trend of emission reductions year on year is evident from FY2026.

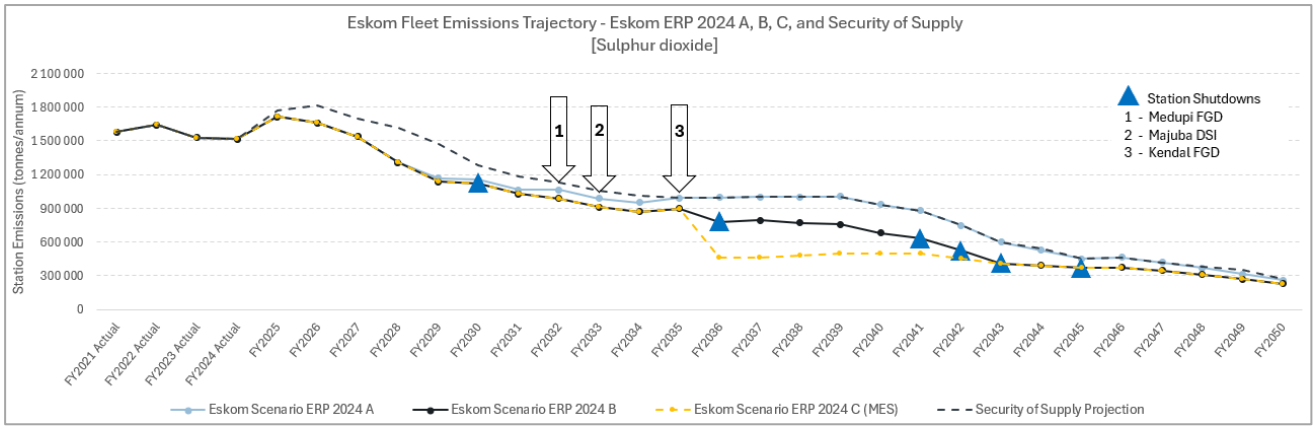


Figure 4-5 - Eskom Fleet sulphur dioxide emission trajectories

4.2.3.1 Abatement Technology Impacts

While SO_2 abatement technologies will lead to reduced SO_2 emissions, the impacts of this technology also need to be considered, predominantly impacting water, waste, and carbon dioxide (CO_2) emissions.

Impacts on Water

Wet FGD, while having higher efficiency in SO_2 removal (up to 98%), has higher operational complexity and environmental impact due to its high-water usage. Semi-dry FGD's have a lower water requirement than wet FGD and a smaller footprint, with no wastewater production, simplifying water management, however there will still be an increase in water usage from current operations.

Power generation is identified as a strategic water use in terms of the National Water Act (Act No. 36 of 1998) and is provided with the highest assurance of supply (99.5 %) in the operation of all water resource systems in the country (National Water Resources Strategy -3 (NWRS-3), DWS 2023). However, a key goal of the NWRS-3 is reducing water demand, and while water supply for electricity generation is afforded priority it is not unlimited and has to be balanced with other strategic objectives of the NWRS-3. The NWRS-3 does refer to the disadvantage of the proposed FGD technology with its high-water usage, and due to water scarcity in the country, recommends further research on alternative technologies and options to meet the future Eskom water demand (DWS, NWRS-3, 2023). Future allocations to meet the increased water supply, should FGD's be installed, to Eskom can thus not be guaranteed if it's not aligned with the strategic goals of the NWRS-3 and imperatives to reduce water demand, increase water conservation and improve water use efficiency.

Table 4-4 presents increased water requirements should SO_2 abatement technologies be installed. Largest increases occur at Medupi due to wet FGD being installed and should the semi-dry FGD at Matimba be installed, a total of 15.3 million m^3/annum would be required, in addition to the current water requirements, with both Medupi and Matimba extracting from the Mokolo River Catchment. While the water balance of the Mokolo system has allocated for this, authorised until 2051, this is allocated from both the Mokolo Dam and MCWAP-2A, with Phase 2A only being available from 2028. Further, based on the 2023/2024 DWS Annual Operating Analyses (AOA) conducted for the Mokolo River System, deficit in the water supply in the Mokolo catchment is expected in 2025, with water security predicted to be low between 2025 to 2028. All scenarios analysed for the AOA indicated that a shortage of water and the risk of violating the assurance of supply to Eskom could happen as early as 2025 (prior to FGD technology). Severe water restrictions will be required from 2025 to 2028 for all users (including Matimba and Medupi power stations for its current water requirement).

Water for Kendal, Majuba, Lethabo, and Tutuka is suppled from the Integrated Vaal River System (IVRS) via various subsystems. Should SO_2 MES compliance be enforced (i.e. semi-dry FGD at Kendal, Lethabo and Tutuka), an additional 16.1 million m^3/annum of water will be required to operate the FGDs. Each station could meet this additional requirement due to their low current water use due to low load factors. However, should loads increase, stations may require additional allocations from the IVRS. This additional supply is not necessarily available over the short-term, with limited water supply development potential existing in the IVRS, with water security remaining a risk. The water security risk from IVRS will be alleviated with the LHWP-Phase 2, expected to be online post 2030.

Table 4-4 – Increase in water use due to SO_2 abatement

	ERP Alternative	Technology	Water Increase (m^3/a)	Water Increase (%)	Water Catchment
Medupi	ERP 2024 A	Wet FGD	9.7 million	146%	Mokolo River
Kendal	ERP 2024 B	Semi-Dry FGD	5.8 million	67%	Upper Olifants
Majuba	ERP 2024 B	DSI[1]	negligible	0%	Upper Vaal
Lethabo	ERP 2024 C	Semi-Dry FGD	5.2 million	13%	Upper Vaal

	ERP Alternative	Technology	Water Increase (m^3/a)	Water Increase (%)	Water Catchment
Tutuka	ERP 2024 C	Semi-Dry FGD	5.1 million	23%	Upper Vaal
Matimba	ERP 2024 C	Semi-Dry FGD	5.6 million	180%	Mokolo River
[1]DSI technology is a dry FGD process, and therefore negligible increase in water is anticipated.					

Impacts on Waste

FGD technology will impact waste production at each station, introducing new waste management challenges. The FGD process typically produces a byproduct known as calcium sulphates (gypsum in the case of wet FGDs), which, based on DFFE waste management requirements, must be managed and stored separately from existing waste streams like ash. Implementing FGD increases both the volume of waste generated and the complexity of waste handling infrastructure. Since co-disposal is not permitted by DFFE, stations will be required to design and construct new facilities to accommodate the gypsum, which requires additional approvals, water management, operational adjustments, and new handling infrastructure. This added waste stream, combined with the increased water use needed for the FGD process, can substantially impact the overall environmental footprint of the facility, making waste management a critical aspect of FGD implementation. Table 4-5 presents estimated waste increases due to SO_2 abatement technologies.

Table 4-5 – Increase in waste production due to SO_2 abatement

	ERP Alternative	Technology	Average Increase (t/a)[1]	Waste Increase (%)
Medupi	ERP 2024 A	Wet FGD	2.7 million	54%
Kendal	ERP 2024 B	Semi-Dry FGD	932kt	31%
Majuba	ERP 2024 B	DSI FGD	931kt	22%
Lethabo	ERP 2024 C	Semi-Dry FGD	840kt	11%
Tutuka	ERP 2024 C	Semi-Dry FGD	827kt	24%
Matimba	ERP 2024 C	Semi-Dry FGD	904kt	18%
[1]Once installation are complete on all generating units.				

Impacts on Carbon Dioxide Emissions

South Africa's revised Nationally Determined Contribution (NDC) will significantly impact Eskom, as most mitigation in the updated NDC target needs to come from the electricity sector which now accounts for approximately 41% of South Africa's greenhouse gas (GHG) emissions. Eskom will need to decommission multiple coal-fired power stations over the next decade for South Africa to align to the objectives of international climate agreements. This means that coal-fired power stations would need to be supplemented with generation capacity from renewable and lower carbon technologies to meet South Africa's climate change commitments while maintaining security of supply. Preliminary analysis by the department shows that greenhouse gases from fossil fuel power generation will need to be limited to 125 – 140Mt CO_2 per annum in 2030 for South Africa to remain within the upper end of the NDC for 2030. While a new NDC is still being developed for 2035, the range (125 – 140 Mt CO_2 per annum) is maintained in the modelling from 2031.

Table 4-6 presents estimated CO_2 increases due to FGD installations, while Figure 4-6 illustrates the addition of CO_2 from the FGD's to Eskom's current estimated CO_2 emissions for the fleet. While the

MES and climate change regulatory process are legally separate it is useful to note both ERP 2024 A and the security of supply projection are aligned with Eskom's current pollution prevention plan running to December 2025. Future CO_2 trajectories will be based on the updated pollution prevention plan and IRP, NDC, and Sectorial Emission Targets (SET).

Due to the FGD installations, should these occur at all stations (ERP 2024 C), an estimated total of 25Mt CO_2 would be added to the Eskom Fleet. Considering each scenario, ERP 2024 A (Medupi only, excluding Kusile), would add 453kt CO_2 per annum; ERP 2024 B would add a further 436kt CO_2, while ERP 2024 C would increase this by a further 481kt. In total, should ERP 2024 C be enforced, a total of 1.5Mt CO_2 per annum would be added to Eskom's GHG emissions. While the focus on reducing CO_2 emissions from coal generation is noted, considering the annual increase in CO_2 emissions due to the FGDs, and Eskom's 2030 CO_2 targets, these annual increases are unlikely to significantly impact Eskom emissions in 2030.

More significantly, if a large investment is required to improve MES compliance at a coal-fired power station, this will drive longer lifetimes and/or higher load factors to achieve a reasonable cost-benefit, which will result in additional CO_2 emissions, and extending South Africa's reliance on coal power generation.

Table 4-6 – Increase in CO_2 emissions due to SO_2 abatement

	ERP Alternative	Technology	Total Increase (t)	Average Increase (t/a)[1]	Contribution to Eskom 2031 target (pa)[2]
Medupi	ERP 2024 A	Wet FGD	10.4 million	453kt	0.32%
Kendal	ERP 2024 B	Semi-Dry FGD	3.8 million	263kt	0.19%
Majuba	ERP 2024 B	DSI FGD	3.8 million	173kt	0.12%
Lethabo	ERP 2024 C	Semi-Dry FGD	2.3 million	211kt	0.15%
Tutuka	ERP 2024 C	Semi-Dry FGD	1.9 million	193kt	0.14%
Matimba	ERP 2024 C	Semi-Dry FGD	3.3 million	251kt	0.18%
		TOTAL	25.5 million	1.5 million	1.1%

[1]Once installation are complete on all generating units.
[2]Contribution to the 2031 target for Eskom based on South Africa's commitment to limit fossil fuel generation to 125 – 140Mt CO_2 per annum.

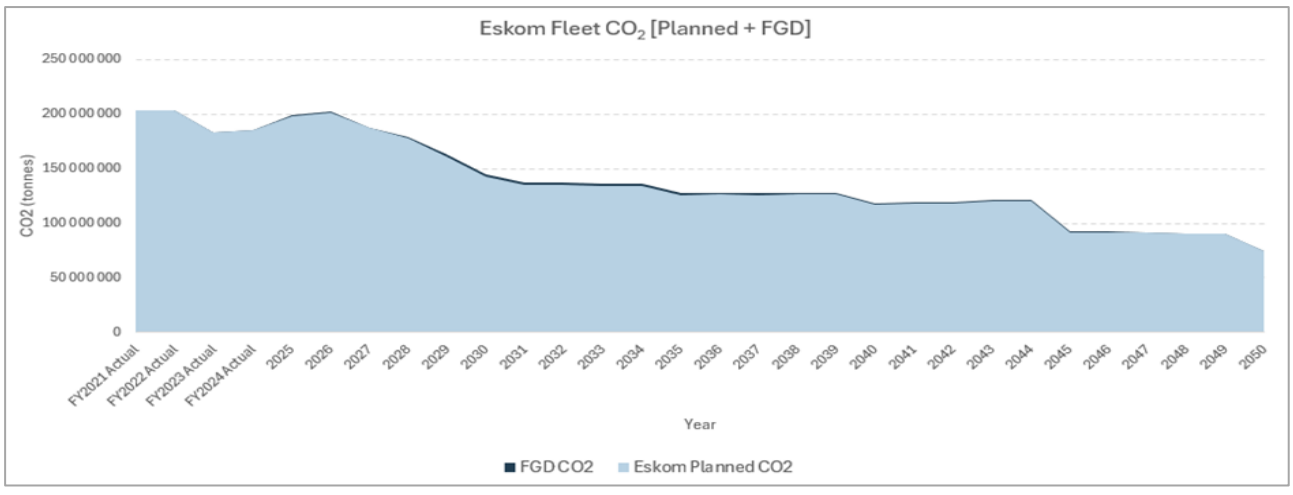


Figure 4-6 – Eskom coal-fired fleet CO_2 emission trajectory and contribution from FGDs

5 ESKOM FLEET AIR QUALITY IMPACTS

5.1 HEALTH IMPACTS

A coal-fired power station releases impurities into the air during coal combustion in the boiler. These pollutants are released through stacks, where they are diluted and endure chemical transformations before ultimately reaching the surface. Here, they may be inhaled or impact the physical environment. The pollutants include SO_2, NO_X, polycyclic aromatic hydrocarbons, and trace substances such as mercury.

The effects of coal combustion-associated air pollution on health are recognised worldwide. The sensitive receptors mainly consist of schools, hospitals, and other locations where children, the elderly, and the infirm might reside. While many factors impact air quality, air pollution exposure in communities near coal-fired power stations is significantly higher than areas without these facilities.

Air emissions are responsible for a variety of detrimental health effects. Examples of these effects include respiratory diseases, lung cancer, cardiovascular diseases, and neurodevelopmental disorders. Potential health impacts associated with power station emissions are outlined below:

- SO_2 that potentially contributes to respiratory illnesses (chronic bronchitis, nasal, throat and lung irritations, asthma attacks) and cardiovascular disease.
- $PM_{2.5}$ is the air pollutant responsible for the most significant health issues and premature mortality. $PM_{2.5}$ is more likely to penetrate and accumulate on the surface of the deeper lung regions. Furthermore:
  - Short-term exposure to $PM_{2.5}$ is linked to premature mortality, acute and chronic bronchitis, asthma attacks, and other respiratory symptoms, as well as heart or lung distress. Infants, children, and older individuals who have preexisting cardiac or lung diseases are more likely to experience these adverse health effects.
  - Long-term exposure to $PM_{2.5}$ (months to years) has been associated with reduced lung function growth in children and premature death, particularly in those with chronic heart or lung diseases.
- PM_{10} contributes to adverse health effects as it is more likely to deposit on the surfaces of the larger airways of the upper lung region, inducing tissue damage and lung inflammation.
  - There is evidence of the adverse effects of short-term exposure on respiratory health.
  - The consequences of prolonged exposure to PM_{10} are less certain, although studies indicate a correlation between respiratory mortality and long-term PM_{10} exposure.
- Nitrogen oxides contribute to respiratory illnesses (e.g., respiratory infection, asthma, chronic bronchitis) and smog.
- Mercury and other heavy metals have been associated with neurological and developmental impairment in humans.

Noting the above issues, the NAAQS described in section 3.2 above were established to protect air quality and public health. Compliance with the standard in an area implies that the area is exposed to an acceptable level of risk from air quality impacts and air quality related health issues. This does not imply that there is no risk associated with lower levels of pollutants in the atmosphere but there is arguably no acceptable risk to some pollutants and the NAAQS thus represent what is considered acceptable in the South African context. The benefit-cost analysis discussed below attempts to put a financial cost on these health impacts.

Considering the existing activities in each airshed impacting air quality, ensuring improvement in air quality in the area and public health requires a targeted, practical and integrated approach to emissions management in the area.

It can also be noted that unplanned electricity outages through load shedding can also result in health impacts due to challenges with the availability of medical facilities, water provision and food storage challenges for example.

5.2 HIGHVELD AND VAAL TRIANGLE FLEET – AIR QUALITY

5.2.1 BASELINE AMBIENT AIR QUALITY MONITORING DATA

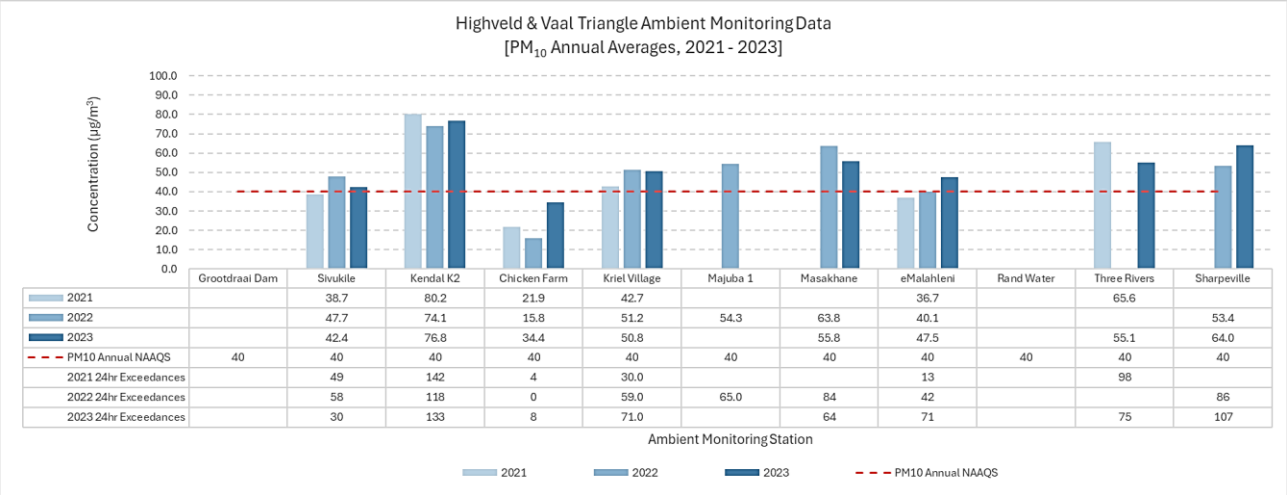
Ambient air quality monitoring stations in the Highveld and Vaal areas considered in this exemption application comprised Eskom owned stations and South African Weather Services (SAWS) stations, for the period 2021 - 2023. Although a minimum data recovery of 90% is required, as stipulated by the SANAS TR 07-03 (SANAS, 2012), for the purposes of this report, data recovery of 50% and greater were considered. Station selection was based on proximity to each power station, as follows:

- Duvha – Masakhane (Eskom) and eMalahleni (SAWS)
- Kendal – Kendal K2 (research station located at the point of maximum impact from Kendal power station) and Chicken Farm (both Eskom)
- Lethabo – Rand Water (Eskom), Sharpeville and Three Rivers (SAWS)
- Matla – Kriel Village (Eskom)
- Majuba – Majuba 1 (Eskom)
- Tutuka – Sivukile and Grootdraai Dam (both Eskom)

Figure 5-1 illustrates annual average PM_{10} concentrations and exceedances of the 24-hour average NAAQS measured in 2021 – 2023; no data was recovered at the Grootdraai Dam and Rand Water monitoring stations. As is evident, except for the annual average at Chicken Farm which remained compliant, ambient PM_{10} concentrations are non-compliant at all stations with both the annual and 24-hour NAAQS, with the frequency of 24-hour exceedances exceeding the permitted frequency of exceedances per calendar year (four exceedances are permitted per calendar year).

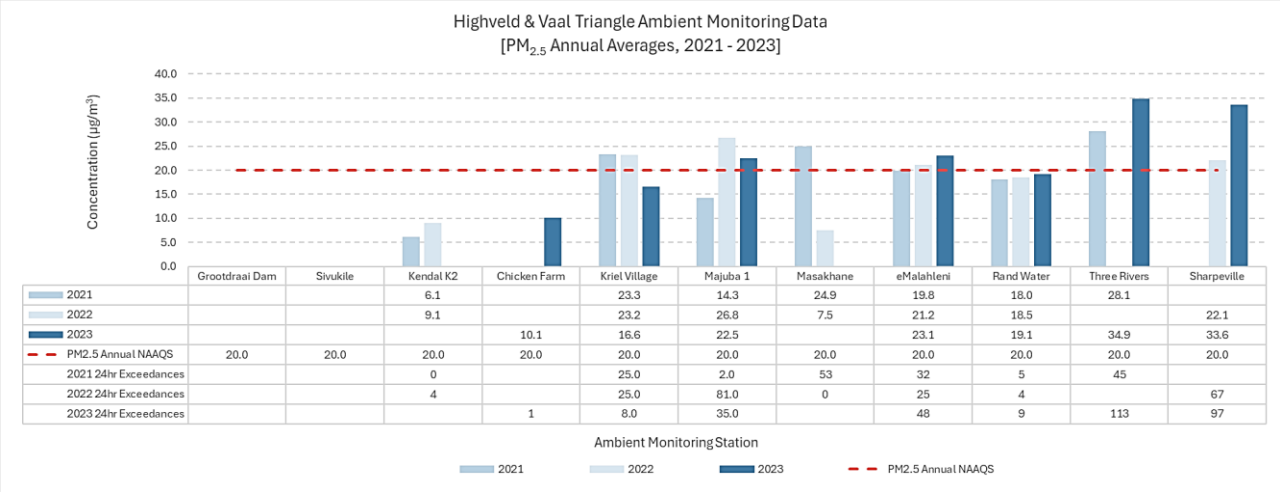
Considering $PM_{2.5}$ concentrations, as illustrated in Figure 5-2, similar to PM_{10}, non-compliance with the annual NAAQS is evident at the Kriel Village, Majuba 1, Masakhane, eMalahleni, Sharpeville and Three Rivers stations, with Kendal K2 (research station at maximum point of impact location), Chicken Farm, and Rand Water showing compliance with the annual $PM_{2.5}$ NAAQS. All stations measured frequent exceedances of the 24-hour NAAQS, while Rand Water, which was compliant with the annual NAAQS, showed non-compliance with the 24-hour NAAQS given the frequency of exceedances.

Given the elevated PM_{10} and $PM_{2.5}$ concentrations throughout the Highveld and Vaal Triangle areas, the PM_{10} and $PM_{2.5}$ NAAQS should be considered saturated, with these contributing emission sources requiring focus. Key sources of emissions in the area comprise mining, industrial activities, the Eskom power stations, vehicle emissions, uncontrolled waste burning, and domestic fuel burning.



	Grootdraai Dam	Sivukile	Kendal K2	Chicken Farm	Kriel Village	Majuba 1	Masakhane	eMalahleni	Rand Water	Three Rivers	Sharpeville
2021		38.7	80.2	21.9	42.7			36.7		65.6	
2022		47.7	74.1	15.8	51.2	54.3	63.8	40.1			53.4
2023		42.4	76.8	34.4	50.8		55.8	47.5		55.1	64.0
PM10 Annual NAAQS	40	40	40	40	40	40	40	40	40	40	40
2021 24hr Exceedances		49	142	4	30.0			13		98	
2022 24hr Exceedances		58	118	0	59.0	65.0	84	42			86
2023 24hr Exceedances		30	133	8	71.0		64	71		75	107

Figure 5-1 - Highveld and Vaal Triangle ambient PM_{10} concentrations, 2021 – 2023



	Grootdraai Dam	Sivukile	Kendal K2	Chicken Farm	Kriel Village	Majuba 1	Masakhane	eMalahleni	Rand Water	Three Rivers	Sharpeville
2021			6.1		23.3	14.3	24.9	19.8	18.0	28.1	
2022			9.1		23.2	26.8	7.5	21.2	18.5		22.1
2023				10.1	16.6	22.5		23.1	19.1	34.9	33.6
PM2.5 Annual NAAQS	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
2021 24hr Exceedances			0		25.0	2.0	53	32	5	45	
2022 24hr Exceedances			4		25.0	81.0	0	25	4		67
2023 24hr Exceedances				1	8.0	35.0		48	9	113	97

Figure 5-2 - Highveld and Vaal Triangle ambient $PM_{2.5}$ concentrations, 2021 – 2023

SO_2 measured concentrations in the Highveld and Vaal Triangle for the period 2021 – 2023 are presented in Figure 5-3. Annual average concentrations across the ambient monitoring network indicate compliance with the annual NAAQS, with no stations exceeding the NAAQS in any year. Although not presented in Figure 5-3, exceedances of the short-term NAAQS (10-minute, hourly and 24-hour) were recorded at most stations, although importantly these remained below the permitted frequency of exceedances.

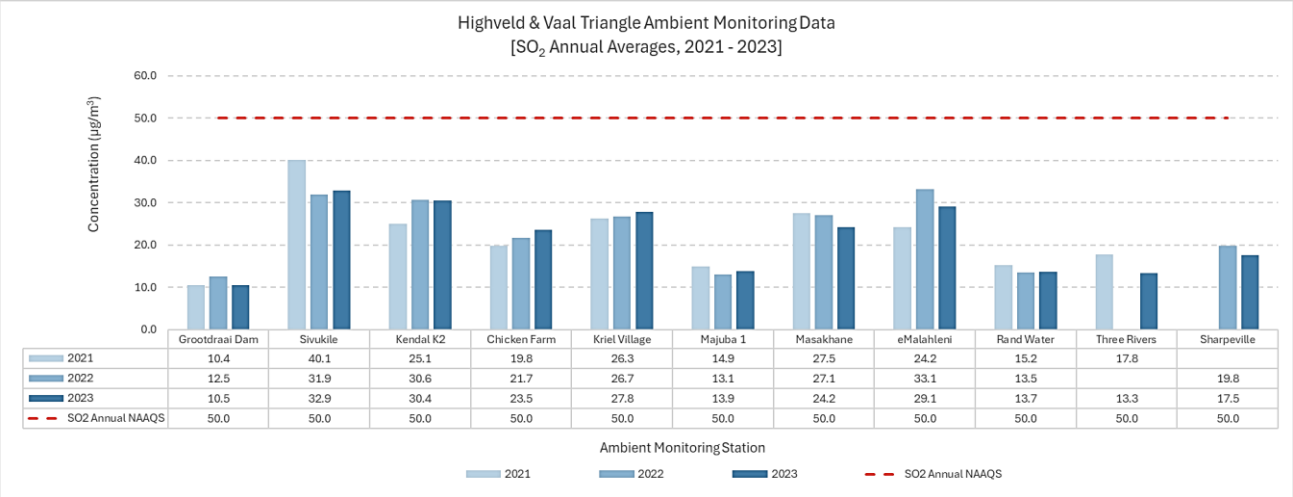


Figure 5-3 - Highveld and Vaal Triangle ambient SO_2 concentrations, 2021 – 2023

Nitrogen dioxide (NO_2) measured concentrations in the Highveld and Vaal Triangle for the period 2021 – 2023 are presented in Figure 5-4. Annual average concentrations across the ambient monitoring network indicate compliance with the annual NAAQS, with no stations exceeding the NAAQS in any year. Although not presented in Figure 5-4, exceedances of the hourly NAAQS were recorded at Chicken Farm, importantly these remained well below the permitted frequency of exceedances, with 15 exceedances recorded and 88 permitted.

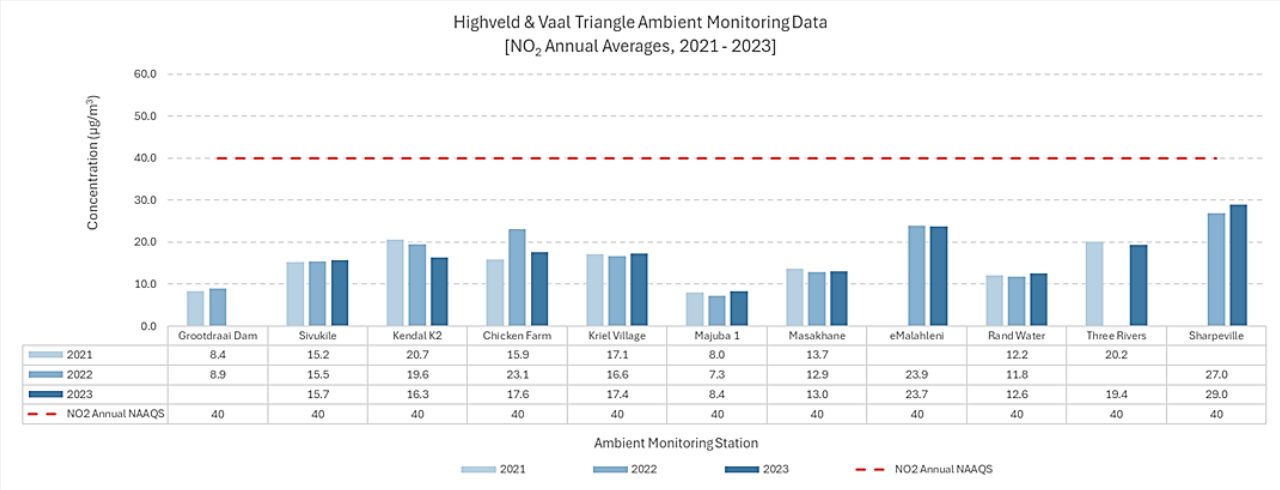


Figure 5-4 - Highveld and Vaal Triangle ambient NO_2 concentrations, 2021 – 2023

5.2.2 DISPERSION MODELLING - CUMULATIVE AIR QUALITY IMPACTS

CALPUFF dispersion modelling was undertaken by uMoya-NILU Consulting (Pty) Ltd, as contained within the Cumulative Highveld and Vaal AIR (report uMN220-24, 2024) to assess various operational scenarios anticipated by Eskom for the Highveld and Vaal Fleet, comprising Komati, Arnot, Camden, Kriel, Grootvlei, Hendrina, Duvha, Matla, Kendal, Lethabo, Tutuka, Majuba, and Kusile in the coming years for SO_2, NO_X, and PM (PM_{10} and $PM_{2.5}$), namely:

- **Scenario 1 (Current)**: The baseline scenario using actual monthly stack emissions for 2021-2023 and fugitive emissions from the ash dump.

- **Scenario A (2025)**: Eskom's planned 2025 stack emissions, representing anticipated station performance between 2025 – 2030, including fugitive emissions from the ash dumps and stockpiles. This includes the shutdown of Komati; the completion of PM abatement projects at Kendal, Lethabo, Tutuka, Duvha, and Matla; and the FGD at Kusile.
- **Scenario B (2031) / ERP 2024 A**: Eskom's planned 2031 stack emissions, representing anticipated station performance between 2031 – 2035, including fugitive emissions from the ash dumps and stockpiles. This includes completion of shutdowns at Arnot, Kriel, Hendrina, Camden, and Grootvlei, including their fugitive sources, with Matla and Duvha also entering shutdown phase; FGD at Kusile and reduced SO_2 emissions achieved through Despatch Prioritisation and efficiency improvement projects; and NO_X abatement (LNB) at Majuba, Lethabo, and Tutuka.
- **Scenario C (2036) / ERP 2024 B**: Representing an alternative scenario for anticipated station performance from 2036 onwards, including fugitive emissions from the ash dumps and stockpiles. This includes the complete shutdown of Matla and Duvha; shutdowns of Tutuka, Lethabo, and Kendal, including their fugitive sources, with Majuba entering shutdown phase in FY2047; SO_2 abatement installed at Kusile (Wet FGD), Majuba (DSI FGD), and Kendal (Semi-dry FGD); as well as reduced SO_2 emissions achieved through Despatch Prioritisation and efficiency improvement projects.
- **Scenario D (MES) / ERP 2024 C**: MES compliance, inclusive of the ash dumps and stockpiles, where relevant (i.e. not for the stations shutdown), and in addition to the abatement included in above scenarios, FGD installations at Tutuka and Lethabo. (Additional NO_X and FGD technology not installed at Duvha and Matla given the shutdown of these stations by 2035).

Table 5-1 presents maximum ground level concentrations predicted at sensitive receptors and monitoring stations (only the highest concentration and predicted exceedances presented) associated with each operational scenario. While the focus of the assessment is on stack emissions, and SO_2 particularly, the inclusion of fugitive PM emissions provides a holistic understanding of the Highveld/ Vaal Fleet contributions to ambient PM_{10} and $PM_{2.5}$ concentrations. Key findings from this AIR comprised:

- For SO_2:
  - Maximum predicted annual concentrations at all receptors remain below the annual NAAQS in all scenarios.
  - No exceedances of the short-term NAAQS (24-hour and hourly) are predicted at receptors in all scenarios.
  - Considering Scenario D (ERP 2024 C) and Scenario C (ERP 2024 B), concentration predictions show an improvement in Scenario D. However, critically, Scenario C and B, inclusive of the abatement planned by Eskom, does not show any exceedances of the NAAQS. This is also evident in Eskom's current operational scenarios (Scenario 1 and A) where abatement has not yet taken effect, although improvements in emissions due to Despatch Prioritisation and efficiency improvements are considered.
- For NO_2:
  - Maximum predicted concentrations remain well below all averaging periods of the NAAQS at all receptors for the five scenarios.
  - No short-term exceedances (hourly) are predicted to occur.
- For PM_{10} and $PM_{2.5}$:
  - Predicted concentrations are attributed to stack emissions and low-level fugitive sources (ash dumps and stockpiles).

- The inclusion of the fugitive sources was done assuming most the area is exposed and available for entrainment, while in reality only a small portion of the modelled area would be exposed to entrainment due to the vegetated sides and wet areas of the dumps. This approach should be considered an over-estimate.

- The PM emissions from stacks and fugitive sources are not speciated into PM_{10} and $PM_{2.5}$, rather all PM emitted is assumed to be PM_{10}, and all PM emitted is assumed to be $PM_{2.5}$, considered environmentally conservative.
- Maximum PM_{10} annual concentrations predicted at sensitive receptors, inclusive of the ambient monitoring stations, are predicted to remain below the annual NAAQS in all scenarios, with a maximum annual average concentration of 28.1µg/m^3 predicted to occur at a receptor.
  - Exceedances of the 24-hour PM_{10} NAAQS are predicted in Scenarios 1, A, and B, exceeding the permitted frequency of exceedance in a three-year period (12 in a three-year period, as modelled). Predicted concentrations decrease in Scenario's C and D, with no 24-hour exceedances predicted, predominantly due to station shutdowns, inclusive of their fugitive sources which are assumed to be rehabilitated, which are the main contributing sources.
- Maximum annual average $PM_{2.5}$ concentrations are predicted to exceed the annual NAAQS in Scenario's 1, A, and B, while 24-hour exceedances are also predicted, exceeding the permitted frequency of exceedance. While the annual averages in Scenario C and D are below the more stringent $PM_{2.5}$ standard coming into effect in 2030, 24-hour exceedances are still predicted, above the permitted frequency.
  - $PM_{2.5}$ predictions must be viewed in light of the conservative assumptions (over-estimate) applied in the dispersion models, as discussed previously.
- Further, considering the areas of predicted non-compliances and their proximity to each power station, as noted in the uMoya-Nilu AIR (report uMN220-24, 2024), the elevated PM can mostly be attributed to the low-level fugitive sources, which have poor buoyancy and disperse poorly, as opposed to the stack emissions which are released at a much higher height above ground-level, with considerable buoyancy, and so disperse well.
- In comparison to measured ambient annual average SO_2, NO_X, PM_{10} and $PM_{2.5}$ concentrations, the modelling scenario representing Eskom current emissions (Scenario 1) predicted lower annual averages compared to the measured data, to be expected as Eskom is not the sole contributor to measured ambient concentrations.
- Given the conservative approach to the fugitive emission source simulations, and that this provided an absolute worst-case emission scenario, and based on recommendations received from uMoya-Nilu, Eskom undertook an additional cumulative modelling scenario, assessing only PM, SO_2, and NO_X stack emissions from the Highveld and Vaal Triangle Fleet. NO_X and SO_2 emissions were included to ensure secondary particulate formation is accounted for. Key findings from this include:

  - Predicted PM_{10} and $PM_{2.5}$ concentrations, including secondary particulate formation, indicated full compliance with the NAAQS, with no 24-hour exceedances predicted within the modelling domain.
  - The maximum PM_{10} annual and 24-hour average predicted was 4.7µg/m^3 and 36.5µg/m^3, respectively, predicted in Scenario A, remaining well below the NAAQS.
  - The maximum $PM_{2.5}$ annual and 24-hour average predicted was 4.2µg/m^3 and 31.3µg/m^3, respectively, predicted in Scenario A, remaining well below the NAAQS.

– This additional modelling confirms ground-level concentrations due to Eskom stack emissions remain well below the NAAQS, with the elevated concentrations originally predicted being influenced by the low-level fugitive sources, rather than the stack emissions.

Table 5-1 - Predicted maximum annual and short-term ground level concentrations occurring at selected receptors and ambient monitoring stations for each operational scenario (uMoya-NILU, report uMN220-24, 2024)

Pollutant			
Predicted maximum SO_2	**Annual**	**24-hour (P99)**	**1-hour (P99)**
Scenario 1 (Current)	11.4	81.3 (0)	150.8 (0)
Scenario A (2025)	23.0	121.1 (0)	344.0 (0)
Scenario B (2031)	17.2	95.8 (0)	289.2 (0)
Scenario C (2036)	13.3	79.7 (0)	241.0 (0)
Scenario D (MES)	5.4	31.8 (0)	105.2 (0)
NAAQS limit value	**50**	**125 (12)***	**350 (264)***
Predicted maximum NO_2	**Annual**	**-**	**1-hour (P99)**
Scenario 1 (Current)	5.1	-	89.4 (0)
Scenario A (2025)	6.7	-	107.8 (0)
Scenario B (2031)	3.9	-	75.3 (0)
Scenario C (2036)	3.9	-	79.0 (0)
Scenario D (MES)	3.9	-	79 (0)
NAAQS limit value	**40**	**-**	**200 (264)***
Predicted maximum PM_{10}	**Annual**	**24-hour (P99)**	**-**
Scenario 1 (Current)	27.7	205.8 (96)	-
Scenario A (2025)	28.1	209.4 (95)	-
Scenario B (2031)	18.7	135.3 (27)	-
Scenario C (2036)	10.4	62.3 (0)	-
Scenario D (MES)	10.2	59.9 (0)	-
NAAQS limit value	**40**	**75 (12)***	**-**
Predicted maximum $PM_{2.5}$	**Annual**	**24-hour (P99)**	**-**
Scenario 1 (Current)	27.7	205.8 (222)	-
Scenario A (2025)	28.1	209.4 (218)	-
Scenario B (2031)	18.7	135.3 (278)	-
Scenario C (2036)	10.4	62.3 (98)	-
Scenario D (MES)	10.2	59.9 (98)	-
NAAQS limit value	**20**	**40 (12)***	Up to 31 Dec 2029
	15	**25 (12)***	From 01 Jan 2030

Note: Red represent non-compliances, with exceedance counts in brackets
*Regulations provide for permitted frequency of exceedance per calendar year; 4 exceedances per year of a 24-hour standard, and 88 exceedances per year of an hourly standard. Since the model simulated three years, these permissible exceedance counts represent a three-year period.

5.3 WATERBERG FLEET – AIR QUALITY

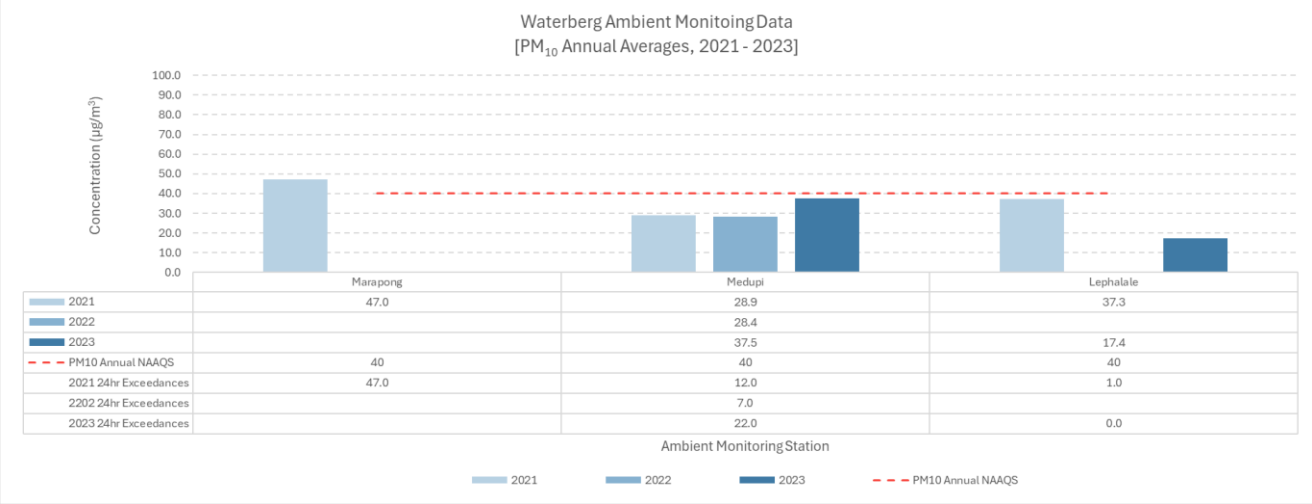
5.3.1 BASELINE AMBIENT AIR QUALITY

Ambient air quality monitoring stations in the Waterberg considered in this exemption application comprised Eskom owned stations and South African Weather Services (SAWS) stations, for the period 2021 - 2023. Although a minimum data recovery of 90% is required, as stipulated by the SANAS TR 07-03 (SANAS, 2012), for the purposes of this report, data recovery of 50% and greater were considered. The stations considered for both Medupi and Matimba were Marapong, Medupi (both Eskom owned) and Lephalale (SAWS).

Figure 5-5 illustrates annual average PM_{10} concentrations and exceedances of the 24-hour average NAAQS measured in 2021 – 2023; no data was recovered from the Marapong station in 2022 and 2023, nor Lephalale in 2022. Except for Marapong, which exceeded the annual NAAQS, all other annual averages remained compliant with the NAAQS, although Medupi does show elevated concentrations. Considering 24-hour averages, both Marapong and Medupi indicate non-compliance with the 24-hour NAAQS given the number of exceedances measured each year, which exceeded the permitted frequency of exceedances (four exceedances are permitted per calendar year).

Considering $PM_{2.5}$ concentrations, as illustrated in Figure 5-2, non-compliance with the annual NAAQS is evident at Marapong, with Medupi and Lephalale showing compliance with the annual $PM_{2.5}$ NAAQS, although this should be viewed with caution given the missing data. While Medupi showed compliance with the annual NAAQS in 2021, the number of 24-hour exceedances recorded exceeded the permitted frequency of exceedances. 24-Hour exceedances at Marapong also exceeded the permitted frequency of exceedances, with four exceedances permitted per calendar year.

While PM concentrations show general compliance with the NAAQS, the standards should be considered as becoming saturated, and therefore the contributing emission sources in the area should receive focus. Key sources of emissions in the area comprise mining, Medupi and Matimba, exposed areas and domestic fuel burning.



	Marapong	Medupi	Lephalale
2021	47.0	28.9	37.3
2022		28.4	
2023		37.5	17.4
PM10 Annual NAAQS	40	40	40
2021 24hr Exceedances	47.0	12.0	1.0
2202 24hr Exceedances		7.0	
2023 24hr Exceedances		22.0	0.0

Figure 5-5 - Waterberg ambient PM_{10} concentrations, 2021 – 2023

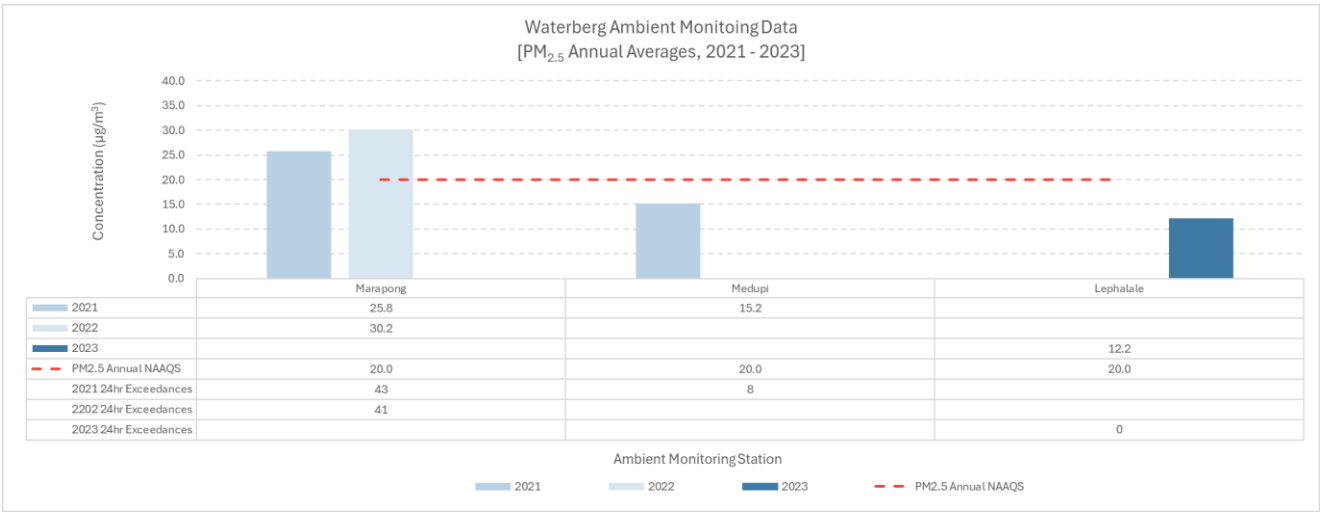


Figure 5-6 - Waterberg ambient $PM_{2.5}$ concentrations, 2021 – 2023

SO_2 measured concentrations in the Waterberg for the period 2021 – 2023 are presented in Figure 5-7. Annual average concentrations across the ambient monitoring network indicate compliance with the annual NAAQS, with no stations exceeding the NAAQS in any year. Highest concentrations were measured at Medupi, which exhibits an increasing trend in SO_2 concentrations year on year, although remaining below the annual NAAQS. Although not presented in Figure 5-7, exceedances of the short-term NAAQS (10-minute, hourly and 24-hour) were recorded at all stations, although importantly these remained below the permitted frequency of exceedance.

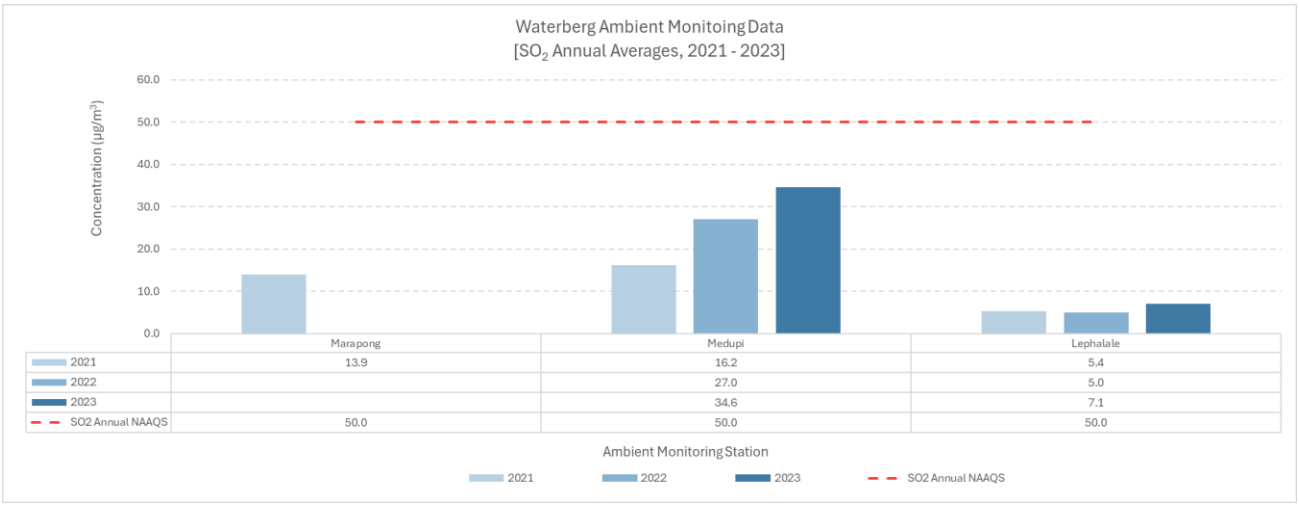


Figure 5-7 - Waterberg ambient SO_2 concentrations, 2021 – 2023

NO_2 measured concentrations in the Waterberg for the period 2021 – 2023 are presented in Figure 5-8. Annual average concentrations across the network indicate compliance with the annual NAAQS, with no stations exceeding the NAAQS in any year. Highest concentrations were typically measured at Marapong. Further, no hourly exceedances of the NAAQS were recorded at any of the stations, illustrating the generally low NO_2 concentrations in the area.

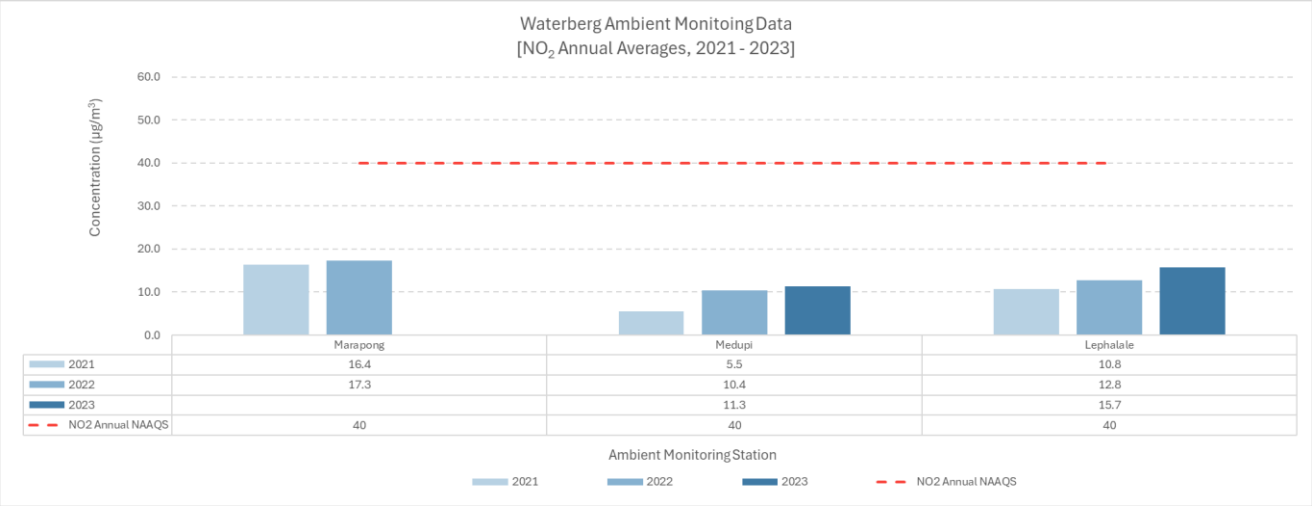


Figure 5-8 - Waterberg ambient NO_2 concentrations, 2021 – 2023

5.3.2 DISPERSION MODELLING – CUMULATIVE AIR QUALITY IMPACTS

CALPUFF dispersion modelling was undertaken by uMoya-NILU Consulting (Pty) Ltd, as contained within the Cumulative Waterberg AIR (report uMN219-24, 2024) to assess various operational scenarios anticipated by Eskom at Medupi and Matimba in the coming years for SO_2, NO_X, and PM (PM_{10} and $PM_{2.5}$), namely:

- **Scenario 1 (Current):** The baseline scenario using actual monthly stack emissions for 2021-2023 and fugitive emissions from the ash dump.
- **Scenario A (2025):** Eskom's planned 2025 stack emissions, representing anticipated station performance between 2025 – 2030, including fugitive emissions from the ash dump.
- **Scenario B (2031) / ERP 2024 A:** Eskom's planned 2031 stack emissions, representing anticipated station performance between 2031 – 2035, including fugitive emissions from the ash dump and the Medupi wet FGD.
- **Scenario C (2036) / ERP 2024 B:** Eskom's planned 2036 stack emissions, representing anticipated station performance from 2036 onwards, including fugitive emissions from the ash dump, and including the Medupi wet FGD.
- **Scenario D (MES) / ERP 2024 C:** Full compliance with the MES from 2036, including wet FGD at Medupi and semi-dry FGD at Matimba.

Table 5-2 presents maximum ground level concentrations predicted at sensitive receptors and monitoring stations (only the highest concentration and predicted exceedances presented) associated with each operational scenario. While the focus of the assessment is on stack emissions, and SO_2 in particular, the inclusion of fugitive PM emissions provides a holistic understanding of the Medupi and Matimba power stations contribution to ambient PM_{10} and $PM_{2.5}$ concentrations. Key findings from this AIR comprise:

- For SO_2:
  - Maximum predicted annual concentrations at all receptors remain well below the annual NAAQS in all scenarios.
  - Exceedances of the 24-hour NAAQS are predicted, exceeding the permitted number of exceedances (12 in a three-year period) in Scenario A and B, while exceedances remain below

the permitted frequency in Scenario C following completion of the Medupi wet FGD, with no exceedances predicted in Scenario 1 and D.
    - No exceedances of the hourly NAAQS are predicted at receptors in all scenarios.
- For NO_2:
    - Maximum predicted concentrations remain well below all averaging periods of the NAAQS at all receptors for the five scenarios.
    - No short-term exceedances due to the cumulative Medupi and Matimba emissions are predicted to occur.
- For PM_{10} and $PM_{2.5}$:
    - Predicted concentrations are attributed to stack emissions and low-level fugitive sources (ash dumps and stockpiles).
        - The inclusion of the fugitive sources was done assuming most the area is exposed and available for entrainment, while in reality only a small portion of the modelled area would be exposed to entrainment due to the vegetated sides and wet areas of the dump. This approach can be considered as an over-estimate.
    - The PM emissions from stacks and fugitive sources are not speciated into PM_{10} and $PM_{2.5}$, rather all PM emitted is assumed to be PM_{10}, and all PM emitted is assumed to be $PM_{2.5}$, considered environmentally conservative.
    - Maximum PM_{10} annual concentrations predicted at sensitive receptors, inclusive of the ambient monitoring stations, are predicted to remain below the annual NAAQS, with a maximum concentration of 17.7µg/m^3 predicted to occur at a receptor.
        - Exceedances of the 24-hour PM_{10} NAAQS are predicted in Scenarios 1, A, and B, although these remain well below the permitted frequency of exceedance (12 in a three-year period). No 24-hour exceedances are predicted in Scenarios C and D.
    - Despite the conservative assumption that $PM_{2.5}$ is equivalent to PM in the modelling simulations, predicted annual average $PM_{2.5}$ concentrations still remain below the annual $PM_{2.5}$ NAAQS at all receptors in Scenarios 1 and A (prior to 2030). Exceedances of the more stringent $PM_{2.5}$ annual NAAQS, coming into effect in 2030, are predicted in Scenarios B, C, and D.
        - Numerous 24-hour exceedances are predicted in all scenarios, well above the permitted frequency of exceedance, although this must be viewed conservatively given the assumption that PM is $PM_{2.5}$. This frequency of exceedance increases from Scenario B due to the more stringent $PM_{2.5}$ NAAQS coming into effect in 2030.
    - Further, considering the proximity of the exceedances to Medupi and Matimba, as noted in the uMoya-Nilu AIR (report uMN219-24, 2024), the elevated PM can mostly be attributed to the low-level fugitive sources, which have poor buoyancy and disperse poorly, as opposed to the stack emissions which are released at a height of 200m above ground-level, with considerable buoyancy, and so disperse well.
    - Comparing measured annual average NO_X and SO_2 concentrations to model predictions, predicted annual averages are lower than measured, which is expected as Eskom activities are not the only source contributing to ambient concentrations.
    - While predicted annual average PM_{10} and $PM_{2.5}$ concentrations at the Marapong and Lephalale monitoring stations are lower than measured concentrations, at Medupi predicted concentrations are higher than measured. As highlighted in the uMoya-Nilu AIR (Report uMN219-24,2024), this is contrary to expectations as the monitoring station measures all sources, and this is likely due to the low data recovery at the Medupi station. Further to this, and

although not specifically highlighted in the uMoya-Nilu AIR, this could also be a result of the worst-case assumptions applied to the simulation of the fugitive sources (ash dumps), which likely provided an over-estimate of emissions.

- Given the conservative approach to the fugitive emission source simulations, and that this provided an absolute worst-case emission scenario, and based on recommendations received from uMoya-Nilu, Eskom undertook an additional cumulative modelling scenario, assessing only PM, SO_2, and NO_X stack emissions from the Waterberg Fleet. NO_X and SO_2 emissions were included to ensure secondary particulate formation is accounted for. Key findings from this include:
  - Predicted PM_{10} and $PM_{2.5}$ concentrations, including secondary particulate formation, indicated full compliance with the NAAQS, with no 24-hour exceedances predicted within the modelling domain.
  - The maximum PM_{10} annual and 24-hour average predicted was 1.7µg/m^3 and 17.9µg/m^3, respectively, predicted in Scenario A, remaining well below the NAAQS.
  - The maximum $PM_{2.5}$ annual and 24-hour average predicted was 1.5µg/m^3 and 16.8µg/m^3, respectively, predicted in Scenario A, remaining well below the NAAQS.
  - This additional modelling confirms ground-level concentrations due to Eskom stack emissions remain well below the NAAQS, with the elevated concentrations originally predicted being influenced by the low-level fugitive sources, rather than the stack emissions.

Table 5-2 - Predicted maximum annual and short-term ground level concentrations occurring at selected receptors and ambient monitoring stations for each operational scenario (uMoya-NILU, report uMN219-24, 2024)

Pollutant			
Predicted maximum SO_2	**Annual**	**24-hour (P99)**	**1-hour (P99)**
Scenario 1 (Current)	9.4	120.3 (0)	226.2 (0)
Scenario A (2025)	14	195.5 (24)*	332.4 (0)
Scenario B (2031)	11.7	186.9 (18)*	315.1 (0)
Scenario C (2036)	8.5	152.4 (7)*	202.4 (0)
Scenario D (MES)	3.5	52.4 (0)	90.1 (0)
NAAQS limit value	**50**	**125 (12)***	**350 (264)***
Predicted maximum NO_2	**Annual**	**-**	**1-hour (P99)**
Scenario 1 (Current)	1.1	-	31.3 (0)
Scenario A (2025)	2.0	-	50.9 (0)
Scenario B (2031)	1.6	-	47.7 (0)
Scenario C (2036)	1.5	-	40.9 (0)
Scenario D (MES)	1.5	-	40.9 (0)
NAAQS limit value	**40**	**-**	**200 (264)***
Predicted maximum PM_{10}	**Annual**	**24-hour (P99)**	**-**
Scenario 1 (Current)	17.4	78.3 (1)	-
Scenario A (2025)	17.7	79.7 (1)	-
Scenario B (2031)	17.6	75.8 (1)	-

Pollutant			
Scenario C (2036)	17.3	74.0 (0)	-
Scenario D (MES)	17.1	70.4 (0)	-
NAAQS limit value	**40**	**75 (12)***	**-**
Predicted maximum $PM_{2.5}$	**Annual**	**24-hour (P99)**	**-**
Scenario 1 (Current)	17.4	78.3 (92)	-
Scenario A (2025)	17.7	79.7 (92)	-
Scenario B (2031)	17.6	75.8 (270)*	-
Scenario C (2036)	17.3	74.0 (269)*	-
Scenario D (MES)	17.1	70.4 (269)	-
NAAQS limit value	**20**	**40 (12)***	**Up to 31 Dec 2029**
	15	**25 (12)***	**From 01 Jan 2030**

Note: Red text represent non-compliances, with exceedance counts in brackets.
*Regulations provide for permitted frequency of exceedance per calendar year; 4 exceedances per year of a 24-hour standard, and 88 exceedances per year of an hourly standard. Since the model simulated three years, these permissible exceedance counts represent a three-year period.

6 FINANCIAL CONSIDERATIONS

6.1 FINANCIAL COSTS

Previous assessments completed as part of the MES and NECA process have shown that attempting to install the technology required to meet new plant SO_2 limits (wet-FGD) at stations by 2025 was unfeasible from a technical, economic and project-implementation perspective, apart from Medupi that was designed for a FGD retrofit, the other plants were not (Eskom 2021). Given the previous analysis and the time and other constraints influencing the present exemption applications only the two most potentially viable SO_2 reduction implementations (Majuba and Kendal) were assessed as part of this exemption application.

The assessments completed previously, included an analysis of the Levelised Cost of Electricity (LCOE) to compare the viability of FGD investments at stations with other options like gas or renewables. They also used stochastic electricity systems modelling to understand the full impact of FGD implementations. The studies indicated that retrofitting the plants with FGD would increase the cost of electricity produced due to the high capital and operating cost of FGD and the limited remaining life of the plants. (Eskom, 2020). Full implementation might have resulted in an increase in the average electricity tariff of around 10%, whereas the partial implementation scenarios would have a lesser impact – depending on the scenario. Studies also showed that the shutdown of multiple stations to enable the rapid implementation of FGD would result in significant security of supply issues which would result in massive levels of load shedding and a resultant destruction of the economy.

With an average age of the coal fleet being almost 40 years old, the long lead time to implement retrofits results in a limited economic life remaining post retrofit of the FGD. Assuming it was technically feasible to retrofit (which is a significant risk), and ignoring the unserved energy and load shedding, even with the increased cost, in the short term the plants would be cost competitive, relative to the comparable alternatives which could be deployed in the same time frames. These alternatives included that of running the OCGTs at 20% p.a. load factor and load shedding of the remaining demand in the earlier years. In the latter years with the increased cost due to the FGD, the plants would need to run at guaranteed higher load factors i.e. have a higher output, to remain competitive with comparable alternatives.

Two years have passed since the last detailed analysis, which now further limits the remaining useful life over which to recover any financial investment.

Eskom has maintained in all previous applications, that the costs associated with retrofitting FGD to any of its plant outweighs the benefits. This has been rejected by the NAQO, and partially by the NECA panel advising the Minister and in the Ministers Appeal decision. Although, in the case of Medupi, the report by the NECA indicated that FGD was very costly and would require Medupi to be offline for 80 additional days per year for six years, increasing load shedding risks. (DFFE, 2024).

From a national strategic and risk perspective, if it is considered necessary for Eskom to implement a SO_2 abatement project at an Eskom station beyond Kusile and Medupi, and if it is proven to be technically feasible, it would be necessary to source funding against the background of guaranteed cost -reflective tariffs. From an economic/financial perspective a defined minimum load factor/take or pay agreement would ensure that the units costs are acceptable compared to known alternatives however if consideration could be given to the extension of the station life the economic/financial viability could improve. Given the quantum of the requirement investment, it is probable that Eskom

would require fiscal support in order to raise funding for additional abatement projects beyond Kusile and Medupi. There might also be implications regarding possible carbon tax and carbon budget allocation target adjustments with the increase in load factor and extended plant life.

With the current uncertainties in the context of the pre-concept phase of planning and not yet having performed the thorough stochastic systems modelling process (based on any updated IRP), factoring in the range of possible outcomes on all the key input variables, it would be reckless for Eskom to make unconditional commitments to any SO_2 reduction implementation. Any commitments must be subject to completion of the mentioned systems modelling process as well as the completion of a detailed technical implementation feasibility study/ pilot. If retrofit proves technically unfeasible, a relief from obligations and commitments should be obtained. This might include SO_2 exemption for relevant stations, depending on the system's alternatives and the potential requirement for the stations to continue operating, as established through the stochastic systems modelling process.

Any Eskom commitments or authority decision should also incorporate an economic viability threshold. The market tendering processes should indicate that if costs exceed the estimates made for purposes of these commitments by a defined degree (which could be linked to budgets, operational cost caps etc), the decision will need to be revisited. Such thresholds should not just be defined in terms of project costs but rather in terms of economic/financial viability, factoring in the likely system alternatives in the event of these power plants not continuing to be operated.

The decision on any SO_2 reduction implementation must consider the benefit of SO_2 reduction from the power stations, against the opportunity cost of such SO_2 reduction. A possible alternative solution is that if funding is available Eskom increases its investments in renewables and grid connection by the same amounts that would have been invested in such SO_2 retrofits, this would result in larger economic value add than FGD retrofits.

6.1.1 COST ANALYSIS FOR MES COMPLIANCE AT KENDAL

Kendal has a lower operating cost and higher load factor than most stations, however it has a relatively short useful life post retrofit to recover the high FGD retrofit cost, resulting in marginal financial and economic viability. Kendal will need to sustain higher load factors than presently planned, to remain competitive with alternative options in an unconstrained power system context, where these alternatives would potentially be the lowest-cost Risk Mitigation Independent Power Producer Program (RMIPPPP) type of projects (The RMIPPP program called for dispatchable technologies including a combination of wind, solar, gas, diesel etc). Like Majuba, if the power system continues to be highly constrained, where the alternatives include OCGTs and the cost of inadequate supply (load shedding/ unserved energy etc) then Kendal could be much cheaper thus economically and financially very viable even at very low load factors, and with the cost of the retrofit included and assuming technical feasibility is proven

It should however be noted that 9.5 years post retrofit for a significant investment is very short. Kendal will be approximately 40 years old by the time the retrofit is complete and will only operate for a full 5 years with all 6 units running with the retrofit, assuming it is delivered on time. In the context of such a short remaining life, consistently higher load factors of a minimum 40% are required to sustain viability within the future market competing with alternative options of potentially the lowest-cost RMIPPPP type of projects. The assumption of a longer remaining life could improve Kendal's competitiveness and make it viable at lower load factors, from a purely economic/financial perspective.

The capital expenditure (Capex) required to ensure SO_2 compliance at Kendal is estimated at R44,4 billion, while the annual Opex is estimated at R1,04 billion. Additionally, the costs associated with Kendal achieving its proposed maximum daily limits for PM is R1,43 billion.

6.1.2 COST ANALYSIS FOR MES COMPLIANCE AT MAJUBA

Despite Majuba having a longer remaining life than Kendal (17 Years post retrofit) and DSI FGD being lower in cost (and technically less efficient relative to the Wet and Semi-dry FGDs), Majuba's high operating cost, even before considering the additional capex, makes the economic and financial viability of the DSI FGD investment challenging.

At low load factors e.g., below 50%, the LCOE for Majuba will probably not be competitive with alternative options in an unconstrained power system, where these alternatives would potentially be the lowest-cost RMIPPP program type of projects Under a constrained power system scenario, where the alternatives include OCGTs and the cost of load shedding/unserved energy, then Majuba with DSI FGD could have a lower cost and be economically and financially viable even at low load factors (assuming it is technically feasible).

With the identified implementation risks, a sensitivity was performed assuming the implementation of DSI FGD is delayed by three years. The LCOE increased i.e. the option became more expensive. For it to remain competitive with alternative options, a minimum load factor of approximately 60% is required.

Which technology to deploy and Majuba's likely range of load factors results in uncertainty, which could only be established and quantified trough the stochastic systems modelling process. Depending on the outcome of such modelling process it might also be appropriate to justify the continued operation of Majuba (with or without the retrofit) based on strategic risk considerations.

The Capex required to ensure SO_2 compliance at Majuba is estimated at R13,1 billion, while the annual Opex is estimated at R1,04 billion. Additionally, the costs associated with Majuba achieving its proposed maximum daily limits for NO_X is R1,1 billion.

6.1.3 ERP NOMINAL COSTS AND TARIFF IMPACTS

Table 6-1 presents estimated nominal costs associated with each ERP option. The total nominal cost of all Eskom ERP scenarios has been estimated by Eskom at a Class 2 accuracy, implying a variance between -15% and +20%. Increases in Eskom capital costs impact on the electricity tariff paid by consumers. The extent of any tariff increases is influenced by multiple factors including the extent and timing of funding and projected energy sales. Implementation of the ERP scenarios with additional SO_2 reduction requirements could increase the electricity tariff by between 3 and 10% from current levels. Work to confirm the extent of increases utilising Eskom NERSA applicable methodologies will be undertaken.

Table 6-1 – Eskom Fleet ERP financial summary

	ERP 2024 A	ERP 2024 B	ERP 2024 C
	Eskom Fleet (cumulative)		
SO_2 Abatement	Kusile, Medupi FGD	Kusile, Medupi, Kendal (FGD), Majuba (DSI)	Kusile, Matimba, Medupi, Kendal, Tutuka, Lethabo (FGD), and Majuba (DSI)
NO_X Abatement	Majuba, Lethabo, Tutuka LNB	Majuba, Lethabo, Tutuka LNB	Majuba, Lethabo, Tutuka LNB
PM Abatement	Kendal, Matimba, Lethabo, Tutuka, Duvha, Matla PM Projects	Kendal, Matimba, Lethabo, Tutuka, Duvha, Matla PM Projects	Kendal, Matimba, Lethabo, Tutuka, Duvha, Matla PM Projects
Capex (nominal)	R77.2 billion	R134.6 billion	R256.9 billion
Opex (real, pa)	R2.1 billion	R4.2 billion	R6.3 billion

6.2 HEALTH COST BENEFIT ANALYSIS

As part of the Eskom exemption applications, a health cost benefit analysis (CBA) was undertaken for the Highveld and Vaal Triangle, and Waterberg regions, evaluating the health benefits and costs associated with ERP 2024 A, ERP 2024 B, ERP 2024 C. These assessments considered a combination of all abatement technologies under each ERP. The CBA uses exposure-response functions (ERFs) to estimate the health benefits in terms of reduced mortality rates due to lower pollutant levels. The value of a statistical life (VSL) is applied to monetize these health benefits (Prime Africa Consult, 2024).

The benefit:cost ratios (BCR) need to be interpreted with care. They are meant only to provide a perspective on and inform the decision-making process underlying the scenarios. They are not meant to be interpreted as a definitive answer to making abatement decisions. Decisions involving human health have to be informed by non-economic criteria as well. In addition, with uncertainty inherent in the analysis, the cost benefit ratio should thus not be viewed as absolute, but rather as a relative value from which to compare scenarios (Prime Africa Consult, 2024).

6.2.1 HIGHVELD AND VAAL TRIANGLE COST BENEFIT ANALYSIS

Table 6-2 summarises the BCR ratio findings (Prime Africa Consult, 2024). The analysis reveals that ERP 2024 A, which includes PM and NO_X reduction and Despatch Prioritisation addressing SO_2 emissions, has a BCR greater than 1, indicating that health benefits exceed costs. ERP 2024 B, which adds SO_2 reduction at Majuba and Kendal, approaches a BCR of 1 in optimistic scenarios but generally shows lower benefits relative to costs. ERP 2024 C, which includes full compliance with MES for SO_2 at Lethabo and Tutuka, has a BCR significantly less than 1, suggesting that the costs far outweigh the health benefits, especially given the short operational period before shutdown of Lethabo and Tutuka.

In summary, greatest benefits relative to costs are evident in ERP 2024 A, which assumes all PM and NO_X reduction projects as planned, with SO_2 abatement only installed at Kusile. The analysis underscores the importance of considering both economic and health impacts in decision-making for emission reduction strategies.

Table 6-2 – Benefit:Cost ratios (lower and upper ranges) for each scenario (Prime Africa Consult, 2024)

	ERP 2024 A		ERP 2024 B		ERP 2024 C	
	Lower	Upper	Lower	Upper	Lower	Upper
Benefit:Cost Ratio (range)	0.34	3.14	0.11	0.99	0.07	0.60
Benefit:Cost Ratio (central)	1.74		0.55		0.33	

6.2.2 WATERBERG COST BENEFIT ANALYSIS

Table 6-3 summarises the BCR findings (Prime Africa Consult, 2024). The results show that for all three scenarios (ERP 2024 A, B, and C), the costs of abatement exceed the health benefits, with benefit-cost ratios significantly less than 1. This remains true even under the most optimistic conditions. Even when evaluated at a social discount rate of 2%, all scenarios still show ratios less than 1, indicating that the financial costs are disproportionately high compared to the health benefits. As highlighted in the Prime Africa Consult (2024) assessment, a key reason for the low BCR is the small population in the Waterberg area that will benefit from reduced pollution levels due to abatement technology installations.

Table 6-3 – Benefit:Cost ratios (lower and upper ranges) for each scenario (Prime Africa Consult, 2024)

	ERP 2024 A		ERP 2024 B		ERP 2024 C	
	Lower	Upper	Lower	Upper	Lower	Upper
Benefit:Cost Ratio (range)	0.0002	0.0012	0.0004	0.0029	0.0006	0.0042
Benefit:Cost Ratio (central)	0.0007		0.0017		0.0024	

7 FLEET EXEMPTION REQUESTS

7.1 EXEMPTION REQUEST MOTIVATIONS

The following section presents each of the projects associated with ERP 2024 A, ERP 2024 B, and ERP 2024 C, summarising timeframes associated with the projects (detailed in section 4.2), and MES exemption requests, where applicable. Emission limits requested, and timeframes attached to each, are presented in section 7.2.

7.1.1 ERP 2024 A SCENARIO

As noted previously, ERP 2024 A includes all PM and NO_X abatement equipment projects, and SO_2 abatement at Medupi, in summary (detailed in section 4.2):

- Duvha:
  - HFPS installations on U4 and U6, complete by 1 April 2026.
- Matla:
  - HFPS installations on U3 and U5, complete by 1 April 2026.
- Kendal:
  - ESP upgrade on U1, and DHP overhaul on U1, complete by 1 April 2026.
- Lethabo:
  - ESP upgrades on U1, U2, U3, U4, and U5, and SO_3 Plant upgrades on U2, U3, U5, complete by 1 October 2027.
  - LNB installations on all units, complete by 1 April 2031
- Tutuka:
  - ESP upgrades on U1, U2, U3, and U4; DHP refurbishments on U1, U2, U3, and U4; and HFPS installations on U1, U2, U3, and U5, all to be complete by 1 January 2027.
  - LNB installations on all units, complete by 1 January 2028.
- Majuba:
  - LNB installations on all units, complete by 1 April 2031.
- Medupi:
  - Wet FGD installation on all units, complete by 1 April 2032.

In addition to the technology implementation scenario A includes:

- Efficiency improvement projects to optimise the air-to-fuel ratio which would reduce SO_2 emissions and maximise combustion efficiency.
- Despatch Prioritisation.
- An extension of the air quality offset programme.

The above installation timeframes consider:

- Time required to secure funding for each project (where applicable).
- Lead time required to procure, design, manufacture, and begin installations.
- The outage schedule to allow generating units to be taken offline for upgrades / retrofitting while maintaining security of supply i.e. ensuring sufficient generating capacity remains across the stations to avoid loadshedding.
- To ensure sufficient capacity remains in the grid, generally only a single generating unit at a station can be taken offline at a time, particularly with regards to the long installation timelines of the equipment.

7.1.1.1 Particulate Matter

Although Matimba has HFPS installations scheduled, Matimba will comply with the new plant PM MES by 1 April 2025 and is therefore not included in the above abatement project list, with no PM exemption requested for Matimba. Medupi and Majuba currently comply with the new plant MES, with no PM abatement projects required, and therefore no PM exemption request is made for Medupi and Majuba.

Following completion of the above PM abatement projects, Duvha, Matla, Kendal, Tutuka, and Lethabo PM emissions will comply with the new plant MES. However, this cannot be achieved prior to the completion of these projects, and given the project lead times, which include equipment optimisations, these will not be complete by 1 April 2025, and therefore these stations will not comply with the new plant MES by 1 April 2025. Importantly, Duvha U1 and U2; Matla U1, U2, and U3; and Lethabo U6 will comply with the new plant MES from 1 April 2025.

While the non-compliant ambient PM_{10} and $PM_{2.5}$ concentrations in the Highveld, Vaal Triangle, and Waterberg are noted (detailed in chapter 5 of this report), and recognising Eskom are not the sole contributor to these, the Eskom Fleet PM emissions show significant improvements from 2025 to 2028 due to the planned abatement projects and shutdown phases of Kriel, Arnot, Camden, Hendrina, and Grootvlei in effect. By FY2030, a PM emission reduction of 65kt (74%) is estimated, and by 2050, compared to 2025, a total reduction of 94% is estimated.

Despite the significant PM emission reductions described above, the cumulative Highveld and Vaal dispersion modelling assessment predicted non-compliant PM_{10} 24-hour, $PM_{2.5}$ annual, and $PM_{2.5}$ 24-hour average concentrations; predicted annual average PM_{10} concentrations remained compliant with the NAAQS in all scenarios. Critically, when considering these predictions, the conservative approach to the PM simulations must be noted, such as assuming all PM was PM_{10}, and all PM was $PM_{2.5}$, as well as the worst-case assumption that most of the ash dumps are exposed and available for entrainment, while in reality much of these surfaces are vegetated and wet, reducing actual exposed areas. Further to this, and as noted in the uMoya-Nilu AIRs (report uMN220-24, 2024 and uMN219-24, 2024), predicted ambient PM concentrations are predominantly due to the low-level fugitive sources, rather than the stack emissions themselves; the benefit of the stack emissions reductions, as evident in the trajectories, is over-shadowed by the impacts associated with fugitive emissions given the conservative assumptions applied to these.

Eskom recognises the importance of reducing PM emissions, and is committed to the planned abatement projects, and in conjunction with these has also implemented its air quality offsets programme. As noted in section 4.2.1, significant indoor PM_{10} and $PM_{2.5}$ concentration reductions have been achieved in participating households of the Highveld and Vaal Triangle communities, with Eskom planning to expand this program to additional communities and explore new interventions to reduce ambient PM_{10} and $PM_{2.5}$ concentrations in surrounding communities further.

In light of the above, Eskom is requesting exemption from the new plant PM MES at Duvha (U4 and U6), Lethabo (U1, U2, U3, U4, and U5), Matla (U4, U5, and U6), Kendal, and Tutuka until completion of the abatement projects, after which these stations will comply with the new plant MES. Emission limits requested, and timeframes attached to each, are presented in section 7.2.

7.1.1.2 Oxides of Nitrogen

Medupi currently has LNBs installed, complying with the new plant MES (750mg/Nm^3), while Kendal and Matimba have low NO_X boilers (corner-fired), with emissions also compliant with the new plant

MES. Given this, no NO_X abatement projects are planned at these stations, and therefore no exemption from the new plant MES are requested for these stations.

NO_X abatement technology, in the form of LNBs, is planned for installation at Lethabo, Tutuka, and Majuba, which, once installation and optimisations are complete, will result in these stations complying with the new plant NO_X MES. LNBs are long-term installations, and once procurement, concept and design, and manufacturing are complete, installations take five years to complete on all generating units, recognising that only one generating unit can be taken offline at a time to ensure maintained security of electricity supply.

The Tutuka LNB manufacturing contract was awarded in February 2024, while the installation contract will be awarded early 2025, depending on market response. Installation on the first generating unit is planned for 2025, after which LNBs will be installed sequentially according to available outages, with the last LNB to be complete by 2029.

Majuba have initiated the LNB project, currently at tender evaluation stage. Installation on the first generating unit is due to commence in 2026, after which LNBs will be installed sequentially according to available outages, with the last LNB to be complete by 2030.

The Lethabo LNB project is currently in Concept Release Approval (CRA) phase. Installation on the first generating unit is due to commence in 2027, after which LNBs will be installed sequentially according to available outages, with the last LNB to be complete by 2031.

Following completion of the above projects, Tutuka, Majuba, and Lethabo will comply with the new plant NO_X MES, however, as shown above, these projects will not be complete by 1 April 2025. Given this, Eskom is requesting exemption from the new plant MES for these stations until completion of the LNB installations. Currently, NO_X emissions at Majuba and Tutuka comply with the existing plant MES (1,100mg/Nm^3) limit, and while two exceedances of the existing limit occurred at Lethabo, the average NO_X emission complies with the existing limit. These emissions will reduce further with the initiation of Despatch Prioritisation to address SO_2 emissions, ensuring compliance with the existing plant MES is maintained. Emission limits requested, and timeframes attached to each, are presented section 7.2.

Regarding Matla and Duvha, installations of NO_X abatement technologies are not being considered. Should the new plant MES be enforced at Matla and Duvha, an LNB installation start date of 2028 is estimated, considering concept and design, market response, and procurement, following which manufacturing can commence. The first LNB installation would be complete in 2029, one year before Matla and Duvha commence shutdown. Considering that both Matla and Duvha commence shutdown in 2030, and the costs associated with an LNB, it is not economically feasible to install this technology. Further, regarding Matla, the National Environmental Consultative and Advisory (NECA) Panel had provided commentary that it was not economically feasible to install LNB at Matla, although if security of supply could be maintained, Matla was to be considered for early shutdown. The same consideration can be given to Duvha as both stations have the same shutdown schedule.

Although NO_X abatement technology is not being considered at Matla and Duvha, both stations currently comply with the exiting plant limit (1,100mg/Nm^3), and with the initiation of Despatch Prioritisation to address SO_2 emissions, will reduce further.

For the period 2021 – 2023, as discussed in chapter 5, measured ambient NO_2 concentrations in the Highveld and Vaal Triangle are compliant with the NAAQS, and although hourly exceedances occurred, these remained well below the permitted frequency of exceedance. While Eskom is not the sole contributor to these concentrations, Eskom emissions still do contribute, recognising these

contributions are made at Eskom's current emission rates i.e. without NO_X abatement at Matla, Duvha, Tutuka, Majuba, and Lethabo. Despite these stations not having NO_X abatement, ambient concentrations are compliant with the NAAQS. Considering the cumulative Eskom Fleet NO_X emissions trajectory, by FY2030 (compared to 2025), NO_X emissions are estimated to reduce by 292kt (40%) due to shutdowns of Arnot, Kriel, Hendrina, Camden, and Grootvlei. Between FY2025 and FY2050, total NO_X emissions are estimated to decrease by 78%.

Considering the cumulative Highveld and Vaal Triangle dispersion model and maximum sensitive receptors predictions, discussed in chapter 5, all modelling scenarios predicted compliant NO_2 concentrations, with annual averages well below the NAAQS, and no hourly exceedances predicted. This included the current scenarios (modelling Scenario 1 and Scenario A), which assumed no NO_X abatement at Matla, Duvha, Tutuka, Majuba, and Lethabo.

In light of the above, Eskom is requesting exemption from the new plant NO_X MES at Matla and Duvha until shutdown is complete, and at Tutuka, Majuba, and Lethabo until LNB installations are complete. Emission limits requested, and timeframes attached to each, are presented section 7.2.

7.1.1.3 Sulphur Dioxide

ERP 2024 A includes the installation of a wet FGD at Medupi, which, after various abatement technology evaluations, was found to be the most suitable for Medupi. The wet FGD has now been conceptualised with Medupi going to market in August 2024 to acquire an EPC contractor to execute the FGD project, anticipated to be concluded by the first quarter of 2025, although this is wholly dependent on market response. Planned commencement of the FGD installations is FY2028, taking five years to complete on all generating units, with the last unit completed in FY2032.

Following completion of these installations, Medupi will comply with the new plant MES (1,000mg/Nm^3), and anticipates improving on this MES and achieving an emission of 800mg/Nm^3 to offset SO_2 emissions from Matimba (discussed further in section 7.1.2). While Medupi will achieve MES compliance after installation of the FGD, it cannot achieve the new plant MES until these are completed. Given this, SO_2 emissions at Medupi will be managed through Despatch Prioritisation (discussed in section 4.1) and efficiency improvement projects optimising the air-to-fuel ratio which will maximise combustion efficiency and reduce SO_2 emissions further.

Measured ambient SO_2 concentrations in the Waterberg for the period 2021 – 2023 show compliance with the NAAQS, and although short-term exceedances were recorded, these did not exceed the permitted frequency of exceedance (discussed in section 5.3). While Eskom is not the sole contributor to these concentrations, Eskom emissions comprise one of the key SO_2 sources in the region, recognising these contributions are made at Eskom's current emission rates i.e. without SO_2 abatement at Medupi, with ambient concentrations remaining compliant with the NAAQS. Considering the cumulative Eskom Fleet SO_2 reductions under ERP 2024 A, by FY2030 a decrease of 555kt (32%) is anticipated, with a further 165kt (14%) by FY2035 due to completion of the wet FGD at Medupi, Despatch Prioritisation, efficiency improvement projects, and shutdown of Arnot, Kriel, Camden, Hendrina, Grootvlei, Duvha, and Matla. Eskom's Security of Supply projection, representing an upper emissions limit, still shows emission reductions, and by FY2030 a 482kt (27%) reduction is anticipated, with a further decrease of 294kt (23%) by FY2035.

The cumulative Waterberg dispersion modelling (discussed in section 5.3) predicts maximum sensitive receptor annual average SO_2 concentrations will remain well below the NAAQS, as well as no exceedances of the hourly NAAQS, in all modelling scenarios, including those where current

Medupi emissions are simulated without wet FGD. Despite this compliance, 24-hour non-compliances are predicted in scenarios where FGD is not yet installed at Medupi, however following FGD completion, 24-hour concentration predictions are compliant with the NAAQS, with no exceedances predicted.

Considering the above, Eskom is requesting exemption from the new plant MES at Medupi until completion of the FGD. For Matla, Duvha, Lethabo, Tutuka, and Matimba, since SO_2 abatement is not being evaluated for these stations in ERP 2024 A, exemption from the new plant SO_2 MES is requested until shutdown; emission limits requested, and timeframes attached to each, are presented in section 7.2. Alternate SO_2 emission limits below the existing plant limits are being requested for all stations (except Matimba).

7.1.1.4 Health Cost Benefit Analysis

As discussed in section 6.2, the health cost benefit analysis (CBA) undertaken considered the costs and health benefits of all projects under ERP 2024 A, although separately for the Highveld and Vaal, and Waterberg.

Considering the Highveld and Vaal CBA, health benefits for ERP 2024 A outweighed the costs to implement the projects, indicating these projects should be considered. As noted previously, Eskom is committed to implementing the ERP 2024 A projects, although given the timeframes associated with completion of these projects, exemption from the new plant MES is being requested for certain stations and pollutants.

Considering the Waterberg CBA, the central BCR was extremely low, well below 1, predominantly due to the small population in the Waterberg area, indicating that the costs to install the FGD at Medupi, outweigh the health benefits that will be recognised from the FGD. Despite this, and as noted previously, a wet FGD will be installed at Medupi to achieve MES compliance, although given the timeframes of installation, exemption from the new plant MES is being requested for Medupi until the FGD is complete.

7.1.1.5 Summary

The total cost (Highveld, Vaal Triangle, and Waterberg) associated with implementation of ERP 2024 A is estimated to be R77 billion, inclusive of the PM, NO_X, and SO_2 projects presented above. Based on the summary above and the multiple other issues and impacts raised in the exemption reports ERP 2024 A is considered the most appropriate scenario for implementation. This is further supported by the high BCR ratio obtained for the Highveld and Vaal areas, implying health benefits realised from ERP 2024 A outweigh the costs associated with ERP 2024 A. While the BCR is low for the Waterberg, Eskom will be installing a wet FGD at Medupi.

7.1.2 ERP 2024 B SCENARIO

As noted previously, in addition to the already discussed projects in ERP 2024 A, ERP 2024 B assessed DSI FGD at Majuba and a semi-dry FGD at Kendal (detailed in section 4.2). This represents a scenario, that based on nationally lead strategic decisions and additional guarantees, could be achieved. This ERP requires careful evaluation of financial consequences, shutdown timeframes, Eskom Fleet emissions reduction, existing ambient concentrations, and dispersion modelling predictions.

While SO_2 emissions at Kendal and Majuba comply with their respective existing plant MES, neither station can comply with the new plant MES (1,000mg/Nm^3) without SO_2 abatement. The semi-dry FGD at Kendal, being evaluated as part of this application, would bring Kendal SO_2 emissions to compliance with the new plant MES. DSI FGD at Majuba, also being evaluated as part of this application, would not result in compliance with the new plant MES, although would approximately reduce emissions by 25%.

Measured ambient SO_2 concentrations in the Highveld and Vaal Triangle for the period 2021 – 2023 show compliance with the NAAQS, and although short-term exceedances were recorded, these did not exceed the permitted frequency of exceedance (discussed in section 5.2). While Eskom is not the sole contributor to these concentrations, Eskom emissions are a key contributor, recognising these contributions are made at Eskom's current emission rates i.e. without SO_2 abatement at Kendal and Majuba, with ambient concentrations remaining compliant with the NAAQS. Considering the cumulative Eskom Fleet SO_2 reductions under ERP 2024 A (excluding SO_2 abatement at Majuba and Kendal), by FY2030 a decrease of 555kt (32%) is anticipated, with a further 165kt (14%) by FY2035 due to completion of the wet FGD at Medupi, Despatch Prioritisation, efficiency improvement projects, and shutdown of Arnot, Kriel, Camden, Hendrina, Grootvlei, Duvha, and Matla. Eskom's Security of Supply projection, representing an upper emissions limit, still shows emission reductions, and by FY2030 a 482kt (27%) reduction is anticipated, with a further decrease of 294kt (23%) by FY2035.

The cumulative Highveld and Vaal Triangle Eskom Fleet dispersion modelling (discussed in section 5.2) predicts maximum sensitive receptor annual average SO_2 concentrations will remain well below the NAAQS, as well as no exceedances of the 24-hour or hourly NAAQS being predicted, in all modelling scenarios, including those where current Majuba and Kendal emissions are simulated without abatement technologies. While annual average ambient concentration predictions do improve when comparing ERP 2024 B (13.3µg/m^3) to ERP 2024 A (17.2µg/m^3), an improvement of 3.9µg/m^3 is realised, but is attributable to a combination of the SO_2 abatement at Majuba and Kendal, but more so from the shutdown of Duvha and Matla, with greatest SO_2 reductions achieved through station shutdowns, rather than SO_2 abatement.

Regarding Kendal, following evaluation of various SO_2 abatement technologies, the semi-dry FGD was identified as the most suitable. Due to the lead times associated with concept and design, procurement, construction, and installation, the semi-dry FGD installation would commence FY2031, with completion of the last unit in FY2035, although this is dependent on market response and timeframe commitments from contractors. Kendal is scheduled to enter shutdown phase in FY2040, with shutdown complete by FY2045, with the full impact of FGD only realised for approximately four years before Kendal enters shutdown. An estimated nominal Capex of R44.4 billion (-15% to +20%) is required for the semi-dry FGD at Kendal, with an annual real Opex of approximately R1 billion.

At Majuba, key technologies considered to abate SO_2 were FGD (either wet or semi-dry) and variations of DSI Dry FGD, such as a combination of DSI (hydrated lime into duct) and/or furnace sorbent injection (limestone into furnace). A semi-dry FGD would require breaking into the existing plant to install the FGD between the boiler and before the PJFFP, which is a very intrusive process with a long timeframe. A wet FGD is installed after the PJFFP but requires a dedicated absorber tower and much more water than both semi-dry and DSI, while space on the existing terrace is limited for an absorber tower. Given this, DSI has been identified as the most appropriate technology at Majuba to reduce emissions, although not to MES compliance. Pilot projects are currently planned to test the effectiveness of the DSI technology. Due to the lead times associated with the pilot project, concept and design, procurement, construction, and installation, DSI installation would commence FY2029, with completion of the last unit in FY2033. Majuba shutdown is due to commence in FY2047, with complete shutdown by FY2052. An estimated nominal Capex of R13.1 billion (-15% to +20%) is required for the DSI at Majuba, with an annual real Opex of approximately R1 billion.

To reduce SO_2 emissions at Kendal and Majuba, either as an interim measure until abatement is installed, or permanently if the decision is made not to install abatement, is the implementation of Despatch Prioritisation and completion of efficiency improvement projects, both of which will have a positive impact on SO_2 emissions, although would not bring emissions into compliance with the new plant MES.

Considering the health cost benefit analysis for ERP 2024 B, the central BCR suggests costs to implement ERP 2024 B outweigh the health benefits that will be achieved with implementation. Implementation of ERP 2024 B, in addition to ERP 2024 A, would have a combined nominal Capex of R134.6 billion.

The installation of SO_2 abatement at Majuba and Kendal needs to be considered carefully, particularly at Kendal where the project will only be complete approximately four years before shutdown starts, and therefore return on investment will not be realised. For ERP 2024 B, it would be necessary to source funding against the background of guaranteed cost-reflective tariffs. From an economic/financial perspective a defined minimum load factor/take or pay agreement would ensure that the unit costs are acceptable compared to known alternatives, however if consideration could be given to the extension of the station life the economic/financial viability could improve.

While extension of a station's life may provide improved viability, this would mean an extension of South Africa's reliance on coal generation, potentially impacting South Africa's GHG commitments. A possible alternative to consider, would be that if funding is made available Eskom increases its investments in renewables and grid connection by the same amounts that would have been invested in such SO_2 retrofits; this would result in larger economic value add than FGD retrofits, and would progress South Africa's transition to renewables quicker.

Based on the summary above, considering the costs of technology installations, the benefits realised from this, and the multiple other issues and impacts raised in the exemption reports ERP 2024 B is not considered an appropriate scenario for implementation.

7.1.3 ERP 2024 C SCENARIO

As noted previously, in addition to the already discussed projects in ERP 2024 A and ERP 2024 B, ERP 2024 C assessed semi-dry FGD at Lethabo, Tutuka, and Matimba (detailed in section 4.2). This represents a scenario that would require substantial guarantees and considerations of financial impacts, such as on electricity tariffs, and return on investments.

While SO_2 emissions at Lethabo, Tutuka, and Matimba comply with their respective existing plant MES, these stations cannot comply with the new plant MES (1,000mg/Nm^3) without SO_2 abatement. Eskom has consistently motivated in previous applications that an FGD, or similar technology, at Lethabo, Tutuka and Matimba is not feasible and has therefore not commenced with concept and design. Eskom maintains this position in this application, as presented below.

Should new plant MES compliance be enforced at Tutuka, Lethabo, and Matimba, and since concept and design have not commenced, followed by procurement and construction, a start date of FY2031 is estimated. Since installation is five years for all generating units, estimated completion dates would be optimistically FY2035. Tutuka starts shutdown in FY2036, one year after completion of the FGD, Lethabo starts shutdown FY2037, two years of completion of FGD, and Matimba starts shutdown FY2039, four years of completion of the FGD. Considering the nominal Capex to install FGD at Tutuka (R38.4 billion), Lethabo (R40 billion), and Matimba (R42 billion), return on investment would not be realised and is therefore not economically feasible to install this equipment.

Further to the above, is the consideration of the existing compliant ambient SO_2 concentrations in the Highveld, Vaal Triangle, and Waterberg regions, with Tutuka, Lethabo, and Matimba currently contributing to these measurements in their respective regions, without SO_2 abatement. Further to this, the cumulative dispersion modelling for the Highveld and Vaal predicts compliant ambient SO_2 concentrations due to the Eskom Fleet, inclusive of the scenarios which simulated Tutuka, Lethabo, and Matimba without abatement. These predictions correlate with the existing compliant ambient concentrations in the area. While the Waterberg cumulative dispersion model predicted non-compliant 24-hour concentrations, it predicted fully compliant annual and hourly concentrations in all scenarios. Further, once the Medupi FGD is complete, model predictions showed full compliance, even with Matimba simulated without abatement. Regarding Matimba, is consideration of the low emissions that will be achieved on completion of the Medupi FGD, which can be considered as offsetting Matimba SO_2 emissions. Further, the NECA Panel questioned the feasibility of installing wet FGD at Medupi, and while Eskom will be installing wet FGD at Medupi, the same consideration can be provided to installing FGD at Matimba.

Comparing predicted air quality improvements between ERP 2024 A and ERP 2024 C, in the Highveld and Vaal region, a maximum sensitive receptor annual average reduction of 11.8µg/m^3 will be realised. Importantly, this reduction is not only due to the FGDs at Lethabo and Tutuka, but more so from the shutdown of Arnot, Kriel, Hendrina, Camden, Grootvlei, Duvha and Matla, with a station shutdown having a much greater impact on SO_2 emission reduction than abatement technology. In the Waterberg, once the Medupi FGD is installed, and should Matimba also receive an FGD, a maximum sensitive receptor annual average reduction of 5µg/m^3 would be realised.

In addition, the health cost benefit analysis, in all regions, suggests the costs to implement ERP 2024 C far outweigh the health benefits that will be realised, and particularly so in the Waterberg due to the small population.

Implementation of ERP 2024 C, in combination with ERP 2024 A and ERP 2024 B, would result in a nominal Capex of R256.9 billion. This would place additional strain on the South African economy, without return on investment, both from a financial perspective, and ambient air quality benefits. While extension of the operational life of the stations would provide economic return on investment, this approach would extend South Africa's reliance on coal power generation.

Based on the summary above, considering the costs of technology installations, the benefits realised from this, and the multiple other issues and impacts raised in the exemption reports ERP 2024 C is not considered an appropriate scenario for implementation.

7.2 REQUESTED EMISSION LIMITS FOR THE EXEMPTION STATIONS

As presented in section 3.2, Eskom are required to comply with the new plant MES by 1 April 2025. As discussed, and motivated in section 7.1, this is not achievable for certain pollutants at certain stations. Given this, Eskom is requesting exemption from the new plant MES until shutdown for certain stations, and until completion of abatement equipment installations at others. Table 7-1 to Table 7-8 present the requested emission limits for each station contained in this exemption application.

Table 7-1 – Emission limits requested for Duvha

POINT SOURCE CODE	POLLUTANT	MAXIMUM RELEASE RATE			DURATION OF EMISSIONS
		mg/Nm^3	Average Period	Date To Be Achieved	
U1, U2, U4, U5, U6	SO_2	2,600 mg/Nm^3	Daily	Immediate - shutdown	Continuous
	NO_X	1,100 mg/Nm^3	Daily	Immediate - shutdown	Continuous
U1, U2, U5	PM	50 mg/Nm^3	Daily	Immediate	Continuous
U4, U6	PM	100 mg/Nm^3	Daily	Immediate	Continuous
		50 mg/Nm^3	Daily	1 October 2026	Continuous
*Emission limits requested are for normal operations, so exclude upset, startup, shutdown, or maintenance conditions					

Table 7-2 - Emission limits requested for Matla

POINT SOURCE CODE	POLLUTANT	MAXIMUM RELEASE RATE*			DURATION OF EMISSIONS
		mg/Nm^3	Average Period	Date To Be Achieved	
U1, U2, U3, U4, U5, U6	SO_2	2,600 mg/Nm^3	Daily	Immediate - shutdown	Continuous
	NO_X	1,100 mg/Nm^3	Daily	Immediate - shutdown	Continuous
U1, U2, U3	PM	100 mg/Nm^3	Daily	Immediate	Continuous
		50 mg/Nm^3	Daily	1 April 2025	Continuous
U4, U5, U6	PM	100 mg/Nm^3	Daily	Immediate	Continuous
		50 mg/Nm^3	Daily	1 April 2026	Continuous
*Emission limits requested are for normal operations, so exclude upset, startup, shutdown, or maintenance conditions					

Table 7-3 - Emission limits requested for Tutuka

POINT SOURCE CODE	POLLUTANT	MAXIMUM RELEASE RATE*			DURATION OF EMISSIONS
		mg/Nm^3	Average Period	Date To Be Achieved	
Stack 1 (U1-3) Stack 2 (U4 -6)	SO_2	3,000 mg/Nm^3	Daily	Immediate - shutdown	Continuous
	NO_X	1,100 mg/Nm^3	Daily	Immediate	Continuous
		750 mg/Nm^3	Daily	1 April 2029	Continuous
	PM	300 mg/Nm^3	Daily	Immediate	Continuous
		50 mg/Nm^3	Daily	1 April 2027	Continuous
*Emission limits requested are for normal operations, so exclude upset, startup, shutdown, or maintenance conditions					

Table 7-4 - Emission limits requested for Lethabo

POINT SOURCE CODE	POLLUTANT	MAXIMUM RELEASE RATE*			DURATION OF EMISSIONS
		mg/Nm^3	Average Period	Date To Be Achieved	
U1, U2, U3, U4, U5, U6	SO_2	2,600 mg/Nm^3	Daily	Immediate - shutdown	Continuous
	NO_X	1,100 mg/Nm^3	Daily	Immediate	Continuous
		750 mg/Nm^3	Daily	1 April 2031	Continuous
U6	PM	100 mg/Nm^3	Daily	Immediate	Continuous
		50 mg/Nm^3	Daily	1 April 2025	Continuous
U2, U3	PM	100 mg/Nm^3	Daily	Immediate	Continuous
		50 mg/Nm^3	Daily	1 April 2026	Continuous
U5	PM	100 mg/Nm^3	Daily	Immediate	Continuous
		50 mg/Nm^3	Daily	1 October 2026	Continuous
U4	PM	100 mg/Nm^3	Daily	Immediate	Continuous
		50 mg/Nm^3	Daily	1 April 2027	Continuous
U1	PM	100 mg/Nm^3	Daily	Immediate	Continuous
		50 mg/Nm^3	Daily	1 October 2027	Continuous
*Emission limits requested are for normal operations, so excludes upset, startup, shutdown, or maintenance conditions.					

Table 7-5 - Emission limits requested for Matimba

POINT SOURCE CODE	POLLUTANT	MAXIMUM RELEASE RATE*			DURATION OF EMISSIONS
		mg/Nm^3	Average Period	Date To Be Achieved	
SV0013, SV0014, SV0015, SV0002, SV0011, SV0012	SO_2	3,500 mg/Nm^3	Monthly	1 April 2025 - shutdown	Continuous
	NO_X	750 mg/Nm^3	Daily	1 April 2025	Continuous
	PM	50 mg/Nm^3	Daily	1 April 2025	Continuous
*Emission limits requested are for normal operations, so exclude upset, startup, shutdown, or maintenance conditions					

Table 7-6 - Emission limits requested for Kendal

POINT SOURCE CODE	POLLUTANT	MAXIMUM RELEASE RATE*			DURATION OF EMISSIONS
		mg/Nm^3	Average Period	Date To Be Achieved	
U1, U2, U3, U4, U5, U6	SO_2	3,000 mg/Nm^3	Daily	Immediate	Continuous
		1,000 mg/Nm^3	Daily	1 April 2036**	Continuous
	NO_X	1,100 mg/Nm^3	Daily	Immediate	Continuous
		750 mg/Nm^3	Daily	1 April 2025	Continuous
U3, U4, U6	PM	100 mg/Nm^3	Daily	Immediate	Continuous
		50 mg/Nm^3	Daily	1 October 2025	Continuous
U1, U2, U5	PM	100 mg/Nm^3	Daily	Immediate	Continuous
		50 mg/Nm^3	Daily	1 April 2026	Continuous
*Emission limits requested are for normal operations, so exclude upset, startup, shutdown, or maintenance conditions **Should semi-dry FGD be installed					

Table 7-7 - Emission limits requested for Majuba

POINT SOURCE CODE	POLLUTANT	MAXIMUM RELEASE RATE*			DURATION OF EMISSIONS
		mg/Nm^3	Average Period	Date To Be Achieved	
SV0013, SV0014, SV0015, SV0002, SV0011, SV0012	SO_2	3,000 mg/Nm^3	Daily	Immediate	Continuous
		2,100 mg/Nm^3	Daily	1 April 2034**	Continuous
	NO_X	1,100 mg/Nm^3	Daily	Immediate	Continuous
		750 mg/Nm^3	Daily	1 April 2030	Continuous
	PM	50 mg/Nm^3	Daily	Immediate	Continuous
*Emission limits requested are for normal operations, so exclude upset, startup, shutdown, or maintenance conditions. **Should DSI be installed					

Table 7-8 - Emission limits requested for Medupi

Point Source Code	Pollutant	Maximum release rate*			Duration of Emissions
		mg/Nm^3	Average Period	Date To Be Achieved	
SV0013, SV0014, SV0015, SV0002, SV0011, SV0012	SO_2	3,500mg/Nm^3	Monthly	Immediate	Continuous
		800mg/Nm^3	Monthly	1 April 2032	Continuous
	NO_X	750 mg/Nm^3	Daily	Immediate	Continuous
	PM	50 mg/Nm^3	Daily	Immediate	Continuous
*Applicable to normal operations, so excludes upset, startup, shutdown, and maintenance periods.					

7.3 EXEMPTION APPLICATION – OTHER CONSIDERATIONS

7.3.1 SOCIOECONOMIC CONSIDERATIONS

While various motivations have been provided in the previous sections supporting Eskom's requests for the various exemptions, consideration needs to be given to the potential impacts associated with the MES being strictly enforced.

Strict adherence to the legal framework and regulations (i.e. MES) will require generating units to be taken offline until abatement installations are complete, or for certain stations (e.g. Matla and Duvha) to enter shutdown early with NERSA approval, which will reduce available capacity in the grid, resulting in an increased degree of loadshedding. Should generating units be taken offline at the various stations, approximately 29,230MW will be at risk.

Over the past decade, South Africa's electricity system has struggled to meet demand due to frequent breakdowns and reduced capacity, leading to recurrent loadshedding. This crisis has severely impacted the economy, particularly the mining and industrial sectors, causing reduced outputs and a loss of investor confidence and government revenue. Power outages have also affected medical care, food storage, sanitation, water, and sewerage facilities, while citizens face daily challenges such as extended commutes, increased crime, and difficulties in food preparation.

As was shown through scenario modelling in 2021/22, full compliance (whether immediate or even over a period of several years) could potentially limit the constitutional rights of South Africans by leading to severe energy deficits, at minimum constraining GDP growth and economic recovery, at worst causing total economic collapse. While impacts of loadshedding on the economy is well understood, considerations also need to be given to local communities potentially impacted by the shutdown of generating units and/or certain stations starting shutdown early. Across the Eskom Fleet applying for exemption, approximately 5,450 people are directly employed, with thousands of contractors associated with the stations, as well as the various collieries supplying the stations. Shutdown of generating units would place a significant risk on these employees, and with extremely high unemployment rates throughout the country, would exacerbate the situation. Numerous impacts are associated with unemployment, such as increasing crime and Gender Based Violence (GBV), alienation in communities, reductions in standards of living, and inability to meet necessities.

A balanced approach to energy policy is required, aiming to reduce reliance on coal while expanding renewable and lower-emission energy sources, although the roll-out of these transitions has been slow. Aligning with the National Energy Crisis Committee (NECOM) Energy Action Plan, Eskom aims to address the energy gap with immediate solutions such as demand reduction, accelerating the construction of new generation and storage capacity, improving infrastructure, and enhancing Eskom's operational efficiency.

7.3.2 ESTABLISHMENT OF AN EMISSION REDUCTION TRAJECTORY

The scenarios described above have referred to emission reduction trajectory in terms of PM, NO_X and SO_2. With scenario ERP 2024 A showing emission reductions by FY2030 for PM (65kt), NO_X (292kt), and SO_2 (555kt), while the Eskom security of supply projection also shows reductions by FY2030 for PM (64kt), NO_X (256kt) and SO_2 (482kt). While the MES and climate change regulatory process are legally separate it is useful to note both ERP 2024 A and the security of supply projection are aligned with Eskom's current pollution prevention plan running to December 2025. Future CO_2

trajectories will be based on the updated pollution prevention plan and IRP, NDC, and Sectorial Emission Targets (SET).

The Priority Area regulations and priority area plans refer to emission reduction targets, with the draft HPA plan indicating that industry should obtain a 40% reduction in total emissions by 2030 from a 2019 base. The emission reduction projections described above are based on the best available assessment of what Eskom is required to generate from coal stations in terms of the nationally driven IRP process and Eskom planning. Neither of these processes are static and they are influenced by a range of factors including economic growth rates, IPP production and national climate change commitments. If economic growth increases and there are substantive delays in the provision of non-coal-based generation then the Eskom coal fleet may be asked to ensure security of supply which will result in an increase in emissions above the trajectories predicted in this application. As such Eskom believes it would be inappropriate for the setting of specific legally binding emission reduction targets at either a fleet or station level and request exemption from any such requirements where they are enforced through air quality related legal mechanisms.

7.3.3 THE LIMITED EXTENT OF THIS APPLICATION

Eskom is mindful that any exemption application should be limited in extent and believes that the alternative emission limits requested above and this application in general complies with that approach. Further, the exemptions requested will ensure security of supply will be maintained. Specifically, Eskom has:

- In respect of PM limits only requested exemption where it is necessary for the time to complete the emission reduction projects to bring the stations into new plant MES compliance. Further, the exemption requested alternate limits is no worse than the MES existing plant limits which the stations have operated at historically.
- In respect of NO_X limits for Lethabo, Tutuka and Majuba only requested exemption where it is necessary for the time to complete the emission reduction projects to bring the stations into compliance with the new plant MES. Further, there is compliance to NAAQS ambient air quality limits for NO_2 and the exemption requested alternate limits is no worse than the MES existing plant limits which the stations have operated at historically.
    - In the case of NO_X limits for Duvha and Matla the exemption request is supported by a clear motivation, there is compliance to NAAQS ambient air quality limits for NO_2 and the requested alternate limits are no worse than the MES existing plant limits which the stations have operated at historically.
- In terms of SO_2 the exemption request has provided clear motivation above of the appropriateness of the alternate limits specifically illustrating that there is compliance to NAAQS ambient air quality limits for SO_2. In addition, Eskom is not seeking a blanket exemption as it intends to operate at alternate SO_2 limits generally below the existing plant limits and it will obtain MES compliance for two out of the three priority pollutants at all stations operating post 2035.

8 ASSUMPTIONS AND LIMITATIONS

The following assumptions, limitations and exclusions are applicable to this application:

- A 50-year operational life for the power stations has been assumed for this application.
- It is assumed the emission trajectories for scenario options of ERP 2024 A, ERP 2024 B, and ERP 2024 C, as provided by Eskom, are accurate and representative of reality and future anticipated plans.
- It is assumed current emissions data, as provided by Eskom, used to assess compliance to emission limits, and used as input to the dispersion models, are accurate and representative of existing operations.
- It is assumed abatement projects, as proposed by Eskom, will be undertaken as presented within the timeframe commitments, to the best of Eskom's ability i.e. should outage schedules and grid capacity allow.
- Operational challenges identified at the stations, and confirmed by Eskom, are assumed to be accurate of current operational conditions at the stations.
- Results from the dispersion modelling, discussed herein, are assumed to accurately represent emissions data provided.
- Due to time constraints, the Security of Supply emission projection could not be assessed in the dispersion modelling.
- Ambient monitoring data, as contained herein, is assumed to accurately represent existing ambient air quality within the various airsheds.
- Qualitative technology evaluations, particularly relating to SO_2 abatement technologies, were undertaken by Eskom. This application assumes these evaluations, and the preferred technologies from these, accurately reflect the most appropriate technology for a particular station. WSP's involvement in this application, and high-level understanding of Eskom stations, does indicate the technologies selected are most suitable, considering all aspects, such as costs, timeframes to commission, water requirements, retrofitting complexities, waste management, and emission reduction efficiencies. Despite this, WSP cannot be held responsible should more appropriate technologies be identified in the future.
- Shutdown dates provided by Eskom are not within Eskom's legal mandate to decide, but require prior approval from NERSA, which may not necessarily be granted should security of supply be jeopardised.

9 STAKEHOLDER ENGAGEMENT

The Ministers Decision issued in May 2024 requires that: “Eskom must ensure that all relevant organs of state, I&APs are notified of its applications for exemption and provided with an opportunity to comment thereon.”

Based on this requirement, a public participation process based on the requirements of the EIA Regulations have been undertaken. Public participation is understood to be a series of inclusive and culturally appropriate interactions aimed at providing stakeholders with opportunities to express their views, so that these can be considered and incorporated into the decision-making process.

9.1 PUBLIC PARTICIPATION

9.1.1 IDENTIFICATION OF KEY STAKEHOLDERS

The stakeholder engagement commenced with the compilation of a stakeholder database to include relevant stakeholders, such as Commenting Authorities, State Owned Enterprises, business landowners/users, and Ward Councillors, as well as any other I&APs who may be interested or affected by the project.

Relevant authorities (organs of state) have been automatically registered as I&APs. In accordance with the EIA Regulations, 2014 all other persons must request in writing to be placed on the register, submit written comments, or attend meetings to be registered as stakeholders and included in future communication regarding the application.

Section 41 of the EIA Regulations, 2014 states that written notices must be given to identified stakeholders as outlined in the table below.

Table 9-1 - I&AP Identification

NEMA REQUIREMENT	DISCUSSION
(i) the owner or person in control of that land if the applicant is not the owner or person in control of the land	The applicant is the landowner.
(ii) the occupiers of the site where the activity is or is to be undertaken or to any alternative site where the activity is to be undertaken	The applicant is the landowner and occupant.
(iii) owners and occupiers of land adjacent to the site where the activity is or is to be undertaken or to any alternative site where the activity is to be undertaken	The landowners and occupant of adjacent properties will be notified of the proposed application by newspaper advert, site notices placed around the proposed site and also emails and SMS for those already registered in the database.
(iv) the municipal councillor of the ward in which the site or alternative site is situated and any organisation of ratepayers that represent the community in the area	The Ward Councillor from Wards 18 of the MLM has been included in the stakeholder database and will be notified by newspaper, received personal email and SMS notifications.
(v) the municipality which has jurisdiction in the area	The Fezile Dabi District Municipality (FDDM) as well as the Metsimaholo Local Municipality have been included in

NEMA REQUIREMENT	DISCUSSION
	the stakeholder database and will be notified by newspaper, received email and SMS notifications.
(vi) any organ of state having jurisdiction in respect of any aspect of the activity	The FDDM will be notified by newspaper, email and SMS notifications.
(vii) any other party as required by the competent authority	All tiers of government, namely, national, provincial, local government and parastatals have been included on the stakeholder database and were notified by newspaper, received email and SMS notifications. Inclusive of: ▪ DESTEA ▪ DFFE ▪ Department of Energy ▪ Department of Water and Sanitation

9.1.2 MES EXEMPTION APPLICATIONS ANNOUNCEMENT

The exemption application process will be announced for public comment for a period of 30 days from **6 November 2024 – 6 December 2024**. Additionally, the technical report along with an electronic version of the comment sheet will be placed on the WSP Group Africa (Pty) Ltd (WSP) website as well as the WSP Datafree website to be accessed by the public at the following links: https://www.wsp.com/en-ZA/services/public-documents and https://wsp-engage.com/.

9.1.2.1 DIRECT NOTIFICATION

9.1.2.1.1 Email notifications

Notification of the exemption application will be issued to registered I&APs and stakeholders, via email on **06 November 2024**. The purpose of the notification was to offer registered I&APs and stakeholders the opportunity to comment on the application process. A total of 830 registered stakeholders were notified via email.

9.1.2.1.2 SMS

Notification of the exemption application will be issued to registered I&APs and stakeholders, via SMS on **06 November 2024**. The purpose of the notification was to offer registered I&APs and stakeholders the opportunity to comment on the application process. A total of 1,321 registered stakeholders were notified via sms.

9.1.2.1.3 Site notices

The EIA Regulations, 2014 require that site notices be fixed at places conspicuous to the public at the boundary or on the fence of the site where the activity (to which the application relates) is to be undertaken, as well as at any alternative sites. Posters (in English, Afrikaans and Sesotho), conforming to the size specifications as per the EIA Regulations, 2014 will be placed on **06 November 2024**. Six posters in each language (where relevant) were placed for each power station.

9.1.3 AVAILABILITY OF TECHNICAL REPORTS

The exemption reports were made available for public comment at the public places outlined in Table 9-2.

Table 9-2 - Public Availability of Exemption Report

LOCATION	ADDRESS	STATION REPORT AVAILABILITY
Lethabo Power Station	Klasie Havenga Street, Vanderbijlpark	Lethabo Power Station
Bophelong Library	Corner Ncuma and Matthews Street, Bophelong	Lethabo Power Station
Vereeniging Library	Lesley Street, Vereeniging	Lethabo Power Station
Sharpeville Library	Seeiso Street, Sharpeville	Lethabo Power Station
Matimba Power Station	Nelson Mandela Dr, Lephalale	Matimba Power Station
Medupi Power Station	Kuipersbuld Street, Marapong	Medupi Power Station
Lephalale Municipality Library	Corner Joe Slovo and Douwater Avenue, Lephalale	Waterberg Power Stations
Marapong Library	916 Phukubye Street, Marapong	Waterberg Power Stations
Kendal Power Station	Kendal Rd, Ogies	Kendal Power Station
Ogies Library	105 R555, Ogies	Kendal Power Station
Phola Public Library	Phola (25°59'44.88"S; 29° 2'21.30"E)	Kendal Power Station
Matla Power Station	Matla, Ga-Nala (26°16'55.63"S, 29° 8'26.34"E)	Matla Power Station
Ga Nala Public Library	c/o Quintin & Heinrich St, Ga-Nala	Matla Power Station
Duvha Power Station	Old Bethal Road, eMalahleni	Duvha Power Station
Majuba Power Station	Volksrust (27° 6'0.25"S; 29°46'9.99"E)	Majuba Power Station
Amersfoort Public Library	Amersfoort (27° 0'24.18"S; 29°52'11.10"E)	Majuba Power Station
Perdekop Public Library	Perdekop (27° 9'41.71"S; 29°37'36.37"E)	Majuba and Tutuka Power Stations
Tutuka Power Station	Thuthukani, Standerton 9 26°46'42.02"S; 29°20'49.16"E0	Tutuka Power Station
Standerton Public Library	Mbonani Mayisela St, Standerton	Tutuka Power Station
Stanwest Public Library	103 Sydney de Lange St, Standerton	Tutuka Power Station
EMalahleni Main Library	28 Hofmeyer St, eMalahleni	All Stations in the Highveld Priority Area
Thubelihle Public library	Thubelihle, Ga-Nala (26°13'1.68"S; 29°17'26.50"E)	All Stations in the Highveld Priority Area
Lynville Public Library	Vector Road, Lynville, eMalahleni	All Stations in the Highveld Priority Area
WSP Website	https://www.wsp.com/en-ZA/services/public-documents	All Power Stations
Data-free Website	https://wsp-engage.com/	All Power Stations

9.1.4 ADVERTISEMENT

Notification of the exemption application as well as opportunity to comment on the application process was issued to the general public via advertisements published in the newspapers outlined in Table 9-3, in **October 2024**, in English in all national newspapers and one other language in local newspapers. As mentioned above, the purpose of the advertisement was to notify the general public of the application, inform the public about the public meetings, and provide an opportunity to register on the project database and provide input into the process.

Table 9-3 - Placement of Adverts

NEWSPAPER NAME	DATE OF PUBLICATION
Vaal Weekblad	31 October 2024
Mogol Pos	1 November 2024
Mpumalanga News	6 November 2024
Standerton Advertiser	1 November 2024
Mpumalanga Lowvelder	1 November 2024
Ridge Times	1 November 2024
Witbank News	1 November 2024
Middelburg Observer	1 November 2024
City Press	3 November 2024
The Star	3 November 2024
Die Beeld	3 November 2024
Sunday Times	3 November 2024
Daily Sun	6 November 2024

9.1.5 PUBLIC MEETINGS

Public meetings will be convened for the project team to present the application to stakeholders as well as gather feedback from them. These meetings offer the stakeholders an opportunity to participate in the decision-making process and ensures that their voices are heard. Meetings will be convened at the locations outlined in Table 9-4 translation services will be available at the meetings and hard copy summaries of key documents will be made available at the physical meetings.

Table 9-4 - Date, venue and time of public meeting

VENUE	ADDRESS	DATE	TIME	MEETING AGENDA
Buitepos Saal	6 Carlyle Ct, Vanderbijlpark	13 November 2024	10:00	Lethabo
NG Kerk	Church St, Ogies	14 November 2024	10:00	Kendal
Secunda Community Hall	Walter Sisulu Road, Cnr Fisant Street - Lilian Ngoyi Centre Building	14 November 2024	18:00	All Stations in the Highveld Priority Area
eMalahleni Civic Centre	Mandela Street eMalahleni	19 November 2024	18:00	Duvha

VENUE	ADDRESS	DATE	TIME	MEETING AGENDA
Ga Nala (Kriel) Municipal Chambers	Quintin St, Ga-Nala	20 November 2024	10:00	Matla
Standerton Community Hall	81 Tamarisk St, Standerton	20 November 2024	18:00	Tutuka
Siyazenzela Community Hall	Durban Street - same street with Police Station & the Clinic Perdekop	21 November 2024	10:00	Majuba
Eskom Academy of Learning	Dale Road, Midrand	26 November 2024	10:00	All Power Stations
Mogol Golf Club	Cnr. George Wells Rd & Nelson Mandela Dr Lephalale	28 November 2024	10:00	Matimba / Medupi
Marapong Hall	458 Phukubje Street, Extension 2 Marapong	28 November 2024	18:00	Matimba / Medupi
Online Meeting	Microsoft Teams Meeting Meeting ID: 334 202 077 604 Passcode: 8PwGGQ	25 November 2024	13:00	All Power Stations
Middelburg Civic Centre	Eastdene Hall - Boncker Street (Verdoeran Street)	03 December	12:00	All Stations in the Highveld Priority Area

9.1.6 COMMENTS AND RESPONSES

Following the receipt of comments from I&APs, a Comments and Response Report (“CRR”) will be prepared and submitted to the Minster.

Proof of stakeholder engagement undertaken will be included in the submission to the Minister.

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Appendix A

CUMULATIVE AIRSHED ATMOSPHERIC IMPACT REPORTS

Public

ATMOSPHERIC IMPACT REPORT IN SUPPORT OF THE APPLICATION FOR EXEMPTION FROM THE MINIMUM EMISSION STANDARDS FOR ESKOM's COAL-FIRED POWER STATIONS ON THE HIGHVELD AND IN THE VAAL TRIANGLE (A CUMULATIVE ASSESSMENT)



Final
4 November 2024

Report issued by:

uMoya-NILU Consulting (Pty) Ltd
P O Box 20622
Durban North, 4016
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EXECUTIVE SUMMARY

Eskom operates a fleet of 14 coal-fired power stations, collectively generating more than 39 000 MW of electricity. Of these, 13 are on the Highveld and the Free State Province, and 2 are in the Waterberg District Municipality. The combustion of coal to generate steam for the generation of electricity is a Listed Activity in terms of the National Environmental Management: Air Quality Act (Act No. 39 of 2004). As such, Eskom holds Atmospheric Emission Licenses (AELs) for the respective power stations and is obligated to operate these power stations according to conditions specified in the respective AELs. Minimum Emission Standards (MES) for Listed Activities were published in 2010 (DEA, 2010) including compliance timeframes for existing and new plants. Existing plants had to comply with the MES for new plants by 30 April 2020 unless otherwise authorised.

Between 2018 and 2020, Eskom submitted applications to the Department of Forestry, Fisheries and the Environment (DFFE) based on an internally approved Emission Reduction Plan, which defined which power stations would have emission reduction technology installed and when. The National Air Quality Officer (NAQO) made decisions on these applications in 2019, which were not in favour of Eskom. Eskom appealed the NAQO's decision, and the Minister established the National Environmental Consultative and Advisory (NECA) Forum to advise her on the issue. The Minister ruled on the Eskom appeals on 22 May 2024 and granted the suspension of the Minimum Emission Standards (MES) at five (5) power stations on the Highveld up to 31 March 2030, namely Arnot, Camden, Grootvlei, Hendrina and Kriel. The Minister further directed Eskom to submit an application in terms of Section 59 of the National Environmental Management: Air Quality Act for the exemption of the MES for eight (8) power stations that will continue to operate post 2030. These are Duvha, Kendal, Majuba, Matla and Tutuka in the Highveld Priority Area; Lethabo in the Vaal Triangle Airshed Priority Area; and Medupi and Matimba in the Waterberg-Bojanala Priority Area.

In terms of the Minister's ruling, Eskom Holdings SOC Ltd appointed WSP Group Africa (Pty) Ltd to prepare the necessary applications. WSP Group Africa (Pty) Ltd sub-contracted uMoya-NILU Consulting (Pty) Ltd to prepare the associated Atmospheric Impact Reports (AIRs) to support these applications. In response, AIRs have been prepared to support the applications for the individual power stations. This AIR collectively assesses the 12 coal-fired power stations in the Highveld Priority Area and Lethabo in the Vaal Triangle Airshed Priority Area to provide further supporting information for the respective application.

Eskom intends to systematically reduce emissions resulting from the fleet of coal-burning power stations. Three emission reduction trajectories from Eskom's financial ERP models are described here and illustrated in Figure E-1 for NO_X, SO_2 and PM.

ERP 2024 A: Eskom continue as planned, which includes all PM and NO_X abatement projects and FGD at Kusile – This is why ERP 2024 A = B = C for NO_X & PM (only security of supply differs) – by the time Grootvlei, Kriel, Arnot, Hendrina, Camden, Duvha and Matla are shutdown, Eskom will be fully compliant with NO_X and PM MES through the fleet.

ERP 2024 B: 2024 A as above, but also FGD at Medupi, DSI at Majuba, and FGD at Kendal, hence the improvement from 2036 in SO_2 for ERP 2024 B. This

is Eskom's middle-ground scenario; doing more than 2024 A, but not doing 2024 C.

ERP 2024 C: All of 2024 A and 2024 B above, but also FGD at Lethabo and Tutuka. Although this shows big improvement in SO_2 vs ERP 2024 B, this is a combination of Lethabo & Tutuka FGD, and actually probably more from shutdown of Duvha & Matla – station shutdowns have bigger impact on SO_2 reduction than FGD. When you look at the modelling results, ERP 2024 B already well within NAAQS (this is our model Scenario C), so enforcing ERP 2024 C not really justifiable, especially considering all the other negative impacts of FGD (age of Tutuka & Lethabo, costs, waste, water etc.).

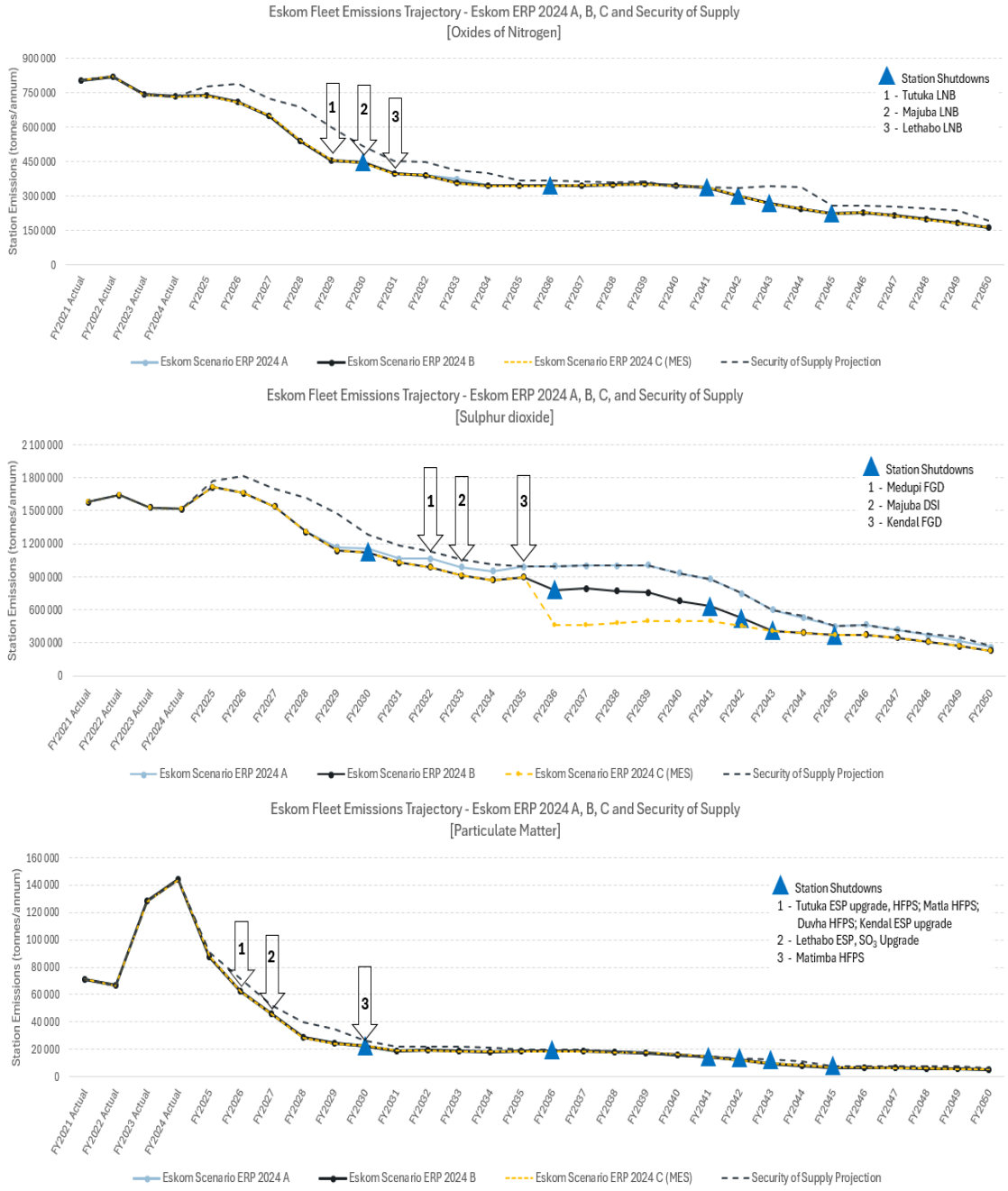
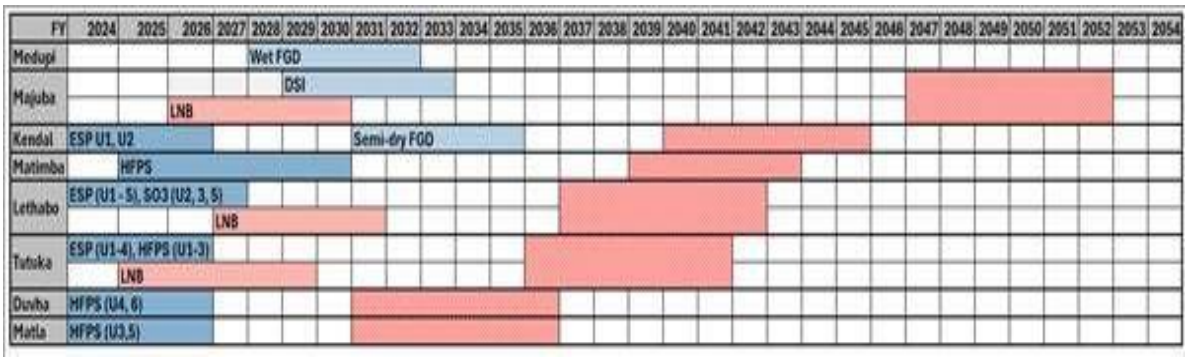


Figure E-1: Eskom's fleet emission trajectory for NO_x (top), SO_2 (middle) and PM (bottom)

The proposed schedule for the installation of NO_X, PM and SO_2 emission reduction technologies and the shutdown schedule for power stations is shown in Figure E-2.



FGD: flue gas desulphurisation
LNB: low NO_X Burner
ESP: Electrostatic precipitator
Station Shutdown
DSI: Dry Sorbent Injection
HFPS: high frequency power supply
DHP: Dust Handling Plant

Figure E-2: Emission reduction installation schedule and the planned shutdown of power stations

Ambient air quality is monitored at several monitoring stations in the area. The measured ambient SO_2 and NO_2 concentrations may be attributed to a number of sources such as industrial combustion of fossil fuels and the related stack emissions. They may also be attributed to domestic coal combustion and vehicle emissions. Annual average ambient SO_2 and NO_2 concentrations are below the respective NAAQS at all the monitoring stations. At these stations the predicted 10-minute, 1-hour and 24-hour concentrations comply with the respective NAAQS, although the limit value is sometimes exceeded.

The measured ambient PM_{10} and $PM_{2.5}$ concentrations may also be attributed to several sources, including industrial processes and the stack emissions as well as low-level sources that include, amongst others, mining activity, domestic coal combustion, agricultural processes, vehicle dust entrainment and wind-blown dust. The ambient 24-hour PM_{10} and $PM_{2.5}$ concentrations are generally high and exceed the NAAQS at several AQMS.

In this AIR five operational scenarios anticipated by Eskom for the Highveld and Vaal power station fleet are assessed, comprising Komati, Arnot, Camden, Kriel, Grootvlei, Hendrina, Duvha, Matla, Kendal, Lethabo, Tutuka, Majuba, and Kusile in the coming years for SO_2, NOx, and PM (PM_{10} and $PM_{2.5}$). The scenarios are:

Scenario 1 (Current): The baseline scenario using actual monthly stack emissions for 2021-2023 and fugitive emissions from the ash dumps and stockpiles.

Scenario A (2025): Eskom's planned 2025 stack emissions, representing anticipated station performance between 2025 – 2030, including fugitive emissions from the ash dumps and stockpiles. This includes the shutdown of Komati; the completion of PM abatement projects at Kendal, Lethabo, Tutuka, Duvha, and Matla; and the FGD at Kusile.

Scenario B (2031): Eskom's planned 2031 stack emissions, representing anticipated station performance between 2031 – 2035, including fugitive emissions from the ash

dumps and stockpiles. This includes completion of shutdowns at Arnot, Kriel, Hendrina, Camden, and Grootvlei, including their fugitive sources, with Matla and Duvha also entering shutdown phase; FGD at Kusile and completion of the DSI at Majuba (SO_2 emissions); reduced SO_2 emissions achieved though load curtailment and efficiency improvement projects; and NO_X abatement (LNB) at Majuba, Lethabo, and Tutuka.

Scenario C (2036): Eskom's planned 2036 stack emissions, representing anticipated station performance from 2036 onwards, including fugitive emissions from the ash dumps and stockpiles. This includes the complete shutdown of Matla and Duvha; shutdowns of Tutuka, Lethabo, and Kendal, including their fugitive sources, with Majuba entering shutdown phase in FY2047; SO_2 abatement installed at Kusile (FGD), Majuba (DSI), Kendal (FGD); as well as reduced SO_2 emissions achieved though load curtailment and efficiency improvement projects.

Scenario D (MES): Full compliance with the MES, inclusive of the ash dumps and stockpiles, where relevant (i.e. not for the stations shutdown), and in addition to the abatement included in above scenarios, FGD installations at Tutuka and Lethabo.

The CALPUFF dispersion model is used to predict ambient concentrations of SO_2, NO_2, PM_{10} and $PM_{2.5}$ resulting from the suite of power stations operating together in each scenario. The dispersion modelling simulates the stack emissions (PM, SO_2, NO_X) and fugitive emissions (PM) from the coal yard and the ash dump for the five scenarios. While the focus of the assessment is on stack emissions, the inclusion of fugitive PM emissions provides a holistic understanding of the contribution of the power stations to ambient PM_{10} and $PM_{2.5}$ concentrations. Modelling is done according to the modelling regulations and 3-years of hourly surface and upper air meteorological data is used.

The PM emissions from the stacks and fugitive sources are not speciated into PM_{10} and $PM_{2.5}$. Rather, all PM emitted is assumed to be firstly PM_{10} in the modelling and is assessed against the NAAQS for PM_{10}. Secondly, all PM emitted is assumed to be $PM_{2.5}$ in the modelling and is assessed against the NAAQS for $PM_{2.5}$. The predicted PM_{10} and $PM_{2.5}$ concentrations also include the formation of secondary particulates from SO_2 and NO_2 stack emissions. Together, this represents a worse-case environmental scenario for PM_{10} and $PM_{2.5}$. The stack emissions generally have an effect some distance from the source as they are released well above ground level and are buoyant. Fugitive emissions are released close to ground level and without any buoyancy, and therefore have an effect close to the source.

In the body of the report, predicted ambient SO_2, NO_2, PM_{10} and $PM_{2.5}$ concentrations are presented as isopleth maps over the modelling domain. The predicted concentrations at 405 identified sensitive receptor points in the study area are included Appendix 2 of this report. In this executive summary the maximum predicted annual SO_2, NO_2, PM_{10} and $PM_{2.5}$ concentrations and the 99th percentile concentration of the 24-hour and 1-hour predicted concentrations in the modelling domain are discussed below.

For SO_2, the predicted concentrations are attributed only to stack emissions. The maximum predicted annual average concentrations for the 5 scenarios are low relative to the limit value of the respective NAAQS. The predicted 99th percentile of the 24-hour SO_2 concentrations are also relatively low compared to the limit value of the NAAQS, except for Scenario A (2025) when the limit value is exceeded. The 99th percentile of the

predicted 1-hour concentrations are higher, but are below the limit value of the NAAQS for all five scenarios. The predicted maximum SO_2 concentration occurs on the central Highveld. Noteworthy is the systematic decrease in the predicted maximum and 99th percentile concentrations from 2025 to 2036 for all averaging periods.

For NO_2, the predicted concentrations are attributed only to the stack emissions. The predicted maximum and 99th percentile concentrations are low relative to the limit values of the respective NAAQS for the 5 scenarios. The predicted maximum NO_2 concentration occurs on the central Highveld.

For PM_{10} and $PM_{2.5}$, the predicted concentrations are attributed to stack emissions and the low-level fugitive sources (coal yard and ash dump) and the contribution from secondary particulate formation. It must be remembered that the total PM emissions are not speciated into PM_{10} or $PM_{2.5}$, rather all PM emitted is assumed to be firstly PM_{10}, and then all PM emitted is assumed to be $PM_{2.5}$. It must also be remembered that it was assumed that entire area of ash dumps are available for emissions compared with the actual exposed area. Included in the predicted $PM_{2.5}$ concentrations is the formation of secondary particulates from SO_2 and NO_2 stack emissions. Together, this represents a worse-case emission scenario for PM_{10} and $PM_{2.5}$.

For PM_{10} and $PM_{2.5}$, the maximum predicted annual average concentrations exceed the limit values of the respective NAAQS in all scenarios. Similarly, the 99th percentile of the 24-hour PM_{10} and $PM_{2.5}$ concentrations exceed the limit value of the NAAQS in all scenarios. The predicted maximum PM_{10} and $PM_{2.5}$ concentrations occur close to the individual power stations.

Occurring close to the power stations, the high predicted PM_{10} and $PM_{2.5}$ are mostly attributed to the low-level fugitive sources. It is noteworthy therefore that the maximum predicted concentrations decrease significantly from 2025 when 13 power stations are in operation to 2031 with the shutdown of 5 power stations and the completion of PM abatement projects at Kendal, Lethabo, Tutuka, Duvha, and Matla

The predicted ambient concentrations of SO_2 and NO_2 at all the AQMS are lower than those measured at the corresponding monitoring stations. This is to be expected since AQMS are exposed to all sources of SO_2 and NO_2 while the model includes only the power station stack emissions. Similarly, the predicted ambient concentrations of PM_{10} and $PM_{2.5}$ are considerably lower than those measured at the corresponding monitoring stations. This too is to be expected since AQMS are exposed to all sources of PM_{10} and $PM_{2.5}$ while the model includes power station stack emissions and the fugitive sources only for each power station. At all AQMS, the difference between the predicted model concentrations and the measured concentrations provides an indication of the contribution of the power station stack and fugitive emissions at the respective AQMS.

The predicted SO_2 and NO_2 concentrations are below the respective limit values of the NAAQS for all averaging periods in all 5 emission scenarios at all sensitive receptors. Similarly, the predicted annual average PM_{10} and $PM_{2.5}$ concentrations are below the limit values of the NAAQS at all sensitive receptor points in all five scenarios. Exceedances of the 24-hour limit value of the NAAQS for PM_{10} and $PM_{2.5}$ are predicted in all five scenarios at several sensitive receptor points (Table E-1). For Scenario A (2025) the exceedances of the limit value for PM_{10} occur at most sensitive receptor points. For $PM_{2.5}$, the limit

value of the NAAQS drops from 40 µg/m^3 to 25 µg/m^3 in 2030, resulting in an increase in the number of receptor points where the limit value is exceeded. The number of receptor points where the limit value is exceeded decreases as power stations are shutdown and emissions from the associated fugitive sources cease.

Table E-1: Number of sensitive receptors where the limit value of the NAAQS is exceeded

Scenario	Number of sensitive receptors	
	PM_{10}	$PM_{2.5}$
Scenario 1 (Current)	26	129
Scenario A (2025)	29	149
Scenario B (2031)	9	157
Scenario C (2036)	0	53
Scenario D (MES)	0	45

Noteworthy findings from the modelling results may be summarised as follows:

i) Ambient SO_2 and NO_2 concentrations are attributed to the stack emissions only, while ambient PM_{10} and $PM_{2.5}$ concentrations are attributed to the stack emissions and the low-level fugitive sources. The stack emissions generally have an effect some distance from the source, while low-level fugitive emissions have an effect close to the source.

ii) The predicted ambient concentrations are lower than the monitored concentrations for all pollutants at all AQMS. This is to be expected since AQMS are exposed to all sources of the pollutants while the modelled concentrations result from power station emission only. The difference between the modelled concentrations and measured concentrations are indicative of the contribution of other sources at the respective AQMS.

iii) For Scenario 1 (Current):
   a. Predicted SO_2 and NO_2 concentrations comply with the NAAQS for all averaging periods throughout the modelling domain.
   b. Predicted PM_{10} and $PM_{2.5}$ concentrations generally comply with the NAAQS, except close to the power stations where the limit value of the 24-hour NAAQS are exceeded. Exceedances of the limit value for PM_{10} and $PM_{2.5}$ are predicted at 26 and 129 sensitive receptor points respectively.

iv) For Scenario A (2025):
   a. Predicted SO_2 and NO_2 concentrations comply with the NAAQS for all averaging periods throughout the modelling domain, except for the 99th percentile of the 24-hour SO_2 concentrations which exceed the limit value of the NAAQS.
   b. Predicted PM_{10} and $PM_{2.5}$ concentrations generally comply with the NAAQS, except close to the power stations where the limit value of the 24-hour NAAQS are exceeded. Exceedances of the limit value for PM_{10} and $PM_{2.5}$ are predicted at 29 and 149 sensitive receptor points respectively.

v) For Scenario B (2031):
   a. Predicted SO_2 and NO_2 concentrations comply with the NAAQS for all averaging periods throughout the modelling domain. Predicted NO_2 concentrations show a reduction with the completion of LNB projects at Kendal and Tutuka.

b. Predicted PM_{10} and $PM_{2.5}$ concentrations generally comply with the NAAQS, except close to the power stations where the limit value of the 24-hour NAAQS are exceeded. The number of predicted exceedances for PM_{10} decrease to 9, while the number of exceedances for $PM_{2.5}$ increase to 157 sensitive receptor points. The increase corresponds to the more stringent $PM_{2.5}$ limit value of 25 $\mu g/m^3$ which is implemented in 2030.
c. The effect of the shutdown of Arnot, Camden, Hendrina, Kendal and Kriel by 2031 and the associated reduction in emissions is clearly evident, with the modelling showing lower ambient concentrations, i.e. improved air quality.

vi) For Scenario C: (2036):
a. Predicted SO_2 and NO_2 concentrations comply with the NAAQS for all averaging periods throughout the modelling domain.
b. Predicted PM_{10} and $PM_{2.5}$ concentrations comply with the NAAQS, except close to the power stations where the limit value of the 24-hour $PM_{2.5}$ NAAQS is exceeded. Exceedances of the limit value for $PM_{2.5}$ is predicted at 53 sensitive receptor points.
c. Reductions in predicted ambient PM concentrations are due to Duvha and Matla entering shutdown phase, as well as abatement improvements from Scenario B for PM. Ambient SO_2 reductions are due to the Majuba DSI and Kendal semi-dry FGD projects. Ambient NO_2 improvements are due to the Lethabo LNB project.

vii) For Scenario D:
a. Predicted SO_2 and NO_2 concentrations comply with the NAAQS for all averaging periods throughout the modelling domain.
b. Predicted PM_{10} and $PM_{2.5}$ concentrations generally comply with the NAAQS, except close to the power stations where the limit value of the 24-hour $PM_{2.5}$ NAAQS is exceeded. Exceedances of the limit value for $PM_{2.5}$ is predicted at 45 sensitive receptor points.

Given the conservative approach to the fugitive emission source simulations, and that this has provided an absolute worst-case emission scenario, and based on recommendations received from uMoya-Nilu, Eskom will be undertaking an additional modelling scenario, assessing only PM, SO_2, and NO_X stack emissions. NO_X and SO_2 emissions will be included in this scenario to ensure secondary particulate formation is accounted for. This will provide improved insight to impacts directly related to stack emissions, which are the focus of this exemption application.

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GLOSSARY OF TERMS AND ACRONYMS

AEL	Atmospheric Emission Licence
AIR	Atmospheric Impact Report
DEA	Department of Environmental Affairs
DFFE	Department of Forestry, Fisheries and the Environment
DSI	Dry Sorbent Injection
EIA	Environmental Impact Assessment
FGD	Flue-gas desulfurisation
g/s	Grams per second
kPa	Kilo Pascal
LNB	Low NO_X burner
MES	Minimum Emission Standards
mg/Nm^3	Milligrams per normal cubic meter refers to emission concentration, i.e. mass per volume at normal temperature and pressure, defined as air at 20°C (293.15 K) and 1 atm (101.325 kPa)
NAAQS	National Ambient Air Quality Standards
NAQO	National Air Quality Officer
NECA	National Environmental Consultative and Advisory
NEM-AQA	National Environment Management: Air Quality Act, 2004 (Act No. 39 of 2004)
NEMA	National Environmental Management Act, 1998 (Act No. 107 of 1998)
USEPA	United States Environmental Protection Agency
µm	1 µm = Micro meter 1 µm = 10^{-6} m

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1. INTRODUCTION

Eskom operates a fleet of 14 coal-fired power stations, collectively generating more than 39 000 MW of electricity. Of these, 13 are on the Highveld and the Free State Province, and 2 are in the Waterberg District Municipality. The combustion of coal to generate steam for the generation of electricity is a Listed Activity in terms of the National Environmental Management: Air Quality Act (Act No. 39 of 2004). As such, Eskom holds Atmospheric Emission Licenses (AELs) for the respective power stations and is obligated to operate these power stations according to conditions specified in the respective AELs. Minimum Emission Standards (MES) for Listed Activities were published in 2010 (DEA, 2010) including compliance timeframes for existing and new plants. Existing plants had to comply with the MES for new plants by 30 April 2020 unless otherwise authorised.

Between 2018 and 2020, Eskom submitted applications to the Department of Forestry, Fisheries and the Environment (DFFE) based on an internally approved Emission Reduction Plan, which defined which power stations would have emission reduction technology installed and when. The National Air Quality Officer (NAQO) made decisions on these applications in 2019, which were not in favour of Eskom. Eskom appealed the NAQO's decision, and the Minister established the National Environmental Consultative and Advisory (NECA) Forum to advise her on the issue. The Minister ruled on the Eskom appeals on 22 May 2024 and granted the suspension of the Minimum Emission Standards (MES) at five (5) power stations on the Highveld up to 31 March 2030, namely Arnot, Camden, Grootvlei, Hendrina and Kriel. The Minister further directed Eskom to submit an application in terms of Section 59 of the National Environmental Management: Air Quality Act for the exemption of the MES for eight (8) power stations that will continue to operate post 2030. These are Duvha, Kendal, Majuba, Matla and Tutuka in the Highveld Priority Area; Lethabo in the Vaal Triangle Airshed Priority Area; and Medupi and Matimba in the Waterberg-Bojanala Priority Area.

In terms of the Minister's ruling, Eskom Holdings SOC Ltd appointed WSP Group Africa (Pty) Ltd to prepare the necessary applications. WSP Group Africa (Pty) Ltd sub-contracted uMoya-NILU Consulting (Pty) Ltd to prepare the associated Atmospheric Impact Reports (AIRs) to support these applications.

While AIRs have been prepared to support the respective applications for the individual power stations, this AIR collectively assesses 12 coal-fired power stations in the Highveld Priority Area and one power station in the Vaal Triangle Airshed Priority Area. The intention is to provide further supporting information for the respective applications. The power stations included in this cumulative assessment are listed in Table 1-1 with information regarding their respective AELs and proposed shutdown dates.

Table 1-1: Power stations and current AEL information

Power Station	District	Installed capacity	AEL No.	Date		Shutdown complete
				Issued	Expire	
Arnot	Nkangala	2 352	17/4/AEL/MP312/11/15	10-06-24	10-06-29	2029
Camden	Gert Sibande	1 561	Muskaligwa/Eskom H SOC Ltd/CPC/0012/2024/F04	28-06-24	31-03-30	2024
Duvha	Nkangala	3 600	17/04/AEL/MP312/11/07	30-06-17	31-05-22	2036
Grootvlei	Gert Sibande	1 180	Dipaleseng/Eskom H SOC Ltd/GPS/0015/2024/F04	28-06-24	31-03-30	2029
Hendrina	Nkangala	1 893	17/4/AEL/MP312/11/16	10-06-24	01-12-28	2029
Kendal	Nkangala	4 116	17/4/AEL/MP312/11/15	30-09-19	31-08-24	2045
Komati	Nkangala	990	NDM/AEL/MP313/12/12			shutdown
Kriel	Nkangala	3 000	17/AEL/MP312/11/19	05-08-24	31-03-30	2031
Kusile	Nkangala	4 800	17/04/AEL/MP311/12/01	09-04-24	09-04-29	2073
Lethabo	Fazile Dabi	3 708	FDDM-MET-2011-08-P1	01-04-15	31-03-20	2042
Majuba	Gert Sibande	4 110	Dr PKI Seme/Eskom H SOC Ltd MPS/0014/2021/F04	25-04-19	25-04-24	2052
Matla	Nkangala	3 600	17/AEL/MP313/11/14	28-06-17	30-06-22	2036
Tutuka	Gert Sibande	3 600	Lekwa/Eskom H SOC Ltd TPS/0013/2019/F03	25-04-19	25-04-24	2041

2. ENTERPRISE DETAILS

2.1 Enterprise Details

Eskom enterprise details are summarised in Table 2-1.

Table 2-1: Enterprise details

Entity Name:	Eskom Holdings SOC Limited
Type of Enterprise, e.g. Company/Close Corporation/Trust, etc.:	State Owned Company
Company Registration Number:	2002/015527/30
Registered Address:	Megawatt Park, Maxwell Drive, Sunninghill, Sandton
Postal Address:	P. O. Box 1091, Johannesburg, 2000
Telephone Number (General):	+27 11 800 3861
Fax Number (General):	
Company Website:	www.eskom.co.za
Industry Type/Nature of Trade:	Electricity Generation
Land Use Zoning as per Town Planning Scheme:	Agricultural/Heavy industry
Land Use Rights if outside Town Planning Scheme:	Not applicable

2.2 Location and extent of the power stations

Thirteen Eskom-owned and operated coal-fired power stations are included in the dispersion modelling assessment for Scenario 1 (Current) and Scenario A (2025). Of these, twelve are in the Mpumalanga Province and one is in the Free State Province. Their relative locations are shown in Figure 2-1. Specific site information for each of the power stations is included in the respective Atmospheric Impact Reports (AIRs). In the three later scenarios Komati is shutdown and is excluded.

2.3 Description of surrounding land use

The Code of Practice for Air Dispersion Modelling in Air Quality Management in South Africa (DEA, 2014a) recommends the Land Use Procedure as sufficient for determining the urban/rural status of a modelling domain. The classification of the study area as urban or rural is based on the Auer method (Auer, 1978), as specified in the USEPA guideline on air dispersion models (USEPA, 2005). From the Auer's method, areas typically defined as rural include residences with grass lawns and trees, large estates, metropolitan parks and golf courses, agricultural areas, undeveloped land and water surfaces. An area is defined as urban if it has less than 35% vegetation coverage or it falls into one of the use types in Table 2-2.

Table 2-2: Land types, use and structures and vegetation cover

Type	Use and Structures	Vegetation
I1	Heavy industrial	Less than 5 %
I2	Light/moderate industrial	Less than 5 %
C1	Commercial	Less than 15 %
R2	Dense single / multi-family	Less than 30 %
R3	Multi-family, two-story	Less than 35 %

Generally, the individual power stations are located in rural areas where the surrounding land use is primarily agriculture and includes coal mining. The surrounding land-use includes amongst others, urban areas with residential, commercial and recreational areas, industrial areas, agriculture, mining, forestry, undeveloped areas and conservation areas.

The US Environmental Protection Agency (USEPA, 2024) recognise Sensitive Receptors as areas which include, but are not limited to, hospitals, schools, daycare facilities, elderly housing and convalescent facilities or specialised healthcare facilities. These are areas where the occupants are more susceptible to the adverse effects of exposure to toxic chemicals, pesticides and other pollutants. The California Air Resources Board (CARB, 2024) identify Sensitive Receptors as children, elderly, asthmatics and others who are at a heightened risk of negative health outcomes due to exposure to air pollution.

The locations where these sensitive receptors congregate are considered sensitive receptor locations and therefore include hospitals, schools and day care centres, and other such locations. Twenty-four ambient air quality monitoring stations (AQMS) and 405 sensitive receptor points were identified in the modelling domain. These are listed in Annexure 1 and shown in Figure 2-1.

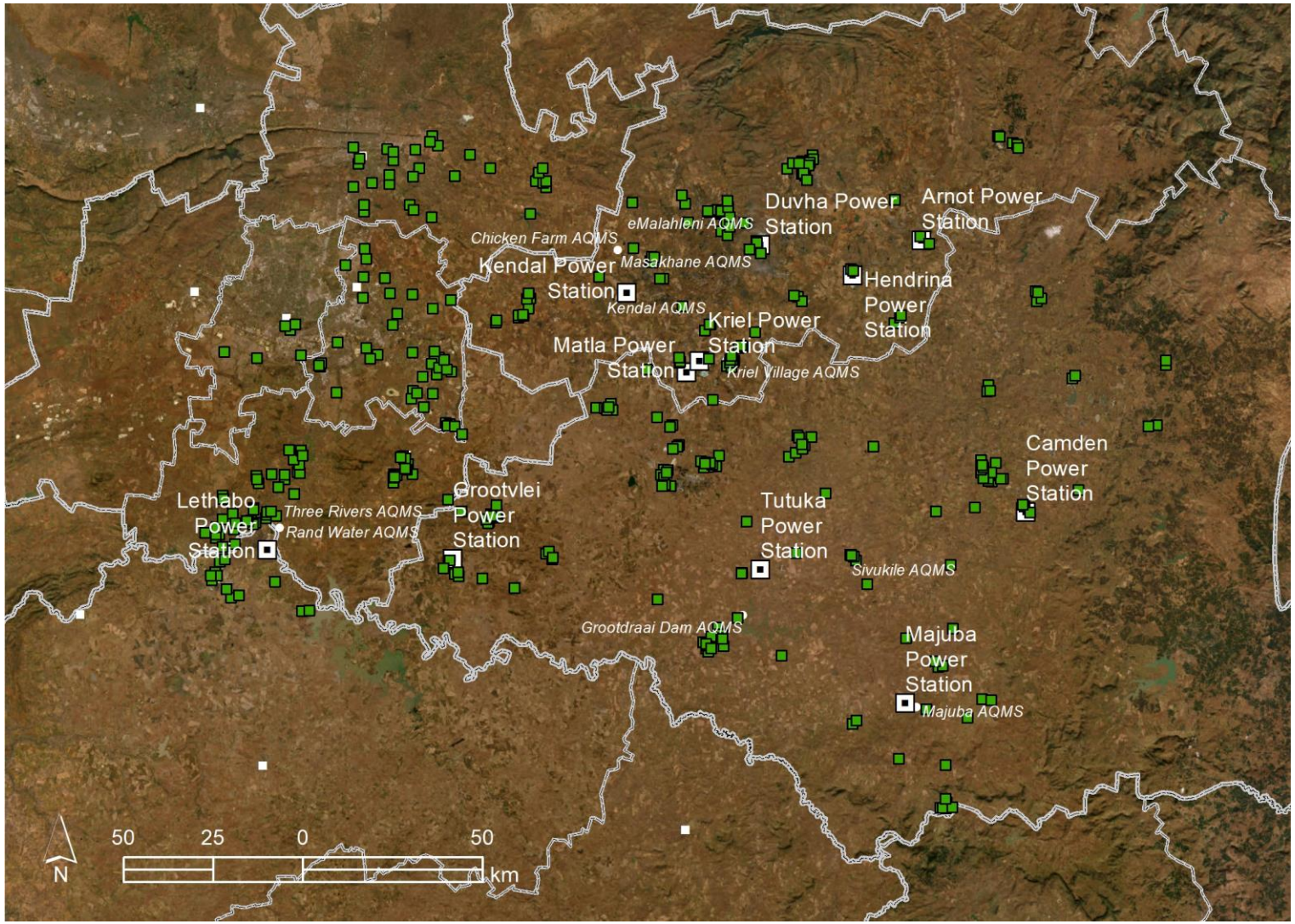


Figure 2-1: Relative location of the Eskom's coal-fired power stations in the modelling domain shown by white squares, with sensitive receptors shown by green squares

2.4 Atmospheric Emission License (AEL) and Other Authorisations

Atmospheric Emissions Licence (AEL) have been issued by the Nkangala, Gert Sibande and Fazile Dabi District Municipalities. The AEL numbers, expiry dates and the AEL status are listed in Table 2-3.

Table 2-3: Current authorisations related to air quality

Power Station	Atmospheric Emission License	Expiry Date	Listed Activity		Listed Activity Process Description
			Category	Sub-category	
Arnot	17/4/AEL/MP312/11/15	10-06-29	1	1.1	Solid Fuel Combustion Installations
Camden	Muskaligwa/Eskom H SOC Ltd/CPC/0012/2024/F04	31-03-30			
Duvha	17/04/AEL/MP312/11/07	31-05-22			
Grootvlei	Dipaleseng/Eskom H SOC Ltd/GPS/0015/2024/F04	31-03-30			
Hendrina	17/4/AEL/MP312/11/16	01-12-28			
Kendal	17/4/AEL/MP312/11/15	31-08-24	2	2.4	Storage and Handling of Petroleum Products
Komati	NDM/AEL/MP313/12/12	N/A			
Kriel	17/AEL/MP312/11/19	31-03-30			
Kusile	17/04/AEL/MP311/12/01	09-04-29			
Lethabo	FDDM-MET-2011-08-P1	31-03-20	5	5.1	Storage and Handling of Ore and Coal
Majuba	Dr PKI Seme/Eskom H SOC Ltd MPS/0014/2021/F04	25-04-24			
Matla	17/AEL/MP313/11/14	30-06-22			
Tutuka	Lekwa/Eskom H SOC Ltd TPS/0013/2019/F03	25-04-24			

2.5 Modelling contractor

The dispersion modelling for this AIR is conducted by:

Company: uMoya-NILU Consulting (Pty) Ltd
Modellers: Dr Mark Zunckel, Atham Raghunandan, Nopasika Xulu
Contact details: Tel: 031 262 3265
Cell: 083 690 2728
email: mark@umoya-nilu.co.za
atham@umoya-nilu.co.za
nopasika@umoya-nilu.co.za

See Annexure 2 for abridged CV's

2.6 Terms of Reference

The terms of reference for this AIR are to assesses the cumulative effect of 13 coal-fired power stations to provide supporting information for the exemption applications for Duvha, Kendal, Matla, Majuba and Tutuka in the Highveld Priority area and Lethabo in the Vaal

Triangle Airshed Priority Area. Five operational scenarios anticipated by Eskom for the Highveld and Vaal power station fleet are assessed, comprising Komati, Arnot, Camden, Kriel, Grootvlei, Hendrina, Duvha, Matla, Kendal, Lethabo, Tutuka, Majuba, and Kusile in the coming years for SO_2, NO_X, and PM (PM_{10} and $PM_{2.5}$). The scenarios are:

Scenario 1 (Current): The baseline scenario using actual monthly stack emissions for 2021-2023 and fugitive emissions from the ash dumps and stockpiles.

Scenario A (2025): Eskom's planned 2025 stack emissions, representing anticipated station performance between 2025 – 2030, including fugitive emissions from the ash dumps and stockpiles. This includes the shutdown of Komati; the completion of PM abatement projects at Kendal, Lethabo, Tutuka, Duvha, and Matla; and the FGD at Kusile.

Scenario B (2031): Eskom's planned 2031 stack emissions, representing anticipated station performance between 2031 – 2035, including fugitive emissions from the ash dumps and stockpiles. This includes completion of shutdowns at Arnot, Kriel, Hendrina, Camden, and Grootvlei, including their fugitive sources, with Matla and Duvha also entering shutdown phase; FGD at Kusile and completion of the DSI at Majuba (SO_2 emissions); reduced SO_2 emissions achieved though load curtailment and efficiency improvement projects; and NO_X abatement (LNB) at Majuba, Lethabo, and Tutuka.

Scenario C (2036): Eskom's planned 2036 stack emissions, representing anticipated station performance from 2036 onwards, including fugitive emissions from the ash dumps and stockpiles. This includes the complete shutdown of Matla and Duvha; shutdowns of Tutuka, Lethabo, and Kendal, including their fugitive sources, with Majuba entering shutdown phase in FY2047; SO_2 abatement installed at Kusile (FGD), Majuba (DSI), Kendal (FGD); as well as reduced SO_2 emissions achieved though load curtailment and efficiency improvement projects.

Scenario D (MES): Full compliance with the MES, inclusive of the ash dumps and stockpiles, where relevant (i.e. not for the stations shutdown), and in addition to the abatement included in above scenarios, FGD installations at Tutuka and Lethabo.

2.7 Assumptions

The following assumptions are relevant to this AIR:

a) No ambient monitoring is done in this assessment, rather available ambient air quality data is used.
b) The assessment of potential human health impacts is based on predicted (modelled) ambient concentrations of SO_2, NO_2, PM_{10} and $PM_{2.5}$ and the health-based National Ambient Air Quality Standards (NAAQS).
c) Emissions data used in this AIR have been provided by Eskom and are deemed to be accurate and representative of operating conditions in the respective scenarios.
d) The PM emissions are not speciated into PM_{10} and $PM_{2.5}$, rather all PM emitted is assumed to be PM_{10}, and all PM emitted is assumed to be $PM_{2.5}$. This represents a worse-case emission scenario for PM_{10} and $PM_{2.5}$.
e) Assumptions regarding emissions from coal yards and ash dumps are included in Section 4.4.

3. NATURE OF THE PROCESS

3.1 Listed Activity or Activities

As a measure to reduce emissions from industrial sources and to improve ambient air quality, Listed Activities and associated Minimum Emission Standards (MES) were initially published in 2010 in Government Notice 248 (DEA, 2010) with the most recent revision applicable in 2020 (Government Notice 421, DEA, 2020).

The Listed Activities relevant to all coal-fired power stations are listed in Table 3-1.

Table 3-1: Details of the Listed Activity for coal-fired power stations according to GN 248 (DEA, 2010) and its revisions (DEA, 2013b, 2019, 2020)

Category of Listed Activities	Sub-category of Listed Activity	Description of Listed Activity	Description and Application of the Listed Activity
1: Combustion Installations	1.1: Solid Fuel Combustion Installations	Solid fuels combustion installations used primarily for steam raising or electricity generation.	All installations with design capacity equal to or greater than 50 MW heat input per unit, based on the lower calorific value of the fuel used.
2: Petroleum Industry, the production of gaseous and liquid fuels as well as petrochemicals from crude oil, coal, gas or biomass	2.4: Storage and handling of petroleum products	Petroleum products storage tanks and product transfer facilities.	All permanent immobile liquid storage facilities at a single site with a combined storage capacity of greater than 1 000 cubic metres.
5: Mineral Processing, Storage and Handling	5.1: Storage and Handling of Ore and Coal	Storage and handling of ore and coal not situated on the premises of a mine or works as defined in the Mines Health and Safety Act 29/1996.	Locations designed to hold more than 100 000 tons.

3.2 Process Description

Eskom Holdings SOC Limited is a South African utility that generates, transmits and distributes electricity. The bulk of that electricity is generated by large coal-fired power stations that are situated close to the sources of coal.

The generic process is that coal is received at the power station's coal yard from nearby mines, it is milled to pulverised fuel and fed to the boilers. Combustion of the coal in the boilers heats water to superheated steam, which drives the turbines. In turn, the turbines drive the generators which generate electricity.

Typical process units at a coal-fired power station are listed in Table 3-2.

Table 3-2: Unit processes at a coal-fired power station

Unit Process	Function of Unit Process	Batch or Continuous Process
Boiler Unit 1	Generation of electricity from coal	Continuous
Boiler Unit 2	Generation of electricity from coal	Continuous
Boiler Unit 3	Generation of electricity from coal	Continuous
Boiler Unit 4	Generation of electricity from coal	Continuous
Boiler Unit 5	Generation of electricity from coal	Continuous
Boiler Unit 6	Generation of electricity from coal	Continuous
Coal stockyard	Storage of coal	Continuous
Fuel oil storage tanks	Storage of fuel oil	Continuous
Ashing facility	Storage of ash	Continuous

3.3 Air pollutants resulting from the process

3.3.1 Air pollutants

Atmospheric emissions depend on the fuel composition and rate of consumption, boiler design and operation, and the efficacy of pollution control devices. Emissions from the boilers are emitted via two stacks and include sulphur dioxide (SO_2), oxides of nitrogen ($NO + NO_2 = NO_X$) and Particulate Matter (PM).

SO_2 is produced from the combustion of sulphur bound in coal. The stoichiometric ratio of SO_2 to sulphur dictates that 2 kg of SO_2 are produced from every kilogram of sulphur combusted. The coal has a sulphur content (wt %) of less than 1 %. NO_X is produced from thermal fixation of atmospheric nitrogen in the combustion flame and from oxidation of nitrogen bound in the coal. The quantity of NO_X produced is directly proportional to the temperature of the flame.

The non-combustible portion of the fuel remains as solid waste. The coarser, heavier waste is called 'bottom ash' and is extracted from the boiler, and the lighter, finer portion is 'fly ash' and is usually suspended in the flue gas, and in the absence of any emission control would be emitted as PM through the stack. The coal used at most power stations have an ash content of between 30 and 40%.

3.3.2 National Ambient Air Quality Standards

National Ambient Air Quality Standards (NAAQS) (DEA, 2009, 2012) apply to the pollutants emitted by the power stations. The NAAQS consists of a 'limit' value and a permitted frequency of exceedance. The limit value is the fixed concentration level aimed at reducing the harmful effects of a pollutant. The permitted frequency of exceedance represents the acceptable number of exceedances of the limit value expressed as the 99th percentile. Compliance with the ambient standard implies that the frequency of exceedance of the limit value does not exceed the permitted tolerance. The NAAQS for SO_2, NO_2, PM_{10} and $PM_{2.5}$ are presented in Table 3-3.

Table 3-3: NAAQS for pollutants emitted by power stations

Pollutant	Averaging period	Limit value (µg/m^3)	Tolerance
SO_2	1 hour	350	88
	24 hour	125	4
	1 year	50	0
NO_2	1 hour	200	88
	1 year	40	0
PM_{10}	24 hour	75	4
	1 year	40	0
$PM_{2.5}$	24 hour	40 (25[a])	4
	1 year	20 (15 [a])	0

[(a)]: Applicable from 01 January 2030

4. ATMOSPHERIC EMISSIONS

4.1 Point Source Emission Rates (Emission scenarios)

Eskom intends to systematically reduce emissions resulting from the fleet of coal-burning power stations. Three emission reduction trajectories from Eskom's financial ERP models are described here and illustrated in Figure 4-1 to Figure 4-3 for NO_X, SO_2 and PM.

ERP 2024 A: Eskom continue as planned, which includes all PM and NO_X abatement projects and FGD at Kusile – This is why ERP 2024 A = B = C for NO_X & PM (only security of supply differs) – by the time Grootvlei, Kriel, Arnot, Hendrina, Camden, Duvha and Matla are shutdown, Eskom will be fully compliant with NO_X and PM MES through the fleet.

ERP 2024 B: 2024 A as above, but also FGD at Medupi, DSI at Majuba, and FGD at Kendal, hence the improvement from 2036 in SO_2 for ERP 2024 B. This is Eskom's middle-ground scenario; doing more than 2024 A, but not doing 2024 C.

ERP 2024 C: All of 2024 A and 2024 B above, but also FGD at Lethabo and Tutuka. Although this shows big improvement in SO_2 vs ERP 2024 B, this is a combination of Lethabo & Tutuka FGD, and actually probably more from shutdown of Duvha & Matla – station shutdowns have bigger impact on SO_2 reduction than FGD. When you look at the modelling results, ERP 2024 B already well within NAAQS (this is our model Scenario C), so enforcing ERP 2024 C not really justifiable, especially considering all the other negative impacts of FGD (age of Tutuka & Lethabo, costs, waste, water etc.).

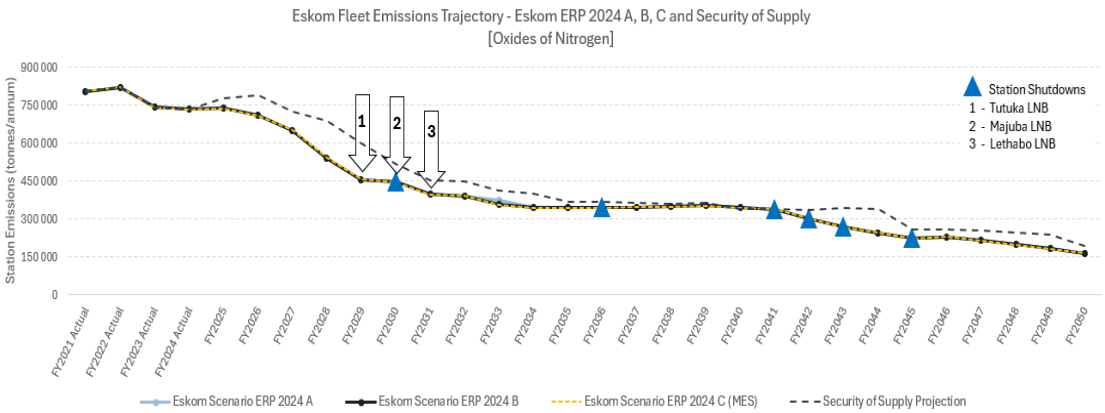


Figure 4-1: Eskom's fleet emission trajectory for NO_X

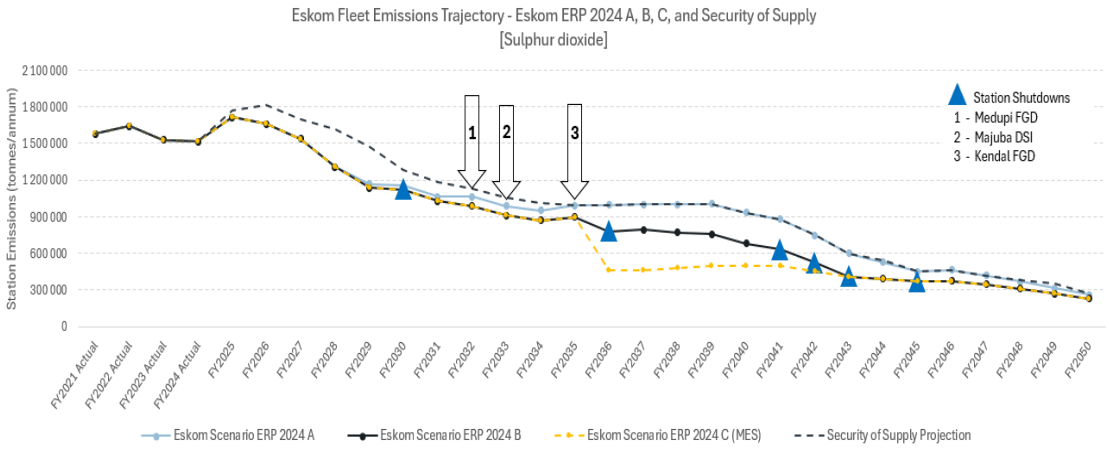


Figure 4-2: Eskom's fleet emission trajectory for SO_2

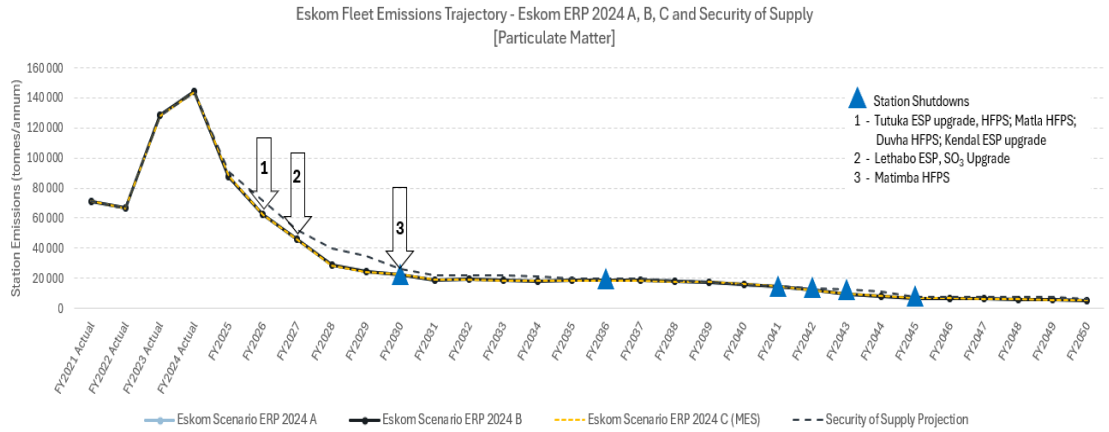
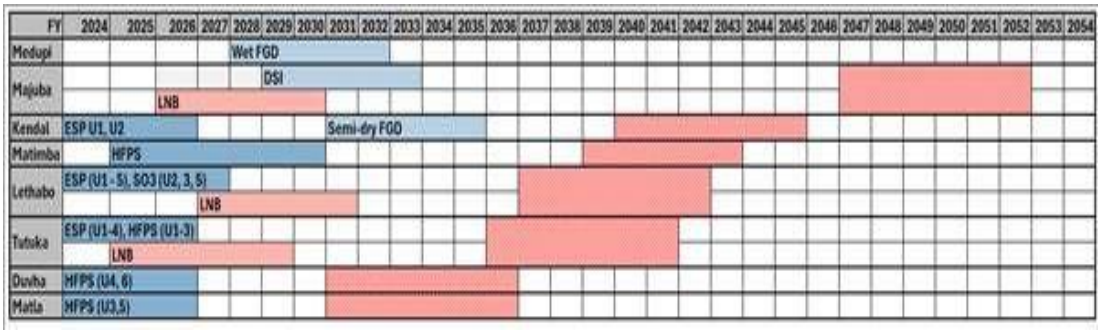


Figure 4-3: Eskom's fleet emission trajectory for PM

The proposed schedule for the installation of NO_X, PM and SO_2 emission reduction technologies and the shutdown schedule for power stations is shown in Figure 4-4.



FGD: flue gas desulphurisation
LNB: low NO_X Burner
ESP: Electrostatic precipitator
Station Shutdown

DSI: Dry Sorbent Injection
HFPS: high frequency power supply
DHP: Dust Handling Plant

Figure 4-4: Emission reduction installation schedule and the planned shutdown of power stations

4.2 Point Source Parameters

Stack parameters for the suite of power stations are included in the respective AIRs.

The stack emission rates for the suite of power station included in this cumulative assessment are shown in Table 4-1, with the equivalent emission concentrations in Table 4-2.

4.3 Point Source Maximum Emission Rates (Start Up, Shut-Down, Upset and Maintenance Conditions)

The estimated emission rates and equivalent emission concentrations that are used in the dispersion modelling for the power stations are shown in Table 4-1. The maximum anticipated emissions during each period are used for simulation in the model. The boiler units are assumed to operate continuously, i.e. 24 hours a day. Since each future scenario is a snapshot of the period of operation (e.g. Scenario A = 2025 to 2030), the maximum anticipated emissions during that period, in a single year was selected for simulation in the model.

Table 4-1: Stack emission rates (tonnes/annum) for the suite of coal-fired power stations and 5 emission scenarios

Power station	Stack	SCENARIO 1 (Current)			SCENARIO A (2025)			SCENARIO B (2031)			SCENARIO C (2036)			SCENARIO D (MES)		
		NO_X	SO_2	PM_{10}	NO_X	SO_2	PM_{10}	NO_x	SO_2	PM_{10}	NO_x	SO_2	PM_{10}	NO_x	SO_2	PM_{10}
Arnot	Stack 1	21 487	24 465	890	21 619	29 833	1 031	0	0	0	0	0	0	0	0	0
	Stack 2	21 487	24 465	890	21 619	29 833	1 031	0	0	0	0	0	0	0	0	0
Camden	Stack 1	8 914	11 941	460	10 730	14 438	473	0	0	0	0	0	0	0	0	0
	Stack 2	8 914	11 941	460	10 730	14 438	473	0	0	0	0	0	0	0	0	0
	Stack 3	8 914	11 941	460	10 730	14 438	473	0	0	0	0	0	0	0	0	0
	Stack 4	8 914	11 941	460	10 730	14 438	473	0	0	0	0	0	0	0	0	0
Duvha	Stack 1	23 685	44 424	1 819	17 200	36 647	1 137	15 709	33 472	692	0	0	0	0	0	0
	Stack 2	23 685	44 424	1 819	25 800	54 971	2 652	23 564	50 208	1 384	0	0	0	0	0	0
Grootvlei	Stack 1	4 894	8 339	143	11 944	23 618	270	0	0	0	0	0	0	0	0	0
	Stack 2	4 894	8 339	143	0	0	0	0	0	0	0	0	0	0	0	0
Hendrina	Stack 1	7 695	15 589	266	10 585	23 572	356	0	0	0	0	0	0	0	0	0
	Stack 2	7 695	15 589	266	10 585	23 572	356	0	0	0	0	0	0	0	0	0
Kendal	Stack 1	22 623	58 298	13 321	26 033	88 749	1 799	22 770	77 970	1 639	27 213	26 557	1 959	27 213	26 557	1 959
	Stack 2	22 623	58 298	13 321	26 033	88 749	1 799	22 770	77 970	1 639	27 213	26 557	1 959	27 213	26 557	1 959
Komati	Stack 1	1 042	1 076	57	0	0	0	0	0	0	0	0	0	0	0	0
	Stack 2	1 042	1 076	57	0	0	0	0	0	0	0	0	0	0	0	0
Kriel	Stack 1	39 460	46 038	7 802	36 937	42 577	5 639	0	0	0	0	0	0	0	0	0
	Stack 2	39 460	46 038	7 802	36 937	42 577	5 639	0	0	0	0	0	0	0	0	0
Kusile	Stack 1	24 940	21 281	737	30 178	46 428	371	23 777	25 752	293	26 703	28 922	329	26 703	28 922	329
	Stack 2	24 940	21 281	737	30 178	46 428	371	23 777	25 752	293	26 703	28 922	329	26 703	28 922	329
Lethabo	Stack 1	51 234	100 147	5 740	46 808	99 197	3 720	28 583	56 370	1 393	22 246	59 258	1 542	22 246	17 777	1 542
	Stack 2	51 234	100 147	5 740	46 808	99 197	3 720	28 583	56 370	1 393	22 246	59 258	1 542	22 246	17 777	1 542
Majuba	Stack 1	58 301	67 177	952	33 034	105 666	837	25 262	80 804	640	33 250	75 779	842	33 250	22 734	842
	Stack 2	58 301	67 177	952	33 034	105 666	837	25 262	80 804	640	33 250	75 779	842	33 250	22 734	842
Matla	Stack 1	49 710	41 603	10 608	49 301	72 014	4 769	38 853	56 752	1 879	0	0	0	0	0	0
	Stack 2	49 710	41 603	10 608	37 490	54 761	3 627	29 545	43 156	1 429	0	0	0	0	0	0
Tutuka	Stack 1	24 217	45 512	7 692	28 989	59 187	7 006	4 945	15 654	597	17 621	55 242	1 982	17 621	16 573	1 982
	Stack 2	24 217	45 512	7 692	28 989	59 187	7 006	4 945	15 654	597	17 621	55 242	1 982	17 621	16 573	1 982

Table 4-2: Stack emission concentration in mg/Nm³ at 10% O_2 for the suite of coal-fired power stations and 5 emission scenarios

Power station	Stack	SCENARIO 1 (Current)			SCENARIO A (2025)			SCENARIO B (2031)			SCENARIO C (2036)			SCENARIO D (MES)		
		NO_X	SO_2	PM_{10}	NO_X	SO_2	PM_{10}	NO_x	SO_2	PM_{10}	NO_x	SO_2	PM_{10}	NO_x	SO_2	PM_{10}
Arnot	Stack 1	334	381	14	587	810	28	0	0	0	0	0	0	0	0	0
	Stack 2	334	381	14	587	810	28	0	0	0	0	0	0	0	0	0
Camden	Stack 1	461	617	24	680	915	30	0	0	0	0	0	0	0	0	0
	Stack 2	461	617	24	680	915	30	0	0	0	0	0	0	0	0	0
	Stack 3	461	617	24	680	915	30	0	0	0	0	0	0	0	0	0
	Stack 4	461	617	24	680	915	30	0	0	0	0	0	0	0	0	0
Duvha	Stack 1	297	557	23	681	1 451	45	681	1 451	30	0	0	0	0	0	0
	Stack 2	297	557	23	681	1 451	70	681	1 451	40	0	0	0	0	0	0
Grootvlei	Stack 1	145	247	4	885	1 750	20	0	0	0	0	0	0	0	0	0
	Stack 2	145	247	4	0	0	0	0	0	0	0	0	0	0	0	0
Hendrina	Stack 1	150	305	5	595	1 325	20	0	0	0	0	0	0	0	0	0
	Stack 2	150	305	5	595	1 325	20	0	0	0	0	0	0	0	0	0
Kendal	Stack 1	269	694	159	550	1 875	38	528	1 808	38	528	515	38	528	515	38
	Stack 2	269	694	159	550	1 875	38	528	1 808	38	528	515	38	528	515	38
Komati	Stack 1	33	35	2	0	0	0	0	0	0	0	0	0	0	0	0
	Stack 2	33	34	2	0	0	0	0	0	0	0	0	0	0	0	0
Kriel	Stack 1	535	624	106	655	755	100	0	0	0	0	0	0	0	0	0
	Stack 2	535	624	106	655	755	100	0	0	0	0	0	0	0	0	0
Kusile	Stack 1	247	210	7.28	325	500	4	325	352	4	325	352	4	325	352	4
	Stack 2	247	210	7.28	325	500	4	325	352	4	325	352	4	325	352	4
Lethabo	Stack 1	696	1 360	78	755	1 600	60	718	1 416	35	505	1 345	35	505	404	35
	Stack 2	696	1 360	78	755	1 600	60	718	1 416	35	505	1 345	35	505	404	35
Majuba	Stack 1	573	660	9	750	2 399	19	750	2 399	19	750	1 709	19	750	513	19
	Stack 2	573	660	9	750	2 399	19	750	2 399	19	750	1 709	19	750	513	19
Matla	Stack 1	551	461	117	827	1 208	80	827	1 208	40	0	0	0	0	0	0
	Stack 2	551	461	118	827	1 208	80	827	1 208	40	0	0	0	0	0	0
Tutuka	Stack 1	244	458	77	600	1 225	145	290	918	35	400	1 254	45	400	376	45
	Stack 2	244	458	77	600	1 225	145	290	918	35	400	1 254	45	400	376	45

4.4 Fugitive Emissions

The methodology to estimate emission rates of particulates from the coal yard and ash dumping activities for the power stations is described in this section.

A general equation for emission estimation is: E = A x EF x (1-ER/100)

where: E = emissions;
A = activity rate;
EF = emission factor; and
ER = overall emission reduction efficiency (%)

An emission factor is a representative value that relates the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of the pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant (e.g., kg of particulate emitted per tonne of coal crushed). Such factors facilitate estimation of emissions from various sources of air pollution. In most cases, these factors are simply averages of all available data of acceptable quality and are generally assumed to be representative of long-term averages for all facilities in the source category (USEPA, 2024b).

The emission factors used for the calculation of particulates in this study are the most recent factors published in the United States Environmental Protection Agency (US EPA), AP 42, Fifth Edition, Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources, Chapter 13: Section 13.2.4 Aggregate Handling and Storage Piles; Section 13.2.5 Industrial Wind Erosion; (USEPA, 2024b).

Wind entrainment of dust and PM_{10} from coal stockpiles and ash dumps is a function of the physical size of the facility and the nature of the exposed surface, i.e. the moisture content, silt content, amount of vegetation cover, size of the particles on the surface and wind speed.

In this assessment, the ash dumps are modelled under worst case conditions (e.g. drought conditions), where it is assumed that it is mostly dry and 80% of the surface area is exposed to wind erosion, providing a worst-case (environmentally conservative) scenario. The annual emission rates for the coal stockpiles and ash dumps are shown in Table 4-3. It is worth noting here that in the dispersion modelling the PM_{10} emission is modelled firstly as PM_{10}, then it is modelled as $PM_{2.5}$.

Table 4-3: Emission rates for PM_{10} in tonnes per annum from the fugitive sources

Power station	Source	PM_{10}
Arnot	Coal yard	163
	Ash Dump	3 594
Camden	Coal yard	10
	Ash Dump 1	1 039
	Ash Dump 2	974
Duvha	Coal yard	24
	Ash Dump	6 317
Grootvlei	Coal yard	9
	Ash Dump	1 430
Hendrina	Coal yard 1	8
	Coal yard 2	7
	Ash Dump	1 884
Kendal	Coal yard	48
	Ash Dump 1	3 050
	Ash Dump 2	1596
Komati	Coal yard	5
	Ash Dump	1 320
Kriel	Coal yard	22
	Ash Dump	2 609
Kusile	Coal yard	17
	Ash Dump	2 410
Lethabo	Coal yard	0
	Ash Dump	3 087
Majuba	Coal yard	42
	Ash Dump	3 564
Matla	Coal yard	23
	Ash Dump	4 702
Tutuka	Coal yard	34
	Ash Dump	2 506

5. BASELINE CONDITIONS

The description of the baseline conditions of the area provides an understanding on the receiving atmospheric environment so that changes as a result of the application or the effect of the application can be assessed. The baseline description therefore includes an overview of the climatology and meteorology of the area, and an assessment of ambient air quality over the last three years measured at monitoring stations in the area. Other sources of air pollution in the area are also discussed.

5.1 Climate and meteorology

The climate of a given location is affected by its latitude, terrain and altitude, as well as nearby water bodies and their currents. Climates are classified according to the average and typical ranges of different variables, most commonly temperature and precipitation.

The Highveld is located in temperate latitudes between 25° S and 26° S and 28° E to 29° E, and approximately 1 600 m above sea level. As a result, it experiences a temperate climate with summer rainfall and dry winters according to the Köppen Climate Classification system. Summer days are generally warm with maximum temperatures sometimes reaching 30 °C, and summer nights are mild. Winter days are mild and nights are cold. The Highveld receives approximately 650 mm of rainfall annually, with more than 85% of its rainfall October and March The area receives an average of 693 mm of rainfall annually, with more than 85% of.

5.2 Air Pollution Dispersion Potential

The air pollution dispersion of an area refers to the ability of atmospheric processes, or meteorological mechanisms, to disperse and remove pollutants from the atmosphere. Dispersion comprises both vertical and horizontal components of motion. The vertical component is defined by the stability of the atmosphere and the depth of the surface mixing layer. The horizontal dispersion of pollution in the boundary layer is primarily a function of the wind field and atmospheric stability. The wind speed determines the rate of downwind transport and wind direction and the variability in wind direction determines the general path of the pollutant. Atmospheric stability, or instability, determines the ability of the atmosphere to mix and dilute pollutants. Stability is a function of solar radiation (thermal turbulence) and wind speed and surface roughness, which induce mechanical turbulence. The dispersion potential of an area therefore experiences diurnal and seasonal changes.

By day, with strong insolation (in-coming solar radiation) and stronger winds, the dispersion potential of the Highveld is generally efficient through vertical dilution and horizontal dispersion. The dispersion potential is generally better on summer days than winter days. At night, as the surface temperature inversion develops, the lowest layer of the atmosphere becomes more stable, reaching a maximum at sunrise. As a result, the dispersion potential typically becomes less efficient during the night and the poorest conditions generally occur towards sunrise. These are known as stable night-time conditions. Under these conditions pollutants released close to ground-level (such as residential fuel burning or waste burning) are often trapped below the surface inversion

tend to accumulate near the point of release. The tall power station stacks together with hot buoyant emissions ensure that pollutants are released above the surface inversion.

5.3 Ambient Air Quality

Poor ambient air quality on the Highveld led to the declaration of the Highveld and Vaal Triangle Airshed Priority Areas in terms of Section 18.1. (a) and (b) of the National Environmental Management Air Quality Act, 2004 (Act No. 39 of 2004). Following the declaration was the development and implementation of Highveld Air Quality Management Plan (AQMP) in 2011. Recognition of importance of ambient air quality monitoring led to the expansion of the monitoring network. For this assessment, data for 2021, 2022 and 2023 at 24 ambient air quality monitoring stations (AQMS) were used to evaluate baseline air quality (Table 5-1). These AQMS are mostly located in residential area where ambient concentrations of SO_2, NO_2, PM_{10} and $PM_{2.5}$ are monitored to understand the exposure to the resident populations. The relative location of the AQMS to the power stations is shown in Figure 2-1.

Table 5-1: AQMS in the Highveld and Vaal Triangle assessment area

Receptor	UTMx	UTMy
Ermelo - Monitoring Station	795.958	7066.241
Grootdraai Dam - Monitoring Station	729.225	7023.458
Hendrina - Monitoring Station	773.405	7106.824
Middelburg - Monitoring Station	747.025	7144.589
Secunda - Monitoring Station	707.218	7061.881
Witbank - Monitoring Station	719.296	7136.019
Camden - Monitoring Station	809.577	7051.594
Kendal - Monitoring Station	698.242	7112.342
Komati - Monitoring Station	745.089	7111.212
Elandsfontein - Monitoring Station	741.853	7094.088
Kriel Village - Monitoring Station	724.814	7094.533
Kwazamokuhle - Monitoring Station	773.851	7106.121
Sharpeville - Monitoring Station	586.333	7047.627
Sebokeng - Monitoring Station	583.743	7058.929
Three Rivers - Monitoring Station	599.457	7051.167
Phola - Monitoring Station	703.970	7123.218
Grootvlei - Monitoring Station	647.357	7038.962
Zamdela - Monitoring Station	584.958	7030.458
Majuba - Monitoring Station	777.612	6997.974
Chicken Farm AQMS - Monitoring Station	694.498	7125.215
Rand Water AQMS - Monitoring Station	600.337	7047.863
Masakhane AQMS - Monitoring Station	731.596	7125.308
Sivukile AQMS - Monitoring Station	759.477	7039.486
Silobela AQMS - Monitoring Station	811.174	7111.050

Ambient SO_2 and NO_2 may be attributed to a number of sources, but mostly to industrial combustion of fossil fuels and the related stack emissions. They may also be attributed to domestic coal combustion and vehicle emissions.

Generally, annual average ambient SO_2 and NO_2 concentrations are below the respective NAAQS at the monitoring stations. However, exceedances of the limit value of the NAAQS for 10-minute, 1-hour and 24-hour averaging periods are exceeded at some AQMS. In all cases the frequency of exceedance is less than the permitted number. The number of exceedances are compared with the permitted number in Table 5-2. The annual average SO_2 and NO_2 at selected monitoring stations for 2021, 2022 and 2023 are shown in Figure 5-1 and Figure 5-2 with the limit value of the respective NAAQS.

Ambient PM_{10} and $PM_{2.5}$ may also be attributed to several sources, including industrial processes and the stack emissions. However, the largest sources of be PM_{10} and $PM_{2.5}$ are low-level sources and include, amongst others, mining activity, domestic coal combustion, agricultural processes, vehicle dust entrainment and wind-blown dust.

The annual average PM_{10} and $PM_{2.5}$ concentrations measured at selected monitoring stations for 2021, 2022 and 2023 are compared with the limit value of the respective NAAQS in Figure 5-3 and Figure 5-4. Exceedances of the NAAQS are seen at several AQMS in all years.

The ambient 24-hour PM_{10} and $PM_{2.5}$ concentrations are generally high and exceed the permitted frequency of the NAAQS several AQMS. The number of exceedances are compared with the permitted number in Table 5-2. Those that do not comply with the respective NAAQS are shown in red.

Table 5-2: Number of exceedances of the 24-hour limit value of the NAAQS for PM_{10} and $PM_{2.5}$ in 2021, 2022 and 2023

AQMS	Pollutant	Averaging Period	Permitted Number of Exceedances	2021	2022	2023
Masakhane	SO_2	10-min	526	8	7	9
		1-hour	88	0	1	5
		24-hour	4	0	1	0
	PM_{10}	24-hour	4	LD	84	64
		1-year	0	LD	1	1
	$PM_{2.5}$	24-hour	4	53	0	LD
		1-year	0	1	0	LD
eMalahleni	SO_2	10-min	526	LD	LD	LD
		1-hour	88	6	26	20
		24-hour	4	0	2	2
	PM_{10}	24-hour	4	13	42	71
		1-year	0	0	1	1
	$PM_{2.5}$	24-hour	4	32	25	48
		1-year	0	0	1	1
Kendal K2	SO_2	10-min	526	86	109	199
		1-hour	88	18	38	49
		24-hour	4	1	2	3
	PM_{10}	24-hour	4	142	118	133
		1-year	0	1	1	1
	$PM_{2.5}$	24-hour	4	0	4	LD
		1-year	0	0	0	LD

AQMS	Pollutant	Averaging Period	Permitted Number of Exceedances	2021	2022	2023
Three Rivers	SO_2	10-min	526	LD	LD	LD
		1-hour	88	5	LD	3
		24-hour	4	0	LD	0
	PM_{10}	24-hour	4	98	LD	75
		1-year	0	1	LD	1
	$PM_{2.5}$	24-hour	4	45	LD	113
		1-year	0	1	LD	1
Sharpeville	SO_2	10-min	526	LD	LD	LD
		1-hour	88	LD	1	4
		24-hour	4	LD	0	0
	PM_{10}	24-hour	4	LD	86	107
		1-year	0	LD	1	1
	$PM_{2.5}$	24-hour	4	LD	67	97
		1-year	0	LD	1	1
Kriel	SO_2	10-min	526	31	10	22
		1-hour	88	13	6	11
		24-hour	4	0	0	0
		1-year	0	0	0	0
	PM_{10}	24-hour	4	30	59	71
		1-year	0	1	1	1
	$PM_{2.5}$	24-hour	4	25	25	8
		1-year	0	1	1	0
Majuba	SO_2	10-min	526	46	33	42
		1-hour	88	7	4	7
		24-hour	4	0	0	0
	PM_{10}	24-hour	4	LD	65	LD
		1-year	0	LD	1	LD
	$PM_{2.5}$	24-hour	4	2	81	35
		1-year	0	0	1	1
Sivukile	SO_2	10-min	526	114	22	1
		1-hour	88	47	10	0
		24-hour	4	2	3	0
	PM_{10}	24-hour	4	49	58	30
		1-year	0	0	1	1

LD: Data capture less than 50% and not used in averaging.

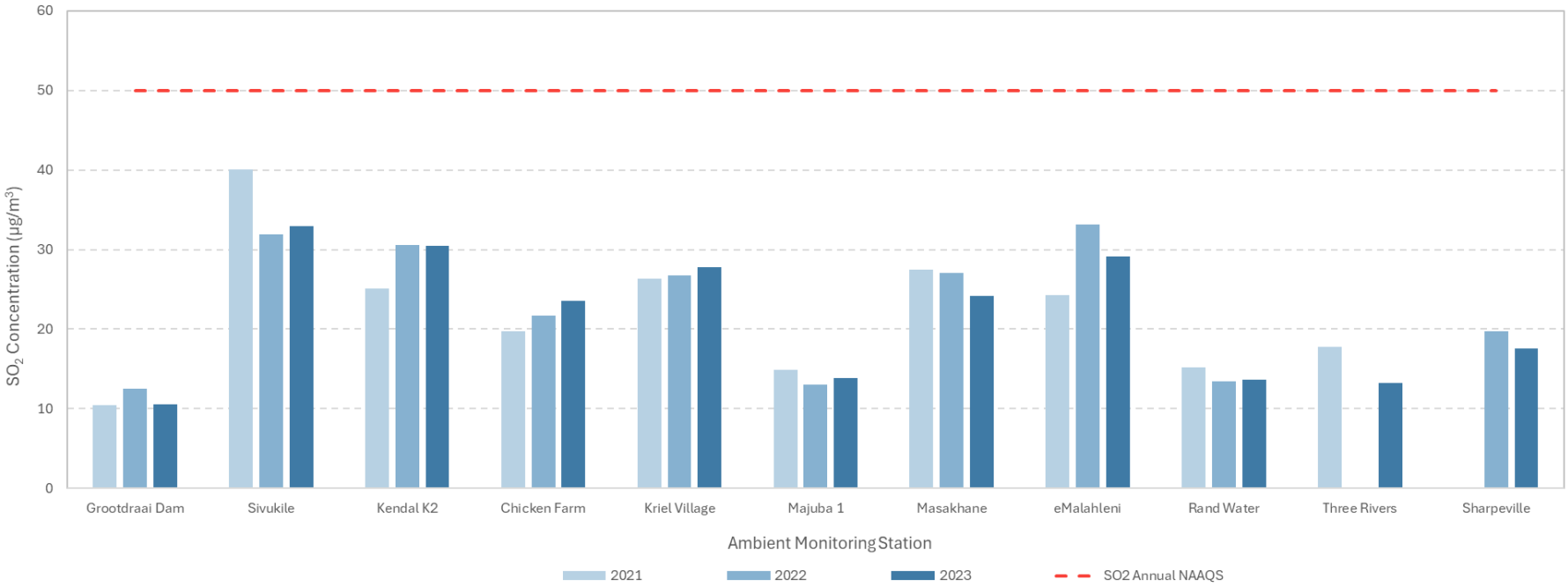


Figure 5-1: Annual average SO_2 concentrations at AQMS in the Highveld assessment area

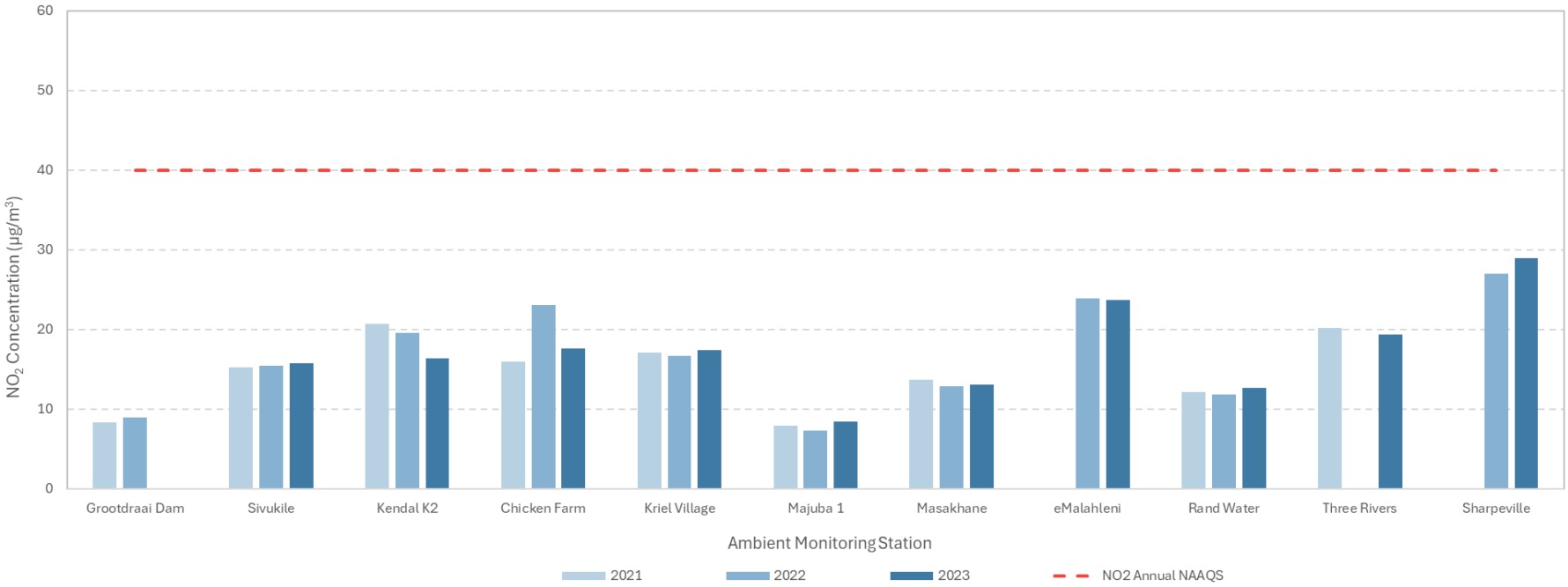


Figure 5-2: Annual average NO_2 concentrations at AQMS in the Highveld assessment area

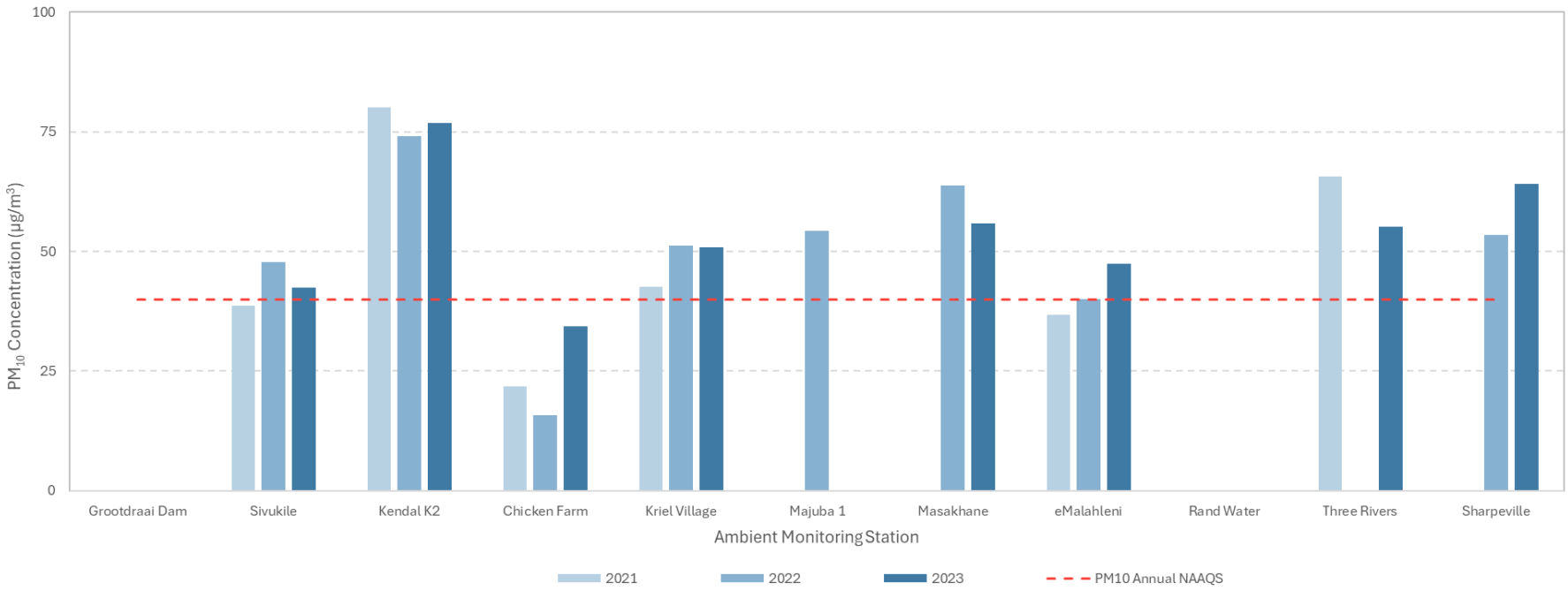


Figure 5-3: Annual average PM_{10} concentrations at AQMS in the Highveld assessment area

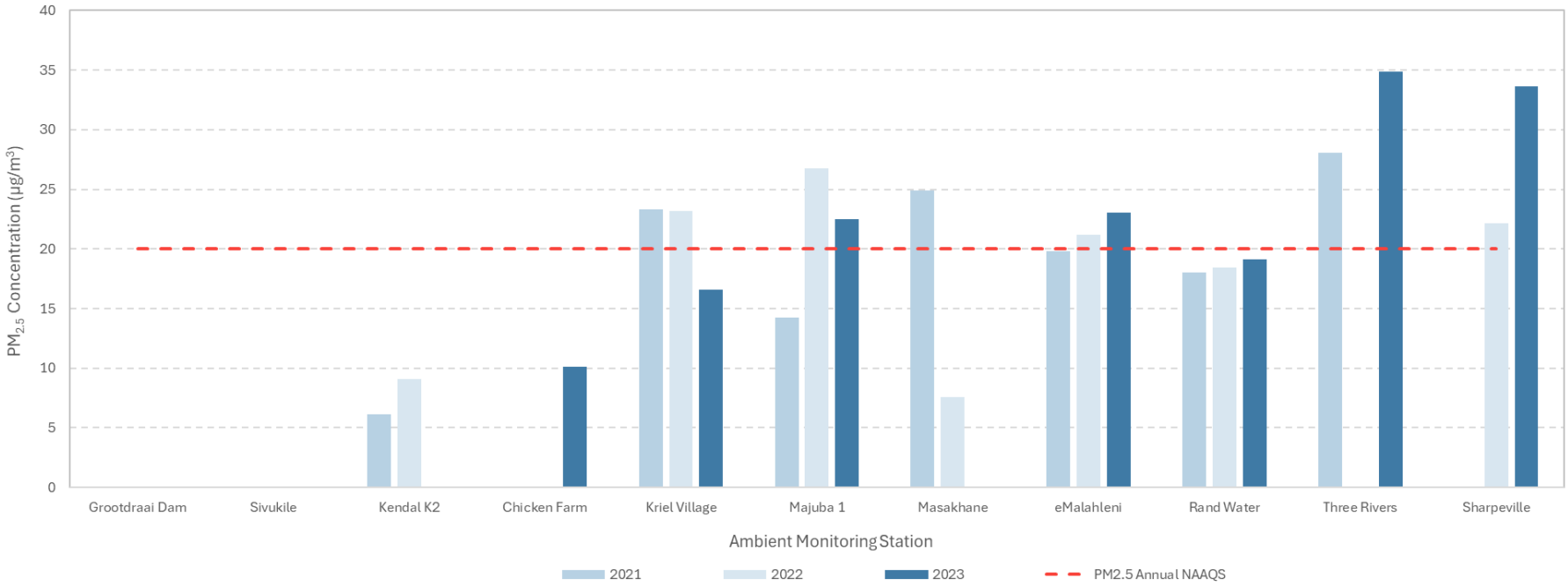


Figure 5-4: Annual average $PM_{2.5}$ concentrations at AQMS in the Highveld assessment area

6. IMPACT OF ENTERPRISE ON THE RECEIVING ENVIRONMENT

6.1 Dispersion Modelling

6.1.1 Models used

A Level 3 air quality assessment must be conducted in situations where the purpose of the assessment requires a detailed understanding of the air quality impacts (time and space variation of the concentrations) and when it is important to account for causality effects, calms, non-linear plume trajectories, spatial variations in turbulent mixing, multiple source types and chemical transformations (DEA, 2014a). A Level 3 assessment may be used in situations where there is a need to evaluate air quality consequences under a permitting or environmental assessment process for large industrial developments that have considerable social, economic and potential environmental consequences. Under these circumstances, the cumulative assessment clearly demonstrates the need for a Level 3 assessment.

The CALPUFF suite of models are approved by the US EPA (http://www.src.com/calpuff/calpuff1.htm) and by the DEA for Level 3 assessments (DEA, 2014a). It consists of a meteorological pre-processor, CALMET, the dispersion model, CALPUFF, and the post-processor, CALPOST. It is an appropriate air dispersion model for the purpose of this assessment as it is well suited to simulate dispersion from several sources. It also has capability to simulate dispersion in the atmosphere's complex land-sea interface. More information about the model can be found in the User's Guide for the CALPUFF Dispersion Model (US EPA, 1995).

The Air Pollution Model (TAPM) (Hurley, 2000; Hurley et al., 2001; Hurley et al., 2002) is used to model surface and upper air metrological data for the study domain. TAPM uses global gridded synoptic-scale meteorological data with observed surface data to simulate surface and upper air meteorology at given locations in the domain, taking the underlying topography and land cover into account. The global gridded data sets that are used are developed from surface and upper air data that are submitted routinely by all meteorological observing stations to the Global Telecommunication System of the World Meteorological Organisation. TAPM has been used successfully in Australia where it was developed (Hurley, 2000; Hurley et al., 2001; Hurley et al., 2002). It is an ideal tool for modelling applications where meteorological data does not adequately meet requirements for dispersion modelling. TAPM modelled output data is therefore used to augment the site-specific surface meteorological data for input to CALPUFF.

6.1.2 TAPM and CALPUFF parameterisation

The TAPM diagnostic meteorological model is used to generate a 3-dimensional temporally and spatially continuous meteorological field for 2021, 2022 and 2023 in hourly increments for the modelling domain.

TAPM is set-up in a nested configuration of two domains, centred on the town of Embalenhle, in the Mpumalanga Highveld. The outer domain is 768 km by 576 km at a

16 km grid resolution and the inner domain is 384 km by 288 km at an 8 km grid resolution (Figure 6-1). The nesting configuration ensures that topographical effects on meteorology are captured, and that meteorology is well resolved and characterised across the boundaries of the inner domain. Twenty-seven vertical levels are modelled in each nest from 10 m to 5 000 m, with a finer resolution in the lowest 1 000 m. The subset of the entire TAPM model output in the form of pre-processed gridded surface meteorological data fields is input into the dispersion model.

The 3-dimensional TAPM meteorological output on the inner grid includes hourly wind speed and direction, temperature, relative humidity, total solar radiation, net radiation, sensible heat flux, evaporative heat flux, convective velocity scale, precipitation, mixing height, friction velocity and Obukhov length. The spatially and temporally resolved TAPM surface and upper air meteorological data is used as input to the CALPUFF meteorological pre-processor, CALMET.

The CALPUFF modelling domain covers an area of 97 200 km^2, where the domain extends 360 km (west-east) by 270 km (north-south) (Figure 6-1). It consists of a uniformly spaced receptor grid with 2 km spacing, giving 24 300 grid cells (180 x 135 grid cells). The size of the modelling domain was informed by previous modelling where the CALPUFF domain of 360 km (west-east) by 270 km (north-south) adequately captured the influence of 13 power stations (Naledzi, 2018). In this case the predicted annual average concentrations were low at the western edge of the domain, i.e. for SO_2 less than for 5 $\mu g/m^3$, for NO_2 less than 2 $\mu g/m^3$ and for PM_{10} and $PM_{2.5}$ less than 1 $\mu g/m^3$.

The topographical and land use for the respective modelling domains is obtained from the dataset accompanying the Commonwealth Scientific and Industrial Research Organisation (CSIRO) The Air Pollution Model (TAPM) modelling package (CSIRO, 2008). This dataset includes global terrain elevation and land use classification data on a longitude/latitude grid at 30-second grid spacing from the US Geological Survey, Earth Resources Observation Systems (EROS) Data Center.

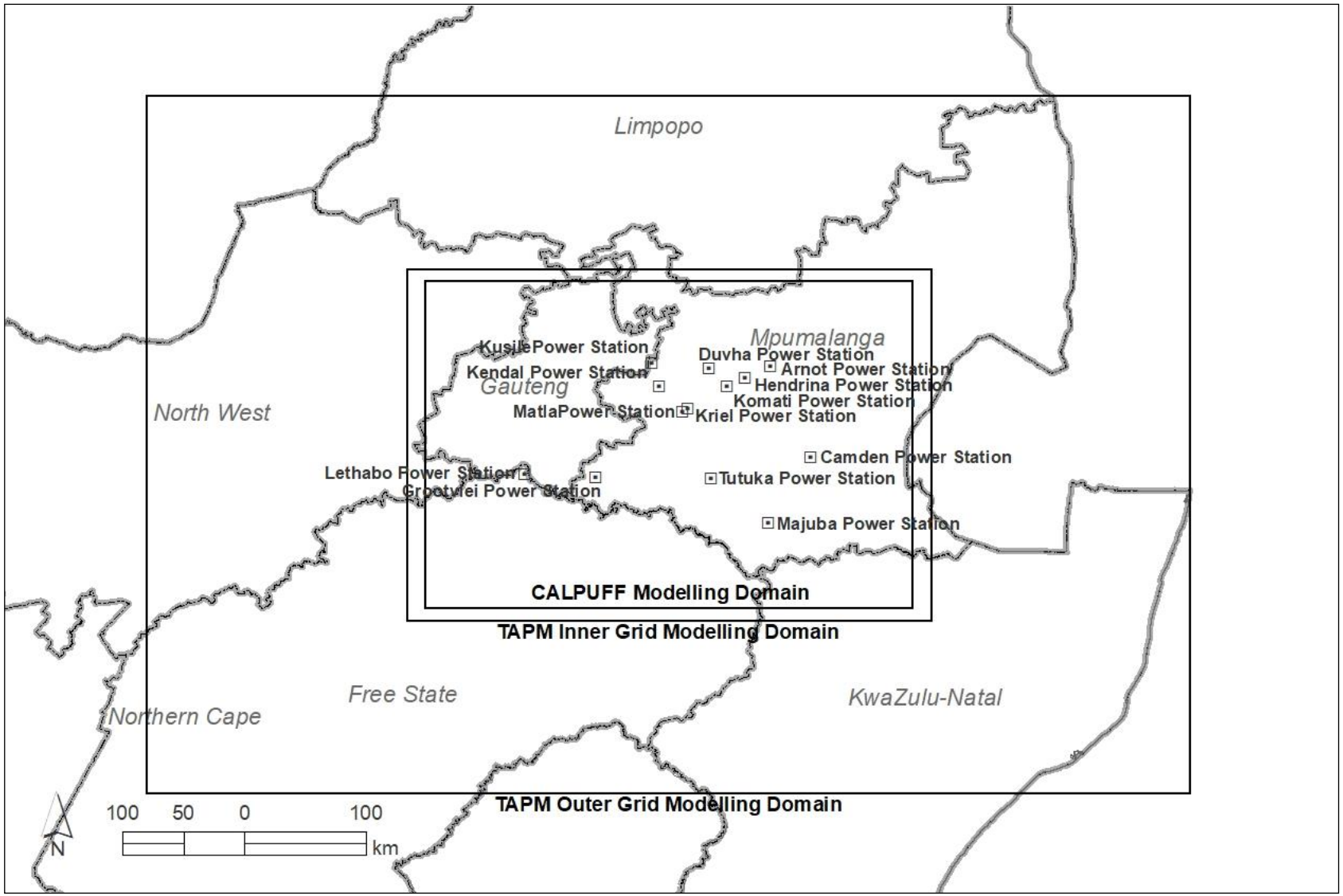


Figure 6-1: TAPM and CALPUFF modelling domains centred on the central Highveld

The parameterisation of key variables that will apply in CALMET and CALPUFF are indicated in Table 6-1 and Table 6-2 respectively.

Table 6-1: Parameterisation of key variables for CALMET

Parameter	Model value
12 vertical cell face heights (m)	0, 20, 40, 80, 160, 320, 640, 1000, 1500, 2000, 2500, 3000, 4000
Coriolis parameter (per second)	0.0001
Empirical constants for mixing height equation	Neutral, mechanical: 1.41 Convective: 0.15 Stable: 2400 Overwater, mechanical: 0.12
Minimum potential temperature lapse rate (K/m)	0.001
Depth of layer above convective mixing height through which lapse rate is computed (m)	200
Wind field model	Diagnostic wind module
Surface wind extrapolation	Similarity theory
Restrictions on extrapolation of surface data	No extrapolation as modelled upper air data field is applied
Radius of influence of terrain features (km)	5
Radius of influence of surface stations (km)	Not used as continuous surface data field is applied

Table 6-2: Parameterisation of key variables for CALPUFF

Parameter	Model value
Chemical transformation	Default NO_2 conversion factor is applied
Wind speed profile	Rural
Calm conditions	Wind speed < 0.5 m/s
Plume rise	Transitional plume rise, stack tip downwash, and partial plume penetration is modelled
Dispersion	CALPUFF used in PUFF mode
Dispersion option	Pasquill-Gifford coefficients are used for rural and McElroy-Pooler coefficients are used for urban
Terrain adjustment method	Partial plume path adjustment

6.1.3 Model accuracy

Air quality models attempt to predict ambient concentrations based on "known" or measured parameters, such as wind speed, temperature profiles, solar radiation and emissions. There are however, variations in the parameters that are not measured, the so-called "unknown" parameters as well as unresolved details of atmospheric turbulent flow. Variations in these "unknown" parameters can result in deviations of the predicted concentrations of the same event, even though the "known" parameters are fixed.

There are also "reducible" uncertainties that result from inaccuracies in the model, errors in input values and errors in the measured concentrations. These might include poor quality or unrepresentative meteorological, geophysical and source emission data, errors in the measured concentrations that are used to compare with model predictions and inadequate model physics and formulation used to predict the concentrations. "Reducible" uncertainties can be controlled or minimised. This is done by using accurate input data, preparing the input files correctly, checking and re-checking for errors, correcting for odd model behaviour, ensuring that the errors in the measured data are minimised and applying appropriate model physics.

Models recommended in the DEA dispersion modelling guideline (DEA, 2014a) have been evaluated using a range of modelling test kits (http://www.epa.gov./scram001). CALPUFF is one of the models that have been evaluated and it is therefore not mandatory to perform any modelling evaluations. Rather the accuracy of the modelling in this assessment is enhanced by every effort to minimise the "reducible" uncertainties in input data and model parameterisation.

6.1.4 Assessment scenarios

The dispersion modelling includes 13 coal-fired power stations on the Highveld and the Free State Province for 5 emission scenarios. The scenarios are:

Scenario 1 (Current): The baseline scenario using actual monthly tonnage of pollutants emitted per stack for 2021-2023 and fugitive emissions from the coal yards and ash dumps for all current operational power stations.
Scenario A (2025): Eskom's planned emissions from 2025 and fugitive emissions from the coal yards and ash dumps for all operational power stations in 2025.
Scenario B (2031): Eskom's planned 2031 stack emissions and fugitive emissions from the coal yards and ash dumps for all operational power stations in 2031.
Scenario C (2036): Eskom's planned 2036 emissions and fugitive emissions from the coal yards and ash dumps for all operational power stations in 2036.
Scenario D (MES): Full compliance with MES and fugitive emissions from the coal yards and ash dumps for all operational power stations in 2036.

6.2 Dispersion Modelling Results

The dispersion modelling results are compared with the NAAQS for SO_2, NO_2, PM_{10} and $PM_{2.5}$ (Table 3-3). It is not possible to apportion the PM_{10} and $PM_{2.5}$ portion of the total PM emitted from the stack emissions. Therefore, the total PM emission is assumed to be firstly PM_{10} and then assumed to be $PM_{2.5}$. For consistency in approach, fugitive emissions of PM_{10} are modelled as $PM_{2.5}$. This is a very conservative assumption. The CALPUFF modelling suite provides for the chemical conversion of SO_2 and NO_X to secondary particulates, i.e. sulphate and nitrate in the modelling results. The predicted PM_{10} and $PM_{2.5}$ concentrations presented are therefore a result of the stack PM emission plus secondary particulate formation.

The ambient SO_2, NO_2, PM_{10} and $PM_{2.5}$ concentrations from the dispersion modelling for the five emission scenarios are presented as isopleth maps over the modelling domain. The DEA (2012c) recommend the 99th percentile concentrations for short-term assessment

with the NAAQS since the highest predicted ground-level concentrations can be considered outliers due to complex variability of meteorological processes. In addition, the limit value in the NAAQS is the 99th percentile.

The impact assessment therefore compares the predicted 99th percentile concentrations with the respective NAAQS (limit values and the permitted frequency of exceedance) for the five scenarios.

6.2.1 Maximum predicted ambient concentrations

The maximum predicted annual SO_2, NO_2, PM_{10} and $PM_{2.5}$ concentrations and the 99th percentile of the 24-hour and 1-hour predicted concentrations are discussed here and are listed in Table 6-3 for the 5 scenarios. Exceedances of the limit value of the NAAQS are shown in red font.

For SO_2, the predicted concentrations are attributed only to the stack emissions. The maximum predicted annual average concentrations for the 5 scenarios are low relative to the limit values of the NAAQS. The highest annual concentrations are predicted in a band extending across the highveld from the centrally located power stations to the southeast to Majuba. Noteworthy is the systematic decrease in the predicted maximum and 99th percentile concentrations from 2025 to 2035 for all averaging periods due to station shutdowns (Arnot, Camden, Hendrina, Kriel, Grootvlei), with most generating units also shutdown at Duvha and Matla by 2035, and completion of DSI installation project at Majuba and semi-dry FGD at Kendal, as well as the benefits of load curtailment at selected stations, and the efficiency improvement projects planned.

The predicted the 99th percentile of the 24-hour SO_2 concentrations are also relatively low compared to the limit value of the NAAQS, except in Scenario A (2025) when the limit value is exceeded. The 99th percentile of the predicted 1-hour concentrations are higher, but are below the limit value of the NAAQS for all five scenarios.

For NO_2, the predicted concentrations are attributed only to the stack emissions. The predicted maximum and 99th percentile concentrations are low relative to the limit values of the respective NAAQS for the 5 scenarios. The predicted maximum NO_2 concentration occur on the central Highveld. Noteworthy is the systematic decrease in the predicted maximum and 99th percentile concentrations from 2025 to 2035 for all averaging periods due to station shutdowns (Arnot, Camden, Hendrina, Kriel, Grootvlei), and completion of LNB installations at Majuba and Tutuka, as well as the benefits of load curtailment at selected stations, and the efficiency improvement projects planned.

For PM_{10} and $PM_{2.5}$, the predicted concentrations are attributed to stack emissions, the low-level fugitive sources (coal yard and ash dump) and the contribution from secondary particulate formation. The total PM emissions are not speciated into PM_{10} or $PM_{2.5}$, rather all PM emitted is assumed to be firstly PM_{10}, and then all PM emitted is assumed to be $PM_{2.5}$.

For PM_{10} and $PM_{2.5}$, the maximum predicted annual average concentrations exceed the limit values of the respective NAAQS in all scenarios. Similarly, the 99th percentile of the 24-hour PM_{10} and $PM_{2.5}$ concentrations exceeds the limit value of the NAAQS. The

predicted maximum PM_{10} and $PM_{2.5}$ concentrations occur close to the power stations where the high predicted PM_{10} and $PM_{2.5}$ are mostly attributed to the low-level fugitive sources. It is noteworthy therefore that the maximum predicted concentrations decrease significantly from 2025 when 13 power stations are in operation to 2031 with the shutdown of 5 power stations, and as a result of PM abatement projects at Kendal, Tutuka, Lethabo, Duvha and Matla being completed, as well as most Duvha and Matla generating nearing completion of shutdown by 2035.

Table 6-3: Maximum predicted ambient annual SO_2, NO_2 PM_{10}, and $PM_{2.5}$ concentrations in µg/m³ and the predicted 99th percentile concentrations for 24-hour and 1-hour averaging periods, with the South African NAAQS

Scenario and Pollutant	**Averaging time**		
Predicted maximum SO_2	**Annual**	**24-hour**	**1-hour**
Scenario 1 (Current)	13.5	81.7	150.8
Scenario A (2025)	24.3	**173.3**	349.5
Scenario B (2031)	18.7	124.0	310.0
Scenario C (2035)	14.2	114.4	246.6
Scenario D (MES)	7.3	61.6	151.5
NAAQS	50	125	350
Predicted maximum NO_2	**Annual**		**1-hour**
Scenario 1 (Current)	5.5		94.4
Scenario A (2025)	7.3		114.6
Scenario B (2031)	4.9		106.5
Scenario C (2035)	4.9		109.9
Scenario D (MES)	4.9		109.9
NAAQS	40		200
Predicted maximum PM_{10}	**Annual**	**24-hour**	
Scenario 1 (Current)	**278.4**	**1 634.3**	
Scenario A (2025)	**278.8**	**1 638.5**	
Scenario B (2031)	**95.6**	**380.7**	
Scenario C (2035)	**94.2**	**330.9**	
Scenario D (MES)	**93.9**	**328.8**	
NAAQS	40	75	
Predicted maximum $PM_{2.5}$	**Annual**	**24-hour**	
Scenario 1 (Current)	**278.4**	**1 634.3**	
Scenario A (2025)	**278.8**	**1 638.5**	
Scenario B (2031)	**95.6**	**380.7**	
Scenario C (2035)	**94.2**	**330.9**	
Scenario D (MES)	**93.9**	**328.8**	
NAAQS	**20**	**40**	Up to 31 Dec 2029
NAAQS	**15**	**25**	From 01 Jan 2030

6.2.2 Predicted concentrations at AQMS and sensitive receptors

The predicted annual SO_2, NO_2, PM_{10} and $PM_{2.5}$ concentrations and the 99th percentile of the 24-hour and 1-hour predicted concentrations at AQMS in the Highveld modelling area are presented in Table 6-4 to Table 6-7. The measured annual averages in 2021, 2022 and 2023 presented with the modelled annual average concentration for Scenario 1: (Current).

For SO_2 and NO_2 the predicted ambient concentrations result from the respective power station stack emissions only. At all the AQMS the modelled concentrations are lower than the monitored concentrations. This is to be expected since AQMS are exposed to all sources of SO_2 and NO_2. The difference between the predicted concentrations and the measured concentrations provides an indication of the contribution of the power station stack emissions at the respective AQMS.

For PM_{10} and $PM_{2.5}$ the predicted ambient concentrations result from the respective power station stack emissions and the fugitive low-level sources, i.e. the coal yards and the ash dumps at each power station. At all the AQMS the modelled concentrations are considerably lower than the monitored concentrations. This is to be expected since AQMS are exposed to all sources of PM_{10} and $PM_{2.5}$. The difference between the predicted concentrations and the measured concentrations provides an indication of the contribution of the power station stack emissions at the respective AQMS.

Table 6-4: Measured annual average SO_2 concentration at the Highveld AQMS compared with predicted concentrations in µg/m^3 for Scenario 1 (Current)

Receptor	2021	2022	2023	Modelled
Grootdraai Dam AQMS	10.4	12.5	10.5	4.3
eMalahleni AQMS	24.2	33.1	29.1	3.0
Kendal AQMS	25.1	30.6	30.4	4.4
Kriel Village AQMS	26.3	26.7	27.8	3.8
Three Rivers AQMS	17.8	-	13.3	2.8
Majuba AQMS	14.9	13.1	13.9	11.5
Chicken Farm AQMS	19.8	21.7	23.5	5.4
Rand Water AQMS	15.2	13.5	13.7	3.2
Masakhane AQMS	27.5	27.1	24.2	3.2
Sivukile AQMS	40.1	31.0	32.9	5.4
Sharpville AQMS	-	19.8	17.5	3.1

Table 6-5: Measured annual average NO_2 concentration at the Highveld AQMS compared with predicted concentrations in µg/m³ for Scenario 1 (Current)

Receptor	2021	2022	2023	Modelled
Grootdraai Dam AQMS	8.4	8.9	-	0.9
eMalahleni AQMS	-	23.9	23.7	1.1
Kendal AQMS	20.7	19.6	16.3	2.1
Kriel Village AQMS	17.1	16.6	17.4	1.4
Three Rivers AQMS	20.2	-	19.4	0.6
Majuba AQMS	8.0	7.3	8.4	3.3
Chicken Farm AQMS	15.9	23.1	17.6	2.9
Rand Water AQMS	12.2	11.8	12.6	0.7
Masakhane AQMS	13.7	12.9	13.0	1.1
Sivukile AQMS	15.2	15.5	15.7	1.2
Sharpville AQMS	-	27.0	29.0	0.7

Table 6-6: Measured annual average PM_{10} concentration at the Highveld AQMS compared with predicted concentrations in µg/m³ for Scenario 1 (Current)

Receptor	2021	2022	2023	Modelled
Grootdraai Dam AQMS	-	-	-	2.9
eMalahleni AQMS	36.7	40.1	47.5	1.4
Kendal AQMS	80.2	74.1	76.8	15.4
Kriel Village AQMS	42.7	51.2	50.8	2.3
Three Rivers AQMS	65.6	-	56.1	3.3
Majuba AQMS	-	54.3	-	9.9
Chicken Farm AQMS	21.9	15.8	34.4	12.6
Rand Water AQMS	-	-	-	7.6
Masakhane AQMS	-	63.8	55.8	1.4
Sivukile AQMS	38.7	47.7	42.4	2.3
Sharpville AQMS	-	53.4	64.0	3.9

Table 6-7: Measured annual average $PM_{2.5}$ concentration at the Highveld AQMS compared with predicted concentrations in µg/m³ for Scenario 1 (Current)

Receptor	2021	2022	2023	Modelled
Grootdraai Dam AQMS	-	-	-	2.9
eMalahleni AQMS	19.8	21.2	23.1	1.4
Kendal AQMS	6.1	9.1	-	15.4
Kriel Village AQMS	23.2	23.2	16.6	2.3
Three Rivers AQMS	28.1	-	34.9	3.3
Majuba AQMS	14.3	26.8	22.5	9.9
Chicken Farm AQMS	-	-	10.1	12.6
Rand Water AQMS	18.0	18.5	19.1	7.6
Masakhane AQMS	24.9	7.5	-	1.4
Sivukile AQMS	-	-	-	2.3
Sharpville AQMS	-	22.1	33.0	3.9

In the Highveld and Vaal Triangle study area 405 sensitive receptors were identified. These are listed in Annexure 1. Predicted ambient concentrations for SO_2 NO_2, PM_{10} and $PM_{2.5}$ for the five scenarios are presented in Annexure 2. The predicted concentrations at the

sensitive receptors are discussed here. As discussed, exceedance of the NAAQS limit does not indicate non-compliance with the standard as in terms of the standard there is a number of times which exceedance of the limit is permitted. The isopleth (maps of concentration) discussed in the following section illustrate the extent of NAAQS non-compliance.

For SO_2, predicted concentrations result from SO_2 emissions from the power station stacks. At all identified sensitive receptors the predicted SO_2 concentrations are below the respective NAAQS for all averaging periods. The highest predicted concentration occur for the proposed Scenario A (2025) emissions. Noteworthy is the systematic decrease in the predicted concentrations from 2025 to 2035 for all averaging periods at all sensitive receptors. The lowest predicted concentration occur for Scenario D (MES) emissions.

For NO_2, the predicted concentrations result from NO_X emissions from the power station stacks. At all identified sensitive receptors the predicted NO_2 concentrations are low and below the respective NAAQS for all averaging period. The highest predicted concentration occur for the proposed Scenario A (2025) emissions.

For PM_{10} and $PM_{2.5}$, it must be remembered that the predicted concentrations are attributed to stack emissions and the low-level fugitive sources (coal yard and ash dump). Furthermore, the total PM emission is not speciated into PM_{10} and $PM_{2.5}$, but rather all PM emitted is assumed to be PM_{10}, and all PM emitted is assumed to be $PM_{2.5}$. In addition, the predicted PM_{10} and $PM_{2.5}$ concentrations account for the formation of secondary particulates from SO_2 and NO_2 stack emissions. This is a very conservative approach.

For PM_{10} and $PM_{2.5}$, the predicted annual average concentrations are below the limit values of the NAAQS at all sensitive receptor points in all five scenarios. Exceedance of the 24-hour limit value of the NAAQS for PM_{10} and $PM_{2.5}$ are predicted in all five scenarios at several sensitive receptor points (Table 6-8). For Scenario A (2025) the exceedances of the limit value for PM_{10} occur at most sensitive receptor points. For $PM_{2.5}$, the limit value of the NAAQS drops from 40 µg/m^3 to 25 µg/m^3 in 2030. This results in an increase in the number of receptor points where the limit value is exceeded. For both PM_{10} and $PM_{2.5}$ the number of receptor points where the limit value is exceeded decreases as power stations are shutdown, and emissions from the associated fugitive sources cease, as well as the completion of the PM abatement projects at Kendal, Tutuka, Duvha, Matla and Lethabo

Table 6-8: Number of sensitive receptors where the limit value of the NAAQS is exceeded

Scenario	Number of sensitive receptors	
	PM_{10}	**$PM_{2.5}$**
Scenario 1 (Current)	26	129
Scenario A (2025)	29	149
Scenario B (2031)	9	157
Scenario C (2036)	0	53
Scenario D (MES)	0	45

6.2.3 Isopleth maps

Isopleth maps of predicted ambient SO_2, NO_2, PM_{10} and $PM_{2.5}$ concentrations are presented in the following sections. The predicted concentrations are shown as isopleths, lines of equal concentration, in $\mu g/m^3$ for the respective NAAQS averaging periods. The isopleths are depicted as coloured lines on the various maps, corresponding to a particular predicted ambient concentration. Areas within red isopleths indicate an area where exceedances of the respective NAAQS limit value are predicted to occur. Sensitive receptors are represented by green squares and AQMS are represented by white dots.

The South African NAAQS permits 4 exceedances of the 24-hour or daily limit value per annum, implying 12 permitted exceedances in a three-year modelling period. For the 24-hour or daily isopleth maps, areas within burgundy isopleths indicate areas where more than 12 exceedances of the limit value is predicted over a 3-year period. The predicted 24-hour concentrations in these areas do not comply with the NAAQS.

The South African NAAQS for SO_2 and NO_2 also permits 88 exceedances of the 1-hour or hourly limit value per annum, implying 264 permitted exceedances in a three-year modelling period. For the 1-hour or hourly isopleth maps, areas within burgundy isopleths indicate areas where more than 264 exceedances of the limit value is predicted over a 3-year period. The predicted 1-hour concentrations in these areas do not comply with the NAAQS.

6.2.3.1 Sulphur dioxide (SO_2)

The isopleth maps showing the predicted annual average SO_2 concentrations clearly demonstrate the effect of the predominant northwesterly winds, with dispersion generally to the southeast across the Highveld and Vaal modelling domain. In all scenarios the highest predicted annual average concentrations occur in a band from the power stations on the central highveld in a southeasterly direction towards Majuba. The predicted annual ambient concentrations are relatively low and are below the NAAQS in all scenarios throughout the modelling domain. Noteworthy is the consistent decrease in predicted ambient concentration with progressive scenarios and the systematic reduction in total SO_2 emissions (see in Figure 4-2).

For the 24-hour and 1-hour averaging periods, the highest predicted concentrations occur in Scenario A (2025) on the central Highveld where several power stations are relatively close together, then around Lethabo in the southwest, around Majuba in the southeast and around Camden in the east. The only predicted exceedance of the NAAQS is near Majuba where the 24-hour limit value is exceeded in a small area. The effect of the shutdown of Arnot, Camden, Hendrina, Grootvlei, Kriel by 2031 is evident in the isopleth plots for Scenario B (2031) by a marked decrease in the predicted ambient concentrations, with a further reduction in Scenario C (2036).

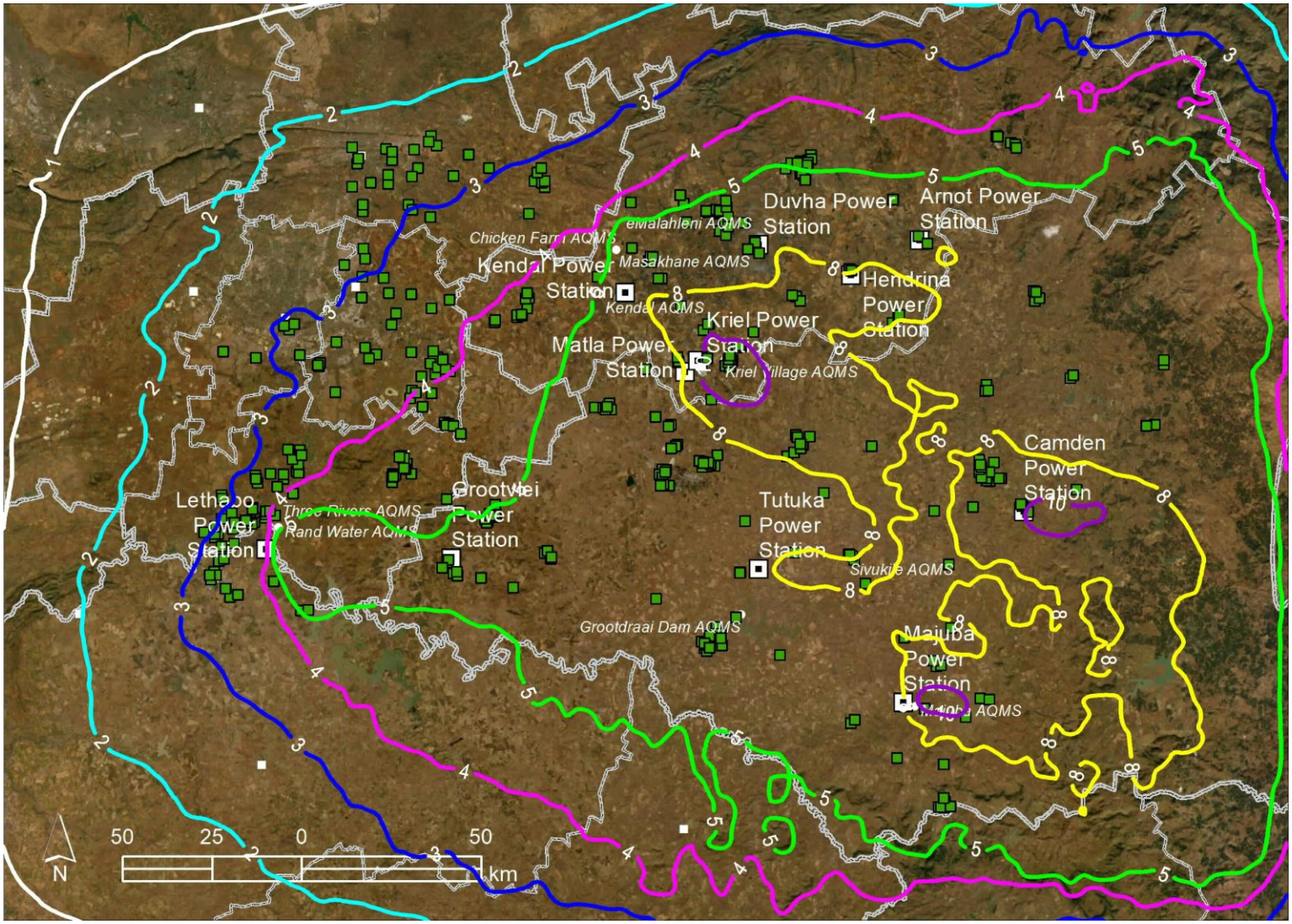


Figure 6-2: Predicted annual average SO_2 concentrations in µg/m³ for Scenario 1 (Current) (NAAQS Limit is 50 µg/m³)

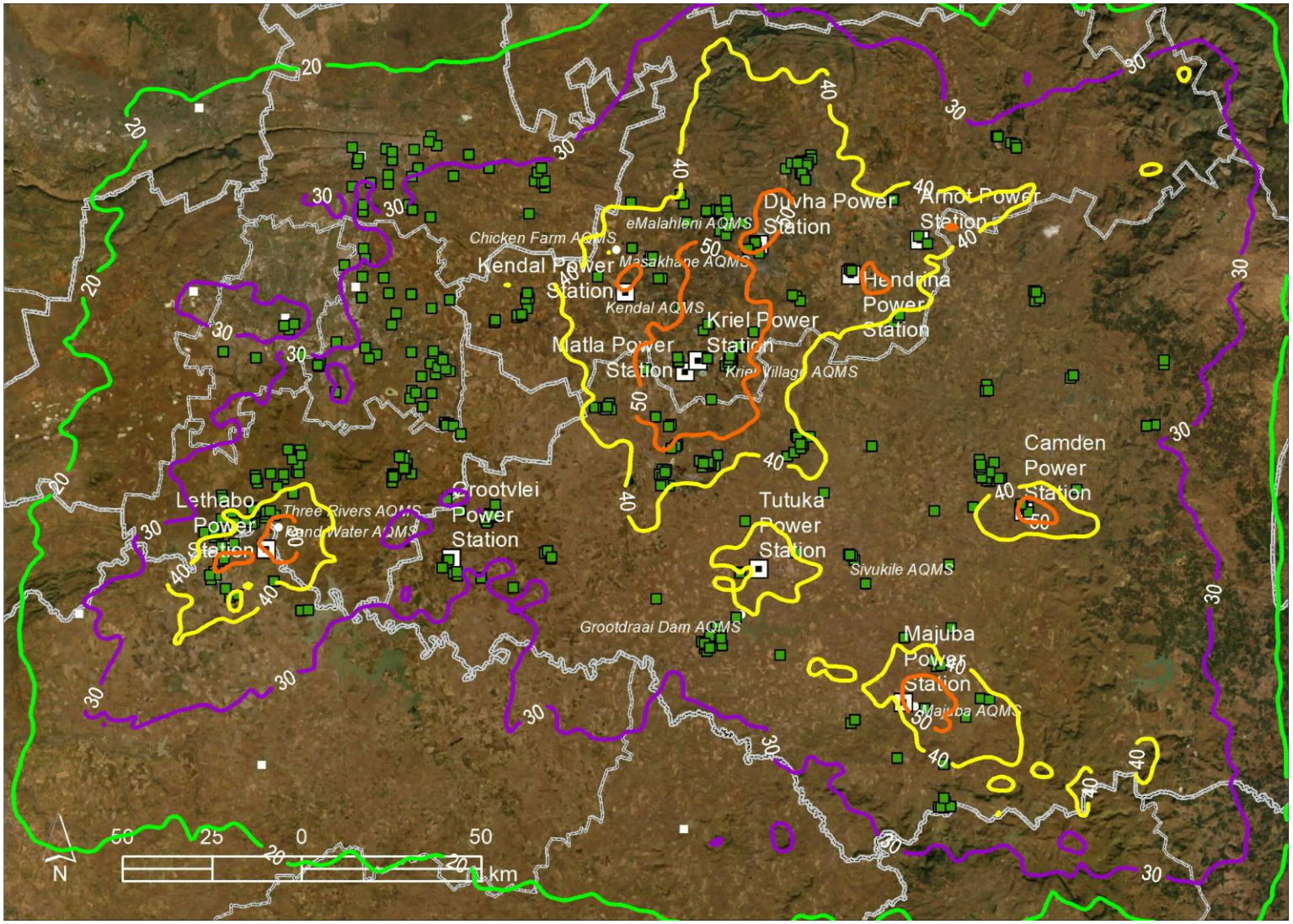


Figure 6-3: Predicted 99th percentile 24-hour SO_2 concentrations in µg/m³ for Scenario 1 (Current) (NAAQS Limit is 125 µg/m³)

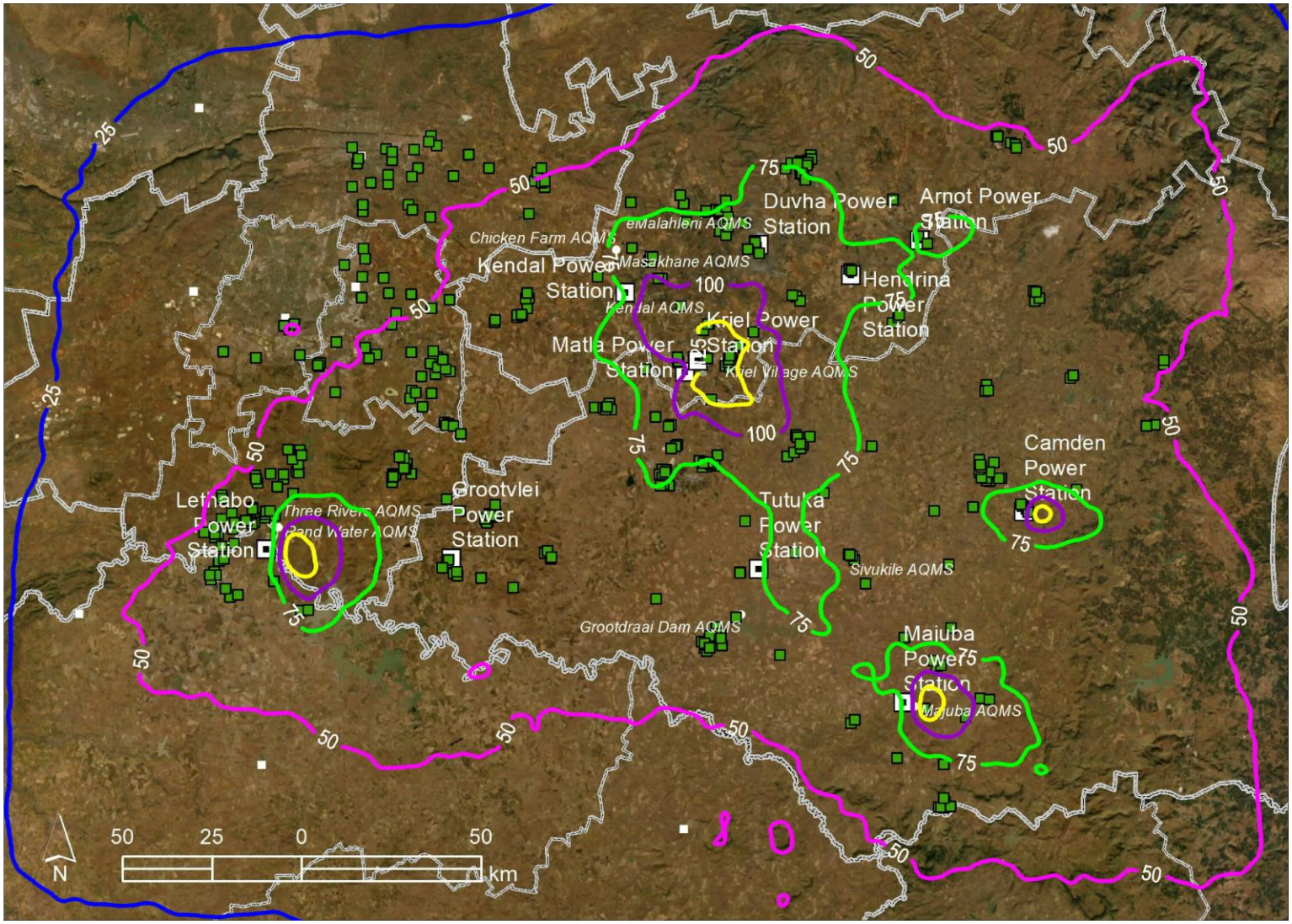


Figure 6-4: Predicted 99th percentile 1-hour SO_2 concentrations in µg/m³ for Scenario 1 (Current) (NAAQS Limit is 350 µg/m³)

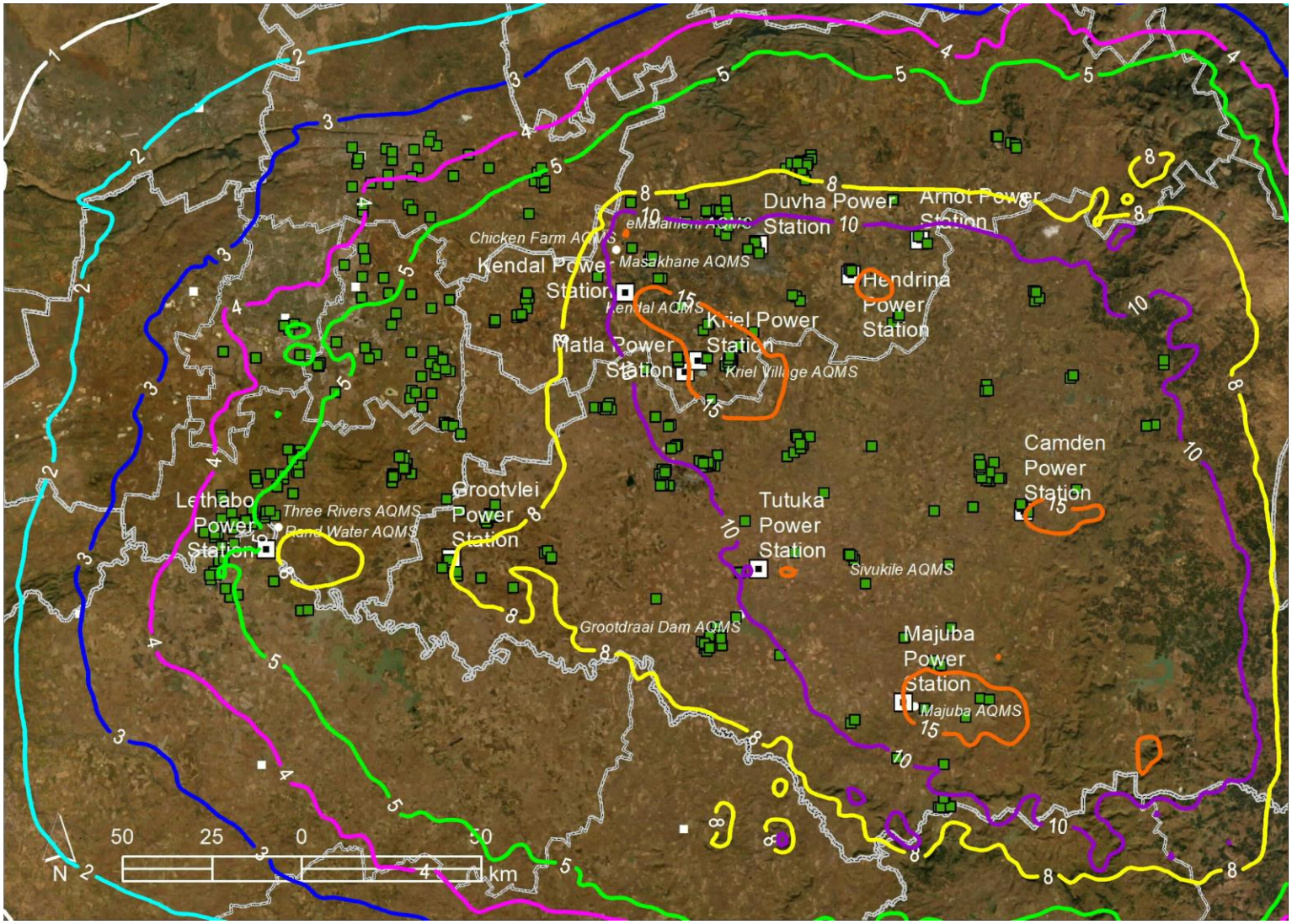


Figure 6-5: Predicted annual average SO_2 concentrations in µg/m³ for Scenario A (2025) (NAAQS Limit is 50 µg/m³)

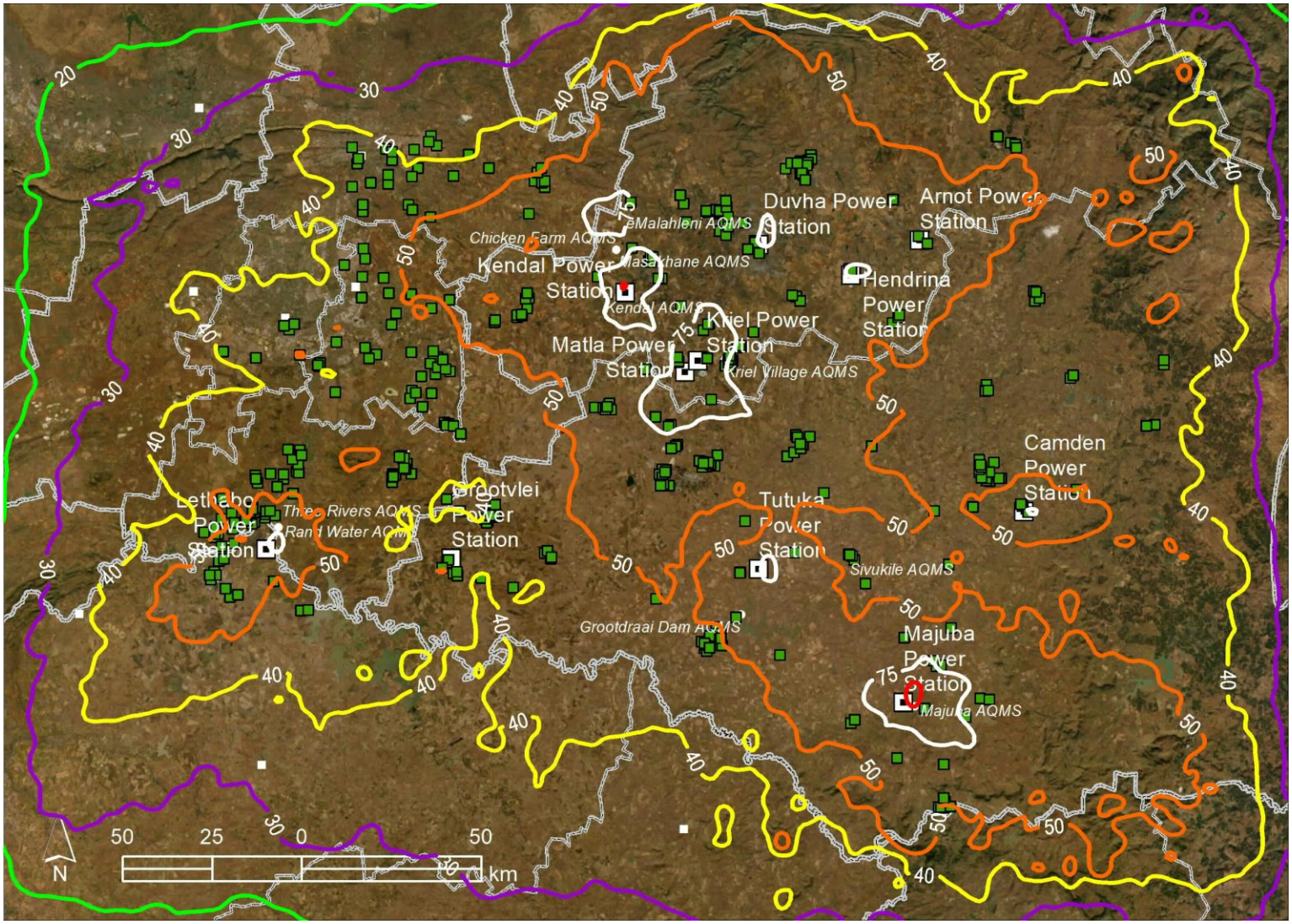


Figure 6-6: Predicted 99th percentile 24-hour SO_2 concentrations in µg/m³ for Scenario A (2025) (NAAQS Limit is 125 µg/m³)

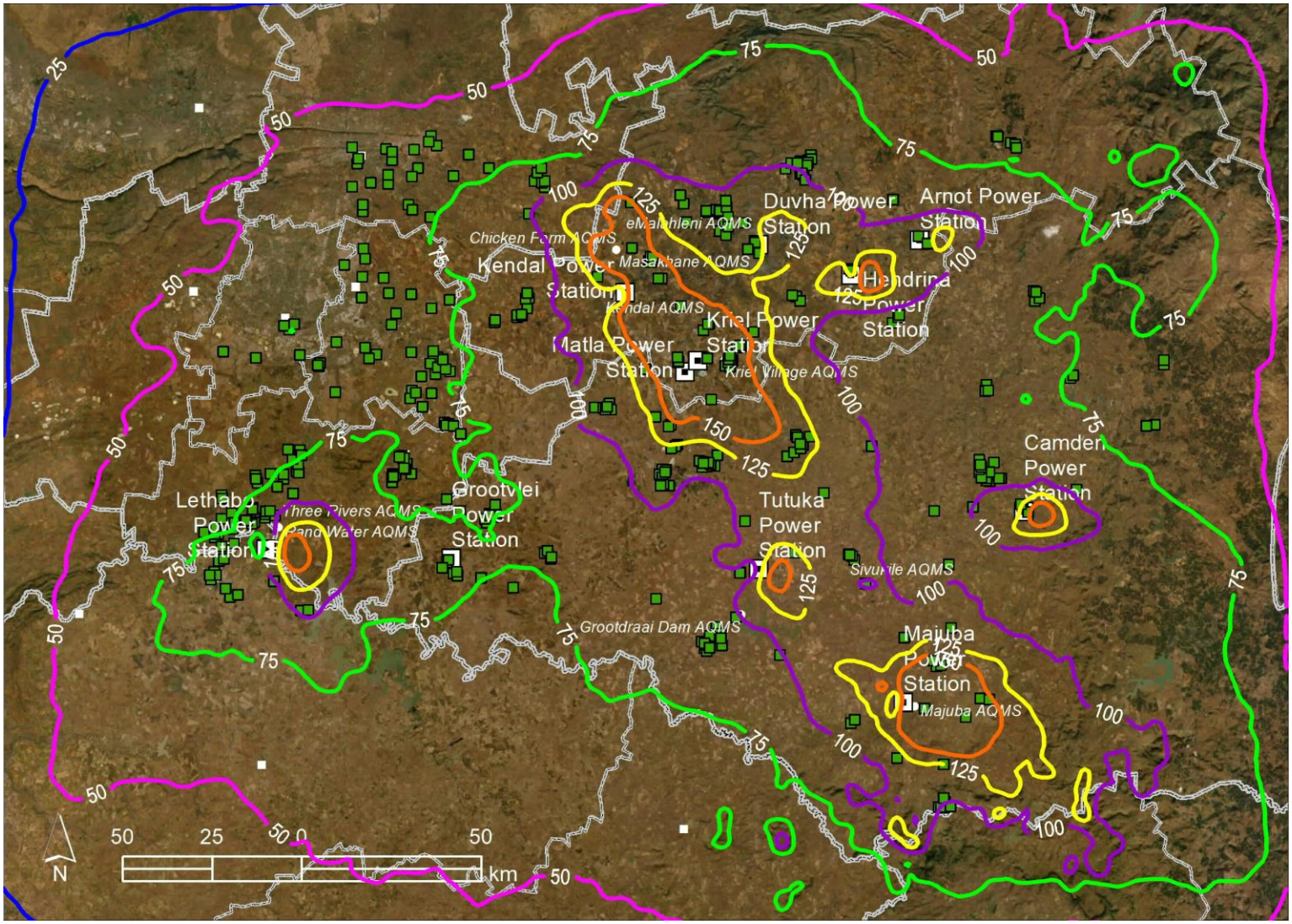


Figure 6-7: Predicted 99th percentile 1-hour SO_2 concentrations in µg/m³ for Scenario A (2025) (NAAQS Limit is 350 µg/m³)

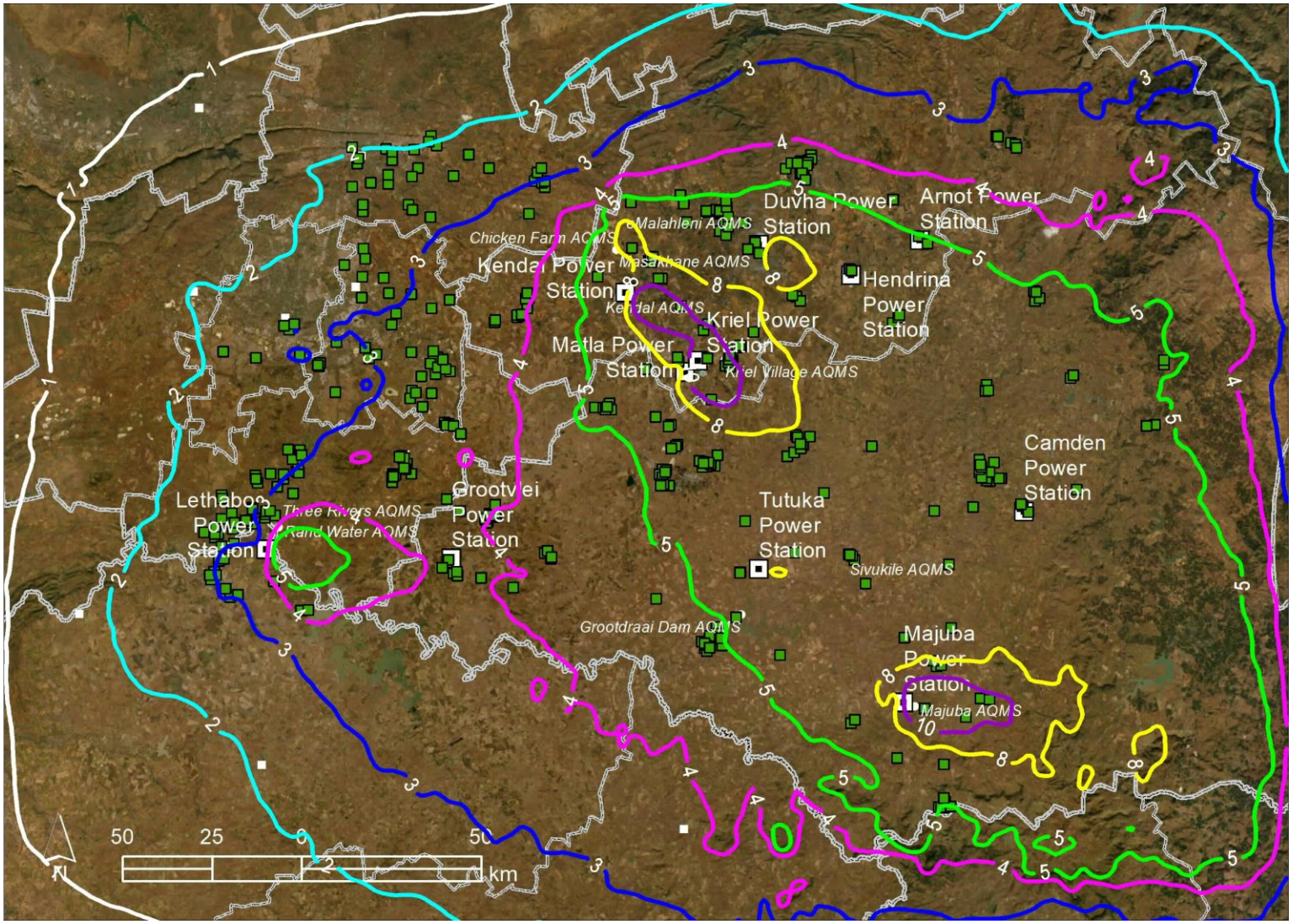


Figure 6-8: Predicted annual average SO_2 concentrations in µg/m³ for Scenario B (2031) (NAAQS Limit is 50 µg/m³)

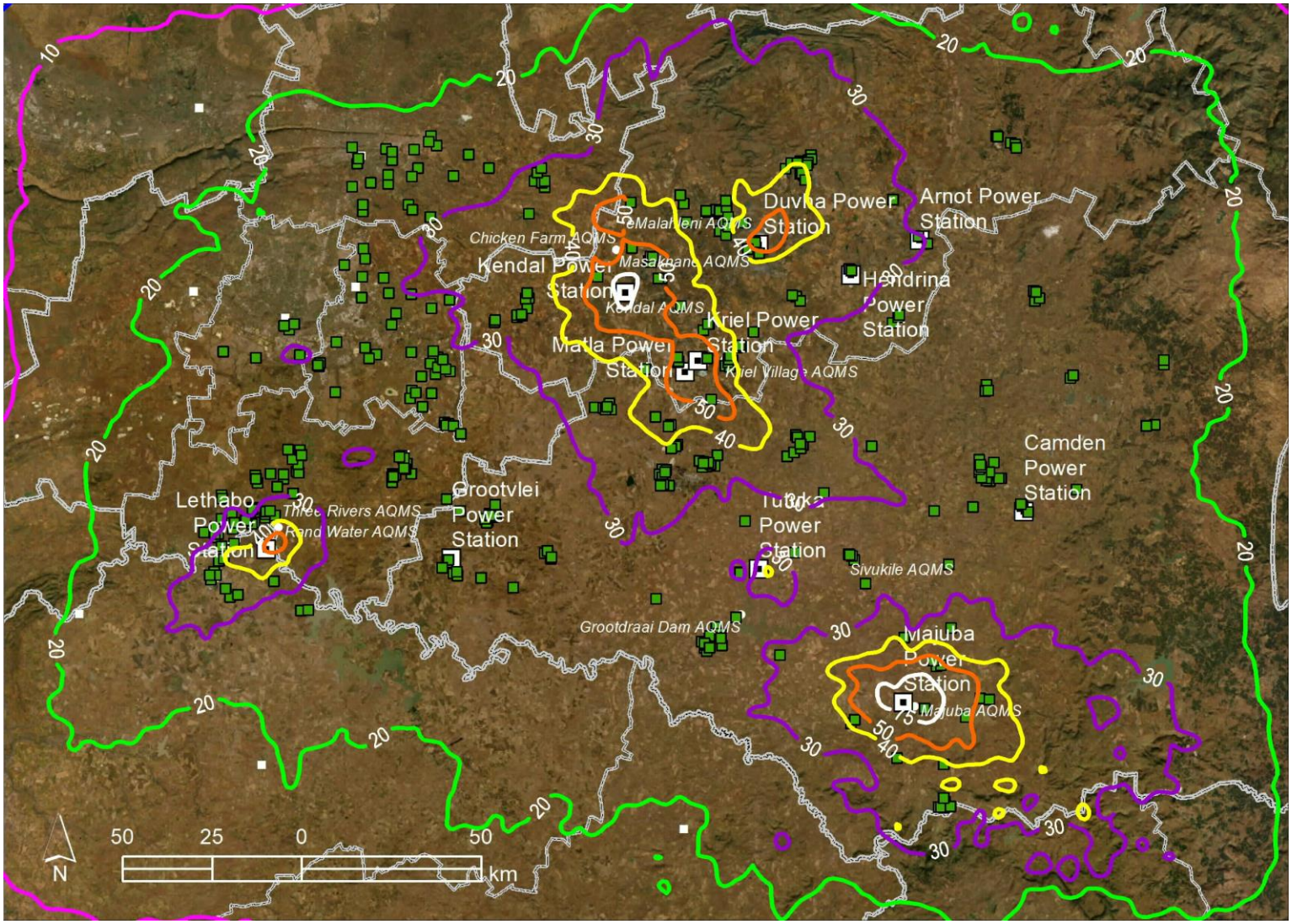


Figure 6-9: Predicted 99th percentile 24-hour SO_2 concentrations in µg/m³ for Scenario B (2031) (NAAQS Limit is 125 µg/m³)

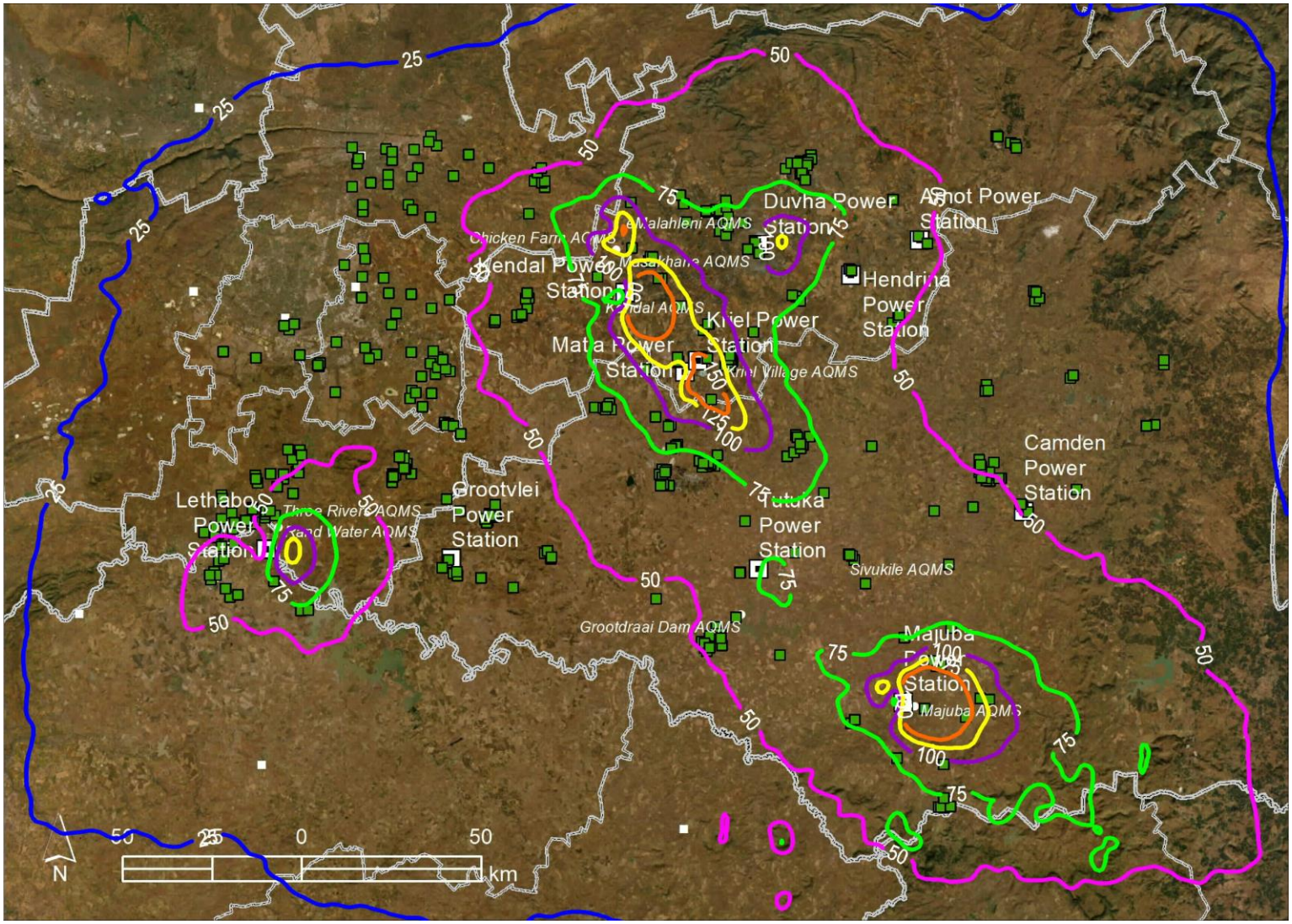


Figure 6-10: Predicted 99th percentile 1-hour SO_2 concentrations in µg/m³ for Scenario B (2031) (NAAQS Limit is 350 µg/m³)

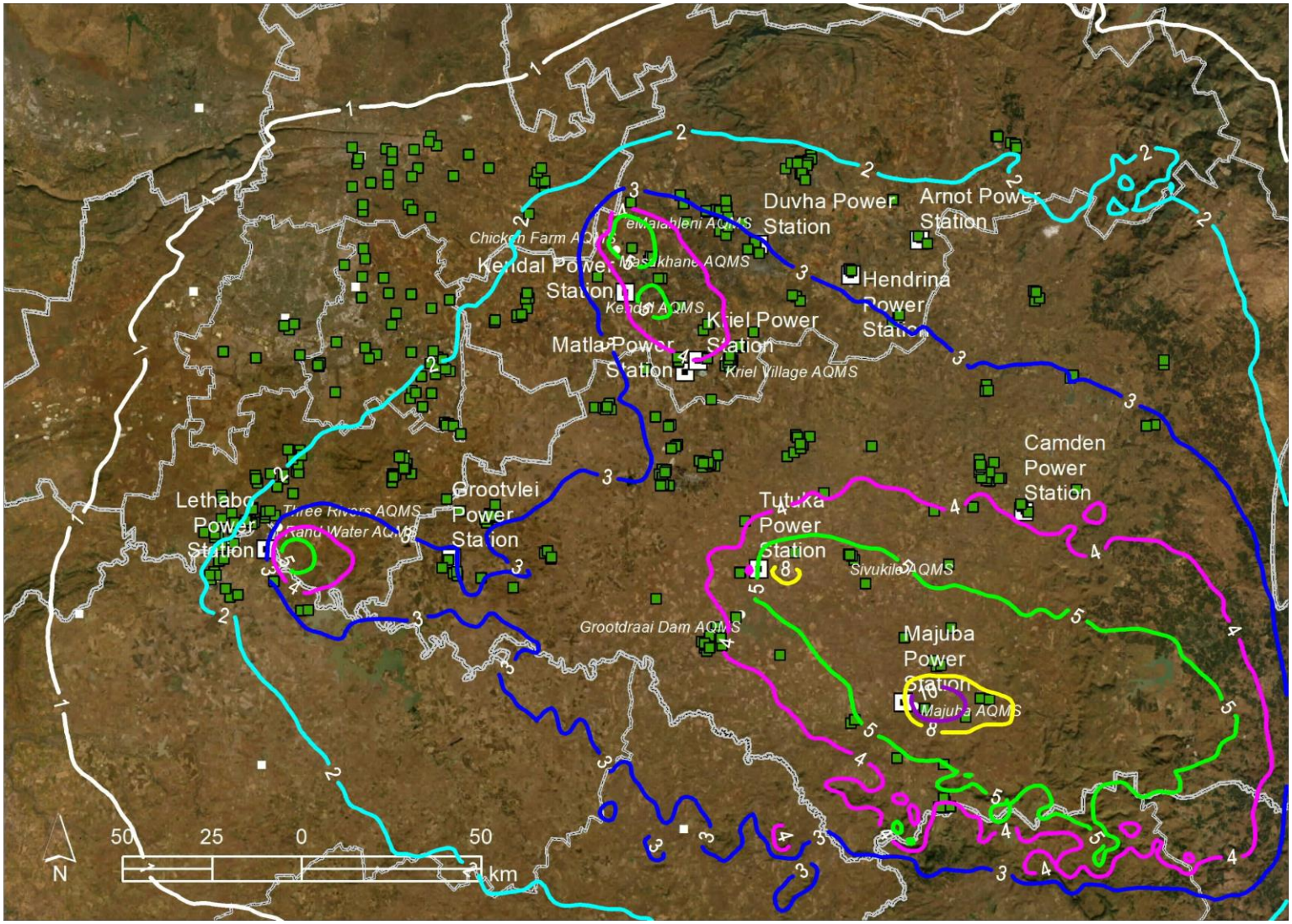


Figure 6-11: Predicted annual average SO_2 concentrations in µg/m³ for Scenario C (2036) (NAAQS Limit is 50 µg/m³)

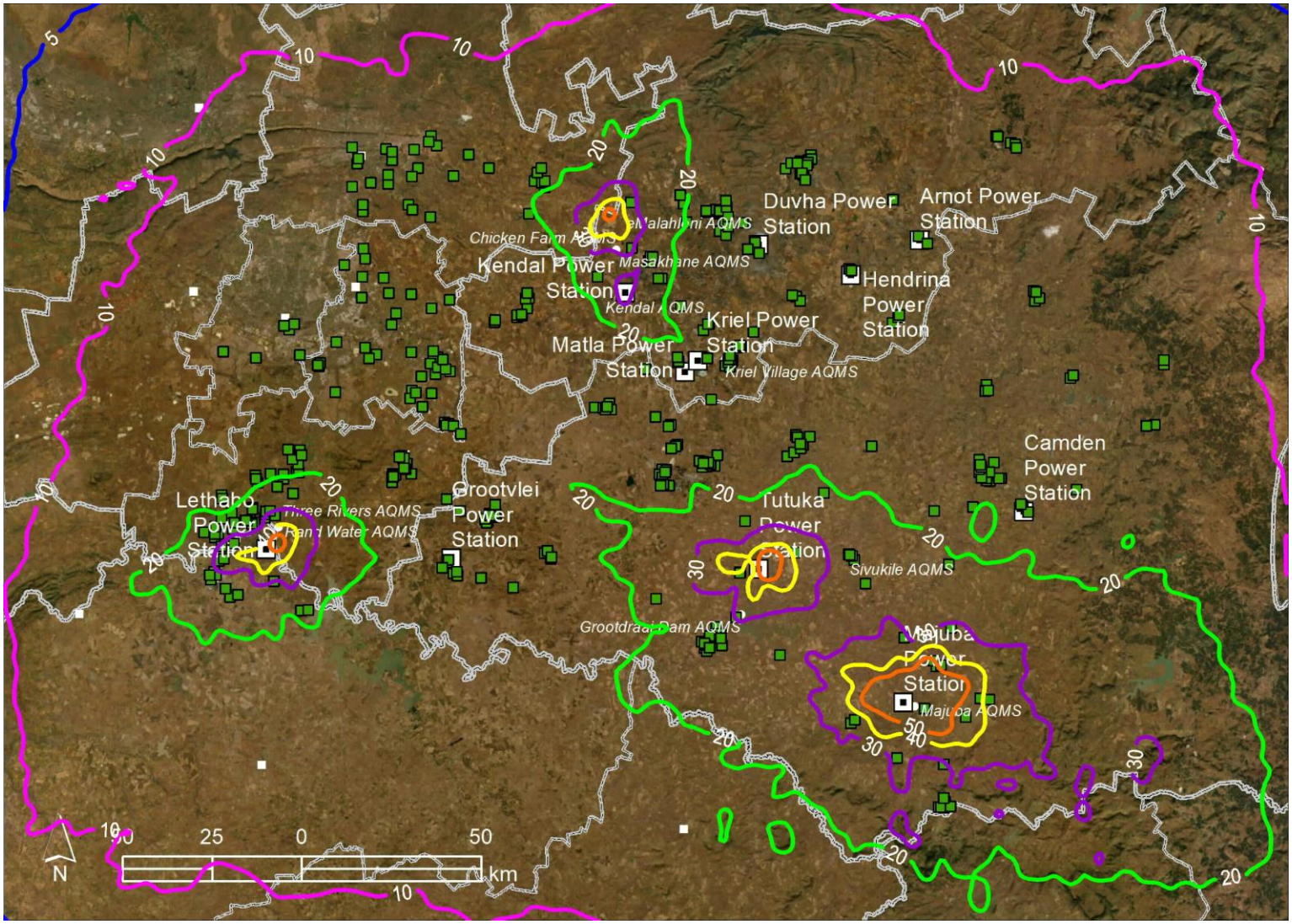


Figure 6-12: Predicted 99th percentile 24-hour SO_2 concentrations in µg/m³ for Scenario C (2036) (NAAQS Limit is 125 µg/m³)

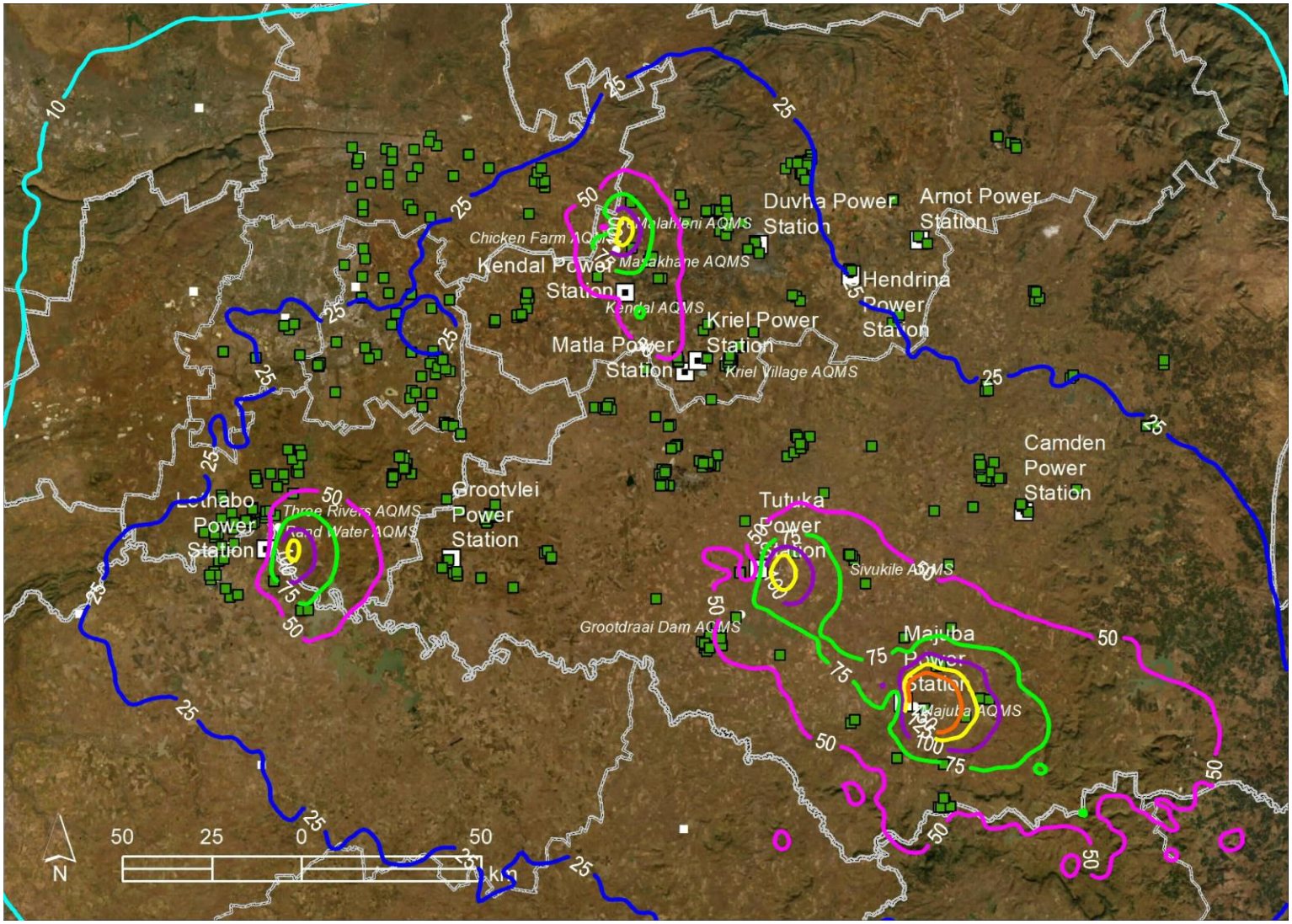


Figure 6-13: Predicted 99th percentile 1-hour SO_2 concentrations in µg/m³ for Scenario C (2036) (NAAQS Limit is 350 µg/m³)

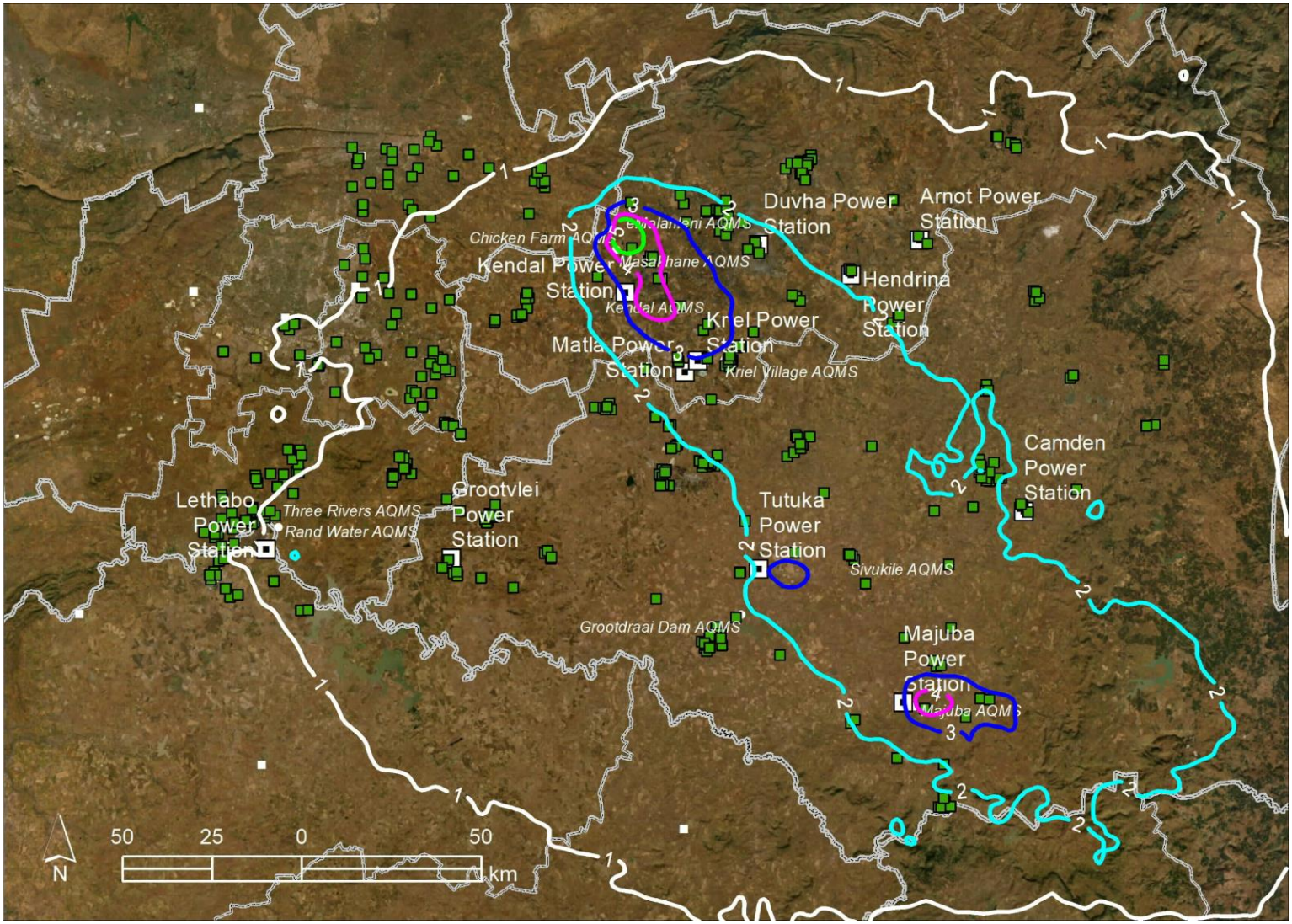


Figure 6-14: Predicted annual average SO_2 concentrations in µg/m³ for Scenario D (MES) (NAAQS Limit is 50 µg/m³)

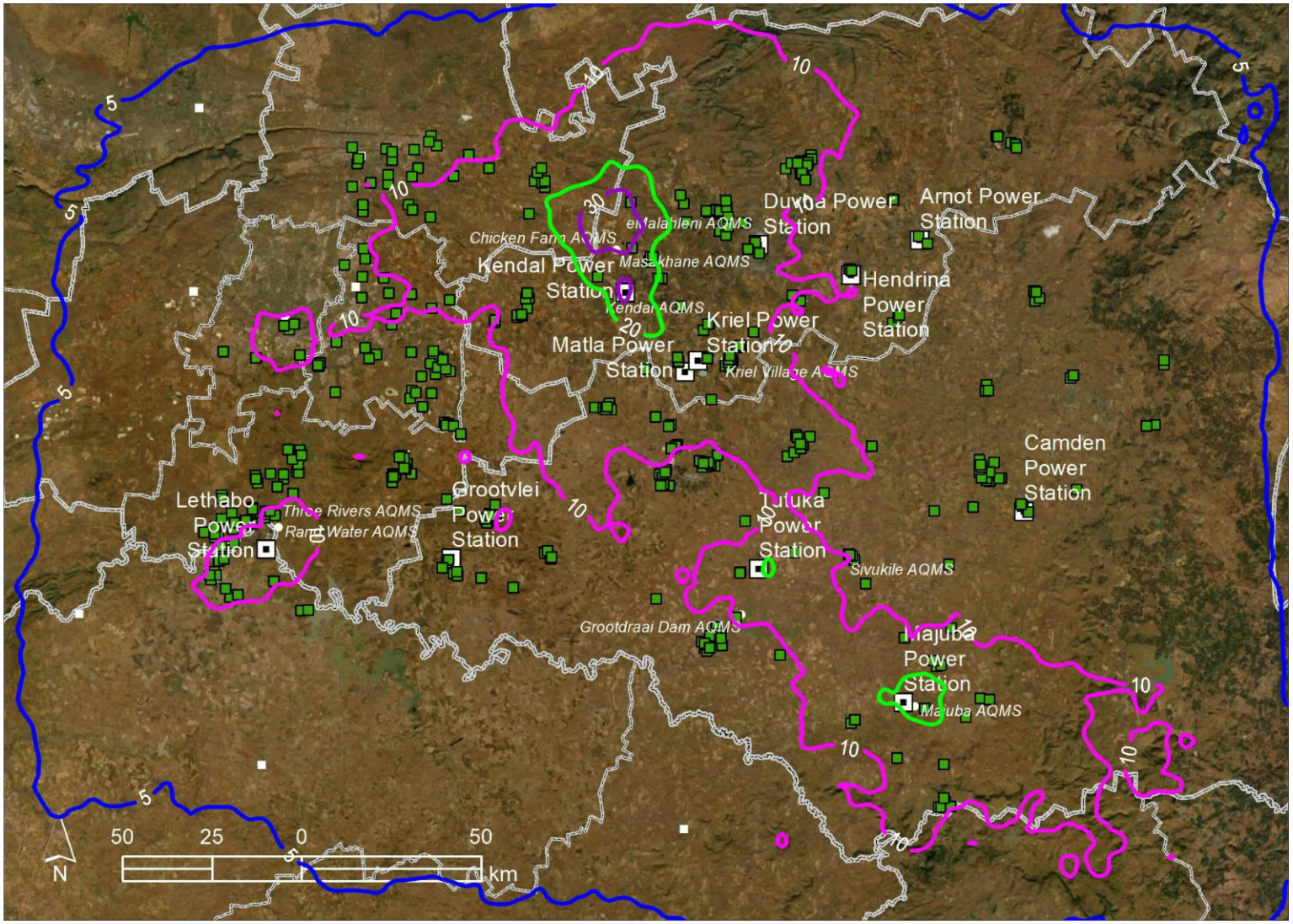


Figure 6-15: Predicted 99th percentile 24-hour SO_2 concentrations in µg/m³ for Scenario D (MES) (NAAQS Limit is 125 µg/m³)

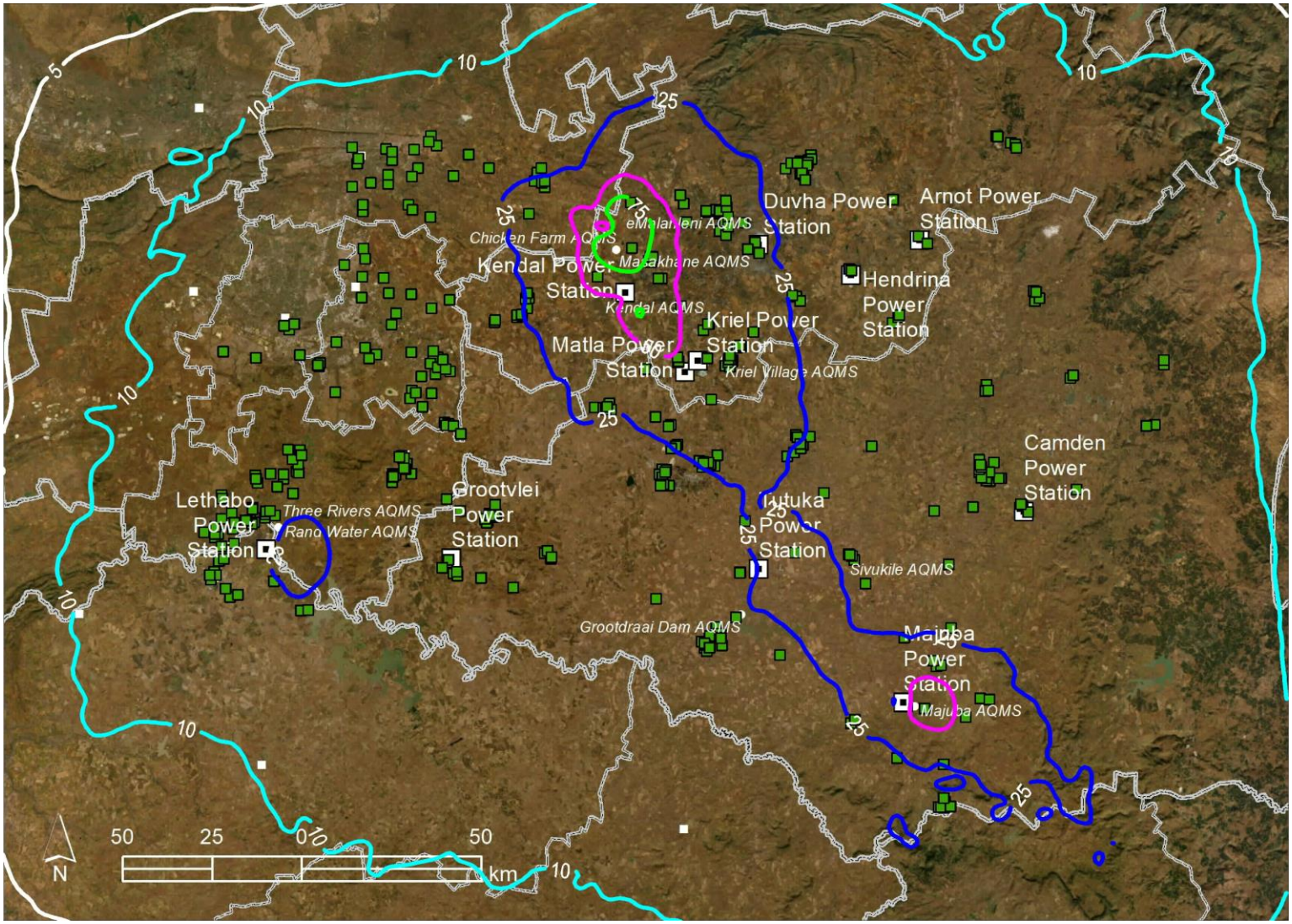


Figure 6-16: Predicted 99th percentile 1-hour SO_2 concentrations in µg/m³ for Scenario D (MES) (NAAQS Limit is 350 µg/m³)

6.2.3.2 Nitrogen dioxide (NO_2)

The isopleth maps showing the predicted annual average NO_2 concentrations clearly demonstrate the effect of the predominant northwesterly winds, with dispersion generally to the southeast across the Highveld and Vaal modelling domain. In all scenarios the highest predicted annual average concentrations occur in a band from the power stations on the central highveld in a southeasterly direction towards Majuba. The predicted annual ambient concentrations are relatively low and are below the NAAQS in all scenarios throughout the modelling domain. Noteworthy is the consistent decrease in predicted ambient concentration with progressive scenarios and the systematic reduction in total NO_X emissions (see in Figure 4-1).

For the 1-hour averaging period, the highest predicted concentrations occur in Scenario A (2025) on the central Highveld where several power stations are relatively close together, then around Lethabo in the southwest, around Majuba in the southeast and around Camden in the east. The effect of the shutdown of Arnot, Camden, Hendrina, Grootvlei, Kriel by 2031 is evident in the isopleth plots for Scenario B (2031) by a marked decrease in the predicted ambient concentrations, with a further reduction in Scenario C (2036).

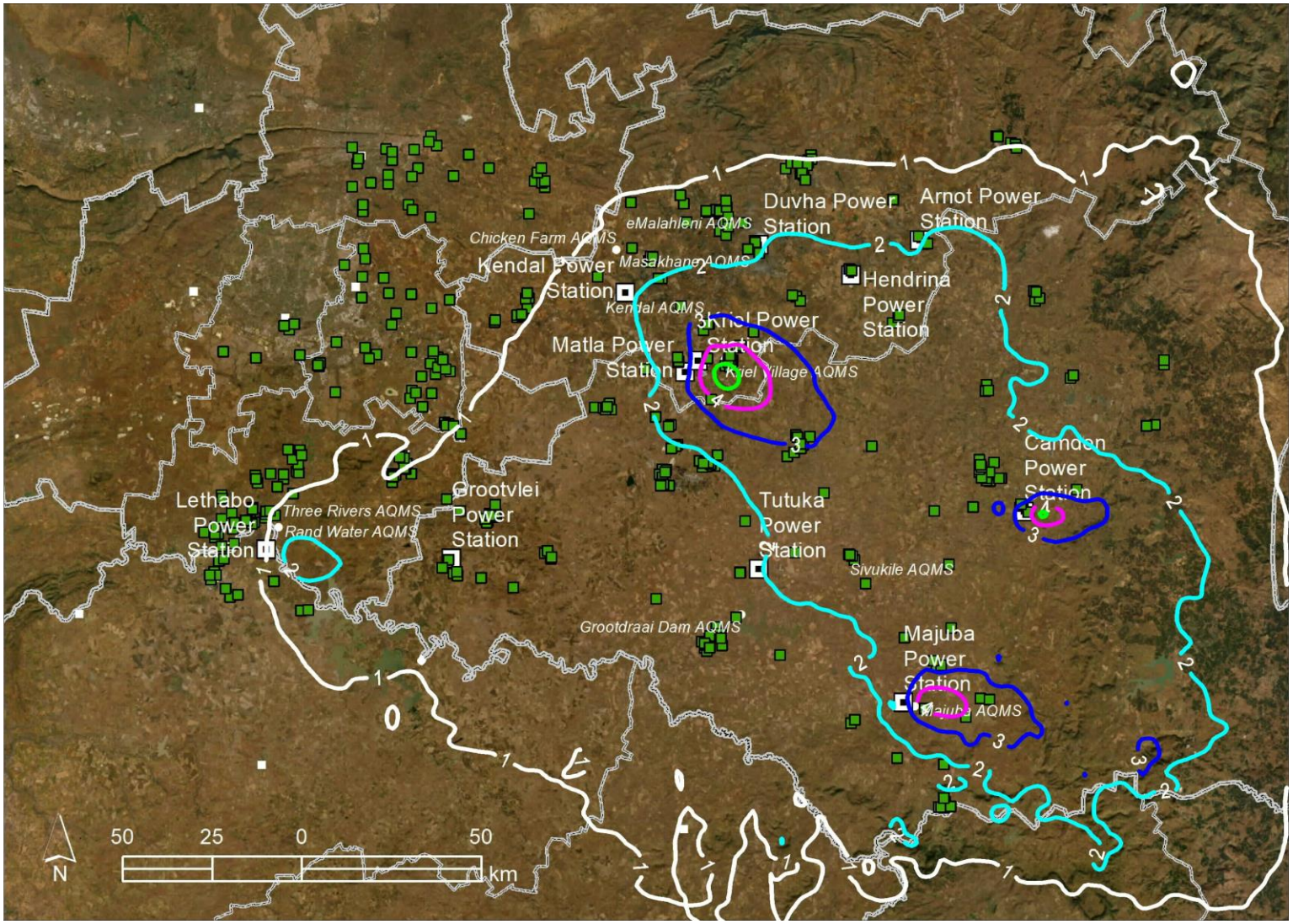


Figure 6-17: Predicted annual average NO_2 concentrations in µg/m³ for Scenario 1 (Current) (NAAQS Limit is 40 µg/m³)

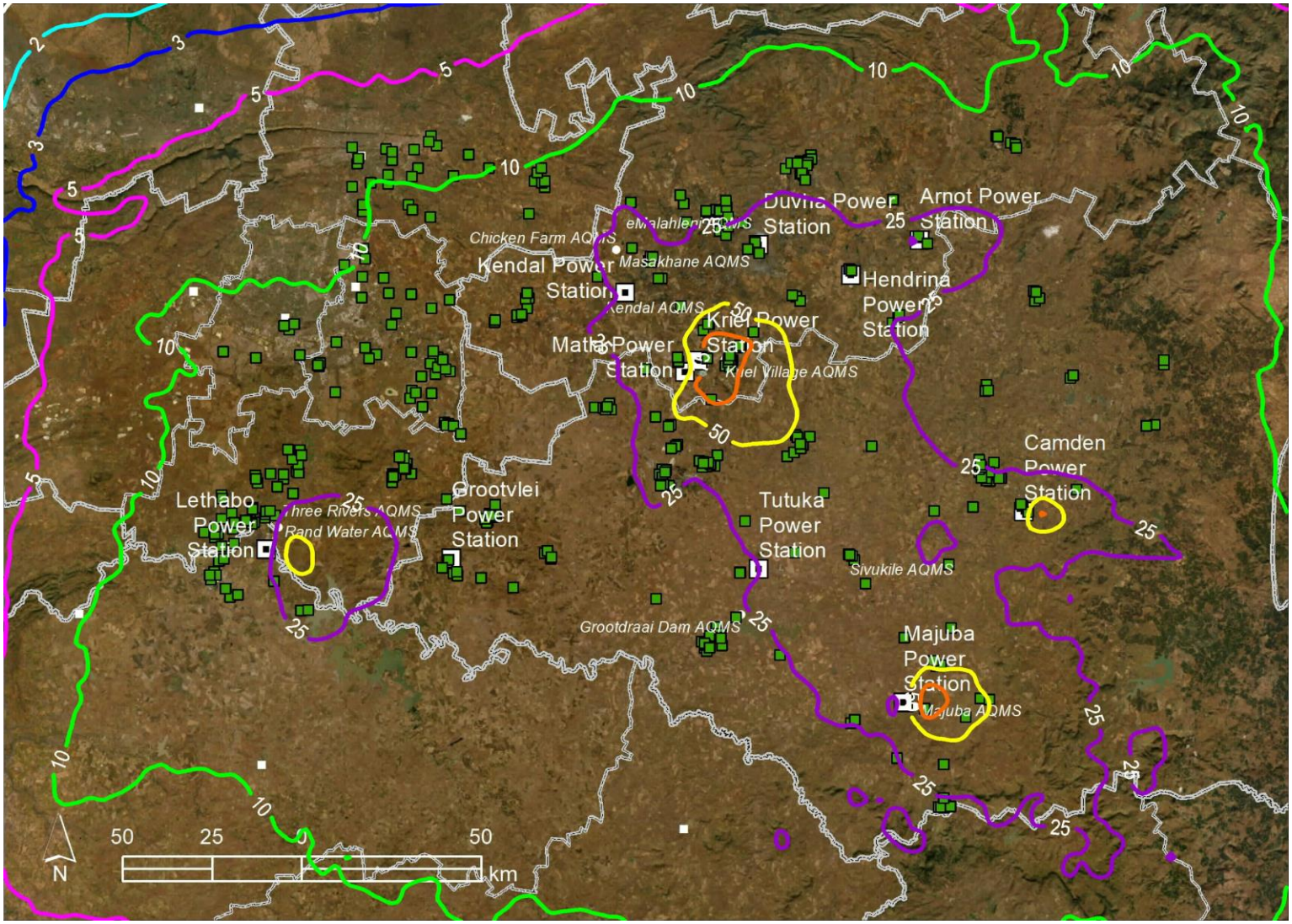


Figure 6-18: Predicted 99th percentile 1-hour NO_2 concentrations in µg/m³ for Scenario 1 (Current) (NAAQS Limit is 200 µg/m³)

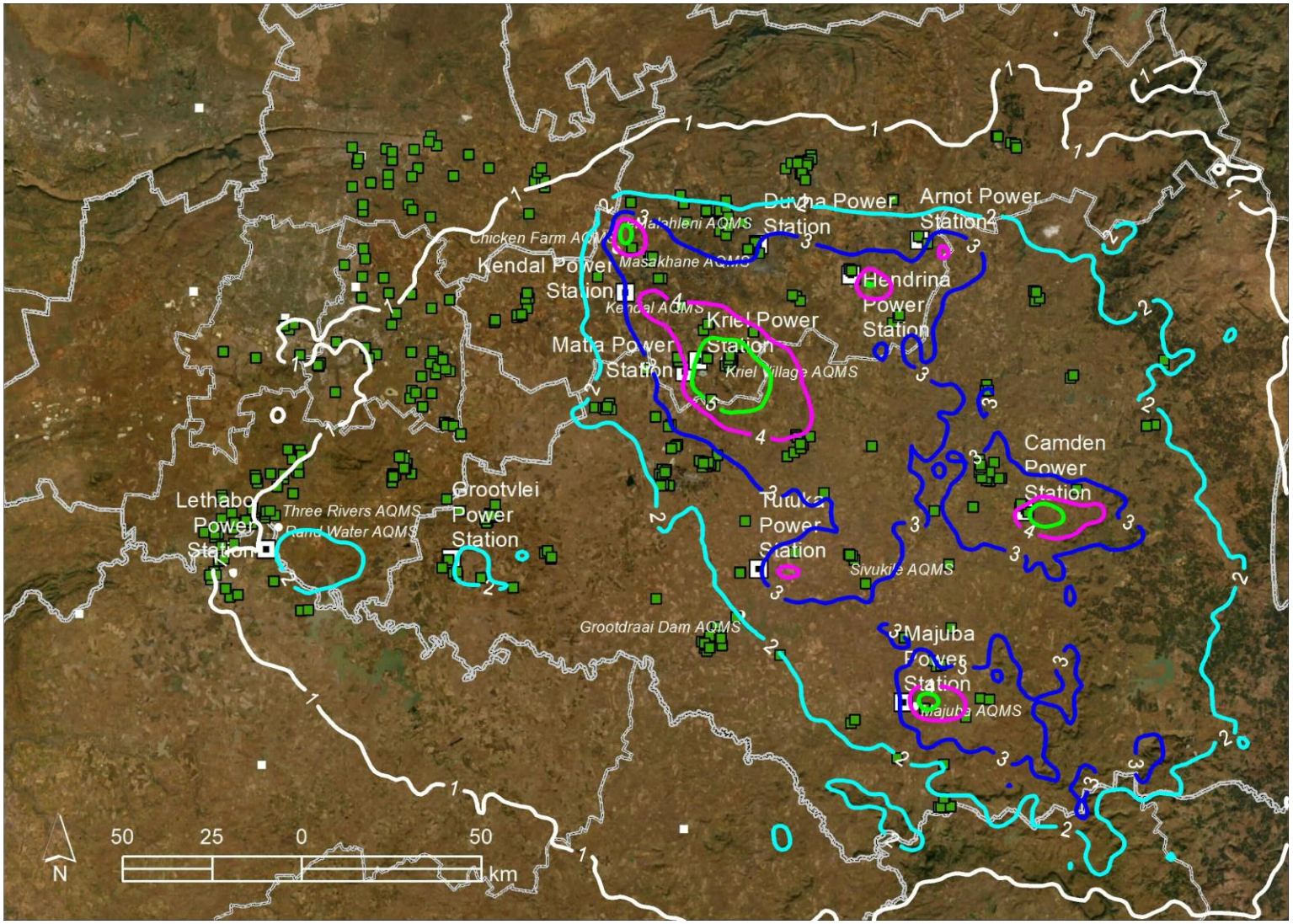


Figure 6-19: Predicted annual average NO_2 concentrations in µg/m³ for Scenario A (2025) (NAAQS Limit is 40 µg/m³)

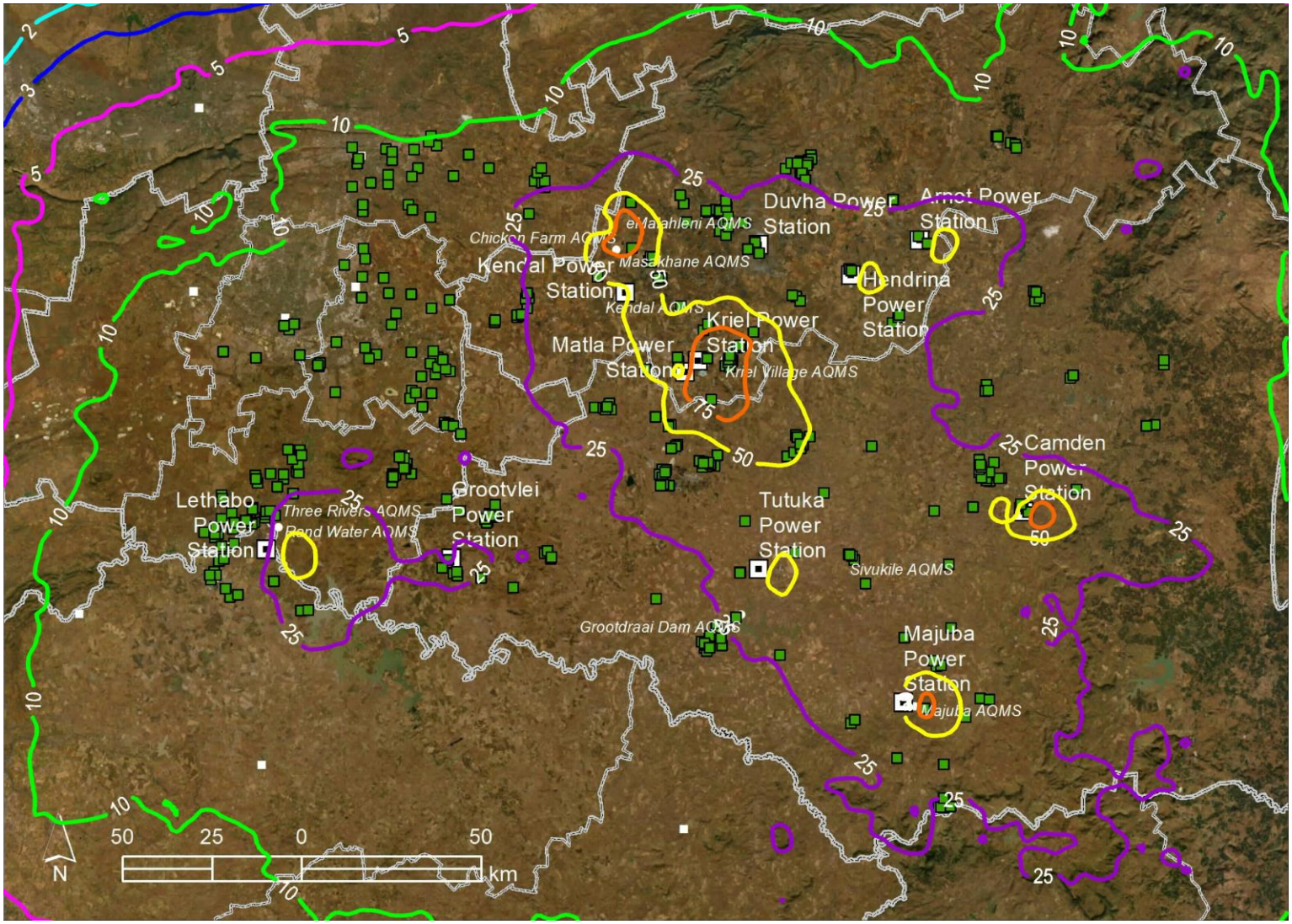


Figure 6-20: Predicted 99th percentile 1-hour NO_2 concentrations in µg/m³ for Scenario A (2025) (NAAQS Limit is 200 µg/m³)

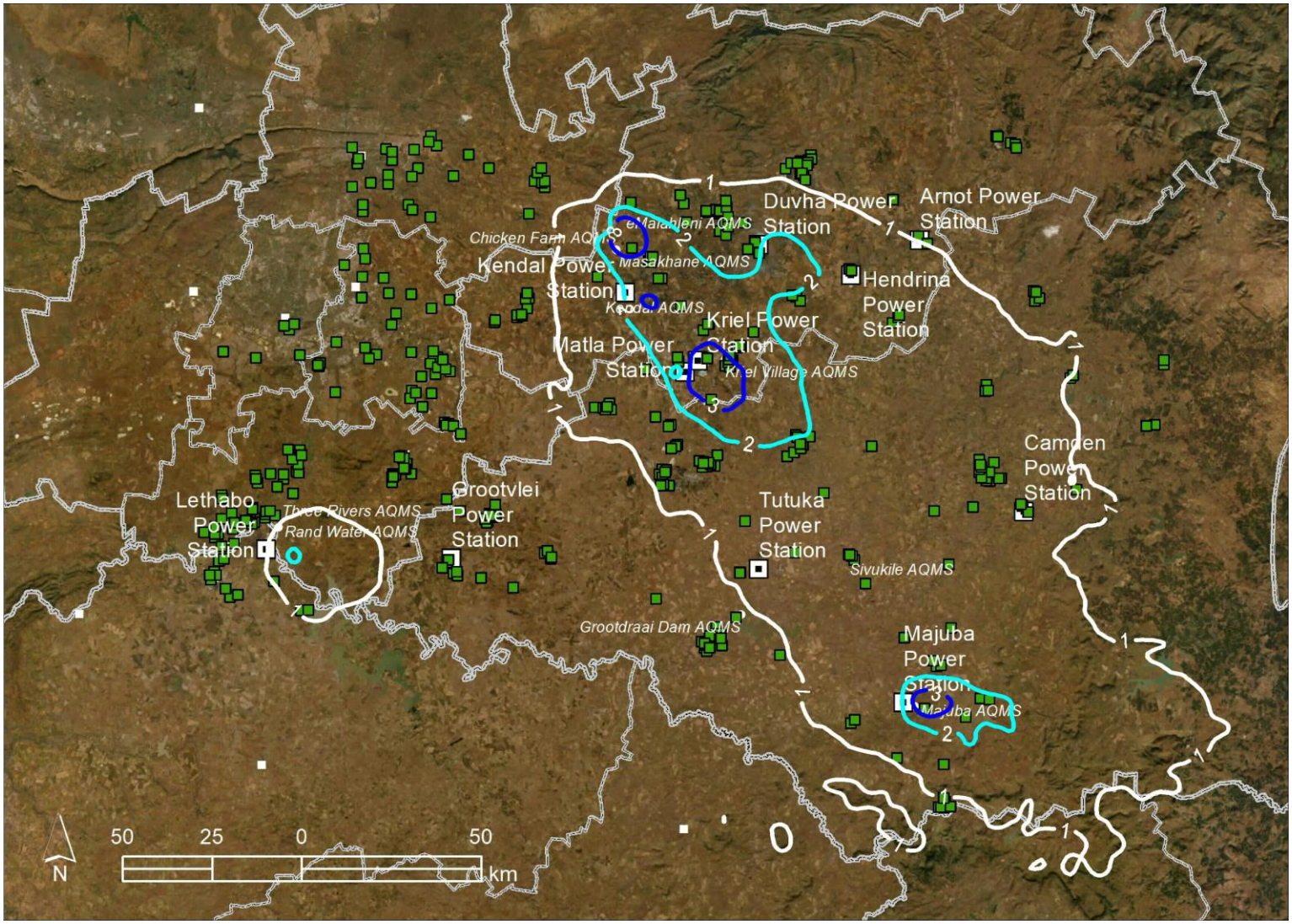


Figure 6-21: Predicted annual average NO_2 concentrations in µg/m³ for Scenario B (2031) (NAAQS Limit is 40 µg/m³)

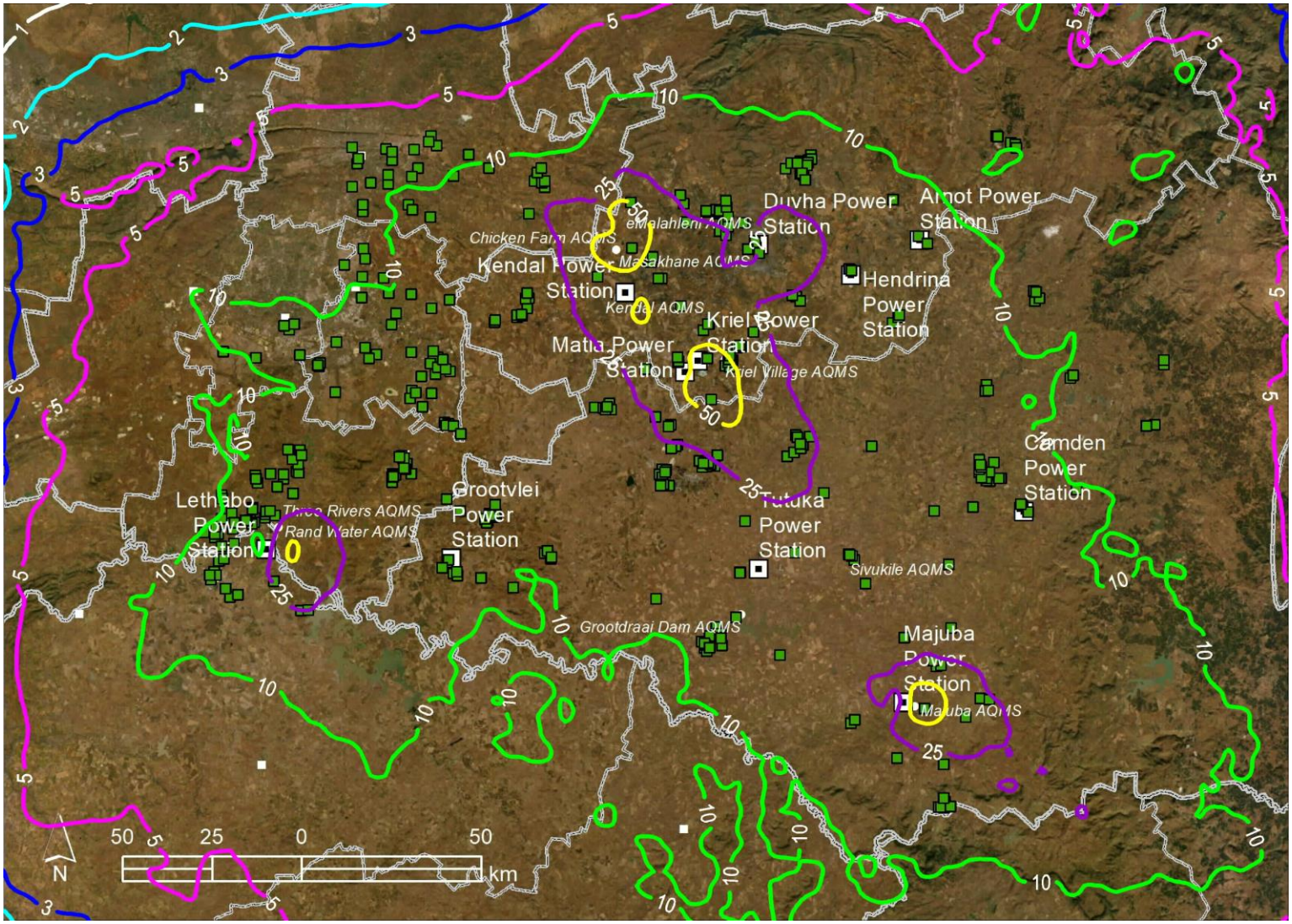


Figure 6-22: Predicted 99th percentile 1-hour NO_2 concentrations in µg/m³ for Scenario B (2031) (NAAQS Limit is 200 µg/m³)

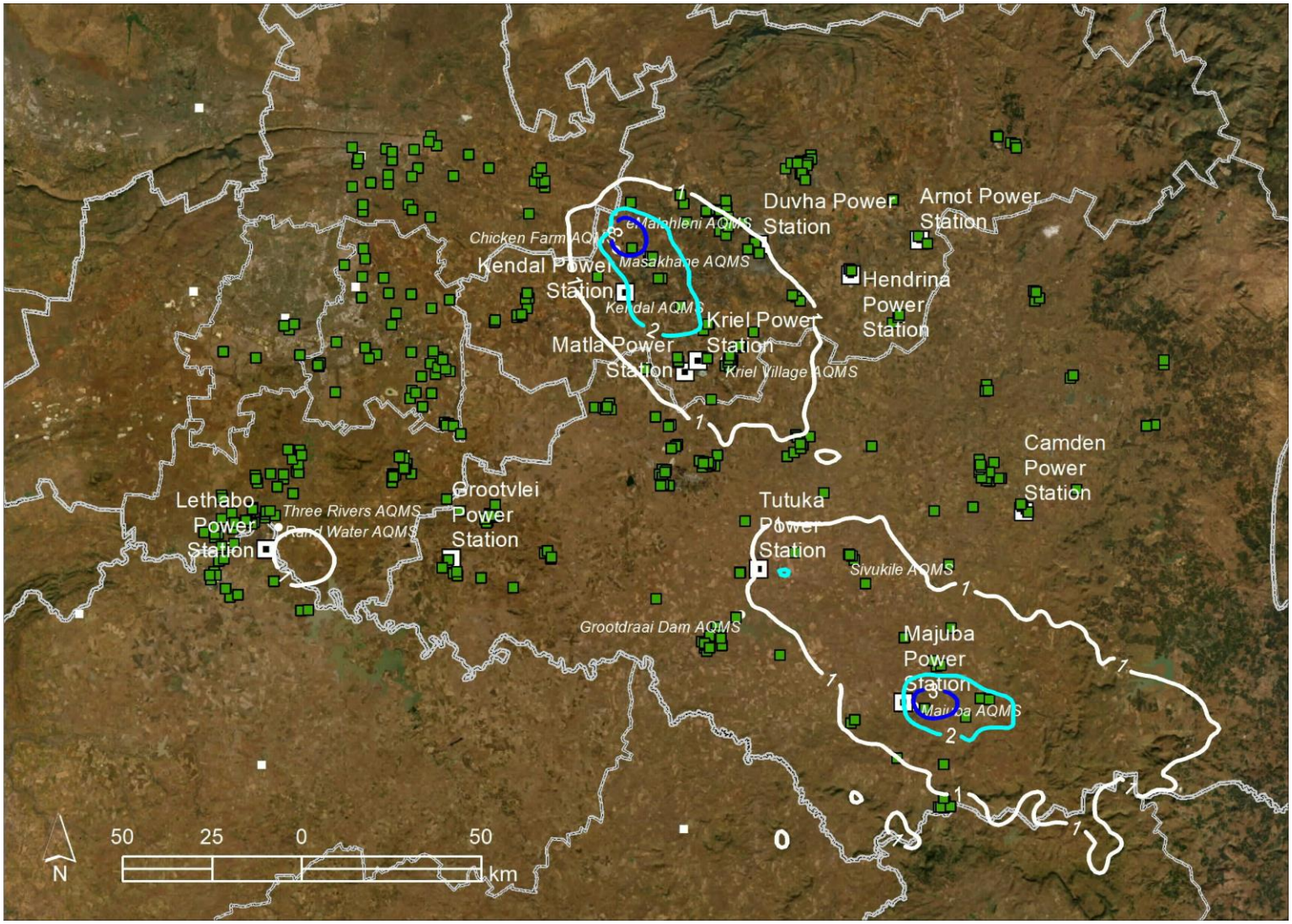


Figure 6-23: Predicted annual average NO_2 concentrations in µg/m³ for Scenario C (2036) (NAAQS Limit is 40 µg/m³)

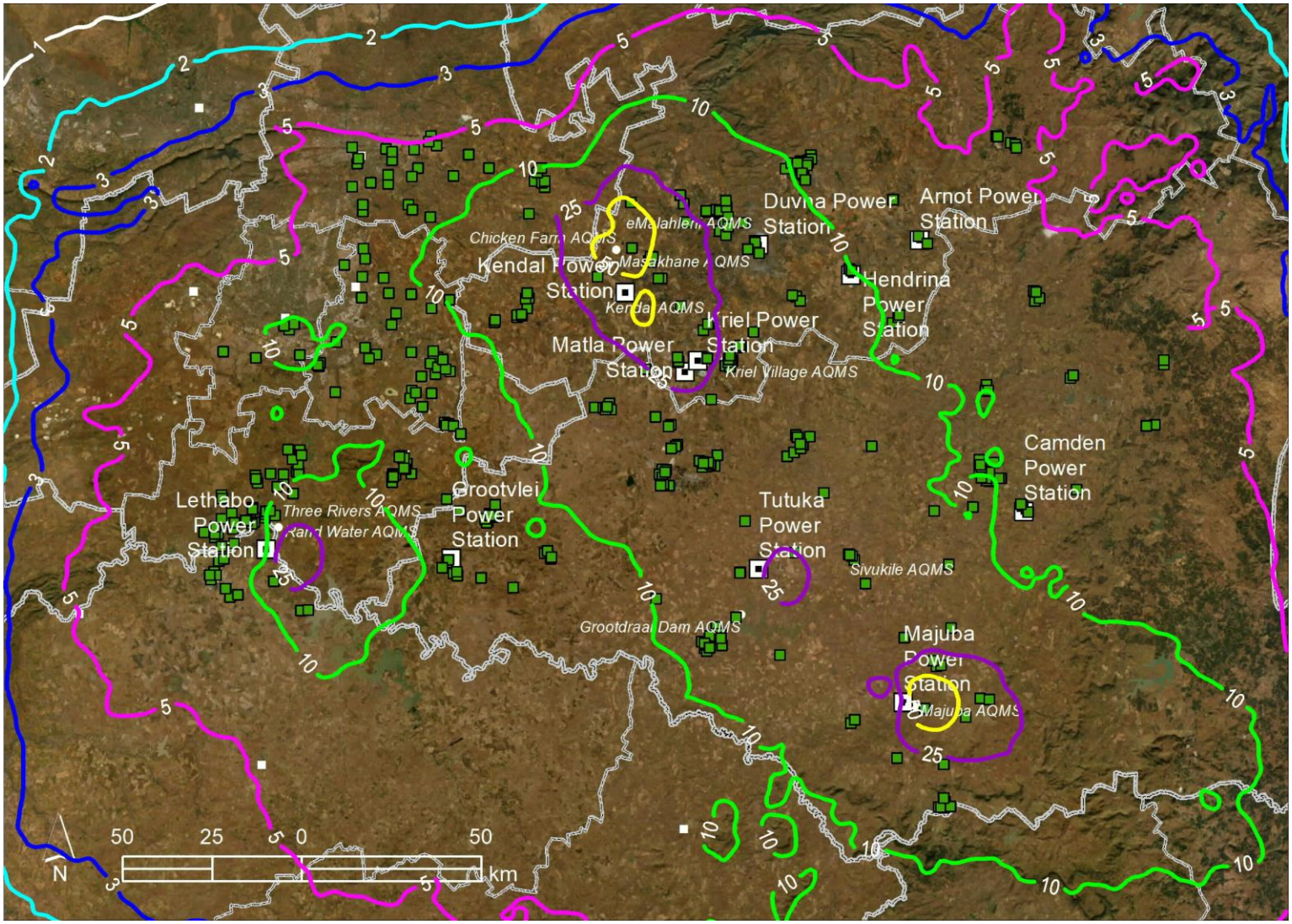


Figure 6-24: Predicted 99th percentile 1-hour NO_2 concentrations in µg/m³ for Scenario C (2036) (NAAQS Limit is 200 µg/m³)

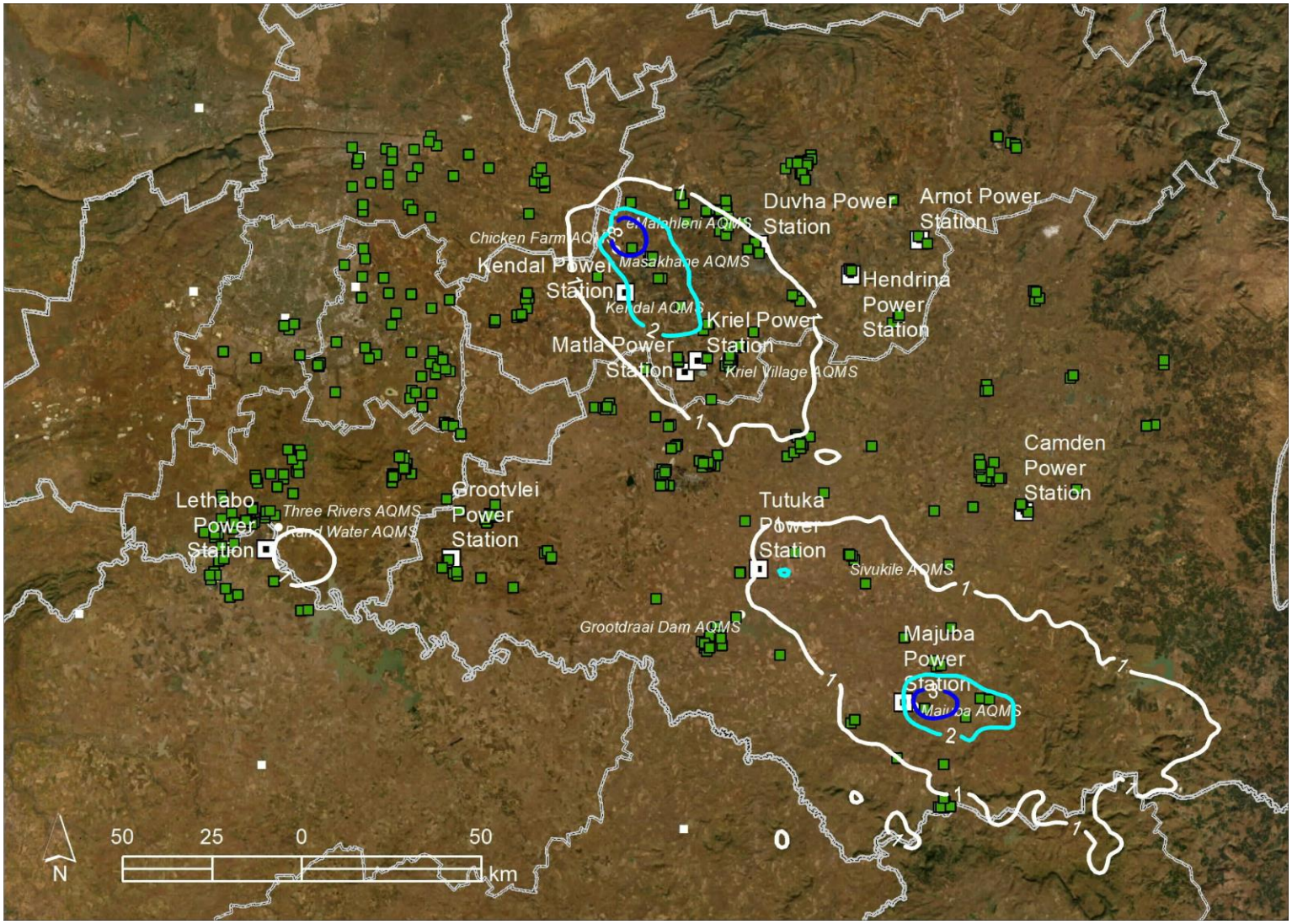


Figure 6-25: Predicted annual average NO_2 concentrations in µg/m³ for Scenario D (MES) (NAAQS Limit is 40 µg/m³)

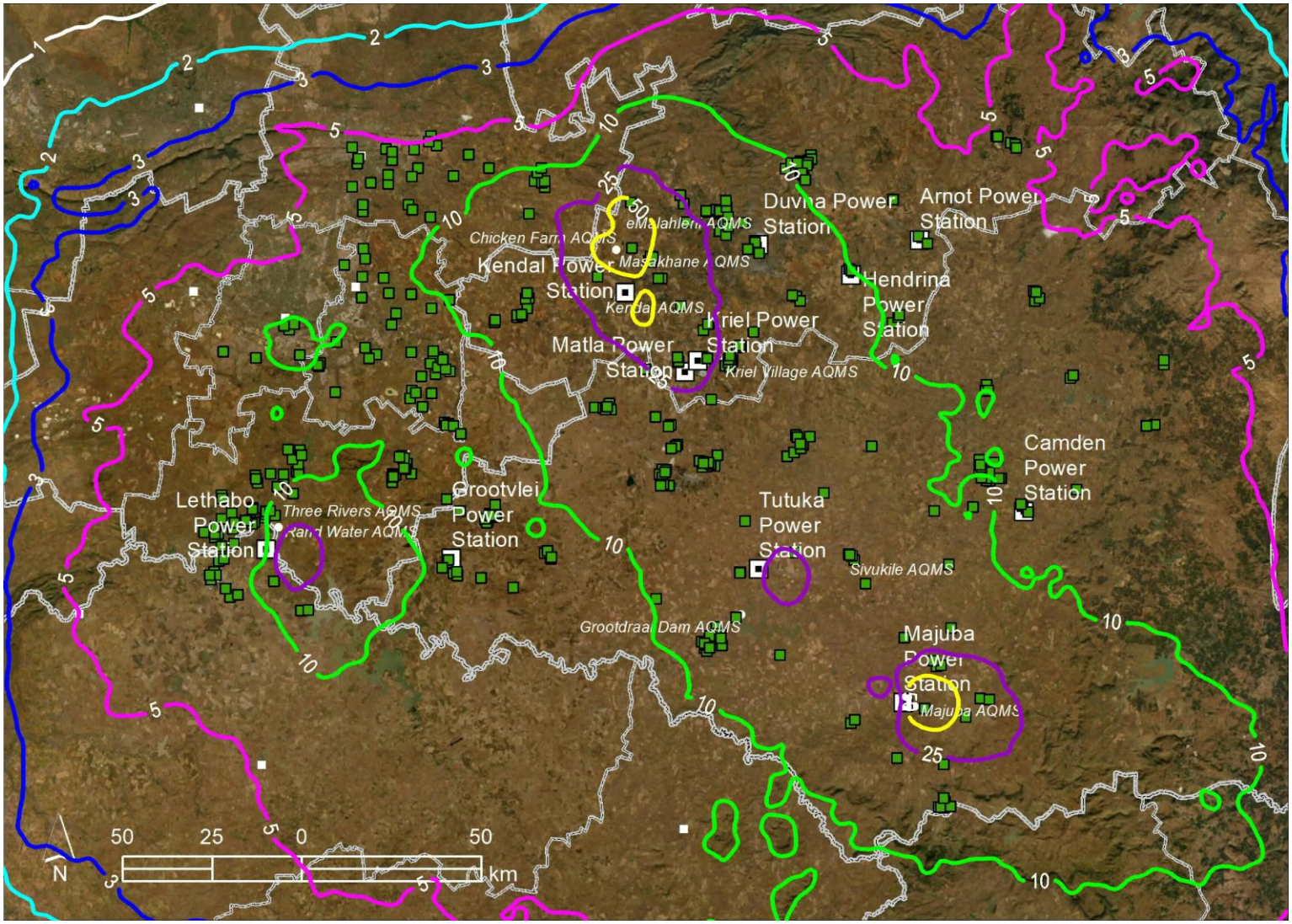


Figure 6-26: Predicted 99th percentile 1-hour NO_2 concentrations in µg/m³ for Scenario D (MES) (NAAQS Limit is 200 µg/m³)

6.2.3.3 Particulates (PM_{10})

The isopleth plots for PM_{10} are similar for all the scenarios due to the significant contribution of the low-level fugitive sources to the ambient concentrations. The fugitive emission from the coal yards and the ash dumps impact on ambient concentrations close to the source, resulting in the highest concentrations around the individual power stations. Noticeable is the effect of the shutdown of Arnot, Camden, Hendrina, Grootvlei, Kriel by 2031 on the isopleths for Scenario B (2031).

The predicted annual average concentrations exceed the NAAQS of 40 µg/m^3 in two small area on the central Highveld in Scenario 1 (Current), Scenario A (2025) and Scenario B (2031), with reductions seen in the subsequent scenarios as a result of the shutdowns. The biggest reductions are seen from Scenario A (2025) to Scenario B (2031) which considers station shutdowns, as well as completion of PM abatement projects.

The area where the predicted 24-hour concentrations exceed the limit value of 75 µg/m^3 (shaded area) is evident around all the power stations in Scenario 1 (Current) and Scenario A (2025) and Scenario B (2031) followed by a reduction in Scenario C (2036). A number of sensitive receptors are located in the areas where the NAAQS are exceeded.

It must be remembered that the predictions are conservative given the assumption that TPM = PM_{10} = $PM_{2.5}$. Remembering too that the fugitive emission have the greatest effect on ambient concentrations close to the source as a result of assumptions concerning the ash dump emissions (Section 2.6), while the effect of the stack emissions is generally further from the power station.

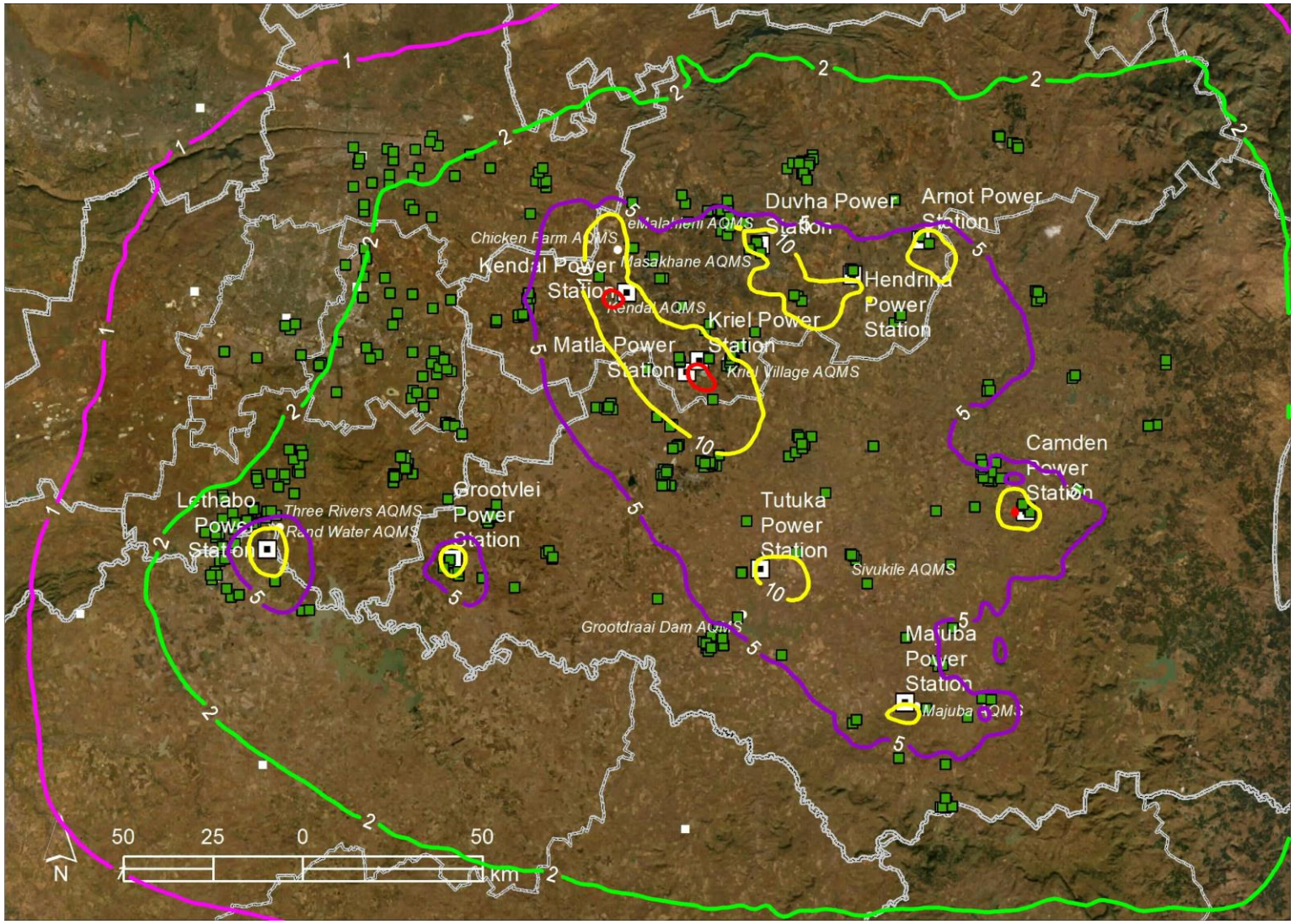


Figure 6-27: Predicted annual average PM_{10} concentrations in µg/m³ for Scenario 1 (Current) (NAAQS Limit is 40 µg/m³)

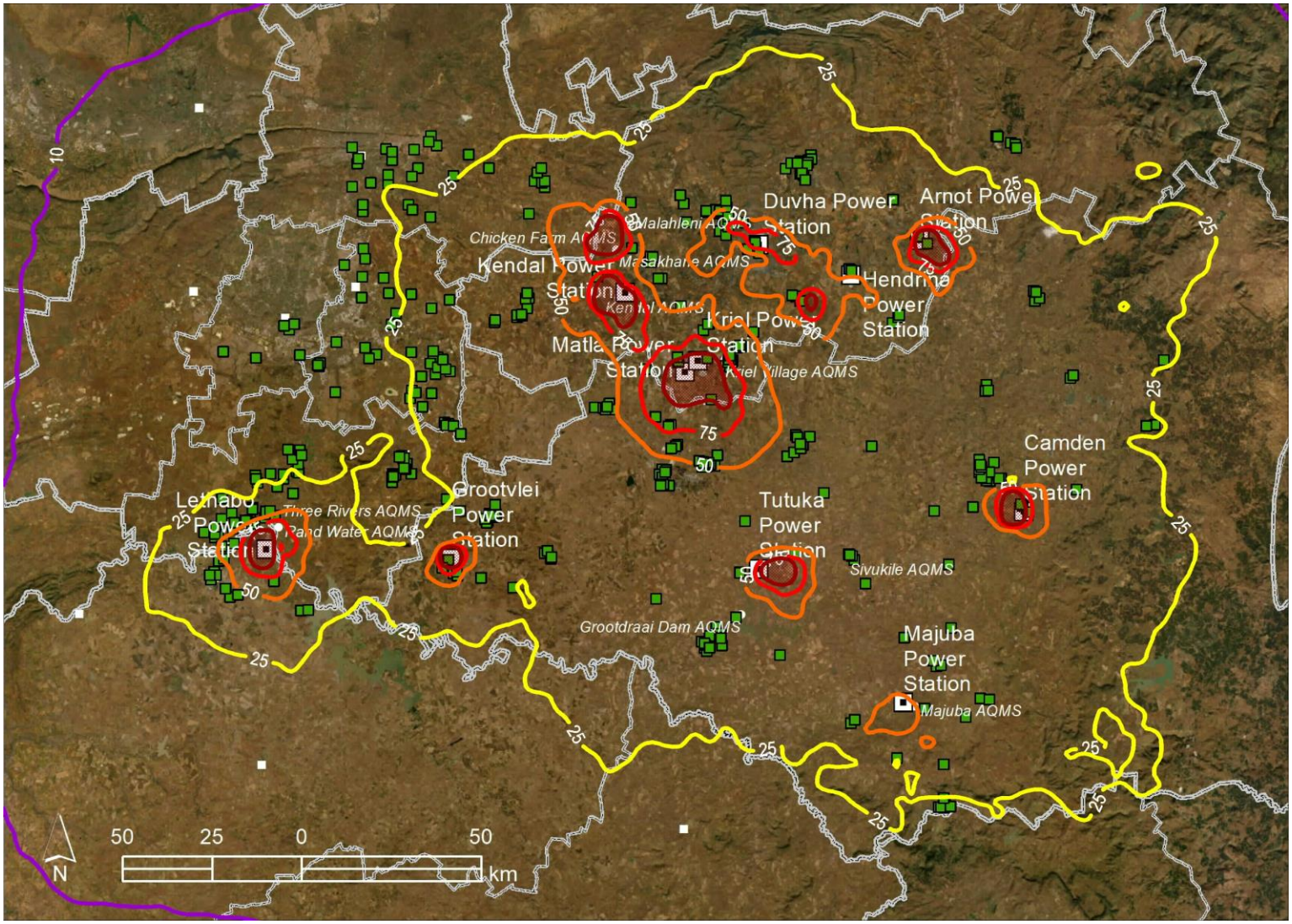


Figure 6-28: Predicted 99th percentile of the 24-hour PM_{10} concentrations in µg/m³ for Scenario 1 (Current) (NAAQS Limit is 75 µg/m³)

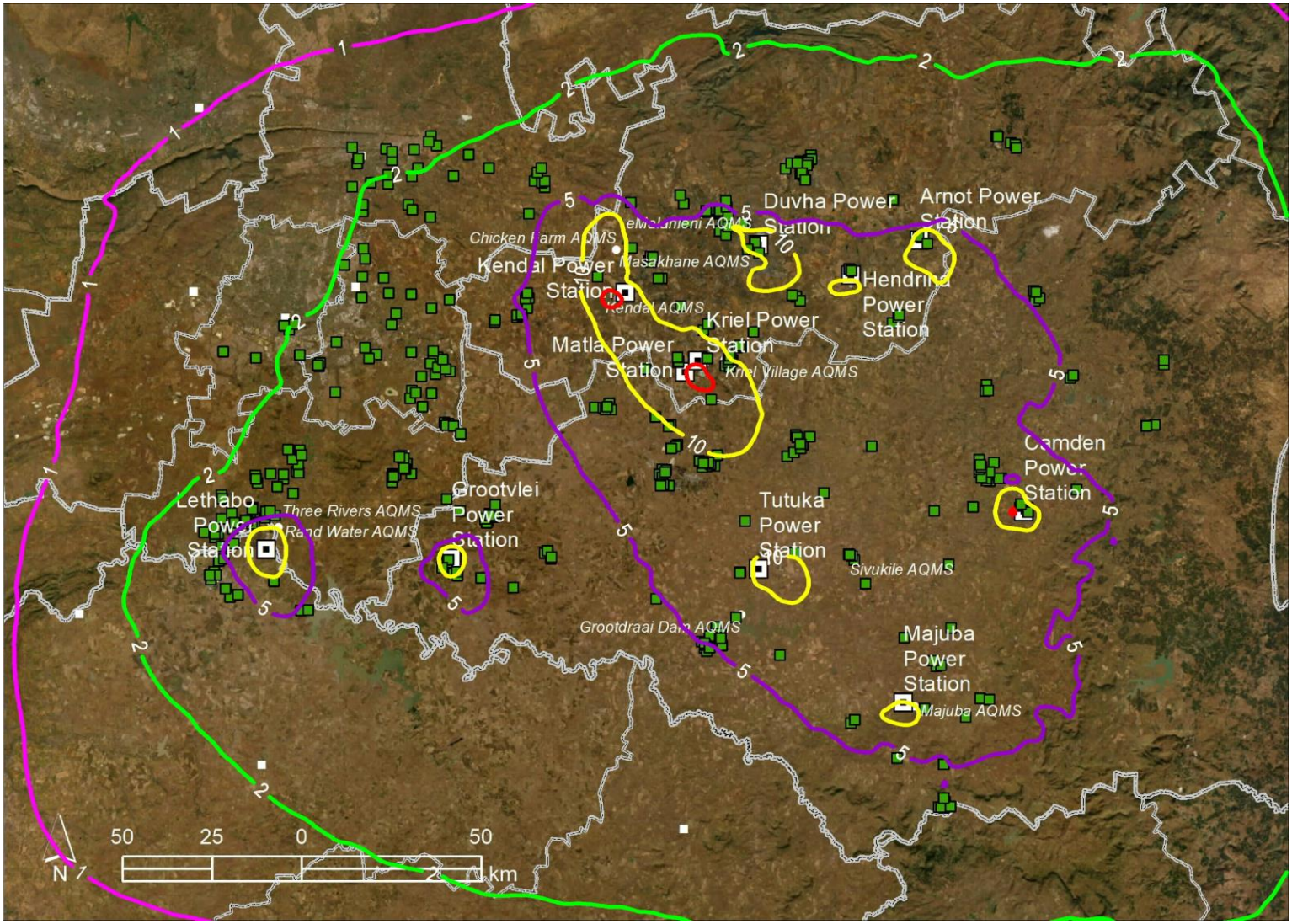


Figure 6-29: Predicted annual average PM_{10} concentrations in µg/m³ for Scenario A (2025) (NAAQS Limit is 40 µg/m³)

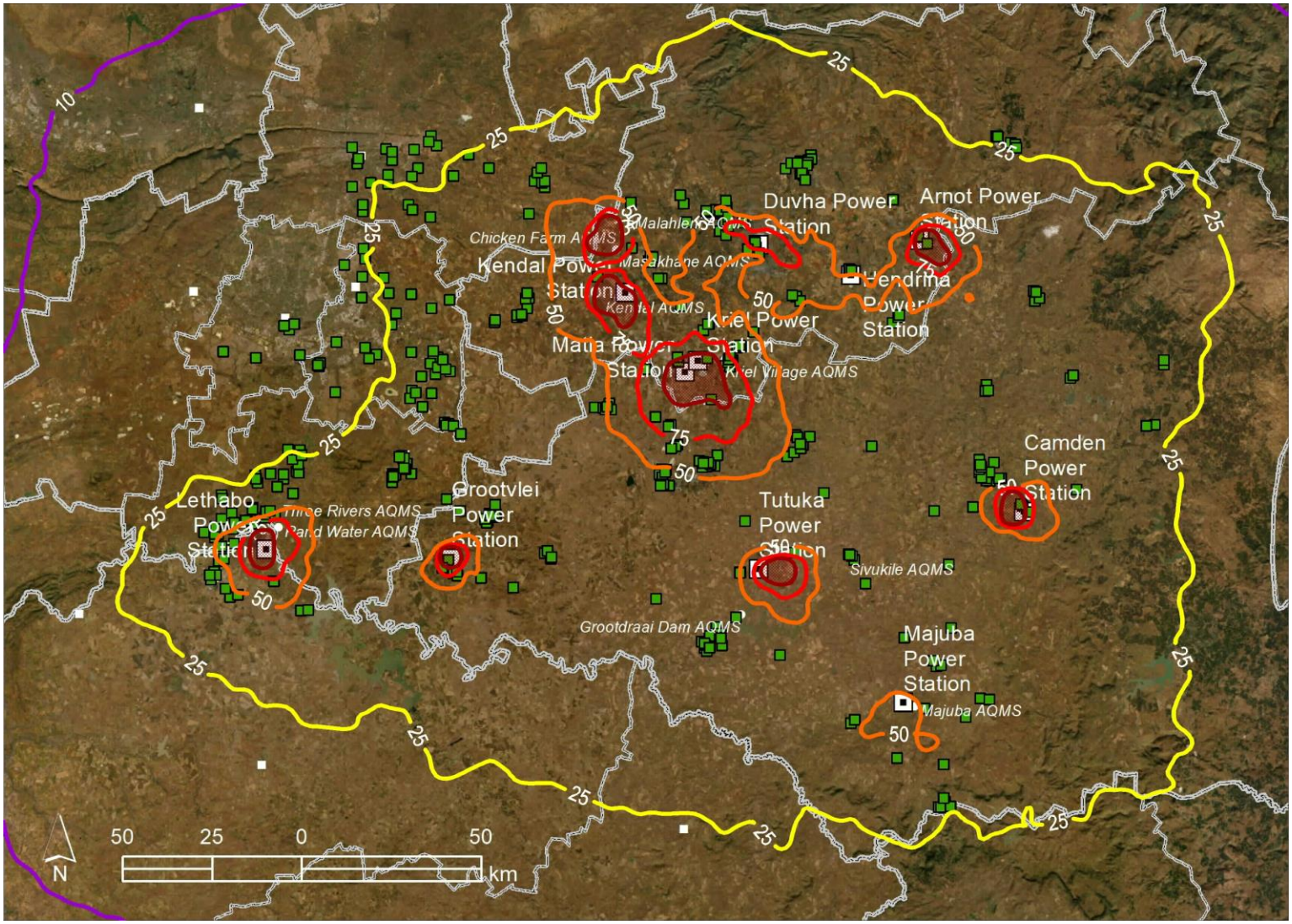


Figure 6-30: Predicted 99th percentile of the 24-hour PM_{10} concentrations in µg/m³ for Scenario A (2025) (NAAQS Limit is 75 µg/m³)

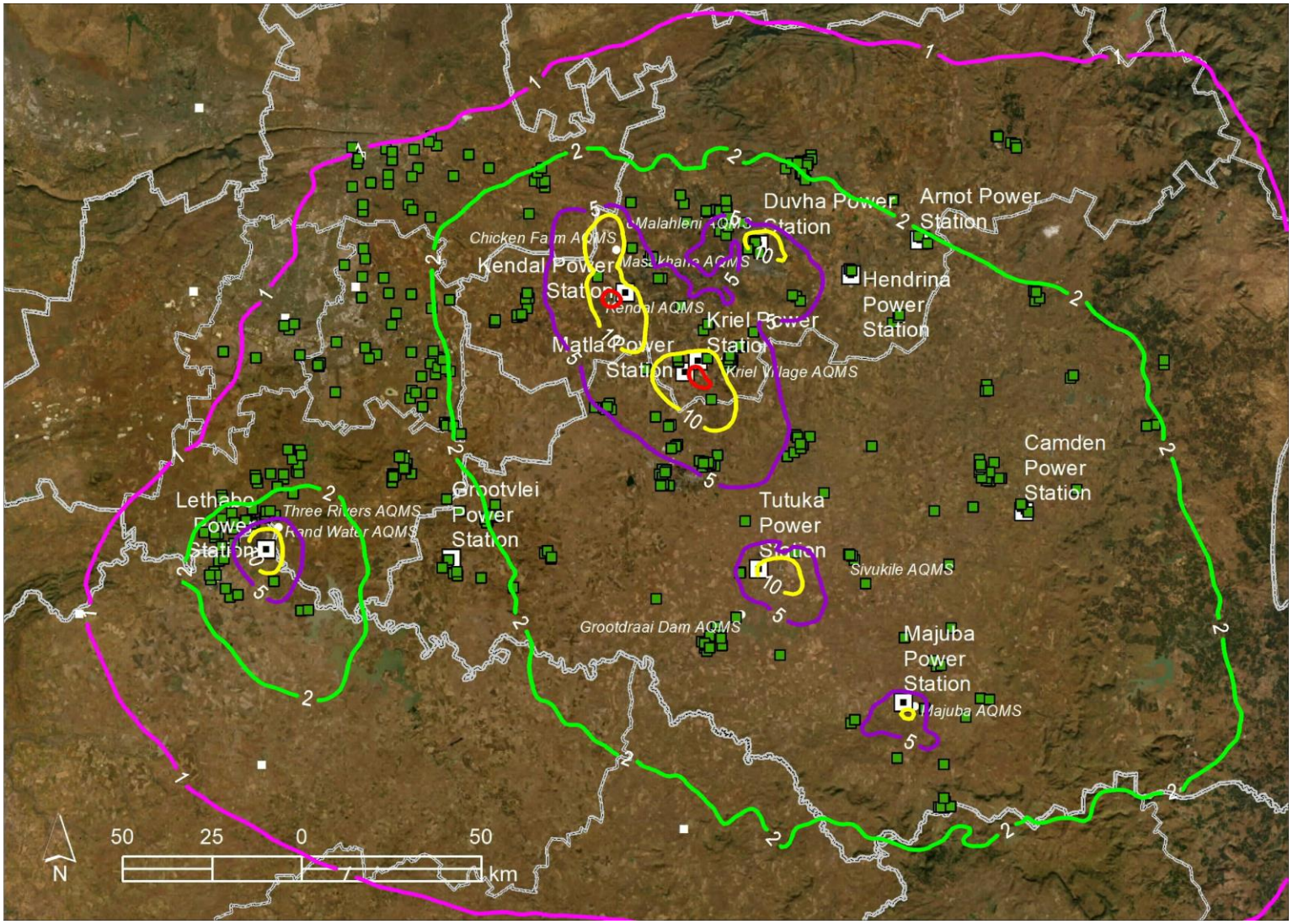


Figure 6-31: Predicted annual average PM_{10} concentrations in µg/m³ for Scenario B (2031) (NAAQS Limit is 40 µg/m³)

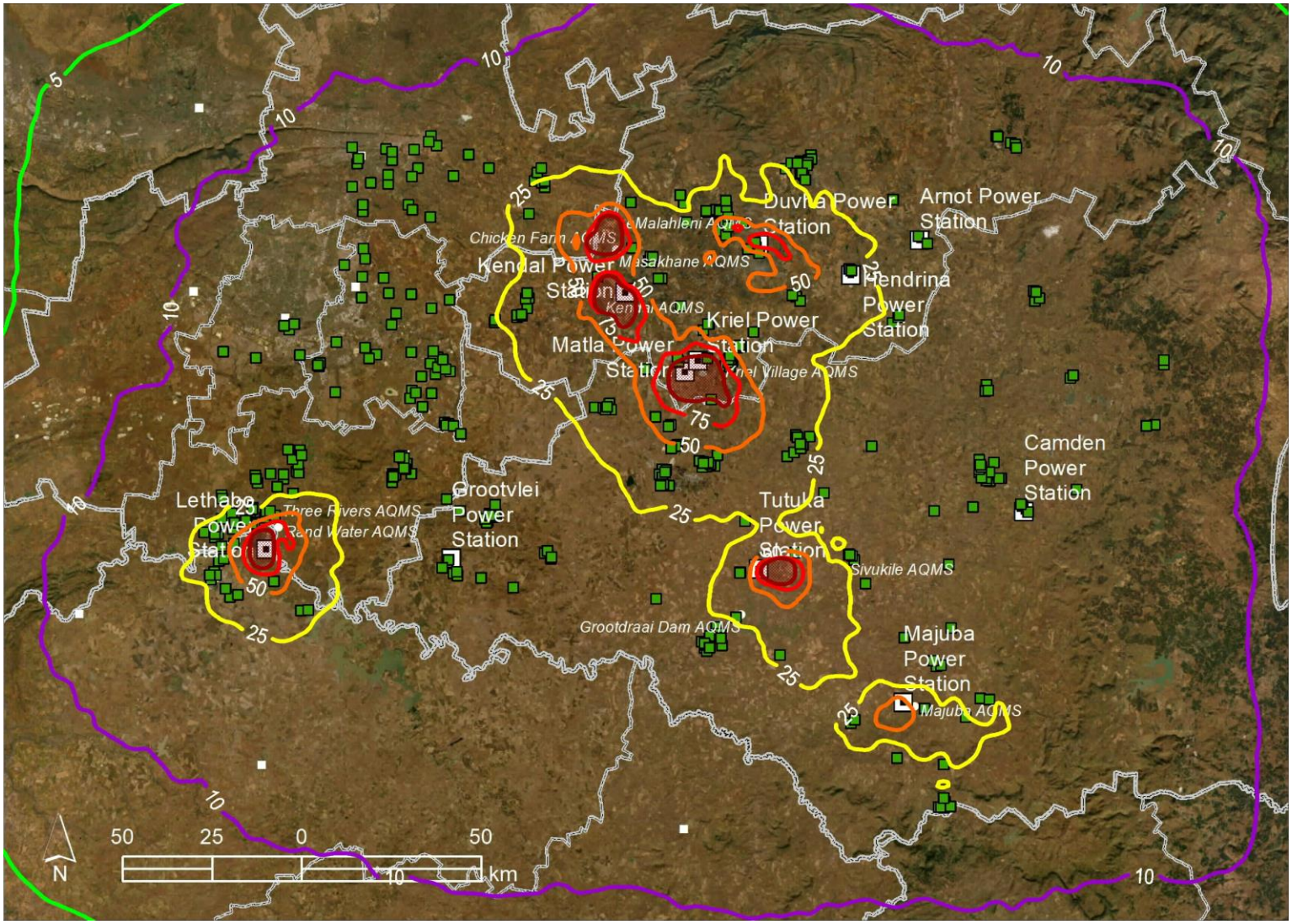


Figure 6-32: Predicted 99th percentile of the 24-hour PM_{10} concentrations in µg/m³ for Scenario B (2031) (NAAQS Limit is 75 µg/m³)

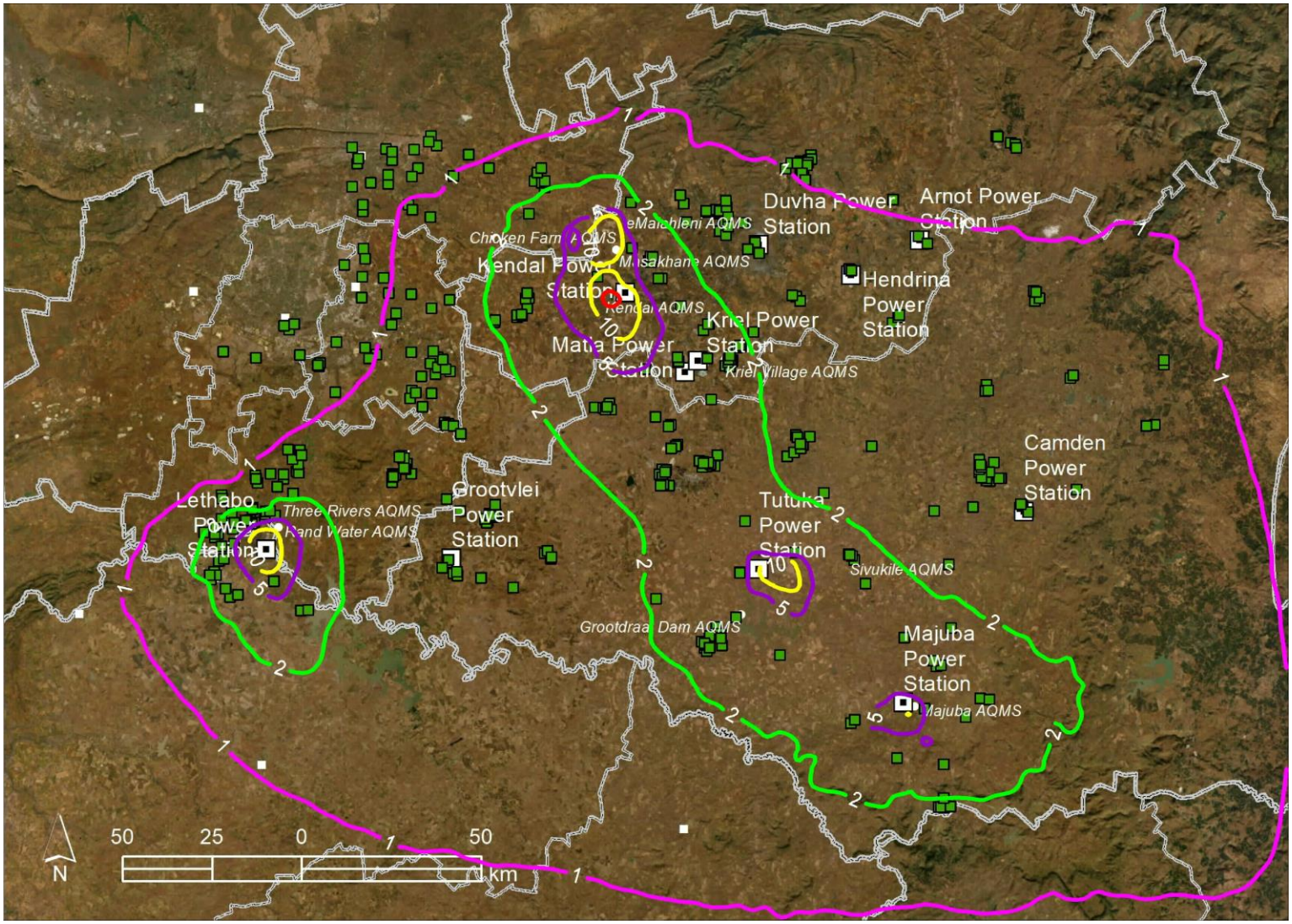


Figure 6-33: Predicted annual average PM_{10} concentrations in µg/m³ for Scenario C (2036) (NAAQS Limit is 40 µg/m³)

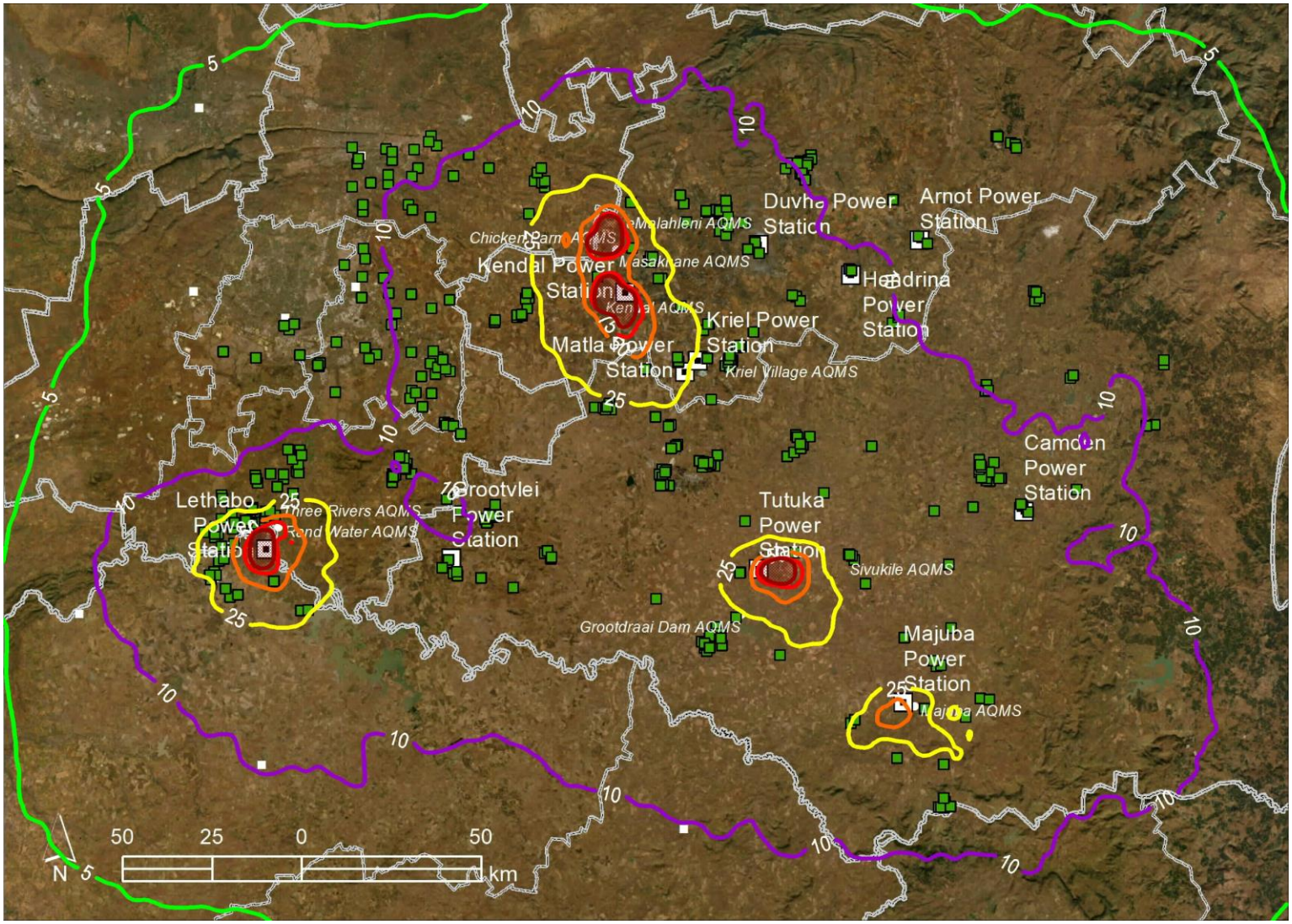


Figure 6-34: Predicted 99th percentile of the 24-hour PM_{10} concentrations in µg/m³ for Scenario C (2036) (NAAQS Limit is 75 µg/m³)

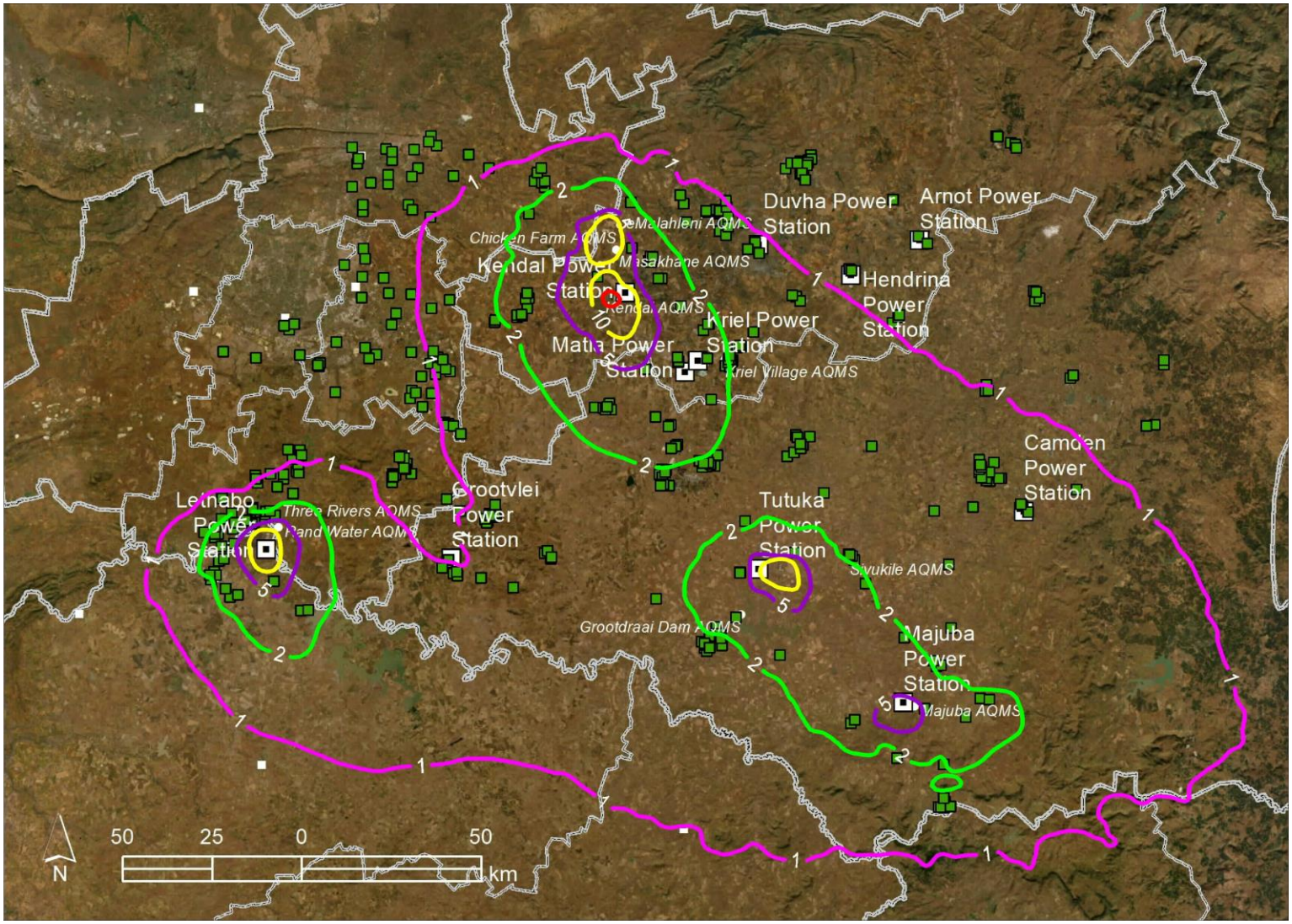


Figure 6-35: Predicted annual average PM_{10} concentrations in µg/m³ for Scenario D (MES) (NAAQS Limit is 40 µg/m³)

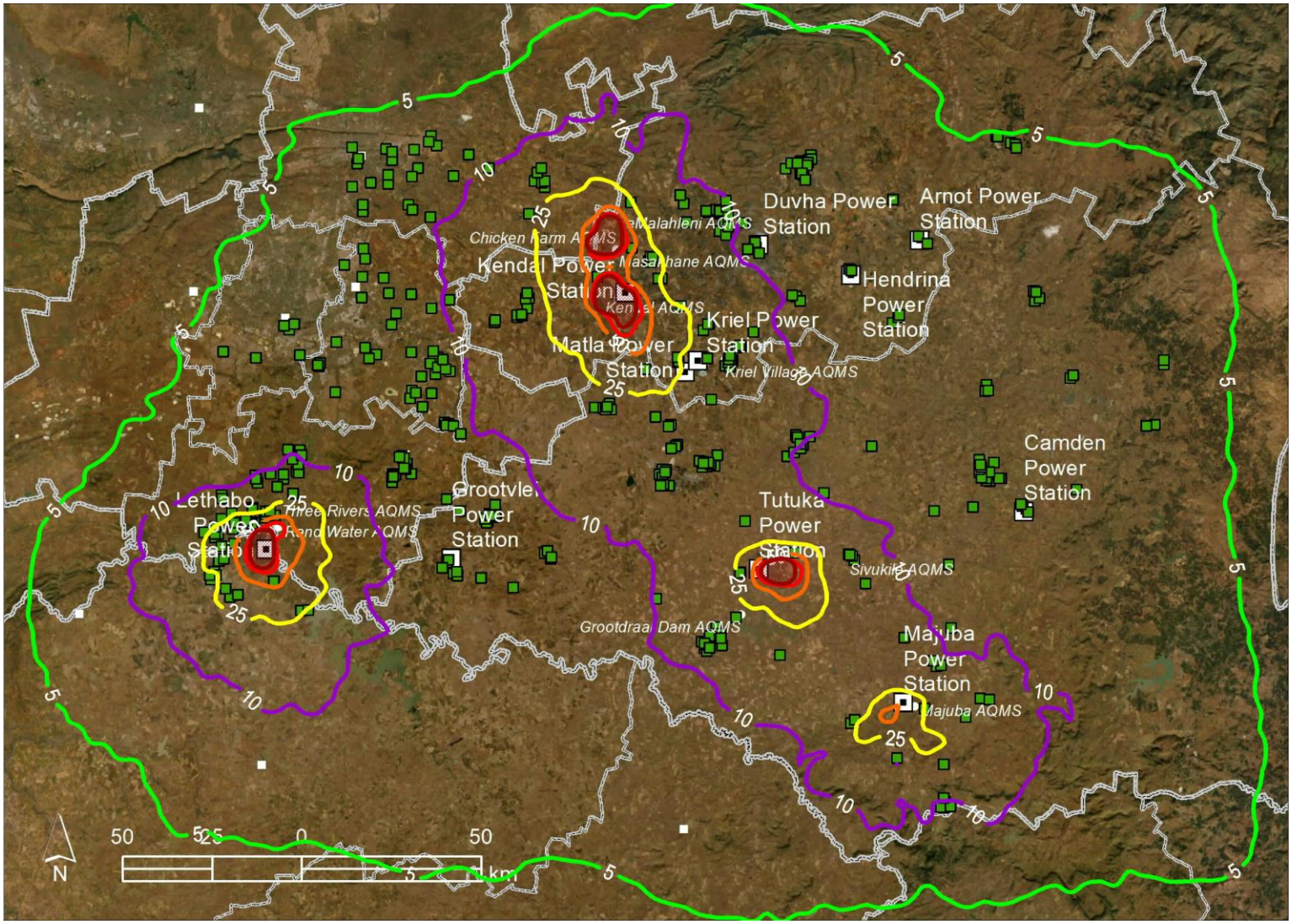


Figure 6-36: Predicted 99th percentile of the 24-hour PM_{10} concentrations in µg/m³ for Scenario D (MES) (NAAQS Limit is 75 µg/m³)

6.2.3.4 Particulates ($PM_{2.5}$)

The isopleth plots for $PM_{2.5}$ are similar for all scenarios due to the significant contribution of the low-level fugitive sources to the ambient concentrations. The fugitive emission from the coal yards and the ash dumps impact on ambient concentrations close to the source, resulting in the highest concentrations around the individual power stations. Noticeable is the effect of the shutdown of Arnot, Camden, Hendrina, Kriel by 2031 on the isopleths for Scenario B (2031).

The predicted annual average concentrations exceed the NAAQS of 20 µg/ around the individual power stations in Scenario 1 (Current) and Scenario A (2025), with reductions seen in the subsequent scenarios as a result of the shut downs. The biggest reductions are seen from Scenario A (2025) to Scenario B (2031) which considers station shutdowns, as well as completion of PM abatement projects.

The area where the predicted 24-hour concentrations exceed the limit value of 40 $\mu g/m^3$ (shaded area) is evident around all the operational power stations. The area is larger than for PM_{10} due the more stringent NAAQS being applied for $PM_{2.5.}$ In all scenarios a number of sensitive receptors are located in the areas where the NAAQS are exceeded in Scenario 1 (Current) and Scenario A (2025) when the limit value of the NAAQS of 25 $\mu g/m^3$ applies. There is an increase in the number of receptor points where the limit value is exceeded in Scenario B (2031), Scenario C (2036) and Scenario D (MES) when a limit value of 25 $\mu g/m^3$ is in force.

It must be remembered that the predictions are conservative given the assumption that TPM = PM_{10} = $PM_{2.5}$. Remembering too that the fugitive emission have the greatest effect on ambient concentrations close to the source as a result of the assumptions concerning the ash dump emissions (Section 2.6), while the effect of the stack emissions is generally further from the power station.

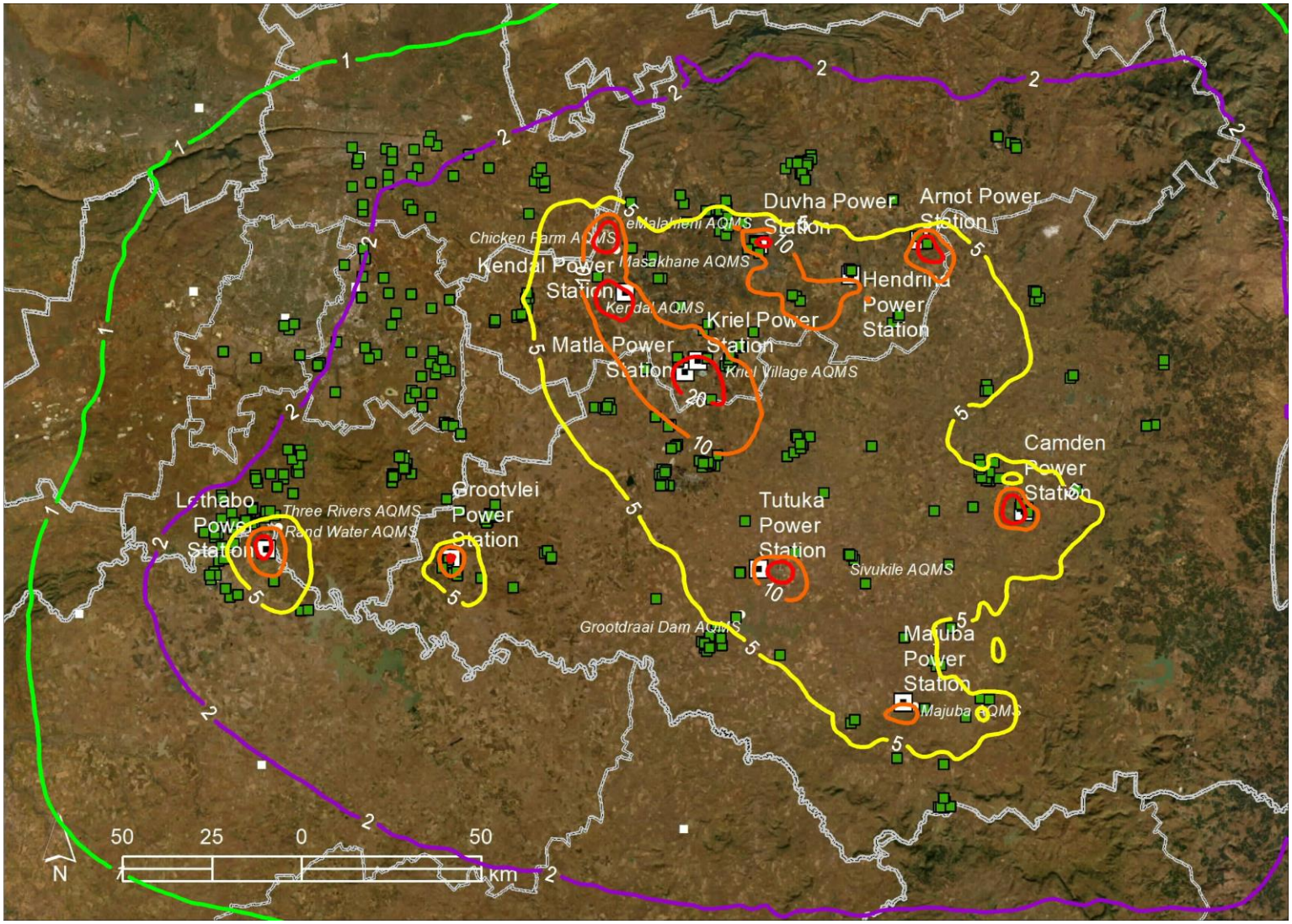


Figure 6-37: Predicted annual average $PM_{2.5}$ concentrations in µg/m³ for Scenario 1 (Current) (NAAQS Limit is 20 µg/m³)

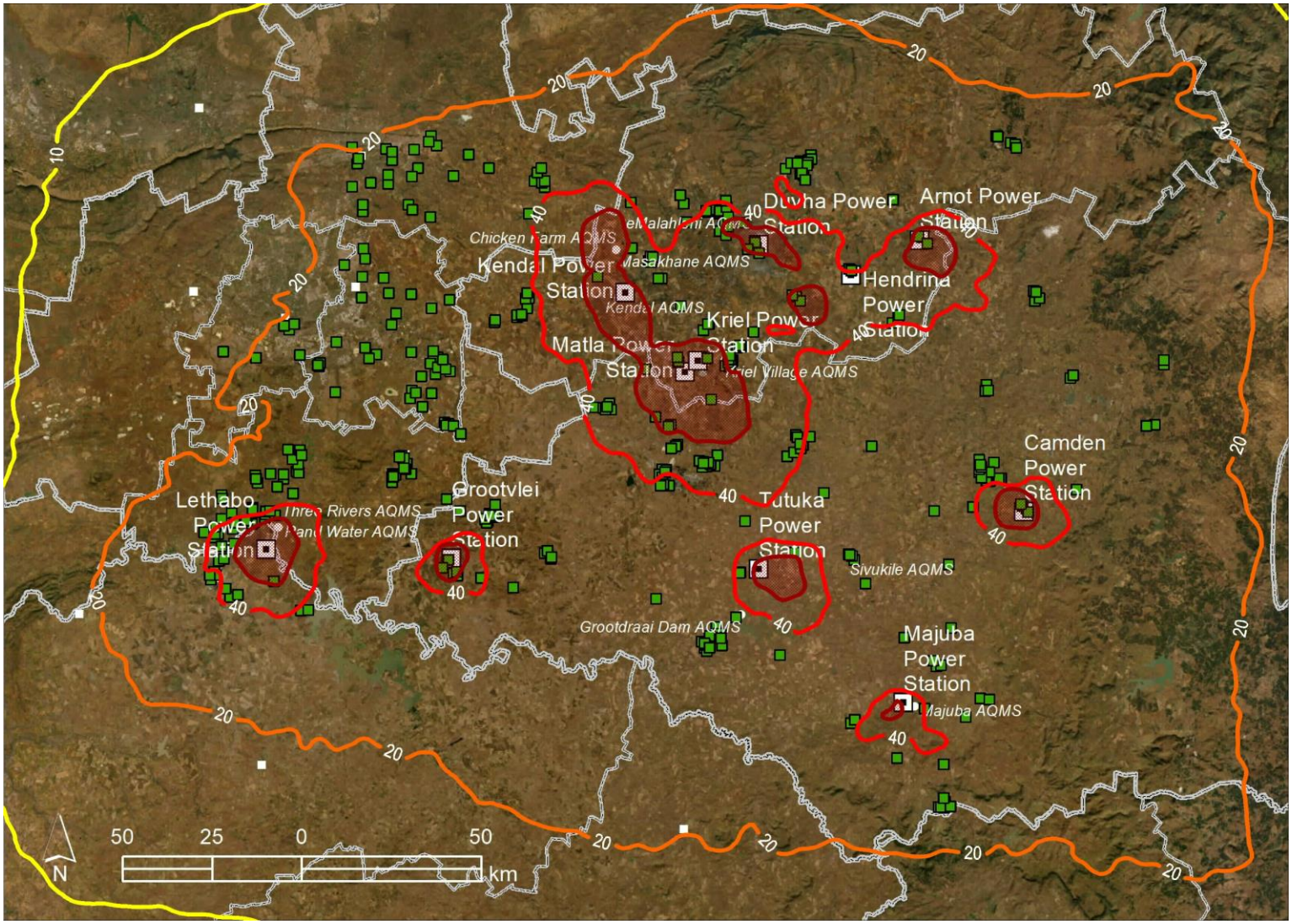


Figure 6-38: Predicted 99th percentile of the 24-hour $PM_{2.5}$ concentrations in µg/m³ for Scenario 1 (Current) (NAAQS Limit is 40 µg/m³)

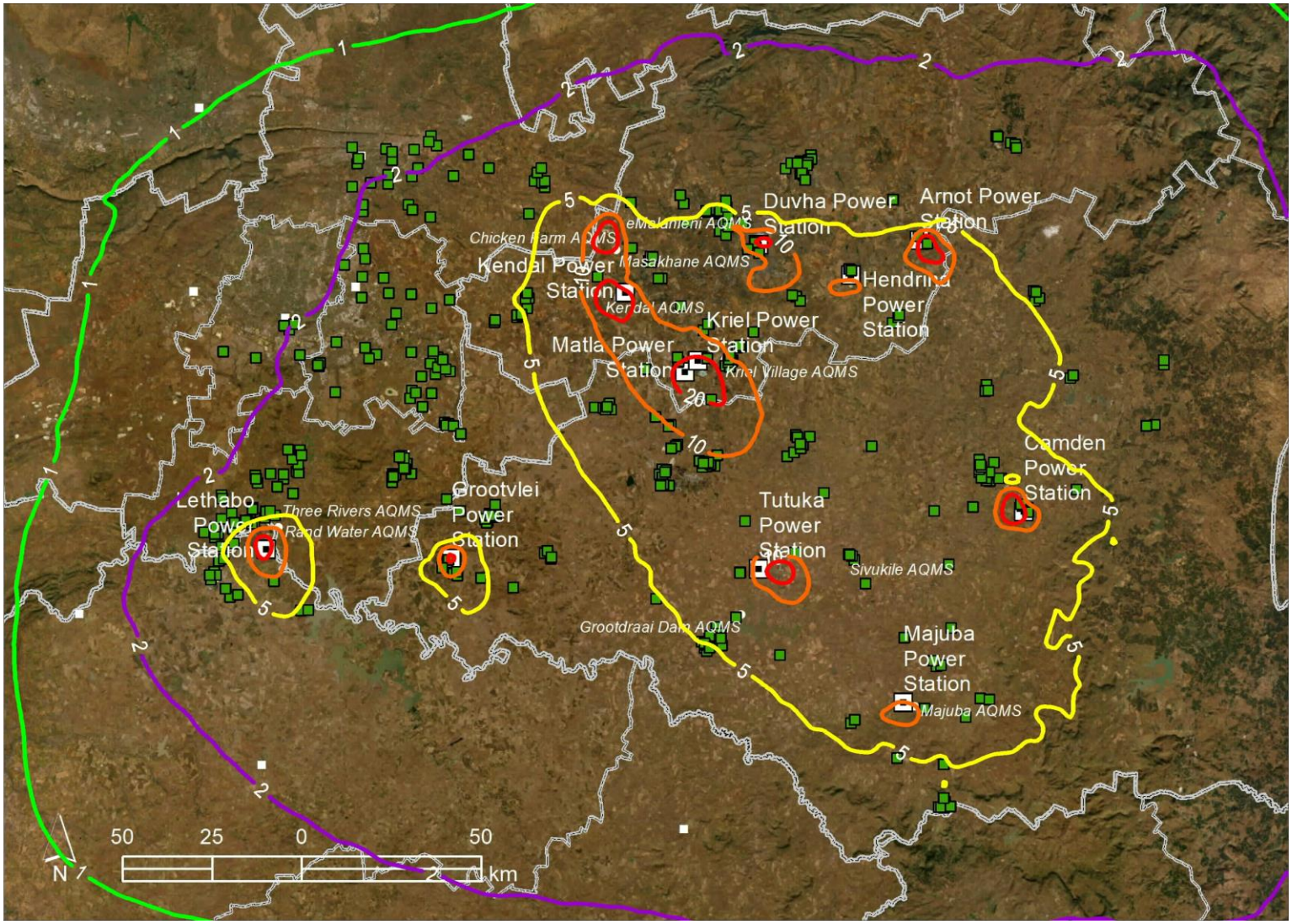


Figure 6-39: Predicted annual average $PM_{2.5}$ concentrations in µg/m³ for Scenario A (2025) (NAAQS Limit is 20 µg/m³)

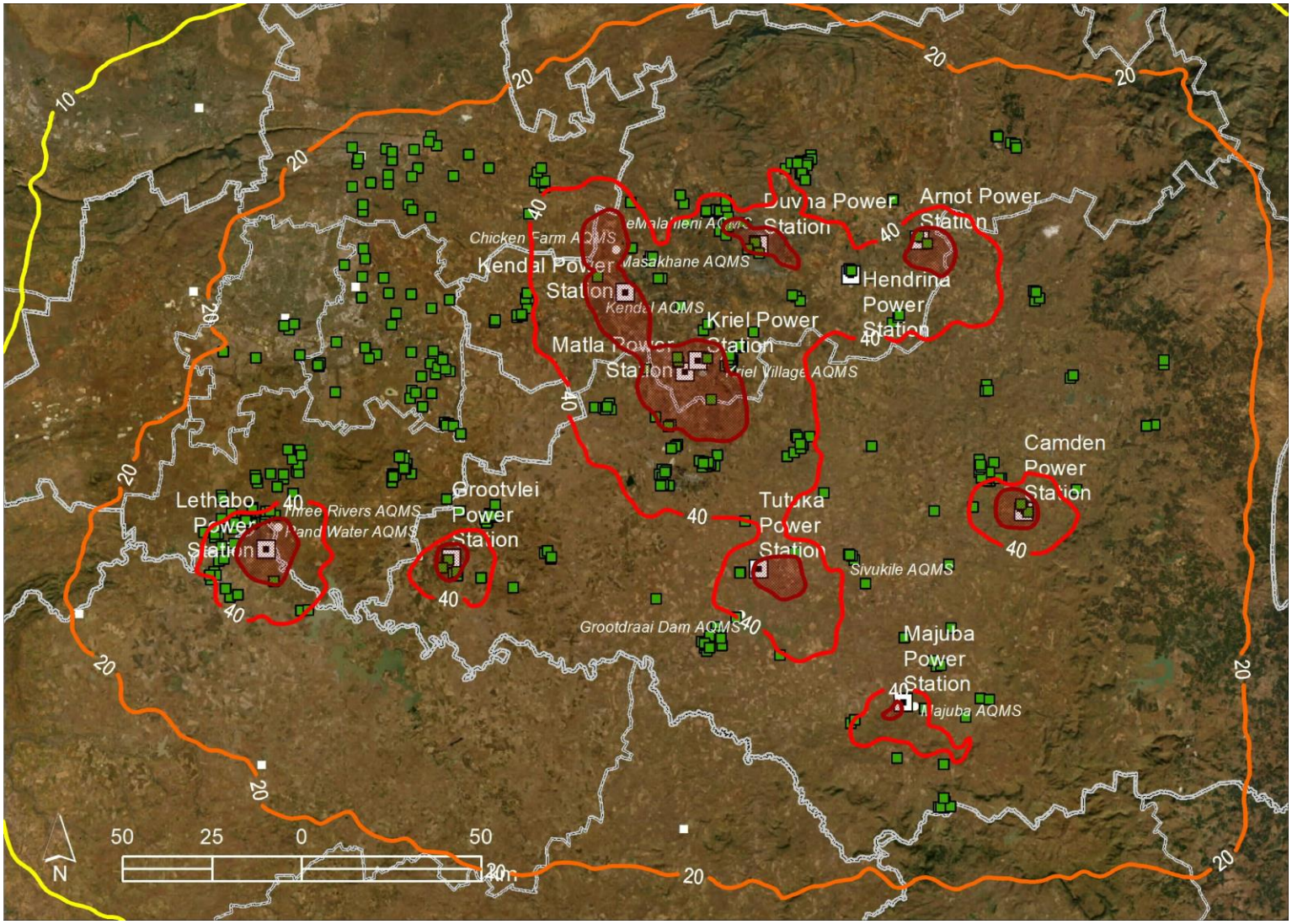


Figure 6-40: Predicted 99th percentile of the 24-hour $PM_{2.5}$ concentrations in µg/m³ for Scenario A (2025) (NAAQS Limit is 40 µg/m³)

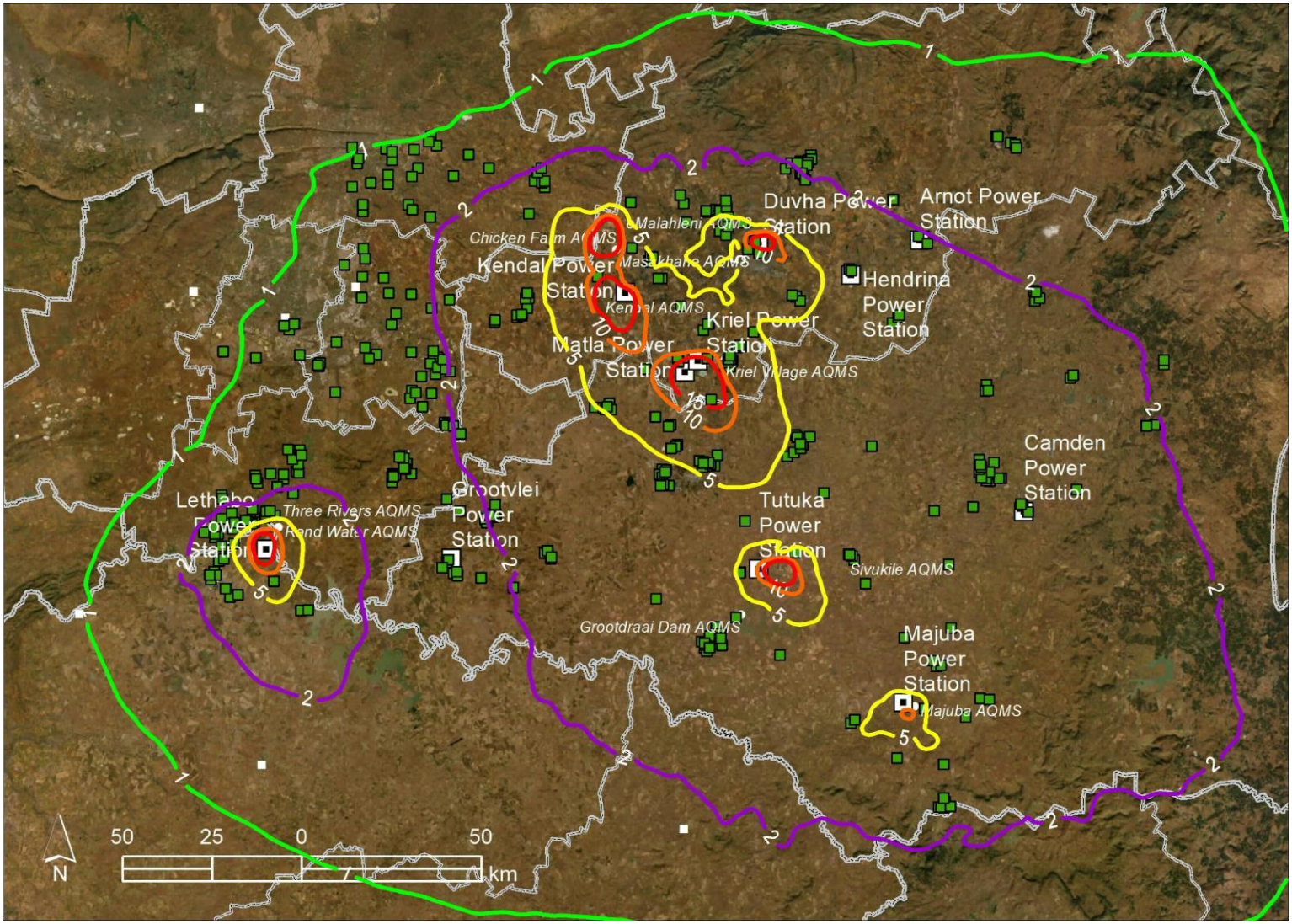


Figure 6-41: Predicted annual average $PM_{2.5}$ concentrations in µg/m³ for Scenario B (2031) (NAAQS Limit is 15 µg/m³)

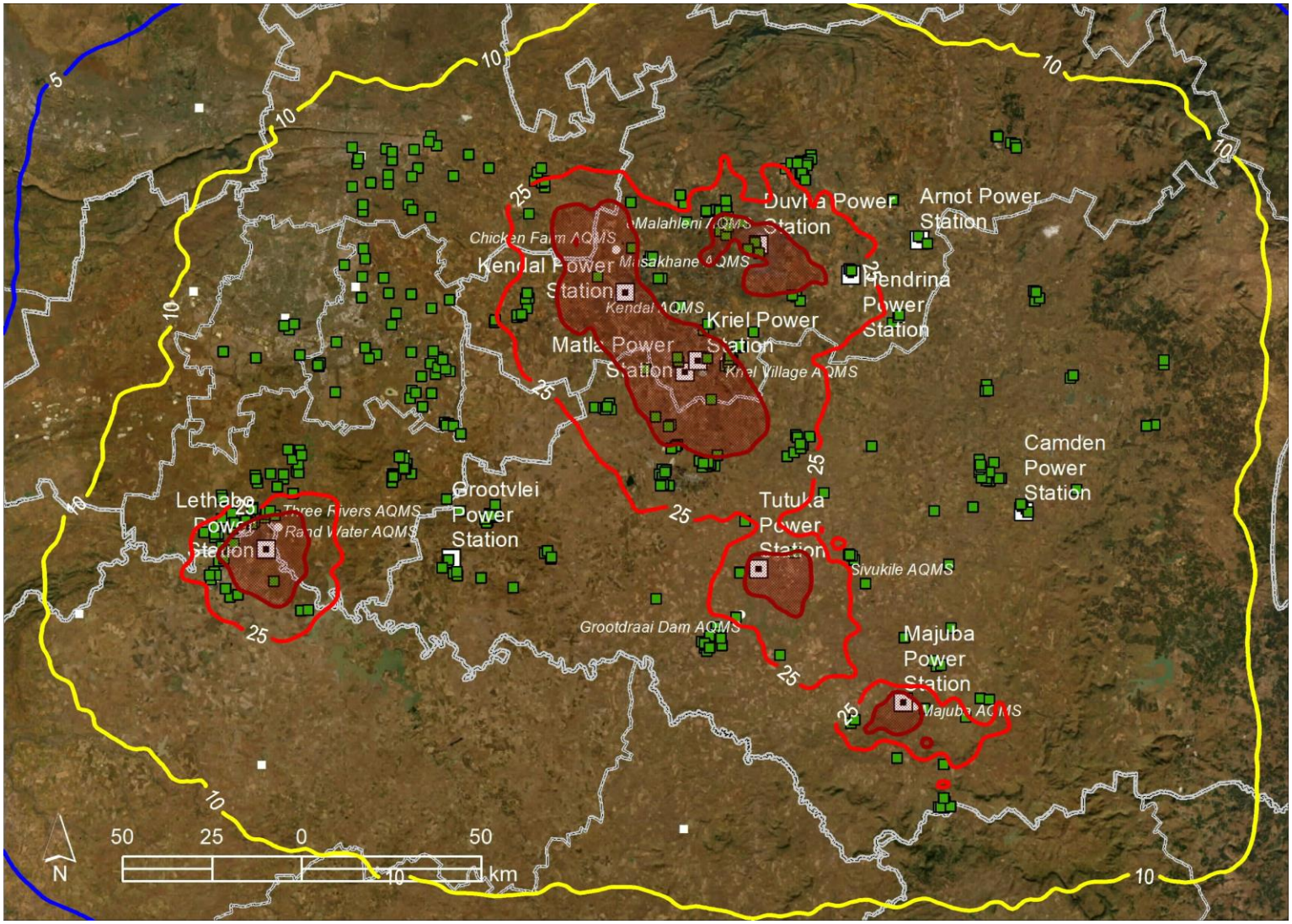


Figure 6-42: Predicted 99th percentile of the 24-hour $PM_{2.5}$ concentrations in µg/m³ for Scenario B (2031) (NAAQS Limit is 25 µg/m³)

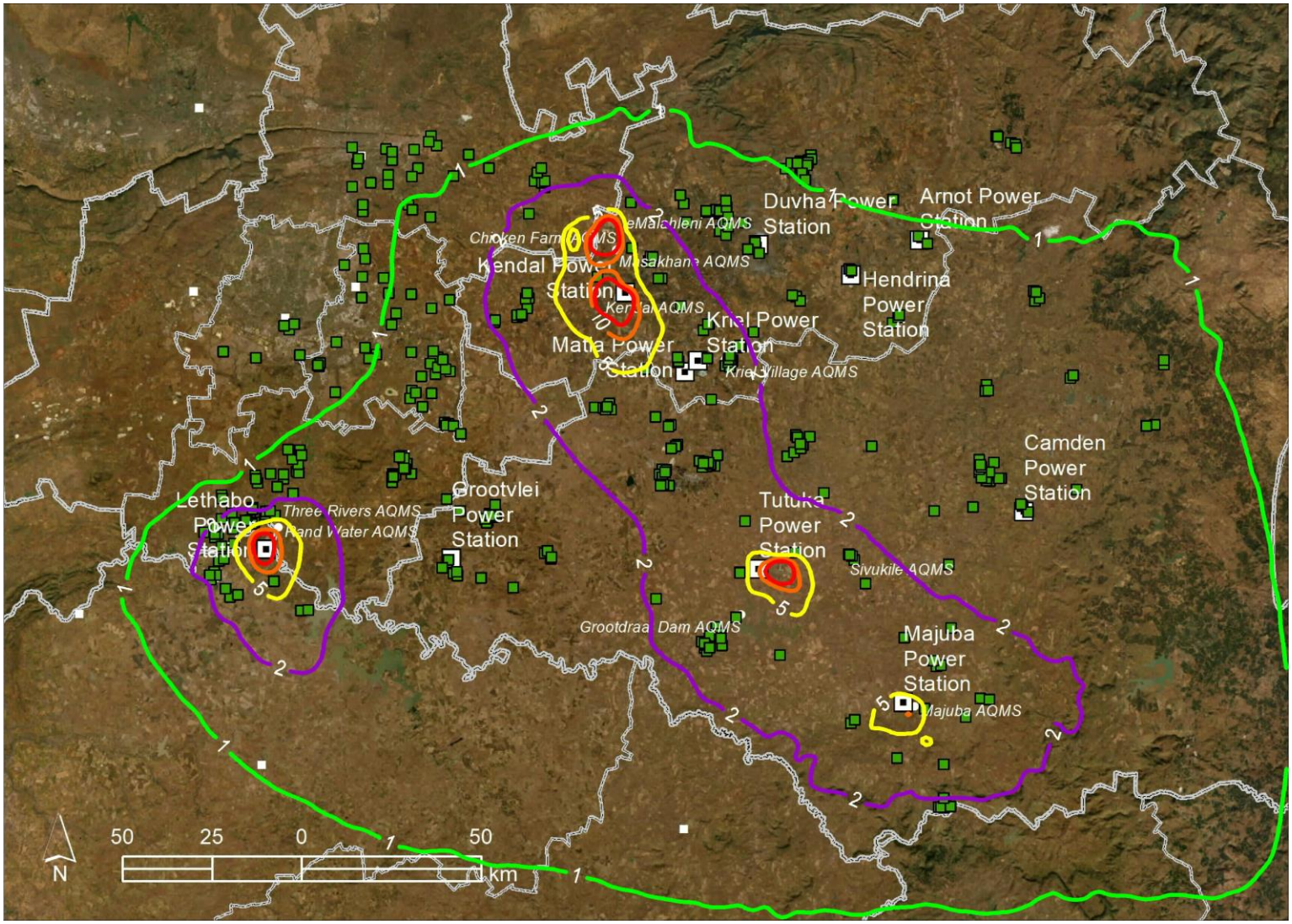


Figure 6-43: Predicted annual average $PM_{2.5}$ concentrations in µg/m³ for Scenario C (2036) (NAAQS Limit is 15 µg/m³)

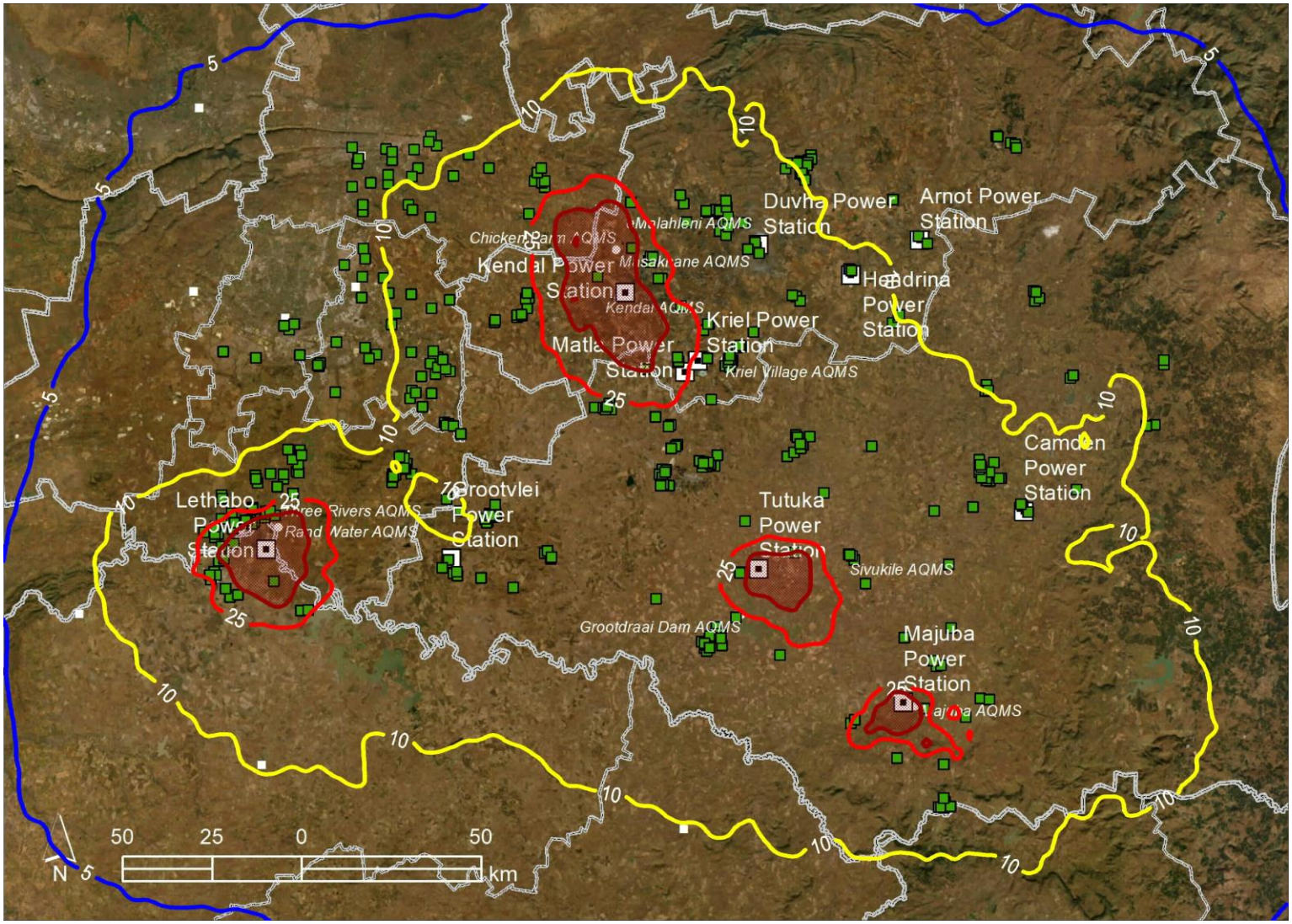


Figure 6-44: Predicted 99th percentile of the 24-hour $PM_{2.5}$ concentrations in µg/m³ for Scenario C (2036) (NAAQS Limit is 25 µg/m³)

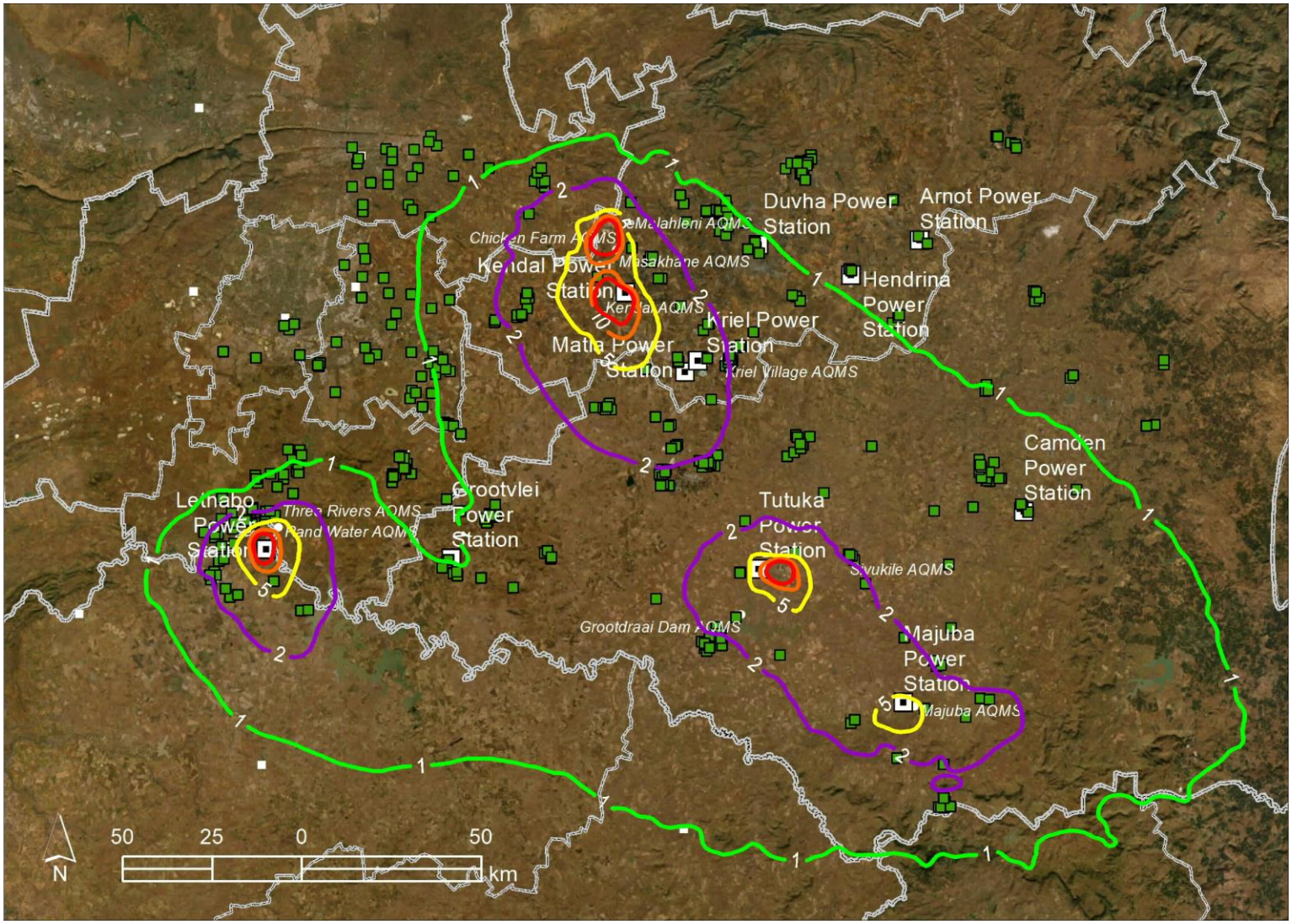


Figure 6-45: Predicted annual average $PM_{2.5}$ concentrations in µg/m³ for Scenario D (MES) (NAAQS Limit is 15 µg/m³)

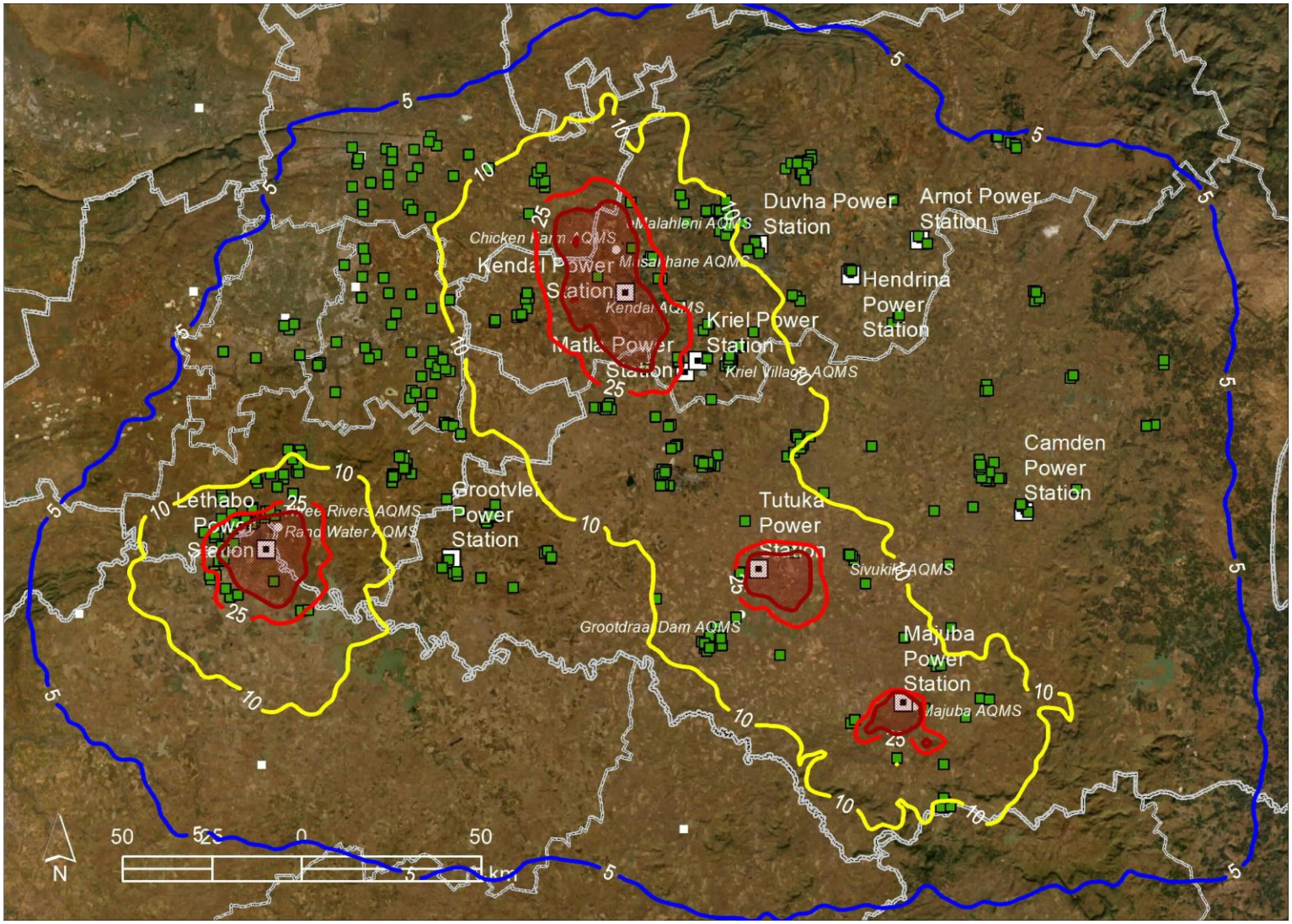


Figure 6-46: Predicted 99th percentile of the 24-hour $PM_{2.5}$ concentrations in µg/m³ for Scenario D (MES) (NAAQS Limit is 25 µg/m³)

7. SUMMARY AND CONCLUSION

In this AIR five emission scenarios are assessed collectively for the suite of 12 coal-fired power stations in the Highveld Priority Area and Lethabo in the Vaal Triangle Airshed Priority Area to support Eskom's application for exemption from the MES for 6 of the power stations. AIRs have been produced for the 6 power stations, i.e. Duvha, Kendal Lethabo, Majuba, Matla and Tutuka.

Dispersion modelling is used to demonstrate the effect of Eskom's emission reduction strategy by assessing 5 sequential emission scenarios. These are from Scenario 1 using actual emissions from 2021 to 2023, Scenario A using proposed 2025 emissions, Scenario B using proposed 2031 emissions and Scenario C using proposed 2036 emissions. Scenario D uses emissions that comply with the MES to demonstrate the relative effect of compliance.

Noteworthy findings from the modelling results may be summarised as follows:

i) Ambient SO_2 and NO_2 concentrations are attributed to stack emissions only, while ambient PM_{10} and $PM_{2.5}$ concentrations are attributed to the stack emissions and the low-level fugitive sources. The stack emissions generally have an effect some distance from the source, while low-level fugitive emissions have an effect close to the source.

ii) The predicted ambient concentrations are lower than the monitored concentrations for all pollutants at all AQMS. This is to be expected since AQMS are exposed to all sources of pollutants while the modelled concentrations result from power station emission only. The difference between the modelled concentrations and measured concentrations are indicative of the contribution of other sources at the respective AQMS.

iii) For Scenario 1 (Current):
   a. Predicted SO_2 and NO_2 concentrations comply with the NAAQS for all averaging periods throughout the modelling domain.
   b. Predicted PM_{10} and $PM_{2.5}$ concentrations generally comply with the NAAQS, except close to the power stations where the limit value of the 24-hour NAAQS are exceeded. Exceedances of the limit value for PM_{10} and $PM_{2.5}$ are predicted at 26 and 129 sensitive receptor points respectively.

iv) For Scenario A (2025):
   a. Predicted SO_2 and NO_2 concentrations comply with the NAAQS for all averaging periods throughout the modelling domain, except for the 99th percentile of the 24-hour SO_2 concentrations which exceed the limit value of the NAAQS.
   b. Predicted PM_{10} and $PM_{2.5}$ concentrations generally comply with the NAAQS, except close to the power stations where the limit value of the 24-hour NAAQS are exceeded. Exceedances of the limit value for PM_{10} and $PM_{2.5}$ are predicted at 29 and 149 sensitive receptor points respectively.

v) For Scenario B (2031):
   a. Predicted SO_2 and NO_2 concentrations comply with the NAAQS for all averaging periods throughout the modelling domain. Predicted NO_2 concentrations show a reduction with the completion of LNB projects at Kendal and Tutuka.

b. Predicted PM_{10} and $PM_{2.5}$ concentrations generally comply with the NAAQS, except close to the power stations where the limit value of the 24-hour NAAQS are exceeded. The number of predicted exceedances for PM_{10} decrease to 9, while the number of exceedances for $PM_{2.5}$ increase to 157 sensitive receptor points. The increase corresponds to the more stringent $PM_{2.5}$ limit value of 25 $\mu g/m^3$ which is implemented in 2030.
c. The effect of the shutdown of Arnot, Camden, Hendrina, Kendal and Kriel by 2031 and the associated reduction in emissions is clearly evident, with the modelling showing lower ambient concentrations, i.e. improved air quality.

vi) For Scenario C: (2036):
a. Predicted SO_2 and NO_2 concentrations comply with the NAAQS for all averaging periods throughout the modelling domain.
b. Predicted PM_{10} and $PM_{2.5}$ concentrations comply with the NAAQS, except close to the power stations where the limit value of the 24-hour $PM_{2.5}$ NAAQS is exceeded. Exceedances of the limit value for $PM_{2.5}$ is predicted at 53 sensitive receptor points.
c. Reductions in predicted ambient PM concentrations are due to Duvha and Matla entering shutdown phase, as well as abatement improvements from Scenario B for PM. Ambient SO_2 reductions are due to the Majuba DSI and Kendal semi-dry FGD projects. Ambient NO_2 improvements are due to the Lethabo LNB project.

vii) For Scenario D:
a. Predicted SO_2 and NO_2 concentrations comply with the NAAQS for all averaging periods throughout the modelling domain.
b. Predicted PM_{10} and $PM_{2.5}$ concentrations generally comply with the NAAQS, except close to the power stations where the limit value of the 24-hour $PM_{2.5}$ NAAQS is exceeded. Exceedances of the limit value for $PM_{2.5}$ is predicted at 45 sensitive receptor points.

Given the conservative approach to the fugitive emission source simulations, and that this has provided an absolute worst-case emission scenario, and based on recommendations received from uMoya-Nilu, Eskom will be undertaking an additional modelling scenario, assessing only PM, SO_2, and NO_X stack emissions. NO_X and SO_2 emissions will be included in this scenario to ensure secondary particulate formation is accounted for. This will provide improved insight to impacts directly related to stack emissions, which are the focus of this exemption application.

8. REFERENCES

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9. FORMAL DECLARATIONS

A declaration of the accuracy of the information contained in this Atmospheric Impact Report is included here. A declaration of the independence of the practitioners in the uMoya-NILU consultancy team that compiled this AIR is also included.

DECLARATION OF ACCURACY OF INFORMATION – APPLICANT

Name of Enterprise: uMoya-NILU Consulting (Pty) Ltd

Declaration of accuracy of information provided:

Atmospheric Impact Report in terms of Section 30 of the Act

I, Mark Zunckel [duly authorised], declare that the information provided in this atmospheric impact report is, to the best of my knowledge, in all respects factually true and correct. I am aware that the supply of false or misleading information to an air quality office is a criminal office in terms of section 51(1)(g) of this Act.

Signed at Durban on this 4th day of November 2024.



SIGNATURE

Managing Director – uMoya-NILU Consulting
CAPACITY OF SIGNATORY

DECLARATION OF INDEPENDENCE – PRACTITIONER

Name of Practitioner: Mark Zunckel

Name of Registered Body: South African Council for Natural Scientific Professionals

Professional Registration Number: 400449/04

Declaration of independence and accuracy of information provided:

Atmospheric Impact Report in terms of Section 30 of the Act

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

Signed at Durban on this 4th day of November 2024.



SIGNATURE

Managing Director – uMoya-NILU Consulting
CAPACITY OF SIGNATORY

ANNEXURE 1: HIGHVELD SENSITIVE RECEPTORS

Area	Sensitive Receptors	Latitude	longitude
Amersfoort	Elsie Ballot Memorial Hospital	-27.011944	29.858333°
	Laerskool Amersfoort	-27.008678°	29.869944°
	Embuzane Primary School	-27.118291°	29.826786°
	Sangqotho Primary School	-26.941649°	29.765980°
Ezamokuhle	Amersfoort Combined School	-26.997325°	29.850319°
Mooifontein	Injubuko Primary School	-26.914817°	29.897307°
Daggaskraal	Daggakraal Primary School	-27.089170°	29.983250°
	Sizenzele Primary School	-27.137908°	29.943203°
	Seme Secondary School	-27.091589°	30.008177°
	Louwra Primary School	-27.257713°	29.884864°
Perdekop	Perdekop Agricultural School	-27.159970°	29.620400°
	Vukuzenzele Combined School	-27.150944°	29.632386°
	Bambelelani Primary School	-27.175659°	29.749177°
	Gunwana Primary School	-27.244071°	29.752985°
Volksrust	Amajuba Memorial Hospital	-27.351190°	29.890921°
	Volksrust High School	-27.365400	29.87400
	Volksrust Municipal Clinic	-27.366264°	29.889272°
	C V O Skool Amajuba	-27.365329°	29.879851°
	Qhubulwazi Combined School	-27.363173°	29.907290°
	Volksrust Primary School	-27.341897°	29.886710°
Ermelo	New Ermelo	-26.534977°	30.026896°
	Ermelo Christian School	-26.543889	29.996389
	Savf Home For Aged	-26.527681°	29.988536°
	Ermelo Hospital	-26.523077°	29.974891°
	Mediclinic Ermelo	-26.542500	29.986389
	Hoerskool Ermelo	-26.526100	29.977900

Area	Sensitive Receptors	Latitude	longitude
	Ermelo Indian Combined School	-26.521100	29.965400
	Lungelo Combined School (Outside Town)	-26.622000	29.841700
	New Ermelo Primary School	-26.535600	30.020700
	Kwashashe (Outside Town)	-26.495602°	30.006254°
	Hts Ligbron	-26.536691°	29.986828°
	Laerskool Ermelo	-26.520178°	29.992883°
	JJ Vd Merwe Pre-Primary School	-26.535660°	29.972140°
Wesselton (Ermelo)	Lindile Secondary School	-26.513500	29.965500
	Emthonjeni Clinic	-26.508028°	29.971060°
	Reggie Masuku Secondary School	-26.489756°	29.964026°
	Cebisa Secondary School	-26.503265°	29.968324°
Camden	Camden	-26.603573°	30.089437°
	Camden Combined School	-26.618056	30.104444
	Camden School	-26.599100	30.083900
	Umzimvelo Secondary School (Rural Area)	-26.558600	30.238500
	BHEKIMFUNDO PRIMARY SCHOOL (Rural Area)	-26.609907°	29.950545°
	ESHWILENI PRIMARY SCHOOL (Rural Area)	-26.754375°	29.885636°
Davel	Davel Combined School	-26.462700	29.663000
Morgenzon	Morgenzon Landbou Akademie	-26.749100	29.621200
	Nqobangolwazi Secondary School	-26.738700	29.615000
	Siqondekhaya Pre Primary School	-26.734260°	29.604270°
	Sizakhele Primary School	-26.734486°	29.607360°
	Phezukwentaba Primary School (South Of Morgenzon)	-26.807276°	29.653596°
	Kwaggalaagte Primary School (North Of Morgenzon)	-26.581578°	29.531897°
	Sizakhele Clinic/Hospital	-26.735610°	29.608568°
Grootvlei	Grootvlei	-26.765600	28.483800
	Olive Grove Country Lodge	-26.785336°	28.467296°
Grootvlei Town	Grootvlei Town (South Of Power Station)	-26.798562°	28.505729°

Area	Sensitive Receptors	Latitude	longitude
	Laerskool Grootvlei	-26.799705°	28.499296°
	Tokoloho Primary School	-26.805037°	28.509491°
	Tshepeha Combined School	-26.794589°	28.507561°
	Warembo Lodge	-26.809803°	28.575820°
Balfour	Balfour	-26.647368°	28.597344°
	Siyathemba	-26.651574°	28.611242°
	Bonukukhanya Primary (Siyathemba)	-26.656389	28.610556
	Qalabocha Primary School (Siyathemba)	-26.648510°	28.610239°
	Vusumuzi Primary School	-26.649302°	28.614483°
	Gekombineerde Skool Balfour	-26.666111	28.593056
	Im Manchu Secondary School	-26.662885°	28.585658°
	Isifisosethu Secondary School (Siyathemba)	-26.654091°	28.616910°
	Setsheng Secondary School (Siyathemba)	-26.646036°	28.613849°
	Dr Nieuwoudt And Dr Kok	-26.670556	28.589722
	Balfour Clinic	-26.660521°	28.584954°
	Siyathemba Clinic	-26.651428°	28.598763°
	Mondoro Lodge	-26.641806°	28.515683°
	Wegelegen Manor	-26.625555°	28.612550°
	The Stone Cellar	-26.611667	28.478056
Greylingstad	Greylingstad	-26.744551°	28.753659°
	Nthorwane	-26.759041°	28.771550°
	Laerskool Greylingstad	-26.740120°	28.761680°
	Nthoroane Secondary School	-26.755300	28.772500
	Badgarleur Bush Lodge	-26.832190°	28.666044°
Matla	Matla Village	-26.259808°	29.119138°
	Sifundise Primary School	-26.257623°	29.120118°
	Kwanala Primary School	-26.249384°	29.199724°
	Matla Coal Health Centre	-26.247649°	29.116928°

Area	Sensitive Receptors	Latitude	longitude
	Gweda Primary School	-26.352145°	29.212688°
	Zithobe Primary School	-26.278423°	29.027500°
Kriel power station area	Kwanala Primary School	-26.249300	29.200000
Reedstream Park	Reedstream Park	-26.178723°	29.188144°
	Rietspruit Clinic	-26.162067°	29.202676°
	Lehlaka Combined School	-26.162533°	29.199891°
Blesboklaagte	Mbali Coal/Blesboklaagte Housing	-26.118280°	29.123520°
Kinross	Kinross	-26.417917°	29.100765°
	Kinross Settlement	-26.397865°	29.058050°
	Kinross Municipal Clinic	-26.421365°	29.094224°
Kriel	Kriel	-26.267078°	29.250870°
	Eagles Nest Guest House	-26.269553°	29.262920°
	Merlin Park Primary School	-26.251667	29.270000
	Kriel Medical Centre	-26.256300	29.269300
	Laerskool Krielpark	-26.258300	29.258500
	Laerskool Onverwacht	-26.250423°	29.265348°
	SILWER FLEUR AFTREE OORD (Old Age Home)	-26.251217°	29.260131°
Thubelihle	Thubelihle	-26.220737°	29.282778°
	Sibongamandla Secondary School	-26.215556	29.290000
	Ga-Nala Clinic	-26.241511°	29.263001°
	Impilo Primary School	-26.180232°	29.327259°
	Bonginhlanhla Primary School	-26.217923°	29.294090°
	Sibongamandla Secondary School	-26.215364°	29.290280°
Leandra	Leandra	-26.365552°	28.928450°
	Eendracht	-26.376131°	28.887873°
	Sidingulwazi Primary School	-26.377834°	28.910979°
	Ss Mshayisa Primary School	-26.381610°	28.933930°
	Chief Ampie Mayisa Secondary School	-26.381780°	28.918580°

Area	Sensitive Receptors	Latitude	longitude
	Lebogang Clinic	-26.375431°	28.921864°
Standerton	Kleuterskool Haas Das	-26.944550°	29.248400°
	Standerton Primary School	-26.941451°	29.250405°
	Laerskool Jeugkrag	-26.924090°	29.237685°
	Laerskool Standerton	-26.948786°	29.249351°
	Laerskool Kalie De Haas	-26.970223°	29.254828°
	Hoerskool Standerton	-26.941403°	29.250366°
	Standerton Provincial Government Hospital	-26.940531°	29.245199°
	Mar-Peh Medicare Private Hospital	-26.950190°	29.244825°
	Standerton Retirement Home	-26.952576°	29.244483°
	Standerton Ouetehuis/Old Age Home	-26.952129°	29.251705°
	Holmdene Secondary School	-26.854996°	29.068283°
	Cathuza Primary School (SE Of Town)	-26.991900°	29.417721°
Sakhile	Sizanani Pre Primary School	-26.965600°	29.219060°
	Hlobisa Primary School	-26.976914°	29.206318°
	Shukuma Primary School	-26.985407°	29.213005°
	Retsebile Primary School	-26.961930°	29.197353°
	Thuto-Thebe Secondary School	-26.947030°	29.220020°
	Jandrell Secondary School	-26.969768°	29.207290°
	Thobelani Secondary School	-26.965240°	29.206523°
	Standerton Tb Hospital	-26.977124°	29.219607°
Thuthukani	Thuthukani Pre Primary School	-26.786030°	29.303590°
	Ulwazi Primary School	-26.785680°	29.301080°
	Zikhetheleni Secondary School	-26.787403°	29.301062°
	Joubertsvlei Primary School (North Of Tutuka)	-26.657110°	29.312830°
	Amalumgelo Primary School (NE Of Tutuka)	-26.733160°	29.453775°
Grootdraai Dam	Grootdraaidam Primary School	-26.898947°	29.292610°
Secunda	Laerskool Secunda	-26.509385°	29.193941°

Area	Sensitive Receptors	Latitude	longitude
	Laerskool Kruinpark	-26.519159°	29.225740°
	Laerskool Oranjegloed Primary	-26.521260°	29.203110°
	Curro Castle Combined School	-26.523097°	29.191675°
	Hoërskool Oosterland	-26.515283°	29.214972°
	Mediclinic Secunda (Hospital)	-26.507573°	29.182451°
	Mediclinic Highveld (Hospital_Trichardt, Secunda)	-26.492055°	29.232606°
	Daviescourt/Davieshof Old Age Home	-26.511249°	29.198892°
	Highveld Park High School	-26.510499°	29.208618°
	Hoerskool Secunda	-26.512707°	29.194632°
EMBALENHLE	Basizeni Special School	-26.530052°	29.079094°
	Maphala-Gulube Primary School	-26.570566°	29.099115°
	Shapeve Primary School	-26.531614°	29.090534°
	Thomas Nhlabathi Secondary School	-26.543169°	29.071362°
	Embalenhle Hospital / Clinic	-26.550013°	29.080121°
	Vukuzithathe Primary School	-26.567722°	29.083243°
	K I Twala Secondary	-26.570501°	29.075089°
	Allan Makunga Primary School	-26.537324°	29.087230°
Evander	Evander Hospital Arv Clinic	-26.467000°	29.120000°
	Laerskool Hoeveld	-26.470539°	29.115757°
	Hoerskool Evander	-26.477655°	29.103231°
Delmas	Bernice Samuel Hospital	-26.152500°	28.667100°
	Hoerskool Delmas	-26.147355°	28.667599°
	Laerskool Delmas	-26.147749°	28.681442°
	Kangela Primary School (North Of Delpark)	-26.130000°	28.695000°
	Savf Ons Eie Ouetehuis / Old Age Home	-26.146154°	28.680927°
Eloff	Laerskool Eloff	-26.165971°	28.605106°
	Rietkol Primary School	-26.159963°	28.606432°
Botleng	Bazani Primary School	-26.104500°	28.699400°

Area	Sensitive Receptors	Latitude	longitude
	Phaphamani Secondary School	-26.105839°	28.690500°
	Vezimfundo Primary School	-26.091625°	28.694387°
Arbor	Arbor Primary School	-26.048219°	28.889804°
Ogies	Ogies Combined School	-26.049221°	29.068832°
	Umthombo Wolwazi Farm School	-26.156451°	28.930509°
	Kendal	-26.079592°	28.975296°
	Ogies Tb Clinic	-26.049669°	29.059596°
	Ogies Police Station	-26.049669°	29.059596°
Phola	Hlangu Phala Primary School	-26.006460°	29.032484°
	Sukumani Primary School	-26.005724°	29.036428°
	Thuthukani Primary School	-26.008877°	29.038899°
	Mehlwana Secondary School	-25.995286°	29.037621°
	Makause Combined School	-25.996758°	29.043456°
Wilge	Sibongindawo Primary School	-25.974651°	28.984930°
Balmoral	Laerskool Balmoral	-25.859262°	28.980030°
Emalahleni	Clewer Primary School	-25.906838°	29.136114°
	Witbank High School	-25.884914°	29.226438°
	Eden Park Retirement Village	-25.902283°	29.237194°
	Savf House Immergroen Old Age Home	-25.879707°	29.217916°
	MTHIMKULU Housing For The Aged	-25.881082°	29.189281°
	Emalahleni Private Hospital	-25.874996°	29.216316°
	Life Cosmos Hospital	-25.883956°	29.232671°
	Duvha Primary School	-25.928700°	29.228835°
	Laerskool Taalfees	-25.882069°	29.226736°
	Witbank Provincial Hospital	-25.876855°	29.226772°
	Nancy Shiba Primary School (Vosman)	-25.860442°	29.127636°
	Wh De Klerk Skool	-25.867762°	29.246453°
	Laerskool Panorama	-25.852265°	29.244652°

Area	Sensitive Receptors	Latitude	longitude
	Laerskool Duvhapark	-25.938354°	29.245539°
	Laerskool Klipfontein	-25.904014°	29.241984°
	Cambridge Academy	-25.893439°	29.251575°
	Besilindile Primary School	-25.839035°	29.116774°
	Reynopark High School	-25.916428°	29.252116°
	Bakenveld Golf Estate	-25.905932°	29.292706°
	Mms Primary School	-25.905558°	29.385417°
	Bongiduvha Primary School	-25.983853°	29.335681°
	Springvalley Primary School	-25.921086°	29.260948°
	Joy Crèche	-25.972528°	29.308427°
	Curro Bankenveld Preschool And Primary School	-25.905248°	29.277348°
	Little Eden Academy	-25.917056°	29.253835°
	Little Steps Pre School	-25.944674°	29.251428°
	Allendale Secondary School	-25.982387°	29.338986°
	Khayalethu Primary School	-25.877710°	29.189130°
	Illanga Secondary School	-25.955537°	29.327107°
	Joy Creche (Duvha)	-25.972408°	29.308161°
Middelburg	Linderus Old Age Home	-25.784009°	29.459212°
	Vergeet My Nie Old Age Home	-25.780787°	29.449413°
	Middleburg Frail Care Unit And Home For Elderly	-25.746481°	29.471782°
	Life Midmed Hospital	-25.763147°	29.457650°
	Middelburg Hospital	-25.775692°	29.450413°
	Makhathini Primary School	-25.749305°	29.448461°
	Laerskool Dennesig	-25.733488°	29.478283°
	Hoerskool Kanonkop	-25.742627°	29.479874°
	Laerskool Kanonkop	-25.751354°	29.470764°
	Steelcrest High School	-25.759514°	29.468012°
	Middelburg Primary	-25.778514°	29.453271°

Area	Sensitive Receptors	Latitude	longitude
	Middleburg Ext 6 Clinic	-25.768193°	29.407838°
	Sofunda Secondary School	-25.754358°	29.423801°
	Mhluzi Primary School	-25.753279°	29.440498°
	Highlands Primary School	-25.795886°	29.463428°
Komati	Blinkpan Primary School	-26.089884°	29.444406°
	Laerskool Koornfontein	-26.099868°	29.456226°
	Blinkpan	-26.086337°	29.433989°
Pullens Hope	Laerskool Kragveld	-26.016735°	29.590369°
	Pullens Hope	-26.020916°	29.597472°
Rietkuil / Arnot	Arnot Colliery Primary School	-25.932110°	29.780624°
	Laerskool Rietkuil	-25.949477°	29.807062°
	Beestepan Agricultural School	-25.841453°	29.709393°
Hendrina	Gekombineerde Skool Hendrina	-26.151386°	29.713726°
Kwazamokhule	Hendrina Primary School	-26.136847°	29.729098°
	Kwazamokuhle Secondary School	-26.131117°	29.732418°
Lothair	Ubuhle Bolwai Secondary School	-26.391734°	30.452159°
	Lothair Primary School	-26.394524°	30.428535°
Warburton	Warburton Combined School	-26.239852°	30.472477°
	Warburton Town	-26.227585°	30.472905°
Chrissiesmeer	Kwachibikhulu Clinic	-26.280125°	30.213918°
	Kwachibikhulu Primary School	-26.272378°	30.221621°
Carolina	Carolina Hospital	-26.074581°	30.111313°
	Zinikeleni Secondary School (Silobela)	-26.087874°	30.109848°
	Volkskool Carolina	-26.062907°	30.106394°
	Sobuza Primary School	-26.080382°	30.122447°
	Ons Eie Ouetehuis (Old Age Home)	-26.065018°	30.112066°
Breyten	Laerskool Breyten	-26.301603°	29.979961°
	Siyazi Primary School (Kwazanele)	-26.316644°	29.977882°

Area	Sensitive Receptors	Latitude	longitude
	Masizakhe Secondary School (Kwazanele)	-26.315348°	29.984385°
Belfast	Belfast Rusoord (Old Age Home)	-25.691737°	30.031956°
	Belfast Hospital	-25.696074°	30.043783°
	Platorand School	-25.704015°	30.047859°
	Belfast Primary School (Siyathuthuka)	-25.675303°	29.991119°
	Siyathuthuka Clinic	-25.676301°	29.995601°
Bethal	Life Bethal Hospital	-26.464532°	29.467456°
	Hoerskool Hoogenhout	-26.461930°	29.472023°
	Jim Van Tonderskool	-26.436887°	29.450970°
	Bethal Independent Primary School	-26.442824°	29.454517°
	Laerskool Marietjie Van Niekerk	-26.440565°	29.489773°
	Laerskool Hm Swart	-26.459925°	29.465474°
	Sakhisizwe Primary School (Emzinoni)	-26.492311°	29.427359°
	Alpheus D Nkosi Secondary School (Emzinoni)	-26.480923°	29.446290°
	Silwerjare Old Age Home	-26.470954°	29.465659°
	Residentia Palm Oord	-26.460488°	29.462766°
Bronkhorstspruit	Bronkhorspruit Hospital	-25.803183°	28.716819°
	Cultura High School	-25.824833°	28.739116°
	Bronkhorspruit Primary School	-25.809124°	28.710617°
	Bronkhorspruit Dam	-25.891281°	28.697112°
	Hoerskool Erasmus	-25.813056°	28.732392°
	Althea Independent School	-25.809393°	28.739630°
	Kgoro Primary School (Zithobeni)	-25.787526°	28.718686°
	Zithobeni Secondary School (Zithobeni)	-25.776080°	28.729297°
Sasolburg	Vaal Power Ah	-26.823034°	27.995199°
	Sasolburg Provincial Hospital	-26.801004°	27.827226°
	Moredou Old Age Home	-26.820627°	27.818609°
	Ons Gryse Jeug Old Age Home	-26.808971°	27.829287°

Area	Sensitive Receptors	Latitude	longitude
	Noord Primere Skool	-26.809079°	27.833205°
	Sasolburg High School	-26.809493°	27.815540°
Zamdela	Sakhubusa Secondary School	-26.864383°	27.872379°
	Bekezela Primary School	-26.858275°	27.895183°
	Isaac Mhlambi Primary	-26.843253°	27.860477°
Deneysville	Refenkgotso Primary School	-26.896796°	28.071849°
	Deneysville Primary School	-26.894767°	28.091936°
Vaalpark	Netcare Vaalpark Hospital	-26.772921°	27.840020°
	Vaalpark Articon Secondary School	-26.766998°	27.854563°
Vanderbijlpark	Mediclinic Emfuleni	-26.705051°	27.837480°
	Curro Vanderbijlpark	-26.721637°	27.881353°
	Jeugland Old Age Home	-26.714240°	27.829000°
	Herfsoord Huis Old Age Home	-26.705218°	27.828579°
	Vaal Christian Combined School	-26.760827°	27.945336°
	Pele-Ya-Pele Secondary School	-26.758447°	27.948168°
	Huis Prinscilla	-26.686758°	27.830074°
	Laerskool Emfulenipark	-26.736622°	27.848162°
	Nw University_Vaal Campus	-26.729104°	27.882396°
	Emfuleni Primary School	-26.701230°	27.798581°
Vereeniging	Mediclinic Vereeniging	-26.669380°	27.927271°
	Kopanong Provincial Hospital (Duncanville)	-26.638409°	27.933352°
	Pride Junior High School	-26.673626°	27.930727°
	Milton Primary School	-26.664438°	27.967937°
	Avondrus Eventide Old Age Home	-26.642726°	27.934453°
	Riviera On Vaal Resort	-26.675535°	27.939516°
	Selborne Primary School	-26.670181°	27.918206°
	Sedibeng TVET College	-26.679262°	27.931965°
	General Smuts High School	-26.672889°	27.917628°

Area	Sensitive Receptors	Latitude	longitude
	Eureuka School & Selbourne Primary	-26.670308°	27.914584°
Three Rivers	Midvaal Private Hospital (Three Rivers)	-26.663943°	27.969386°
	Three Rivers Retirement Village	-26.654433°	27.970966°
	Drie Riviere Aftreeoord Old Age Home	-26.648419°	27.972201°
	Fundamental Faculty And Factory	-26.662652°	27.979278°
	Mannabos Retirement Centre	-26.659008°	28.007140°
	Riverside High School	-26.657354°	27.997307°
	Hoërskool Drie Riviere	-26.658617°	27.974794°
	Laerskool Drie Riviere	-26.656514°	27.967703°
	Panfontein Intermediate School	-26.718701°	28.017031°
	Risiville Primary School	-26.645815°	27.982017°
Sebokeng	Sebokeng Hospital	-26.607161°	27.847550°
	Clinix-Naledzi Private Hospital	-26.616004°	27.848311°
Sharpville	Mohloli Secondary School	-26.691794°	27.878703°
	Tshirela Primary School (Boipatong)	-26.667125°	27.846609°
	Tsoaranang Primary School (Thepiso)	-26.672748°	27.875504°
	Thepiso Primary School	-26.652388°	27.875650°
	Emmanuel Primary School	-26.676238°	27.883255°
Rust Ter Vaal	Rust Ter Vaal Combined School	-26.575722°	27.947132°
Dadaville	Roshnee Primary School	-26.557834°	27.940930°
	Roshnee High School	-26.566323°	27.942320°
Meyerton	Hoerskool Dr Malan	-26.564977°	28.019234°
	Laerskool Voorwaarts	-26.601766°	28.046543°
	Meyerton Secondary School	-26.585957°	28.003034°
	Ratasetjhaba Primary School	-26.553412°	27.983147°
	Meyerton Primary School	-26.553487°	28.020296°
Henley On Klip	Oprah Leadership Academy	-26.547041°	28.055309°
	Henley River Retirement Village	-26.548818°	28.062594°

Area	Sensitive Receptors	Latitude	longitude
	Henley High & Preparatory School	-26.528413°	28.060892°
	Randvaal Clinic	-26.515421°	28.044906°
Daleside / Valley Settlements	Laerskool Japie Greyling	-26.492618°	28.065508°
	Thomas Nhlapo Primary	-26.506179°	28.069969°
	Randvaal Old Age Home	-26.491357°	28.032070°
Heidelberg	Laerskool Ag Visser	-26.527385°	28.364387°
	Lethaba Siyangobe	-26.535127°	28.363146°
	Shalimar Ridge Primary School	-26.512296°	28.352566°
	Jw Luckoff High School	-26.550141°	28.377976°
	Heidelberg Hospital	-26.505180°	28.350463°
	Thulatsatsi Operation (Rensburg)	-26.524848°	28.363676°
	Silwer Akker Tehuis	-26.510276°	28.356255°
	Riversands Retirement Village	-26.507195°	28.343400°
Ratanda	Qhaqholla Primary School	-26.550719°	28.325743°
	Ratanda Primary School	-26.571045°	28.323848°
	Boneha Primary School	-26.551890°	28.328050°
	Sithokomele Primary School	-26.552180°	28.332480°
	Ratanda Bertha Gxowa Primary School	-26.539078°	28.360724°
	Khanya Lesedi Secondary School	-26.558920°	28.323980°
	Ratanda Secondary School	-26.556930°	28.327600°
	New Ratanda Secondary School	-26.536066°	28.356365°
	Kgoro Ya Thuto Secondary School	-26.536087°	28.356288°
Katlehong	Ekurhuleni School For The Deaf	-26.345596°	28.163239°
Tsakane	Pholosong Hospital	-26.340323°	28.376981°
	Tsakane Home For Aged	-26.359892°	28.371919°
	Mmuso Primary School	-26.380790°	28.406465°
	Michael Zulu Primary School	-26.345305°	28.387950°
	Nkabinde Primary School (Thembilisha)	-26.303995°	28.403039°

Area	Sensitive Receptors	Latitude	longitude
Nigel	Nigel Clinic	-26.419586°	28.467950°
	Tehuis Vir Bejaardes	-26.422307°	28.479643°
	Hoerskool John Vorster	-26.427357°	28.472668°
	Laerskool Hannes Visagie	-26.427603°	28.494581°
	Nigel Secondary School	-26.447243°	28.514293°
	Laerskool Dunnottar	-26.346668°	28.431510°
Springs	Springs Retirement Village	-26.255461°	28.447029°
	Life Springs Parkland Hospital	-26.266018°	28.435500°
	Netcare N17 Hospital (Springs)	-26.271306°	28.427831°
	Springs Boys High School	-26.298323°	28.442511°
	Laerskool Selectionpark	-26.280731°	28.447617°
	Kwasa College Pre&Primary School	-26.290089°	28.483292°
	Edelweis Medical Centre	-26.285282°	28.469920°
	Laerskool Christiaan Beyers	-26.260785°	28.462528°
	Hoerskool Hugenote	-26.240027°	28.434373°
Brakpan	Brakpan Primary School	-26.243109°	28.373344°
Boksburg	Parkrand Primary School	-26.249653°	28.276180°
	Thabo Memorial Hospital	-26.232875°	28.244243°
	Sunward Park Hospital	-26.260136°	28.256683°
Alberton	Alberton High School	-26.281920°	28.117084°
	Netcare Clinton Hospital	-26.273268°	28.120227°
	Alberton Tuiste Vir Bejaardes	-26.278995°	28.113435°
Germiston	Bertha Gxowa Hospital	-26.220611°	28.165186°
Benoni	Linmed Hospital	-26.145829°	28.330060°
	Hoerskool Brandwag (Airfield)	-26.174468°	28.317457°
	Thepiso Noto Intermediate School	-26.110681°	28.478384°
	Laerskool Bredell	-26.095549°	28.309374°
	Sibonelo Primary School (Daveyton)	-26.133366°	28.428877°

Area	Sensitive Receptors	Latitude	longitude
	Petit High School (Kempton Park Nu)	-26.097238°	28.371925°
Kempton Park	Arwyp Medical Centre	-26.106876°	28.233229°
	Hoerskool Birchleigh	-26.055418°	28.234975°
	Curro Serengeti Acadamy	-26.056936°	28.294549°
JHB South	South Rand Hospital	-26.252897°	28.062148°
Soweto	Chris Hani Baragwanath Hospital	-26.261492°	27.940355°
	Thulani Primary School	-26.245828°	27.848300°
Johannesburg	University Of Witwatersrand	-26.189947°	28.031656°
	Milpark Hospital	-26.180234°	28.017865°
	Charlotte Maxixe Academic Hospital	-26.175864°	28.045603°
	Thembisa West Secondary School (Thembisa)	-26.026012°	28.184597°
	Lenmed Zamokuhle Private Hospital (Thembisa)	-25.983681°	28.237972°
	Ikusasa Comprehensive School	-26.009079°	28.242320°
Centurion	Gem Village Old Age Home	-25.890517°	28.235196°
	Rustoord Old Age Home	-25.828157°	28.203777°
	Cornwell Hill College (Irene)	-25.873186°	28.234287°
Pretoria East	Kleinfontein Sorg Sentrum Old Age Home (Donkerhoek)	-25.799673°	28.486162°
	Valtaki AH (Rayton)	-25.777795°	28.584606°
	Laerskool Rayton (Rayton)	-25.744732°	28.527243°
	Tierkop AH	-25.902813°	28.422585°
	Redford House The Hills Private School (Mooikloof Glen)	-25.872295°	28.361134°
	Rietvlei View Country Estate	-25.884742°	28.372901°
	Hazeldean Curro School (Tyger Valley)	-25.780919°	28.387427°
	Tyger Valley College	-25.801750°	28.369799°
	Pretoria East Hospital (Moreletapark)	-25.820584°	28.304652°
	Groenkloof Old Age Home	-25.770356°	28.217846°
Pretoria	Steve Biko Academic Hospital	-25.729693°	28.203318°
	Willow Ridge High School (Wilgers)	-25.760751°	28.315444°

Area	Sensitive Receptors	Latitude	longitude
	Hoerskool Waterkloof	-25.818863°	28.255795°
	Hoerskool Garsfontein	-25.797751°	28.304342°
	Afrikaanse Hoer Seunskool	-25.758166°	28.220742°
	Huis Silversig Savf Old Age Home (Silverton)	-25.732724°	28.297254°
	Laersekool Meyerspark (Meyerspark)	-25.740127°	28.313935°
Mamelodi	Curro Academy Mamelodi	-25.698567°	28.422449°
	Impendulo Primary School	-25.723669°	28.437518°
	Nellmapius Ext 6 Primary School	-25.733098°	28.375745°
	Mamelodi Home For Aged	-25.714091°	28.415290°

ANNEXURE 2: PREDICTED CONCENTRATIONS AT SENSITIVE RECEPTORS

Predicted concentrations in µg/m^3 at the sensitive receptors for Scenario 1 (Current), together with the limit value of the NAAQS and number of exceedances (NoE)

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Elsie Ballot Memorial Hospital	89.6	41.6	8.5	45.4	2.8	27.7		5.1	27.7		5.1
Laerskool Amersfoort	86.5	40.1	8.3	44.2	2.7	27.4		5.0	27.4		5.0
Embuzane Primary School	134.9	64.2	10.5	81.8	4.4	45.5		7.7	**45.5**	1	7.7
Sangqotho Primary School	73.3	38.3	8.1	30.3	2.4	29.3		5.5	29.3		5.5
Amersfoort Combined School	88.7	45.2	8.5	44.3	2.8	27.4		5.1	27.4		5.1
Injubuko Primary School	68.3	34.8	7.9	29.1	2.3	26.1		4.9	26.1		4.9
Daggakraal Primary School	94.1	41.0	9.5	53.4	3.6	28.5		5.0	28.5		5.0
Sizenzele Primary School	104.5	46.6	9.8	61.2	3.8	34.8		5.5	34.8		5.5
Seme Secondary School	88.8	41.4	9.6	50.1	3.6	30.7		5.2	30.7		5.2
Louwra Primary School	71.3	36.7	6.3	30.9	1.8	29.0		4.2	29.0		4.2
Perdekop Agricultural School	65.6	37.2	6.3	26.5	1.7	34.5		5.5	34.5		5.5
Vukuzenzele Combined School	68.7	36.5	6.4	26.9	1.7	34.1		5.5	34.1		5.5
Gunwana Primary School	66.4	36.2	6.0	25.3	1.6	25.9		4.1	25.9		4.1
Amajuba Memorial Hospital	59.4	32.5	5.5	23.1	1.4	23.2		3.5	23.2		3.5
Volksrust High School	60.3	33.7	5.5	23.2	1.4	23.9		3.5	23.9		3.5
Volksrust Municipal Clinic	59.4	33.0	5.4	22.8	1.4	22.4		3.4	22.4		3.4
C V O Skool Amajuba	60.3	33.4	5.4	23.0	1.4	23.4		3.4	23.4		3.4
Qhubulwazi Combined School	58.8	31.8	5.4	22.5	1.4	22.7		3.4	22.7		3.4
Volksrust Primary School	60.0	33.0	5.7	23.7	1.5	24.5		3.7	24.5		3.7
New Ermelo	65.0	34.1	8.4	26.0	2.4	35.4		5.5	35.4		5.5
Ermelo Christian School	67.1	36.3	8.6	27.7	2.6	35.4		5.6	35.4		5.6
SAVF Home For Aged	64.3	33.9	8.5	27.0	2.5	29.9		5.1	29.9		5.1
Ermelo Hospital	63.9	33.9	8.4	26.3	2.5	29.5		5.1	29.5		5.1
Mediclinic Ermelo	66.7	36.1	8.6	27.8	2.6	33.7		5.5	33.7		5.5
Hoerskool Ermelo	63.9	33.9	8.4	26.6	2.5	29.6		5.1	29.6		5.1

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Ermelo Indian Combined School	62.8	33.9	8.3	25.9	2.4	29.4		5.1	29.4		5.1
Lungelo Combined School (Outside Town)	63.5	34.2	7.8	26.1	2.3	27.8		5.3	27.8		5.3
New Ermelo Primary School	65.2	34.8	8.4	25.7	2.5	34.9		5.5	34.9		5.5
Kwashashe (Outside Town)	60.7	34.4	8.4	24.0	2.4	30.2		5.1	30.2		5.1
Hts Ligbron	66.0	36.1	8.5	27.1	2.5	31.8		5.3	31.8		5.3
Laerskool Ermelo	63.5	33.8	8.4	26.1	2.5	29.4		5.1	29.4		5.1
JJ Vd Merwe Pre-Primary School	66.0	35.8	8.5	27.6	2.5	30.5		5.3	30.5		5.3
Lindile Secondary School	62.9	33.1	8.2	25.6	2.4	29.2		5.0	29.2		5.0
Emthonjeni Clinic	62.2	33.9	8.3	25.3	2.4	29.5		5.0	29.5		5.0
Reggie Masuku Secondary School	60.7	34.1	8.2	24.0	2.4	29.2		5.0	29.2		5.0
Cebisa Secondary School	61.7	33.9	8.2	25.0	2.4	29.5		5.0	29.5		5.0
Camden	72.8	51.1	8.8	29.3	2.7	**188.2**	**78**	26.3	**188.2**	**222**	**26.3**
Camden Combined School	91.5	63.2	10.1	40.1	3.5	**107.2**	10	18.1	**107.2**	**113**	18.1
Camden School	78.7	47.5	9.1	32.9	2.9	**205.8**	**96**	27.7	**205.8**	**195**	**27.7**
Umzimvelo Secondary School (Rural Area)	72.3	38.2	8.9	29.9	2.7	32.1		4.9	32.1		4.9
Bhekimfundo Primary School (Rural Area)	70.3	38.4	8.6	30.0	2.6	37.0		6.4	37.0		6.4
Eshwileni Primary School (Rural Area)	64.3	36.2	7.9	25.2	2.2	28.1		5.2	28.1		5.2
Davel Combined School	72.4	35.0	8.4	33.0	2.7	32.8		6.2	32.8		6.2
Morgenzon Landbou Akademie	69.3	34.6	8.0	27.7	2.3	31.4		5.7	31.4		5.7
Nqobangolwazi Secondary School	68.8	33.9	7.9	27.6	2.3	31.2		5.7	31.2		5.7
Siqondekhaya Pre Primary School	68.1	34.3	7.9	28.0	2.3	31.7		5.7	31.7		5.7
Sizakhele Primary School	68.2	34.0	7.9	27.7	2.3	32.0		5.7	32.0		5.7
Phezukwentaba Primary School (South of Morgenzon)	66.8	33.1	8.0	26.8	2.3	32.0		5.7	32.0		5.7
Kwaggalaagte Primary School (North of Morgenzon)	74.9	36.9	7.6	34.0	2.3	34.4		6.1	34.4		6.1
Sizakhele Clinic/Hospital	68.1	34.1	7.9	27.7	2.3	31.8		5.7	31.8		5.7
Grootvlei	63.2	31.7	5.2	21.3	1.4	**163.2**	**82**	21.8	**163.2**	**211**	**21.8**
Olive Grove Country Lodge	66.1	34.9	5.4	23.0	1.4	**91.3**	1	9.3	**91.3**	**33**	9.3
Grootvlei Town (South of Power Station)	63.3	30.5	5.3	20.7	1.4	68.5		12.9	**68.5**	**34**	12.9
Laerskool Grootvlei	63.8	31.2	5.3	21.1	1.4	73.4		11.8	**73.4**	**44**	11.8

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Tokoloho Primary School	62.5	30.5	5.4	20.5	1.4	64.1		11.1	**64.1**	**16**	11.1
Tshepeha Combined School	64.3	30.7	5.3	20.8	1.4	**78.7**	1	14.9	**78.7**	**64**	14.9
Warembo Lodge	58.1	30.1	5.7	19.0	1.5	47.3		5.5	**47.3**	1	5.5
Balfour	57.8	30.6	5.1	19.0	1.3	27.7		3.6	27.7		3.6
Siyathemba	58.1	31.5	5.2	18.6	1.3	28.3		3.6	28.3		3.6
Bonukukhanya Primary (Siyathemba)	58.5	31.1	5.2	18.7	1.3	27.9		3.6	27.9		3.6
Qalabocha Primary School (Siyathemba)	58.2	31.5	5.1	18.8	1.3	28.0		3.6	28.0		3.6
Vusumuzi Primary School	58.2	32.1	5.2	18.8	1.3	28.0		3.6	28.0		3.6
Gekombineerde Skool Balfour	58.4	30.4	5.1	18.7	1.3	27.9		3.7	27.9		3.7
Im Manchu Secondary School	58.1	30.4	5.1	18.8	1.3	28.0		3.6	28.0		3.6
Isifisosethu Secondary School (Siyathemba)	58.4	32.1	5.2	18.8	1.3	27.9		3.6	27.9		3.6
Setsheng Secondary School (Siyathemba)	58.1	32.1	5.2	18.9	1.3	28.1		3.6	28.1		3.6
Dr Nieuwoudt And Dr Kok	58.7	30.5	5.2	18.8	1.3	27.9		3.7	27.9		3.7
Balfour Clinic	58.0	30.3	5.1	18.7	1.3	28.1		3.6	28.1		3.6
Siyathemba Clinic	58.5	30.7	5.1	19.0	1.3	28.4		3.6	28.4		3.6
Mondoro Lodge	57.6	31.1	4.9	19.9	1.3	26.9		3.4	26.9		3.4
Wegelegen Manor	57.6	31.4	5.0	18.5	1.2	28.1		3.5	28.1		3.5
The Stone Cellar	56.2	29.3	4.5	18.0	1.1	24.5		3.0	24.5		3.0
Greylingstad	58.9	32.4	5.7	19.2	1.4	26.8		3.7	26.8		3.7
Nthorwane	58.6	31.7	5.5	18.6	1.3	26.8		3.7	26.8		3.7
Laerskool Greylingstad	59.4	33.2	5.8	19.9	1.5	27.2		3.8	27.2		3.8
Nthoroane Secondary School	58.7	31.6	5.6	18.5	1.3	26.8		3.7	26.8		3.7
Badgarleur Bush Lodge	55.2	31.2	5.6	18.2	1.4	25.4		3.7	25.4		3.7
Matla Village	100.6	50.4	7.8	39.9	2.4	**155.5**	**27**	18.5	**155.5**	**102**	18.5
Sifundise Primary School	101.8	49.4	7.8	39.0	2.4	**146.3**	**21**	17.7	**146.3**	**92**	17.7
Matla Coal Health Centre	102.1	54.6	7.9	41.5	2.5	**100.8**	5	14.5	**100.8**	**54**	14.5
Gweda Primary School	130.1	65.2	9.4	77.2	3.7	**114.0**	**15**	22.3	**114.0**	**164**	**22.3**
Zithobe Primary School	85.5	51.9	6.5	33.5	1.8	**75.3**	1	11.6	**75.3**	**17**	11.6
Kwanala Primary School	150.8	81.3	10.5	83.9	4.3	**160.3**	**44**	19.4	**160.3**	**128**	19.4
Reedstream Park	124.8	72.5	9.7	63.8	3.4	61.2		9.9	**61.2**	1	9.9
Rietspruit Clinic	126.5	66.7	9.5	60.4	3.2	54.3		9.4	**54.3**	1	9.4

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Lehlaka Combined School	124.7	67.2	9.6	59.7	3.2	53.3		9.5	**53.3**	1	9.5
Mbali Coal/Blesboklaagte Housing	103.5	50.0	8.4	38.1	2.6	45.5		8.0	**45.5**	1	8.0
Kinross	91.2	57.7	7.2	47.3	2.3	**84.0**	1	10.0	**84.0**	**27**	10.0
Kinross Settlement	83.1	53.6	6.6	34.3	2.0	**79.0**	1	9.3	**79.0**	**14**	9.3
Kinross Municipal Clinic	89.6	57.0	7.1	44.3	2.2	**83.1**	1	9.6	**83.1**	**21**	9.6
Kriel	133.2	56.1	11.3	83.2	5.0	**98.1**	1	12.6	**98.1**	**30**	12.6
Eagles Nest Guest House	132.5	56.2	11.4	82.2	5.1	**101.0**	1	12.1	**101.0**	**19**	12.1
Merlin Park Primary School	129.3	59.2	11.1	82.1	4.7	**80.7**	1	10.3	**80.7**	6	10.3
Kriel Medical Centre	130.6	56.0	11.1	80.1	4.8	**82.9**	1	10.7	**82.9**	9	10.7
Laerskool Krielpark	135.4	57.3	11.2	83.7	4.9	**91.3**	1	11.4	**91.3**	**18**	11.4
Laerskool Onverwacht	131.6	59.6	11.1	83.7	4.7	73.0		10.3	**73.0**	9	10.3
Silwer Fleur Aftree Oord (Old Age Home)	134.8	57.7	11.2	85.2	4.7	74.4		10.6	**74.4**	**14**	10.6
Thubelihle	138.6	66.4	10.5	87.3	4.2	55.8		9.1	**55.8**	1	9.1
Sibongamandla Secondary School	135.5	63.6	10.4	85.3	4.1	54.9		9.4	**54.9**	1	9.4
Ga-Nala Clinic	141.1	63.0	10.9	89.4	4.5	66.6		9.7	**66.6**	3	9.7
Impilo Primary School	105.7	53.0	9.1	62.3	3.3	47.2		8.5	**47.2**	1	8.5
Bonginhlanhla Primary School	135.9	64.3	10.3	83.9	4.1	56.9		9.3	**56.9**	1	9.3
Sibongamandla Secondary School	135.1	63.4	10.3	85.4	4.1	55.3		9.4	**55.3**	1	9.4
Leandra	70.1	44.8	5.7	22.7	1.6	44.6		7.4	**44.6**	1	7.4
Eendracht	71.4	42.2	5.7	23.3	1.5	42.4		6.6	**42.4**	1	6.6
Sidingulwazi Primary School	70.9	43.9	5.7	22.8	1.5	44.2		6.9	**44.2**	1	6.9
Ss Mshayisa Primary School	69.6	43.7	5.7	22.6	1.5	47.3		7.1	**47.3**	1	7.1
Chief Ampie Mayisa Secondary School	70.0	44.4	5.7	22.9	1.5	44.6		6.9	**44.6**	1	6.9
Lebogang Clinic	70.7	43.8	5.7	22.9	1.5	44.6		7.1	**44.6**	1	7.1
Kleuterskool Haas Das	57.4	31.4	5.8	19.1	1.3	31.2		4.7	31.2		4.7
Standerton Primary School	56.7	31.7	5.8	19.3	1.3	31.4		4.8	31.4		4.8
Laerskool Jeugkrag	56.8	33.1	5.8	19.0	1.4	33.1		4.9	33.1		4.9
Laerskool Standerton	58.1	31.0	5.8	19.3	1.3	31.0		4.7	31.0		4.7
Laerskool Kalie De Haas	58.5	31.2	5.9	20.2	1.4	30.9		4.6	30.9		4.6
Hoerskool Standerton	56.7	31.8	5.8	19.3	1.3	31.4		4.8	31.4		4.8
Standerton Provincial Government Hospital	57.0	31.5	5.8	19.0	1.3	31.6		4.8	31.6		4.8

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Mar-Peh Medicare Private Hospital	57.8	30.7	5.8	19.1	1.3	31.0		4.7	31.0		4.7
Standerton Retirement Home	57.8	30.7	5.8	19.1	1.3	30.9		4.7	30.9		4.7
Standerton Ouetehuis/Old Age Home	58.3	31.1	5.8	19.6	1.4	30.8		4.7	30.8		4.7
Holmdene Secondary School	60.7	34.9	5.8	19.3	1.4	32.0		4.5	32.0		4.5
Cathuza Primary School (SE of Town)	62.6	36.0	6.2	23.7	1.5	33.5		5.2	33.5		5.2
Sizanani Pre Primary School	56.1	31.4	5.8	18.6	1.3	30.7		4.6	30.7		4.6
Hlobisa Primary School	55.0	31.6	5.7	17.9	1.3	30.1		4.5	30.1		4.5
Shukuma Primary School	54.7	31.5	5.7	18.4	1.3	30.4		4.4	30.4		4.4
Retsebile Primary School	55.7	31.8	5.8	17.9	1.3	30.7		4.6	30.7		4.6
Thuto-Thebe Secondary School	57.0	32.2	5.8	18.6	1.3	32.3		4.7	32.3		4.7
Jandrell Secondary School	55.5	31.5	5.8	18.1	1.3	30.4		4.6	30.4		4.6
Thobelani Secondary School	55.7	31.6	5.8	17.9	1.3	31.2		4.6	31.2		4.6
Standerton Tb Hospital	55.9	31.2	5.7	18.9	1.3	30.2		4.5	30.2		4.5
Thuthukani Pre Primary School	62.2	40.5	6.2	22.7	1.5	45.0		7.2	**45.0**	1	7.2
Ulwazi Primary School	61.9	40.1	6.2	22.1	1.5	43.4		7.0	**43.4**	1	7.0
Zikhetheleni Secondary School	62.1	40.1	6.2	22.0	1.5	44.1		7.0	**44.1**	1	7.0
Joubertsvlei Primary School (North of Tutuka)	71.6	36.5	6.8	27.0	1.8	35.0		6.4	35.0		6.4
Amalumgelo Primary School (NE of Tutuka)	84.2	40.1	8.0	34.7	2.3	53.3		7.8	**53.3**	1	7.8
Grootdraaidam Primary School	62.3	38.0	6.2	22.3	1.5	34.9		5.4	34.9		5.4
Laerskool Secunda	74.5	46.5	6.7	29.5	1.8	52.2		8.2	**52.2**	1	8.2
Laerskool Kruinpark	73.5	44.0	6.8	31.7	1.9	50.5		8.5	**50.5**	1	8.5
Laerskool Oranjegloed Primary	73.0	45.9	6.6	28.8	1.8	49.8		8.0	**49.8**	1	8.0
Curro Castle Combined School	73.4	44.5	6.5	27.5	1.8	48.4		7.7	**48.4**	1	7.7
Hoërskool Oosterland	73.8	45.4	6.8	30.1	1.9	50.1		8.5	**50.1**	1	8.5
Mediclinic Secunda (Hospital)	75.4	44.7	6.6	29.5	1.8	51.7		8.0	**51.7**	1	8.0
Mediclinic Highveld (Hospital_Trichardt, Secunda)	79.7	48.7	7.2	37.1	2.1	56.7		9.8	**56.7**	1	9.8
Daviescourt/Davieshof Old Age Home	73.7	46.6	6.7	29.3	1.9	52.9		8.2	**52.9**	1	8.2
Highveld Park High School	73.6	46.2	6.8	29.7	1.9	50.7		8.5	**50.7**	1	8.5
Hoerskool Secunda	73.9	46.4	6.6	29.3	1.8	51.7		8.1	**51.7**	1	8.1

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Basizeni Special School	79.8	46.6	6.2	29.4	1.7	44.7		6.3	**44.7**	1	6.3
Maphala-Gulube Primary School	74.0	40.8	6.2	26.4	1.6	37.3		5.9	37.3		5.9
Shapeve Primary School	78.5	44.1	6.3	29.1	1.7	42.2		6.4	**42.2**	1	6.4
Thomas Nhlabathi Secondary School	77.4	47.6	6.2	29.1	1.6	41.8		6.0	**41.8**	1	6.0
Embalenhle Hospital / Clinic	77.9	43.9	6.2	28.0	1.6	40.9		6.0	**40.9**	1	6.0
Vukuzithathe Primary School	74.9	41.1	6.2	27.0	1.6	38.8		5.9	38.8		5.9
K I Twala Secondary	75.7	42.0	6.2	27.4	1.6	39.3		5.8	39.3		5.8
Allan Makunga Primary School	78.3	43.1	6.2	28.9	1.7	41.9		6.3	**41.9**	1	6.3
Evander Hospital Arv Clinic	86.4	47.5	6.8	37.8	2.0	58.5		8.2	**58.5**	1	8.2
Laerskool Hoeveld	85.8	47.4	6.7	37.5	2.0	56.8		8.0	**56.8**	1	8.0
Hoerskool Evander	84.9	49.1	6.6	37.9	1.9	59.9		7.8	**59.9**	1	7.8
Bernice Samuel Hospital	61.0	38.0	4.3	17.3	1.0	34.9		4.6	34.9		4.6
Hoerskool Delmas	60.6	37.5	4.3	16.8	1.0	34.8		4.6	34.8		4.6
Laerskool Delmas	62.0	37.6	4.3	17.3	1.0	35.3		4.7	35.3		4.7
Kangela Primary School (North of Delpark)	60.0	37.7	4.3	17.6	1.0	37.0		5.0	37.0		5.0
Savf Ons Eie Ouetehuis / Old Age Home	61.8	37.5	4.3	17.1	1.0	35.1		4.7	35.1		4.7
Laerskool Eloff	60.1	38.1	4.2	16.7	1.0	32.6		4.1	32.6		4.1
Rietkol Primary School	59.9	38.3	4.2	16.9	0.9	32.5		4.1	32.5		4.1
Bazani Primary School	59.0	36.1	4.2	17.9	1.0	36.9		5.1	36.9		5.1
Phaphamani Secondary School	58.8	36.0	4.2	17.7	0.9	36.8		5.0	36.8		5.0
Vezimfundo Primary School	57.6	35.7	4.1	17.3	0.9	36.5		5.0	36.5		5.0
Arbor Primary School	70.0	43.9	4.9	23.8	1.2	**78.5**	1	12.8	**78.5**	**32**	12.8
Ogies Combined School	99.4	48.4	7.1	32.1	2.0	50.4		7.4	**50.4**	1	7.4
Ogies Tb Clinic	99.9	50.3	7.0	31.5	2.0	50.4		7.4	**50.4**	1	7.4
Ogies Police Station	99.9	50.3	7.0	31.5	2.0	50.4		7.4	**50.4**	1	7.4
Hlangu Phala Primary School	93.6	44.7	6.2	29.3	1.8	42.6		6.3	**42.6**	1	6.3
Sukumani Primary School	94.8	44.7	6.2	29.1	1.8	43.9		6.3	**43.9**	1	6.3
Thuthukani Primary School	94.5	44.4	6.2	28.7	1.8	42.1		6.3	**42.1**	1	6.3
Mehlwana Secondary School	93.7	46.1	6.1	28.4	1.7	46.5		6.4	**46.5**	1	6.4
Makause Combined School	93.1	42.5	6.2	28.3	1.8	43.3		6.4	**43.3**	1	6.4
Sibongindawo Primary School	98.7	44.0	6.0	33.1	1.8	72.0		8.7	**72.0**	8	8.7

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Laerskool Balmoral	66.2	37.8	4.3	24.1	1.1	37.5		4.4	37.5		4.4
Clewer Primary School	78.8	45.7	5.5	23.0	1.4	39.0		5.1	39.0		5.1
Witbank High School	76.4	47.8	5.5	22.1	1.4	55.4		6.4	**55.4**	1	6.4
Eden Park Retirement Village	79.7	47.4	5.7	23.7	1.5	67.5		7.9	**67.5**	8	7.9
Savf House Immergroen Old Age Home	74.7	46.2	5.4	21.6	1.3	50.4		5.8	**50.4**	1	5.8
Mthimkulu Housing For The Aged	75.5	44.1	5.3	20.9	1.3	42.1		5.0	**42.1**	1	5.0
Emalahleni Private Hospital	74.5	47.4	5.3	21.0	1.3	47.8		5.5	**47.8**	1	5.5
Life Cosmos Hospital	76.4	48.2	5.5	22.3	1.4	61.5		6.5	**61.5**	1	6.5
Duvha Primary School	83.3	46.4	5.9	26.2	1.5	57.0		7.5	**57.0**	1	7.5
Laerskool Taalfees	75.9	47.8	5.5	21.7	1.4	56.9		6.3	**56.9**	1	6.3
Witbank Provincial Hospital	74.5	47.8	5.4	21.8	1.3	51.8		5.9	**51.8**	1	5.9
Nancy Shiba Primary School (Vosman)	70.3	42.5	4.9	19.3	1.2	35.1		3.9	35.1		3.9
Wh De Klerk Skool	76.6	45.5	5.4	22.2	1.3	41.5		4.7	**41.5**	1	4.7
Laerskool Panorama	75.2	45.8	5.2	21.3	1.2	36.8		4.1	36.8		4.1
Laerskool Duvhapark	85.8	47.1	6.1	27.2	1.6	63.4		8.5	**63.4**	3	8.5
Laerskool Klipfontein	80.5	47.9	5.7	23.8	1.5	68.7		8.1	**68.7**	12	8.1
Cambridge Academy	79.1	47.0	5.7	23.2	1.4	64.1		7.2	**64.1**	4	7.2
Besilindile Primary School	68.9	39.8	4.7	18.5	1.1	33.1		3.7	33.1		3.7
Reynopark High School	83.0	47.7	5.9	25.7	1.5	**82.0**	1	9.8	**82.0**	**32**	9.8
Bakenveld Golf Estate	83.1	46.5	5.9	25.5	1.5	54.1		5.9	**54.1**	1	5.9
Allendale Secondary School	84.9	51.2	6.8	32.6	1.9	49.6		9.7	**49.6**	1	9.7
Khayalethu Primary School	74.6	44.2	5.2	20.9	1.3	41.9		4.9	**41.9**	1	4.9
Illanga Secondary School	87.3	56.5	6.5	30.6	1.8	**87.5**	1	18.9	**87.5**	**84**	18.9
Joy Creche (Duvha)	82.3	50.2	6.4	29.6	1.7	52.8		8.3	**52.8**	1	8.3
Linderus Old Age Home	74.8	42.6	5.1	21.1	1.1	30.7		3.2	30.7		3.2
Vergeet My Nie Old Age Home	75.3	43.8	5.1	20.5	1.1	30.8		3.2	30.8		3.2
Middleburg Frail Care Unit And Home For Elderly	70.6	43.2	4.8	18.2	1.0	29.1		2.9	29.1		2.9
Life Midmed Hospital	73.3	43.7	4.9	19.6	1.1	29.1		3.0	29.1		3.0
Middelburg Hospital	75.6	44.2	5.1	20.5	1.1	30.8		3.2	30.8		3.2
Makhathini Primary School	72.0	44.9	4.9	19.0	1.0	29.5		2.9	29.5		2.9

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Laerskool Dennesig	68.9	43.2	4.7	17.6	1.0	29.2		2.9	29.2		2.9
Hoerskool Kanonkop	69.4	43.0	4.8	18.4	1.0	29.0		2.9	29.0		2.9
Laerskool Kanonkop	70.8	43.4	4.8	18.6	1.0	29.2		2.9	29.2		2.9
Steelcrest High School	71.3	43.1	4.9	19.3	1.0	29.3		3.0	29.3		3.0
Middelburg Primary	75.5	43.5	5.1	20.8	1.1	30.5		3.2	30.5		3.2
Middleburg Ext 6 Clinic	76.0	46.9	5.1	20.9	1.1	35.1		3.6	35.1		3.6
Sofunda Secondary School	73.5	44.6	5.0	20.3	1.1	32.2		3.2	32.2		3.2
Mhluzi Primary School	73.0	45.0	4.9	19.3	1.0	29.9		3.0	29.9		3.0
Highlands Primary School	76.5	44.3	5.2	21.8	1.2	31.4		3.3	31.4		3.3
Blinkpan Primary School	86.7	47.9	8.1	37.1	2.5	60.0		12.0	**60.0**	5	12.0
Laerskool Koornfontein	87.4	45.8	8.1	36.8	2.5	**91.7**	1	19.6	**91.7**	**140**	19.6
Blinkpan	87.9	49.3	8.1	37.0	2.4	53.5		10.8	**53.5**	1	10.8
Laerskool Kragveld	83.4	47.9	8.0	33.3	2.4	39.6		6.9	39.6		6.9
Pullens Hope	84.5	47.3	8.0	32.1	2.4	39.6		7.1	39.6		7.1
Arnot Colliery Primary School	75.7	50.0	6.8	24.8	2.0	**90.8**	1	9.1	**90.8**	**26**	9.1
Laerskool Rietkuil	80.6	43.5	7.2	30.3	2.2	**144.1**	**93**	26.1	**144.1**	**217**	**26.1**
Beestepan Agricultural School	67.3	42.3	5.6	20.3	1.3	29.0		3.5	29.0		3.5
Gekombineerde Skool Hendrina	67.5	38.2	8.0	25.4	2.3	38.9		7.4	38.9		7.4
Hendrina Primary School	66.9	38.0	8.0	25.0	2.3	39.4		7.1	39.4		7.1
Kwazamokuhle Secondary School	67.1	39.3	8.1	25.3	2.3	40.8		7.0	**40.8**	1	7.0
Ubuhle Bolwai Secondary School	51.9	32.7	7.2	15.8	1.7	25.5		4.0	25.5		4.0
Lothair Primary School	51.7	32.9	7.3	16.1	1.8	25.5		4.1	25.5		4.1
Warburton Combined School	50.3	32.9	7.0	14.3	1.6	25.5		3.8	25.5		3.8
Warburton Town	50.7	33.0	7.0	14.3	1.6	25.5		3.8	25.5		3.8
Kwachibikhulu Clinic	53.8	33.7	7.4	16.9	1.8	27.7		4.5	27.7		4.5
Kwachibikhulu Primary School	54.1	33.7	7.4	16.7	1.9	27.7		4.5	27.7		4.5
Carolina Hospital	56.2	33.8	7.1	17.7	1.8	31.7		4.6	31.7		4.6
Zinikeleni Secondary School (Silobela)	55.7	33.5	7.1	17.4	1.8	31.6		4.6	31.6		4.6
Volkskool Carolina	56.4	34.2	7.1	18.4	1.8	32.7		4.6	32.7		4.6
Sobuza Primary School	55.8	33.6	7.1	16.9	1.8	31.6		4.6	31.6		4.6
Ons Eie Ouetehuis (Old Age Home)	56.4	34.2	7.1	18.3	1.9	32.5		4.6	32.5		4.6

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Laerskool Breyten	55.7	32.6	7.7	20.7	2.2	28.4		5.2	28.4		5.2
Siyazi Primary School (Kwazanele)	55.8	32.9	7.8	21.2	2.2	27.7		5.1	27.7		5.1
Masizakhe Secondary School (Kwazanele)	55.8	32.8	7.7	21.0	2.2	27.7		5.1	27.7		5.1
Belfast Rusoord (Old Age Home)	51.5	35.0	4.5	13.7	0.9	23.1		2.5	23.1		2.5
Belfast Hospital	51.6	34.9	4.6	14.1	1.0	23.2		2.5	23.2		2.5
Platorand School	52.4	35.2	4.7	14.4	1.0	23.2		2.5	23.2		2.5
Belfast Primary School (Siyathuthuka)	51.9	31.5	4.4	13.5	0.9	22.1		2.4	22.1		2.4
Siyathuthuka Clinic	51.8	31.7	4.4	13.6	0.9	22.0		2.4	22.0		2.4
Life Bethal Hospital	89.7	41.4	8.5	45.6	3.0	40.3		7.3	**40.3**	1	7.3
Hoerskool Hoogenhout	90.0	41.8	8.5	45.6	3.0	40.1		7.2	**40.1**	1	7.2
Jim Van Tonderskool	95.8	41.2	8.7	49.5	3.2	45.0		7.9	**45.0**	1	7.9
Bethal Independent Primary School	94.9	41.4	8.7	48.7	3.1	44.2		7.8	**44.2**	1	7.8
Laerskool Marietjie Van Niekerk	88.3	39.5	8.7	45.3	3.1	39.6		7.3	39.6		7.3
Laerskool Hm Swart	90.6	42.4	8.5	46.3	3.0	41.2		7.3	**41.2**	1	7.3
Sakhisizwe Primary School (Emzinoni)	86.7	41.8	8.1	44.7	2.7	42.6		7.6	**42.6**	1	7.6
Alpheus D Nkosi Secondary School (Emzinoni)	86.5	41.4	8.2	45.8	2.8	41.3		7.4	**41.3**	1	7.4
Silwerjare Old Age Home	88.1	42.4	8.4	44.7	2.9	41.0		7.2	**41.0**	1	7.2
Residentia Palm Oord	90.6	42.4	8.5	46.5	3.0	41.4		7.4	**41.4**	1	7.4
Bronkhorspruit Hospital	49.5	32.5	3.2	11.5	0.6	30.4		3.0	30.4		3.0
Cultura High School	52.8	33.9	3.4	12.9	0.6	35.4		3.4	35.4		3.4
Bronkhorspruit Primary School	50.2	32.3	3.2	12.0	0.6	30.5		3.0	30.5		3.0
Bronkhorspruit Dam	54.6	35.3	3.5	14.9	0.7	36.4		4.1	36.4		4.1
Hoerskool Erasmus	51.5	33.7	3.3	12.1	0.6	32.9		3.2	32.9		3.2
Althea Independent School	51.1	33.3	3.3	12.2	0.6	31.7		3.1	31.7		3.1
Kgoro Primary School (Zithobeni)	48.3	32.0	3.2	11.1	0.6	28.7		2.8	28.7		2.8
Zithobeni Secondary School (Zithobeni)	47.8	31.7	3.1	10.6	0.6	29.5		2.8	29.5		2.8
Vaal Power AH	74.1	41.0	4.3	24.4	1.2	68.8		9.1	**68.8**	**30**	9.1
Sasolburg Provincial Hospital	59.8	49.3	3.3	16.5	0.8	39.3		3.4	39.3		3.4
Moredou Old Age Home	58.4	47.1	3.3	15.5	0.8	35.0		3.1	35.0		3.1
Ons Gryse Jeug Old Age Home	58.1	48.9	3.3	16.0	0.8	36.6		3.3	36.6		3.3

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Noord Primere Skool	58.0	49.3	3.3	15.8	0.8	37.1		3.3	37.1		3.3
Sasolburg High School	58.5	48.1	3.2	15.9	0.8	38.0		3.1	38.0		3.1
Sakhubusa Secondary School	63.4	40.3	3.4	18.0	0.8	42.9		3.7	**42.9**	1	3.7
Bekezela Primary School	63.3	37.4	3.4	18.8	0.8	47.3		4.3	**47.3**	1	4.3
Isaac Mhlambi Primary	58.9	42.6	3.4	16.1	0.8	48.3		3.9	**48.3**	1	3.9
Refenkgotso Primary School	88.3	37.5	5.1	33.7	1.5	40.9		4.6	**40.9**	1	4.6
Deneysville Primary School	91.3	35.7	5.3	33.5	1.6	32.8		4.3	32.8		4.3
Netcare Vaalpark Hospital	58.6	51.6	3.3	16.0	0.8	50.4		4.4	**50.4**	1	4.4
Vaalpark Articon Secondary School	58.6	51.5	3.4	15.7	0.8	54.8		4.9	**54.8**	1	4.9
Mediclinic Emfuleni	53.2	37.3	3.0	14.0	0.7	43.4		3.5	**43.4**	1	3.5
Jeugland Old Age Home	53.3	39.6	3.0	14.0	0.7	37.6		3.4	37.6		3.4
Herfsoord Huis Old Age Home	53.5	36.4	3.0	13.8	0.7	38.4		3.2	38.4		3.2
Huis Prinscilla	50.9	35.6	3.0	13.3	0.7	36.9		3.1	36.9		3.1
Laerskool Emfulenipark	57.1	46.8	3.3	14.9	0.8	50.3		4.3	**50.3**	1	4.3
Nw University_Vaal Campus	54.4	44.2	3.2	14.2	0.7	60.6		5.6	**60.6**	4	5.6
Emfuleni Primary School	51.2	34.4	2.9	13.2	0.6	34.7		2.8	34.7		2.8
Mediclinic Vereeniging	52.7	39.0	3.2	13.1	0.7	46.5		4.5	**46.5**	1	4.5
Kopanong Provincial Hospital (Duncanville)	56.2	36.9	3.4	14.6	0.8	29.5		2.7	29.5		2.7
Avondrus Eventide Old Age Home	56.0	38.2	3.4	14.5	0.8	31.7		2.9	31.7		2.9
Riviera On Vaal Resort	52.2	39.3	3.3	13.4	0.8	54.5		5.2	**54.5**	1	5.2
Sedibeng Tvet College	52.2	38.1	3.3	13.4	0.7	56.2		5.3	**56.2**	1	5.3
General Smuts High School	53.3	41.0	3.3	13.8	0.7	46.6		4.5	**46.6**	1	4.5
Eureuka School & Selbourne Primary	53.0	39.5	3.2	13.7	0.7	45.9		4.3	**45.9**	1	4.3
Midvaal Private Hospital (Three Rivers)	62.0	47.3	3.7	16.5	0.9	54.4		4.8	**54.4**	1	4.8
Three Rivers Retirement Village	62.8	43.9	3.8	16.9	0.9	45.0		3.9	**45.0**	1	3.9
Drie Riviere Aftreeoord Old Age Home	62.9	43.2	3.8	17.0	0.9	38.6		3.5	38.6		3.5
Riverside High School	73.4	44.8	4.3	21.9	1.1	62.1		4.7	**62.1**	3	4.7
Risiville Primary School	66.4	41.8	3.9	18.1	0.9	36.5		3.5	36.5		3.5
Sebokeng Hospital	50.7	33.8	2.9	13.7	0.6	26.0		2.3	26.0		2.3
Clinix-Naledzi Private Hospital	50.8	35.1	2.9	13.7	0.6	26.8		2.4	26.8		2.4
Mohloli Secondary School	52.2	40.4	3.1	13.4	0.7	45.9		4.1	**45.9**	1	4.1

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Tshirela Primary School (Boipatong)	50.6	35.4	3.0	13.4	0.7	32.1		2.9	32.1		2.9
Tsoaranang Primary School (Thepiso)	50.3	39.4	3.1	13.3	0.7	37.9		3.5	37.9		3.5
Thepiso Primary School	50.7	40.8	3.1	13.8	0.7	37.1		3.1	37.1		3.1
Emmanuel Primary School	50.3	39.0	3.1	13.1	0.7	40.6		3.7	**40.6**	1	3.7
Rust Ter Vaal Combined School	52.1	35.4	3.2	14.4	0.7	25.0		2.3	25.0		2.3
Roshnee Primary School	50.8	33.9	3.1	14.0	0.7	23.2		2.2	23.2		2.2
Roshnee High School	51.0	35.2	3.2	14.2	0.7	24.8		2.2	24.8		2.2
Hoerskool Dr Malan	59.0	35.7	3.6	16.9	0.8	26.4		2.5	26.4		2.5
Laerskool Voorwaarts	72.9	41.8	4.2	22.6	1.0	29.0		2.9	29.0		2.9
Meyerton Secondary School	58.1	36.7	3.7	16.6	0.8	25.3		2.6	25.3		2.6
Ratasetjhaba Primary School	54.2	36.0	3.4	15.5	0.7	23.4		2.3	23.4		2.3
Meyerton Primary School	57.9	35.7	3.5	16.4	0.8	25.5		2.4	25.5		2.4
Oprah Leadership Academy	60.8	35.4	3.7	18.0	0.8	25.2		2.4	25.2		2.4
Henley River Retirement Village	60.9	34.3	3.8	18.3	0.9	24.9		2.4	24.9		2.4
Henley High & Preparatory School	59.3	34.6	3.6	17.5	0.8	23.7		2.3	23.7		2.3
Randvaal Clinic	55.9	34.8	3.4	16.7	0.8	23.6		2.3	23.6		2.3
Laerskool Japie Greyling	56.4	32.0	3.4	16.1	0.7	22.6		2.2	22.6		2.2
Thomas Nhlapo Primary	57.9	32.1	3.5	16.6	0.8	23.2		2.3	23.2		2.3
Randvaal Old Age Home	53.7	33.6	3.3	15.6	0.7	22.3		2.2	22.3		2.2
Laerskool Ag Visser	57.5	32.7	4.2	17.1	1.0	23.6		2.7	23.6		2.7
Lethaba Siyangobe	57.9	32.6	4.2	17.4	1.0	23.7		2.7	23.7		2.7
Shalimar Ridge Primary School	56.1	33.1	4.1	16.9	1.0	23.9		2.7	23.9		2.7
Jw Luckoff High School	59.0	33.0	4.4	18.3	1.1	23.9		2.7	23.9		2.7
Heidelberg Hospital	56.7	33.8	4.2	17.2	1.0	23.8		2.7	23.8		2.7
Thulatsatsi Operation (Rensburg)	57.8	32.8	4.2	17.0	1.0	23.7		2.7	23.7		2.7
Silwer Akker Tehuis	56.1	33.0	4.1	16.9	1.0	24.0		2.7	24.0		2.7
Riversands Retirement Village	57.1	34.0	4.2	17.5	1.0	23.6		2.7	23.6		2.7
Qhaqholla Primary School	59.5	32.1	4.2	17.8	1.0	23.2		2.6	23.2		2.6
Ratanda Primary School	60.7	32.2	4.3	19.1	1.0	22.9		2.6	22.9		2.6
Boneha Primary School	59.5	32.1	4.2	18.0	1.0	23.3		2.6	23.3		2.6
Sithokomele Primary School	59.6	32.2	4.2	17.9	1.0	23.4		2.6	23.4		2.6

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Ratanda Bertha Gxowa Primary School	58.3	32.9	4.3	17.4	1.0	23.7		2.7	23.7		2.7
Khanya Lesedi Secondary School	60.0	32.3	4.2	18.0	1.0	23.0		2.6	23.0		2.6
Ratanda Secondary School	59.7	32.4	4.2	18.0	1.0	23.2		2.6	23.2		2.6
New Ratanda Secondary School	58.1	32.7	4.2	17.2	1.0	23.6		2.7	23.6		2.7
Kgoro Ya Thuto Secondary School	58.1	32.7	4.2	17.2	1.0	23.6		2.7	23.6		2.7
Ekurhuleni School For The Deaf	52.1	30.1	3.4	13.5	0.7	21.9		2.1	21.9		2.1
Pholosong Hospital	55.8	33.4	3.9	16.1	0.9	25.1		2.7	25.1		2.7
Tsakane Home For Aged	56.5	32.9	4.0	17.0	0.9	24.9		2.7	24.9		2.7
Mmuso Primary School	58.3	35.7	4.2	17.9	1.0	25.5		2.8	25.5		2.8
Michael Zulu Primary School	56.5	33.4	4.0	16.7	0.9	25.4		2.7	25.4		2.7
Nkabinde Primary School (Thembilisha)	56.1	32.4	3.9	15.5	0.9	25.3		2.7	25.3		2.7
Nigel Clinic	57.7	36.8	4.2	16.5	1.0	25.7		3.0	25.7		3.0
Tehuis Vir Bejaardes	58.1	36.7	4.2	16.6	1.0	26.2		3.0	26.2		3.0
Hoerskool John Vorster	57.5	37.1	4.2	16.7	1.0	25.9		3.0	25.9		3.0
Laerskool Hannes Visagie	57.1	36.6	4.3	16.8	1.0	26.8		3.0	26.8		3.0
Nigel Secondary School	58.1	34.9	4.4	17.3	1.0	26.8		3.1	26.8		3.1
Laerskool Dunnottar	58.1	35.3	4.1	16.9	0.9	25.6		2.9	25.6		2.9
Springs Retirement Village	55.7	33.1	3.8	15.0	0.8	25.8		2.9	25.8		2.9
Life Springs Parkland Hospital	55.7	32.5	3.8	15.1	0.8	25.6		2.8	25.6		2.8
Netcare N17 Hospital (Springs)	56.0	32.1	3.8	15.1	0.8	25.5		2.8	25.5		2.8
Springs Boys High School	56.1	32.8	4.0	15.9	0.9	26.0		2.9	26.0		2.9
Laerskool Selectionpark	55.6	32.2	3.9	15.2	0.8	25.8		2.9	25.8		2.9
Kwasa College Pre&Primary School	57.1	32.7	4.0	15.9	0.9	26.2		3.0	26.2		3.0
Edelweis Medical Centre	57.2	32.3	4.0	15.6	0.9	26.3		2.9	26.3		2.9
Laerskool Christiaan Beyers	56.2	33.1	3.9	15.0	0.8	25.9		2.9	25.9		2.9
Hoerskool Hugenote	54.9	33.3	3.8	14.9	0.8	25.9		2.8	25.9		2.8
Brakpan Primary School	52.5	33.3	3.6	14.2	0.8	25.3		2.6	25.3		2.6
Parkrand Primary School	50.6	32.2	3.5	13.6	0.7	23.8		2.3	23.8		2.3
Thabo Memorial Hospital	49.7	30.8	3.4	13.8	0.7	23.4		2.2	23.4		2.2
Sunward Park Hospital	50.3	31.5	3.4	13.4	0.7	23.6		2.2	23.6		2.2
Alberton High School	48.5	30.9	3.2	13.1	0.7	21.6		2.0	21.6		2.0

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Netcare Clinton Hospital	48.3	30.7	3.1	13.1	0.6	21.3		2.0	21.3		2.0
Alberton Tuiste Vir Bejaardes	48.4	30.8	3.2	13.1	0.7	21.3		2.0	21.3		2.0
Bertha Gxowa Hospital	48.8	29.8	3.3	14.0	0.7	21.7		2.0	21.7		2.0
Linmed Hospital	49.4	33.5	3.4	14.0	0.7	24.4		2.4	24.4		2.4
Hoerskool Brandwag (Airfield)	50.4	32.0	3.5	14.2	0.8	24.8		2.4	24.8		2.4
Thepiso Noto Intermediate School	51.5	33.8	3.7	13.8	0.8	29.5		3.2	29.5		3.2
Laerskool Bredell	46.9	33.3	3.2	11.8	0.6	24.4		2.3	24.4		2.3
Sibonelo Primary School (Daveyton)	50.6	34.7	3.6	13.5	0.8	27.5		2.9	27.5		2.9
Petit High School (Kempton Park Nu)	48.6	34.2	3.4	12.7	0.7	26.1		2.6	26.1		2.6
Arwyp Medical Centre	46.6	31.6	3.2	12.4	0.6	22.9		2.1	22.9		2.1
Hoerskool Birchleigh	45.4	30.9	3.0	11.1	0.6	22.8		2.0	22.8		2.0
Curro Serengeti Acadamy	46.6	31.5	3.1	11.3	0.6	24.1		2.2	24.1		2.2
South Rand Hospital	49.5	30.5	3.3	15.6	0.8	21.3		1.9	21.3		1.9
Chris Hani Baragwanath Hospital	43.4	27.3	2.7	12.6	0.6	20.6		1.6	20.6		1.6
Thulani Primary School	40.1	26.1	2.4	11.6	0.5	18.9		1.5	18.9		1.5
University of Witwatersrand	50.3	30.6	3.2	16.0	0.7	20.9		1.8	20.9		1.8
Milpark Hospital	48.6	31.4	3.1	14.8	0.7	20.4		1.7	20.4		1.7
Charlotte Maxixe Academic Hospital	49.3	31.9	3.2	15.5	0.7	20.6		1.8	20.6		1.8
Thembisa West Secondary School (Thembisa)	42.0	30.3	2.8	9.9	0.5	21.7		1.9	21.7		1.9
Lenmed Zamokuhle Private Hospital (Thembisa)	43.2	29.1	2.8	10.0	0.5	22.6		2.0	22.6		2.0
Ikusasa Comprehensive School	43.9	29.8	2.9	10.3	0.5	21.9		2.0	21.9		2.0
Gem Village Old Age Home	43.0	30.6	2.7	9.7	0.5	23.1		1.9	23.1		1.9
Rustoord Old Age Home	43.0	30.0	2.6	9.2	0.4	23.9		1.8	23.9		1.8
Cornwell Hill College (Irene)	43.4	30.4	2.7	9.7	0.5	23.5		1.9	23.5		1.9
Kleinfontein Sorg Sentrum Old Age Home (Donkerhoek)	45.6	31.2	2.9	10.0	0.5	24.8		2.3	24.8		2.3
Valtaki AH (Rayton)	45.6	30.5	2.9	9.7	0.5	26.5		2.4	26.5		2.4
Laerskool Rayton (Rayton)	42.0	29.2	2.7	8.2	0.4	24.2		2.0	24.2		2.0
Tierkop AH	48.7	33.1	3.1	12.1	0.6	26.9		2.5	26.9		2.5

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Redford House The Hills Private School (Mooikloof Glen)	49.4	30.4	3.0	11.8	0.6	26.6		2.3	26.6		2.3
Rietvlei View Country Estate	48.8	31.5	3.0	12.0	0.6	26.7		2.3	26.7		2.3
Hazeldean Curro School (Tyger Valley)	43.5	29.4	2.6	8.5	0.4	22.7		1.8	22.7		1.8
Tyger Valley College	44.8	29.0	2.7	9.3	0.4	24.2		1.9	24.2		1.9
Pretoria East Hospital (Moreletapark)	46.2	28.1	2.7	10.1	0.5	24.4		2.0	24.4		2.0
Groenkloof Old Age Home	41.4	28.8	2.5	8.6	0.4	21.9		1.7	21.9		1.7
Steve Biko Academic Hospital	39.5	27.6	2.3	7.6	0.4	19.7		1.5	19.7		1.5
Willow Ridge High School (Wilgers)	42.0	29.1	2.5	8.1	0.4	21.7		1.7	21.7		1.7
Hoerskool Waterkloof	44.6	30.5	2.7	9.9	0.5	24.5		1.9	24.5		1.9
Hoerskool Garsfontein	44.7	28.2	2.6	9.3	0.4	23.8		1.9	23.8		1.9
Afrikaanse Hoer Seunskool	40.6	28.4	2.4	8.2	0.4	21.2		1.6	21.2		1.6
Huis Silversig SAVF Old Age Home (Silverton)	40.6	27.7	2.4	7.4	0.4	20.8		1.6	20.8		1.6
Laersekool Meyerspark (Meyerspark)	41.6	28.1	2.4	7.6	0.4	21.2		1.6	21.2		1.6
Curro Academy Mamelodi	39.1	26.5	2.3	6.7	0.3	21.2		1.6	21.2		1.6
Impendulo Primary School	40.6	27.8	2.4	7.2	0.4	21.8		1.7	21.8		1.7
Nellmapius Ext 6 Primary School	40.7	28.1	2.4	7.0	0.4	21.2		1.6	21.2		1.6
Mamelodi Home For Aged	40.0	27.6	2.4	6.9	0.4	21.2		1.6	21.2		1.6

Predicted concentrations in µg/m³ at the sensitive receptors for Scenario A (2025), together with the limit value of the NAAQS and number of exceedances (NoE)

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Elsie Ballot Memorial Hospital	176.0	74.9	14.2	40.7	3.1	30.9		5.6	30.9		5.6
Laerskool Amersfoort	166.5	67.7	13.9	38.9	3.0	30.3		5.5	30.3		5.5
Embuzane Primary School	344.0	121.1	23.0	81.7	5.3	51.0		8.4	**51.0**	1	8.4
Sangqotho Primary School	115.3	52.9	13.0	32.9	3.0	32.2		6.0	32.2		6.0
Amersfoort Combined School	161.8	75.1	14.0	38.8	3.1	30.7		5.6	30.7		5.6
Injubuko Primary School	110.7	53.2	12.6	29.5	2.7	29.7		5.4	29.7		5.4
Daggakraal Primary School	168.0	65.4	16.6	38.5	3.5	30.9		5.5	30.9		5.5
Sizenzele Primary School	206.0	71.7	17.6	47.4	3.9	39.3		6.1	39.3		6.1
Seme Secondary School	156.0	62.9	16.7	36.4	3.6	33.9		5.8	33.9		5.8
Louwra Primary School	125.7	59.3	10.5	30.0	2.1	33.7		4.7	33.7		4.7
Perdekop Agricultural School	110.1	57.5	10.5	30.3	2.2	39.3		6.0	39.3		6.0
Vukuzenzele Combined School	114.5	59.0	10.6	31.5	2.2	39.0		6.0	39.0		6.0
Gunwana Primary School	113.1	60.8	9.9	29.8	1.9	30.5		4.6	30.5		4.6
Amajuba Memorial Hospital	101.9	52.2	8.9	23.7	1.7	26.8		4.0	26.8		4.0
Volksrust High School	101.4	51.5	8.8	23.9	1.6	27.3		3.9	27.3		3.9
Volksrust Municipal Clinic	100.7	50.9	8.6	23.3	1.6	25.7		3.8	25.7		3.8
C V O Skool Amajuba	100.5	51.2	8.7	23.4	1.6	26.3		3.9	26.3		3.9
Qhubulwazi Combined School	99.1	49.1	8.7	22.9	1.6	26.2		3.9	26.2		3.9
Volksrust Primary School	104.6	52.7	9.2	24.6	1.8	28.0		4.1	28.0		4.1
New Ermelo	91.2	49.9	12.6	29.7	3.1	38.5		5.8	38.5		5.8
Ermelo Christian School	92.2	47.5	13.1	32.6	3.3	38.0		5.9	38.0		5.9
SAVF Home For Aged	89.4	47.8	12.9	30.8	3.2	31.0		5.4	31.0		5.4
Ermelo Hospital	88.2	46.7	12.7	29.9	3.2	30.4		5.3	30.4		5.3
Mediclinic Ermelo	91.3	48.0	13.1	32.6	3.3	35.9		5.8	35.9		5.8
Hoerskool Ermelo	89.0	47.2	12.8	30.1	3.2	30.4		5.4	30.4		5.4
Ermelo Indian Combined School	87.0	45.2	12.6	29.2	3.1	30.8		5.3	30.8		5.3
Lungelo Combined School (Outside Town)	94.0	48.7	12.2	30.2	2.9	30.3		5.6	30.3		5.6
New Ermelo Primary School	90.9	46.2	12.7	29.7	3.1	38.1		5.8	38.1		5.8

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Kwashashe (Outside Town)	85.1	47.3	12.9	27.2	3.2	31.9		5.4	31.9		5.4
Hts Ligbron	89.4	47.9	13.0	31.5	3.3	33.0		5.6	33.0		5.6
Laerskool Ermelo	87.9	47.7	12.8	29.8	3.2	30.7		5.4	30.7		5.4
JJ Vd Merwe Pre-Primary School	90.6	47.3	12.9	31.1	3.3	33.4		5.6	33.4		5.6
Lindile Secondary School	86.8	45.2	12.5	28.4	3.1	30.5		5.3	30.5		5.3
Emthonjeni Clinic	86.4	46.3	12.6	28.7	3.1	29.9		5.3	29.9		5.3
Reggie Masuku Secondary School	83.4	45.4	12.5	27.6	3.0	29.3		5.2	29.3		5.2
Cebisa Secondary School	85.4	45.9	12.6	28.6	3.1	29.8		5.3	29.8		5.3
Camden	101.1	66.4	13.2	33.9	3.5	**189.8**	**78**	26.7	**189.8**	**218**	**26.7**
Camden Combined School	128.5	85.1	15.0	54.7	4.5	**111.6**	8	18.5	**111.6**	**111**	18.5
Camden School	112.5	60.6	13.5	39.5	3.6	**209.4**	**95**	28.1	**209.4**	**195**	**28.1**
Umzimvelo Secondary School (Rural Area)	96.2	51.7	13.1	34.7	3.3	35.1		5.3	35.1		5.3
Bhekimfundo Primary School (Rural Area)	100.1	50.5	13.4	36.4	3.5	42.3		6.8	**42.3**	1	6.8
Eshwileni Primary School (Rural Area)	94.4	50.1	12.3	29.3	2.8	30.3		5.6	30.3		5.6
Davel Combined School	101.4	51.0	13.4	35.6	3.5	34.7		6.2	34.7		6.2
Morgenzon Landbou Akademie	100.8	48.3	12.7	33.1	3.1	34.1		6.2	34.1		6.2
Nqobangolwazi Secondary School	101.6	47.4	12.5	32.9	3.0	33.2		6.1	33.2		6.1
Siqondekhaya Pre Primary School	101.7	47.6	12.4	33.0	3.0	35.4		6.2	35.4		6.2
Sizakhele Primary School	101.4	47.5	12.4	33.2	3.0	35.3		6.1	35.3		6.1
Phezukwentaba Primary School (South of Morgenzon)	99.5	48.5	12.7	31.3	3.0	34.2		6.2	34.2		6.2
Kwaggalaagte Primary School (North of Morgenzon)	114.4	53.4	12.2	40.0	3.1	37.2		6.4	37.2		6.4
Sizakhele Clinic/Hospital	101.5	47.6	12.4	32.9	3.0	35.0		6.1	35.0		6.1
Grootvlei	81.1	45.5	7.3	22.3	1.6	**170.0**	**79**	22.0	**170.0**	**211**	**22.0**
Olive Grove Country Lodge	94.7	53.4	7.9	29.5	1.9	**95.6**	1	9.6	**95.6**	**29**	9.6
Grootvlei Town (South of Power Station)	92.2	44.8	8.2	29.2	2.0	73.5		13.2	**73.5**	**35**	13.2
Laerskool Grootvlei	93.0	47.7	8.1	28.8	1.9	**78.6**	1	12.1	**78.6**	**42**	12.1
Tokoloho Primary School	90.9	45.2	8.2	29.3	2.0	68.8		11.4	**68.8**	**16**	11.4
Tshepeha Combined School	92.8	45.3	8.3	29.4	2.0	**83.6**	1	15.2	**83.6**	**63**	15.2
Warembo Lodge	75.8	40.4	8.7	23.8	2.1	51.3		5.8	**51.3**	1	5.8

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Balfour	73.0	42.4	7.3	20.5	1.6	30.2		3.8	30.2		3.8
Siyathemba	74.7	42.1	7.5	20.8	1.6	30.3		3.9	30.3		3.9
Bonukukhanya Primary (Siyathemba)	74.7	41.8	7.5	20.8	1.6	30.6		3.9	30.6		3.9
Qalabocha Primary School (Siyathemba)	74.5	42.1	7.5	20.7	1.6	29.9		3.9	29.9		3.9
Vusumuzi Primary School	75.1	42.7	7.6	21.1	1.6	30.7		3.9	30.7		3.9
Gekombineerde Skool Balfour	73.7	40.5	7.4	20.8	1.6	31.0		3.9	31.0		3.9
Im Manchu Secondary School	73.6	40.3	7.3	20.5	1.6	30.9		3.9	30.9		3.9
Isifisosethu Secondary School (Siyathemba)	75.4	42.6	7.6	21.3	1.7	30.8		3.9	30.8		3.9
Setsheng Secondary School (Siyathemba)	74.9	42.7	7.5	21.0	1.6	29.8		3.9	29.8		3.9
Dr Nieuwoudt And Dr Kok	73.9	40.5	7.4	21.0	1.6	31.6		4.0	31.6		4.0
Balfour Clinic	73.0	40.2	7.3	20.4	1.6	31.1		3.9	31.1		3.9
Siyathemba Clinic	73.9	42.0	7.4	20.7	1.6	30.5		3.9	30.5		3.9
Mondoro Lodge	73.9	39.6	7.0	21.3	1.5	29.0		3.6	29.0		3.6
Wegelegen Manor	73.5	42.3	7.3	20.7	1.5	29.6		3.8	29.6		3.8
The Stone Cellar	72.1	38.3	6.3	18.8	1.3	27.2		3.2	27.2		3.2
Greylingstad	77.5	44.8	8.4	22.4	1.8	30.0		4.1	30.0		4.1
Nthorwane	76.6	45.1	8.2	21.3	1.7	30.8		4.0	30.8		4.0
Laerskool Greylingstad	79.5	45.6	8.6	22.9	1.9	30.0		4.1	30.0		4.1
Nthoroane Secondary School	76.6	45.3	8.2	21.2	1.7	30.5		4.0	30.5		4.0
Badgarleur Bush Lodge	73.3	41.4	8.4	20.8	1.9	29.9		4.0	29.9		4.0
Matla Village	168.5	77.0	13.6	56.7	3.7	**159.5**	**27**	18.6	**159.5**	**96**	18.6
Sifundise Primary School	167.1	78.4	13.7	55.3	3.7	**150.4**	**21**	17.8	**150.4**	**89**	17.8
Matla Coal Health Centre	171.2	80.3	13.9	58.1	3.8	**105.5**	5	14.6	**105.5**	**53**	14.6
Gweda Primary School	224.5	87.1	16.2	97.4	5.3	**120.8**	**14**	22.4	**120.8**	**158**	**22.4**
Zithobe Primary School	144.3	68.2	11.0	49.9	2.8	**79.3**	1	11.8	**79.3**	**18**	11.8
Kwanala Primary School	221.7	99.8	18.0	107.8	6.1	**164.0**	**43**	19.5	**164.0**	**126**	19.5
Reedstream Park	180.7	90.8	16.3	68.5	4.6	65.2		9.7	**65.2**	1	9.7
Rietspruit Clinic	176.3	90.3	16.0	66.1	4.5	58.7		9.2	**58.7**	1	9.2
Lehlaka Combined School	174.9	88.5	16.0	64.0	4.5	58.2		9.2	**58.2**	1	9.2
Mbali Coal/Blesboklaagte Housing	165.2	67.5	15.5	47.3	4.0	49.6		7.8	**49.6**	1	7.8
Kinross	147.8	80.2	11.5	55.7	3.0	**89.9**	1	10.3	**89.9**	**25**	10.3

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Kinross Settlement	128.2	78.9	10.6	40.1	2.6	**83.1**	1	9.6	**83.1**	12	9.6
Kinross Municipal Clinic	141.8	77.7	11.3	51.1	2.9	**88.9**	1	9.9	**88.9**	**16**	9.9
Kriel	179.2	77.1	18.6	90.5	6.7	**104.8**	1	12.6	**104.8**	**27**	12.6
Eagles Nest Guest House	176.3	72.9	18.6	87.3	6.7	**106.0**	1	12.0	**106.0**	**16**	12.0
Merlin Park Primary School	167.7	71.1	17.7	85.7	6.1	**81.8**	1	10.3	**81.8**	5	10.3
Kriel Medical Centre	167.8	70.8	17.8	86.3	6.2	**87.9**	1	10.7	**87.9**	9	10.7
Laerskool Krielpark	172.1	75.3	18.1	89.2	6.4	**95.0**	1	11.3	**95.0**	**16**	11.3
Laerskool Onverwacht	171.6	73.0	17.8	88.5	6.1	**76.8**	1	10.3	**76.8**	9	10.3
Silwer Fleur Aftree Oord (Old Age Home)	175.2	75.3	17.9	90.6	6.2	**78.4**	1	10.5	**78.4**	**14**	10.5
Thubelihle	179.4	75.4	16.7	92.1	5.3	57.5		9.0	**57.5**	1	9.0
Sibongamandla Secondary School	175.1	73.5	16.5	89.9	5.2	57.9		9.1	**57.9**	1	9.1
Ga-Nala Clinic	178.8	76.0	17.5	91.7	5.9	72.0		9.7	**72.0**	1	9.7
Impilo Primary School	140.9	65.1	14.8	64.9	4.3	47.1		8.2	**47.1**	1	8.2
Bonginhlanhla Primary School	170.6	73.7	16.4	86.7	5.2	60.8		9.1	**60.8**	1	9.1
Sibongamandla Secondary School	175.1	73.4	16.5	89.6	5.2	57.9		9.1	**57.9**	1	9.1
Leandra	108.7	59.8	9.3	29.9	2.2	49.4		7.7	**49.4**	1	7.7
Eendracht	103.5	57.1	9.1	29.4	2.1	46.1		6.9	**46.1**	1	6.9
Sidingulwazi Primary School	105.4	57.3	9.2	29.5	2.1	48.1		7.2	**48.1**	1	7.2
Ss Mshayisa Primary School	109.2	58.3	9.3	30.1	2.2	52.4		7.4	**52.4**	1	7.4
Chief Ampie Mayisa Secondary School	107.5	56.0	9.2	29.2	2.1	49.7		7.2	**49.7**	1	7.2
Lebogang Clinic	107.1	57.2	9.3	30.0	2.2	50.0		7.4	**50.0**	1	7.4
Kleuterskool Haas Das	88.3	47.3	9.0	23.3	1.8	35.7		5.2	35.7		5.2
Standerton Primary School	88.3	48.0	9.1	23.3	1.8	36.0		5.2	36.0		5.2
Laerskool Jeugkrag	88.8	48.5	9.1	23.4	1.8	37.5		5.4	37.5		5.4
Laerskool Standerton	88.1	48.5	9.1	23.4	1.8	35.6		5.2	35.6		5.2
Laerskool Kalie De Haas	89.7	50.0	9.1	24.3	1.8	34.9		5.1	34.9		5.1
Hoerskool Standerton	88.3	48.0	9.1	23.2	1.8	36.0		5.2	36.0		5.2
Standerton Provincial Government Hospital	86.8	47.2	9.0	23.1	1.8	35.7		5.2	35.7		5.2
Mar-Peh Medicare Private Hospital	87.5	48.1	9.0	22.9	1.7	35.3		5.1	35.3		5.1
Standerton Retirement Home	87.2	48.6	9.0	22.9	1.7	35.0		5.1	35.0		5.1
Standerton Ouetehuis/Old Age Home	88.2	49.5	9.1	23.7	1.8	35.6		5.1	35.6		5.1

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Holmdene Secondary School	83.8	48.1	8.8	21.3	1.7	35.3		4.9	35.3		4.9
Cathuza Primary School (SE of Town)	97.0	51.0	9.9	26.1	2.0	38.4		5.6	38.4		5.6
Sizanani Pre Primary School	86.3	45.9	9.0	21.8	1.8	34.8		5.1	34.8		5.1
Hlobisa Primary School	85.1	45.5	8.9	21.3	1.7	34.0		4.9	34.0		4.9
Shukuma Primary School	83.8	46.8	8.8	21.7	1.7	33.6		4.8	33.6		4.8
Retsebile Primary School	84.3	46.4	9.0	21.5	1.7	34.5		5.0	34.5		5.0
Thuto-Thebe Secondary School	85.5	45.9	9.0	22.6	1.8	36.0		5.2	36.0		5.2
Jandrell Secondary School	85.0	45.4	9.0	21.8	1.7	34.3		5.0	34.3		5.0
Thobelani Secondary School	85.1	45.5	9.0	21.8	1.8	34.5		5.0	34.5		5.0
Standerton Tb Hospital	85.8	46.5	8.9	21.9	1.7	34.2		4.9	34.2		4.9
Thuthukani Pre Primary School	98.9	61.5	10.1	29.2	2.2	50.4		7.6	**50.4**	1	7.6
Ulwazi Primary School	98.3	62.0	10.1	29.4	2.2	49.2		7.5	**49.2**	1	7.5
Zikhetheleni Secondary School	98.7	58.3	10.1	28.9	2.2	49.8		7.4	**49.8**	1	7.4
Joubertsvlei Primary School (North of Tutuka)	102.9	47.3	10.6	32.2	2.4	39.5		6.7	39.5		6.7
Amalumgelo Primary School (NE of Tutuka)	132.3	60.5	13.3	46.4	3.4	57.4		8.4	**57.4**	1	8.4
Grootdraaidam Primary School	96.4	54.7	9.6	26.5	1.9	38.9		5.8	38.9		5.8
Laerskool Secunda	107.6	58.5	10.5	35.5	2.5	59.2		8.5	**59.2**	1	8.5
Laerskool Kruinpark	108.4	54.8	10.8	36.7	2.6	55.5		8.8	**55.5**	1	8.8
Laerskool Oranjegloed Primary	104.9	57.3	10.4	34.4	2.4	54.6		8.3	**54.6**	1	8.3
Curro Castle Combined School	103.8	57.1	10.2	32.9	2.4	54.6		8.0	**54.6**	1	8.0
Hoërskool Oosterland	108.6	56.7	10.7	36.9	2.6	55.9		8.8	**55.9**	1	8.8
Mediclinic Secunda (Hospital)	107.6	59.7	10.4	35.6	2.4	59.0		8.3	**59.0**	1	8.3
Mediclinic Highveld (Hospital_Trichardt, Secunda)	115.1	56.5	11.4	42.6	2.9	62.2		10.0	**62.2**	1	10.0
Daviescourt/Davieshof Old Age Home	107.2	58.3	10.5	35.7	2.5	57.8		8.5	**57.8**	1	8.5
Highveld Park High School	108.6	56.9	10.7	36.2	2.6	56.3		8.8	**56.3**	1	8.8
Hoerskool Secunda	106.8	58.4	10.5	34.9	2.5	57.8		8.4	**57.8**	1	8.4
Basizeni Special School	111.0	62.7	9.6	32.0	2.2	50.4		6.6	**50.4**	1	6.6
Maphala-Gulube Primary School	102.9	58.3	9.5	29.1	2.1	43.0		6.3	**43.0**	1	6.3
Shapeve Primary School	112.3	62.4	9.7	32.1	2.2	48.2		6.7	**48.2**	1	6.7

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Thomas Nhlabathi Secondary School	110.9	61.9	9.5	31.4	2.1	48.0		6.3	**48.0**	1	6.3
Embalenhle Hospital / Clinic	109.5	61.4	9.5	30.6	2.1	46.4		6.3	**46.4**	1	6.3
Vukuzithathe Primary School	106.5	59.5	9.5	29.4	2.1	44.5		6.2	**44.5**	1	6.2
K I Twala Secondary	107.6	59.5	9.4	29.5	2.0	45.0		6.1	**45.0**	1	6.1
Allan Makunga Primary School	111.2	62.3	9.6	31.5	2.1	47.7		6.6	**47.7**	1	6.6
Evander Hospital Arv Clinic	124.6	68.5	10.8	41.9	2.7	64.5		8.5	**64.5**	1	8.5
Laerskool Hoeveld	123.3	69.8	10.7	41.8	2.6	63.8		8.3	**63.8**	1	8.3
Hoerskool Evander	123.8	70.1	10.5	40.5	2.6	67.1		8.1	**67.1**	1	8.1
Bernice Samuel Hospital	87.3	56.6	6.7	23.5	1.4	36.8		4.8	36.8		4.8
Hoerskool Delmas	87.9	57.2	6.7	23.7	1.4	36.8		4.8	36.8		4.8
Laerskool Delmas	88.4	56.5	6.8	24.3	1.4	37.0		4.9	37.0		4.9
Kangela Primary School (North of Delpark)	89.3	55.2	6.9	24.9	1.4	39.0		5.2	39.0		5.2
Savf Ons Eie Ouetehuis / Old Age Home	88.8	56.7	6.8	24.3	1.4	37.2		4.9	37.2		4.9
Laerskool Eloff	83.5	54.1	6.5	22.5	1.3	35.3		4.3	35.3		4.3
Rietkol Primary School	83.1	54.3	6.5	22.6	1.3	35.1		4.3	35.1		4.3
Bazani Primary School	88.1	52.1	6.8	24.6	1.4	37.9		5.3	37.9		5.3
Phaphamani Secondary School	86.9	53.7	6.7	24.5	1.4	37.7		5.2	37.7		5.2
Vezimfundo Primary School	87.8	47.5	6.7	25.2	1.4	39.2		5.2	39.2		5.2
Arbor Primary School	131.8	70.2	9.2	47.5	2.3	**83.3**	1	13.0	**83.3**	**30**	13.0
Ogies Combined School	179.4	74.7	14.3	48.7	3.8	52.5		7.4	**52.5**	1	7.4
Ogies Tb Clinic	186.0	76.3	14.2	50.5	3.8	55.0		7.4	**55.0**	1	7.4
Ogies Police Station	186.0	76.3	14.2	50.5	3.8	55.0		7.4	**55.0**	1	7.4
Hlangu Phala Primary School	165.5	77.1	12.8	54.4	3.7	48.6		6.5	**48.6**	1	6.5
Sukumani Primary School	165.6	76.2	12.8	53.8	3.6	48.6		6.5	**48.6**	1	6.5
Thuthukani Primary School	166.6	76.4	12.9	52.8	3.6	49.0		6.4	**49.0**	1	6.4
Mehlwana Secondary School	157.7	78.4	12.7	53.6	3.7	52.2		6.6	**52.2**	1	6.6
Makause Combined School	156.7	75.3	12.8	52.7	3.7	49.7		6.6	**49.7**	1	6.6
Sibongindawo Primary School	186.5	74.3	13.6	81.1	4.4	**77.2**	1	8.9	**77.2**	8	8.9
Laerskool Balmoral	151.6	72.9	9.0	60.9	2.5	41.4		4.6	**41.4**	1	4.6
Clewer Primary School	117.5	60.1	10.1	36.5	2.6	43.5		5.3	**43.5**	1	5.3
Witbank High School	108.1	64.4	9.6	30.2	2.3	60.7		6.7	**60.7**	1	6.7

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Eden Park Retirement Village	112.1	61.8	10.0	31.1	2.4	68.5		8.1	**68.5**	6	8.1
Savf House Immergroen Old Age Home	107.8	64.8	9.4	29.7	2.2	54.9		6.1	**54.9**	1	6.1
Mthimkulu Housing For The Aged	107.4	63.4	9.2	30.3	2.2	44.9		5.2	**44.9**	1	5.2
Emalahleni Private Hospital	106.3	65.3	9.3	29.1	2.2	52.2		5.8	**52.2**	1	5.8
Life Cosmos Hospital	108.6	63.6	9.6	29.5	2.3	62.5		6.7	**62.5**	1	6.7
Duvha Primary School	119.7	58.6	10.4	34.9	2.6	61.2		7.7	**61.2**	1	7.7
Laerskool Taalfees	108.9	64.4	9.6	30.0	2.2	62.3		6.5	**62.3**	1	6.5
Witbank Provincial Hospital	106.6	63.4	9.4	29.1	2.2	56.7		6.1	**56.7**	1	6.1
Nancy Shiba Primary School (Vosman)	108.3	59.8	8.7	32.2	2.1	36.2		4.1	36.2		4.1
Wh De Klerk Skool	105.7	62.1	9.1	28.0	2.1	47.9		4.9	**47.9**	1	4.9
Laerskool Panorama	103.6	61.5	8.7	26.2	1.9	41.8		4.4	**41.8**	1	4.4
Laerskool Duvhapark	119.9	59.9	10.6	35.8	2.6	66.1		8.7	**66.1**	1	8.7
Laerskool Klipfontein	112.1	60.8	10.0	31.3	2.4	70.3		8.3	**70.3**	10	8.3
Cambridge Academy	109.9	62.9	9.9	30.4	2.4	67.6		7.4	**67.6**	6	7.4
Besilindile Primary School	108.2	61.8	8.3	31.3	1.9	34.8		3.9	34.8		3.9
Reynopark High School	117.0	58.6	10.3	33.7	2.5	**86.8**	1	10.0	**86.8**	**31**	10.0
Bakenveld Golf Estate	114.4	60.9	10.0	33.2	2.4	55.8		6.1	**55.8**	1	6.1
Allendale Secondary School	112.3	66.2	11.7	34.6	3.0	53.3		9.7	**53.3**	1	9.7
Khayalethu Primary School	106.3	63.4	9.2	29.6	2.1	45.5		5.1	**45.5**	1	5.1
Illanga Secondary School	114.6	73.4	11.4	34.2	2.9	**91.4**	1	19.0	**91.4**	**81**	19.0
Joy Creche (Duvha)	115.2	60.7	11.0	34.6	2.7	56.3		8.4	**56.3**	1	8.4
Linderus Old Age Home	101.7	61.1	7.9	23.2	1.5	33.1		3.4	33.1		3.4
Vergeet My Nie Old Age Home	100.9	63.1	7.9	23.3	1.5	33.5		3.5	33.5		3.5
Middleburg Frail Care Unit And Home For Elderly	96.3	57.6	7.4	20.9	1.4	30.7		3.1	30.7		3.1
Life Midmed Hospital	99.0	61.5	7.7	22.2	1.4	31.7		3.3	31.7		3.3
Middelburg Hospital	101.0	63.3	7.8	23.1	1.5	32.4		3.4	32.4		3.4
Makhathini Primary School	96.4	58.4	7.5	22.0	1.4	31.4		3.2	31.4		3.2
Laerskool Dennesig	94.6	56.6	7.3	20.4	1.3	30.9		3.1	30.9		3.1
Hoerskool Kanonkop	95.8	57.3	7.4	20.5	1.3	31.1		3.1	31.1		3.1
Laerskool Kanonkop	97.4	57.7	7.5	21.1	1.4	30.9		3.1	30.9		3.1

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Steelcrest High School	98.3	58.5	7.6	21.7	1.4	31.7		3.2	31.7		3.2
Middelburg Primary	101.1	61.9	7.9	23.2	1.5	33.1		3.4	33.1		3.4
Middleburg Ext 6 Clinic	101.6	59.6	7.9	23.5	1.6	38.3		3.8	38.3		3.8
Sofunda Secondary School	99.5	60.0	7.7	22.3	1.5	33.8		3.4	33.8		3.4
Mhluzi Primary School	98.5	59.9	7.6	22.5	1.4	32.5		3.3	32.5		3.3
Highlands Primary School	102.3	61.7	8.1	24.4	1.6	34.5		3.6	34.5		3.6
Blinkpan Primary School	115.1	57.8	13.5	40.5	3.5	51.1		8.7	**51.1**	1	8.7
Laerskool Koornfontein	115.4	57.6	13.5	41.1	3.5	52.0		8.6	**52.0**	1	8.6
Blinkpan	114.7	58.1	13.5	40.7	3.5	52.2		8.7	**52.2**	1	8.7
Laerskool Kragveld	119.9	69.1	13.0	37.5	3.3	44.9		7.0	**44.9**	1	7.0
Pullens Hope	114.0	70.6	12.9	35.8	3.3	45.7		7.2	**45.7**	1	7.2
Arnot Colliery Primary School	109.2	67.3	10.8	30.5	2.7	**96.1**	1	9.4	**96.1**	**26**	9.4
Laerskool Rietkuil	115.1	64.7	11.4	36.2	3.0	**150.5**	**94**	26.4	**150.5**	**214**	**26.4**
Beestepan Agricultural School	90.8	55.2	8.5	22.8	1.7	32.9		3.7	32.9		3.7
Gekombineerde Skool Hendrina	88.7	52.7	12.9	27.3	3.2	43.1		7.3	**43.1**	1	7.3
Hendrina Primary School	90.5	53.2	13.2	28.1	3.2	42.0		7.1	**42.0**	1	7.1
Kwazamokuhle Secondary School	91.1	53.3	13.2	28.4	3.3	43.5		7.1	**43.5**	1	7.1
Ubuhle Bolwai Secondary School	70.3	41.6	10.8	18.3	2.2	26.8		4.3	26.8		4.3
Lothair Primary School	71.1	42.0	10.9	18.5	2.2	26.7		4.4	26.7		4.4
Warburton Combined School	71.2	44.7	10.4	18.2	2.0	28.6		4.1	28.6		4.1
Warburton Town	71.9	45.1	10.4	18.3	2.1	28.4		4.1	28.4		4.1
Kwachibikhulu Clinic	74.1	46.2	11.4	19.0	2.4	30.7		4.9	30.7		4.9
Kwachibikhulu Primary School	74.3	46.0	11.4	19.3	2.4	30.4		4.8	30.4		4.8
Carolina Hospital	77.2	46.7	10.9	20.6	2.4	35.8		4.9	35.8		4.9
Zinikeleni Secondary School (Silobela)	77.5	46.0	10.9	20.9	2.4	35.5		4.9	35.5		4.9
Volkskool Carolina	78.5	47.4	10.9	21.0	2.4	35.8		4.9	35.8		4.9
Sobuza Primary School	76.6	46.6	10.9	20.3	2.4	35.0		4.9	35.0		4.9
Ons Eie Ouetehuis (Old Age Home)	78.3	47.4	11.0	21.1	2.4	36.1		4.9	36.1		4.9
Laerskool Breyten	78.7	47.1	12.4	23.3	3.0	30.5		5.5	30.5		5.5
Siyazi Primary School (Kwazanele)	78.6	48.2	12.6	23.7	3.0	29.8		5.4	29.8		5.4
Masizakhe Secondary School (Kwazanele)	78.6	47.9	12.5	23.7	3.0	29.7		5.4	29.7		5.4

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Belfast Rusoord (Old Age Home)	68.9	45.8	6.8	17.0	1.3	24.2		2.7	24.2		2.7
Belfast Hospital	70.4	46.4	7.0	17.9	1.4	24.2		2.7	24.2		2.7
Platorand School	71.4	47.2	7.2	18.8	1.4	24.6		2.8	24.6		2.8
Belfast Primary School (Siyathuthuka)	68.4	44.9	6.6	16.8	1.2	24.1		2.6	24.1		2.6
Siyathuthuka Clinic	68.1	45.2	6.6	16.9	1.2	24.1		2.6	24.1		2.6
Life Bethal Hospital	132.8	62.0	13.5	51.1	3.8	43.8		7.4	**43.8**	1	7.4
Hoerskool Hoogenhout	132.2	61.9	13.6	50.2	3.8	43.1		7.3	**43.1**	1	7.3
Jim Van Tonderskool	138.1	63.1	14.1	53.9	4.1	48.3		8.0	**48.3**	1	8.0
Bethal Independent Primary School	137.8	63.0	14.0	52.8	4.0	47.7		7.8	**47.7**	1	7.8
Laerskool Marietjie Van Niekerk	129.6	61.6	14.0	49.5	4.0	42.2		7.3	**42.2**	1	7.3
Laerskool Hm Swart	134.3	62.1	13.6	51.3	3.8	44.1		7.4	**44.1**	1	7.4
Sakhisizwe Primary School (Emzinoni)	135.0	65.4	13.0	52.8	3.5	47.7		7.7	**47.7**	1	7.7
Alpheus D Nkosi Secondary School (Emzinoni)	134.0	63.8	13.1	51.7	3.6	46.2		7.6	**46.2**	1	7.6
Silwerjare Old Age Home	133.0	61.6	13.4	50.1	3.7	43.1		7.3	**43.1**	1	7.3
Residentia Palm Oord	134.5	62.2	13.5	51.8	3.8	44.5		7.4	**44.5**	1	7.4
Bronkhorspruit Hospital	83.7	53.3	5.1	20.4	0.9	33.2		3.1	33.2		3.1
Cultura High School	91.7	57.4	5.5	24.0	1.0	39.1		3.6	39.1		3.6
Bronkhorspruit Primary School	86.7	52.8	5.2	20.8	0.9	33.1		3.2	33.1		3.2
Bronkhorspruit Dam	100.7	57.3	5.8	28.5	1.2	40.1		4.3	**40.1**	1	4.3
Hoerskool Erasmus	87.5	55.6	5.3	21.8	1.0	36.2		3.4	36.2		3.4
Althea Independent School	86.7	54.9	5.3	21.4	1.0	34.9		3.3	34.9		3.3
Kgoro Primary School (Zithobeni)	81.5	50.1	5.0	18.6	0.9	31.8		3.0	31.8		3.0
Zithobeni Secondary School (Zithobeni)	79.9	49.6	4.9	17.9	0.9	32.0		3.0	32.0		3.0
Vaal Power AH	97.9	49.7	6.1	28.2	1.4	72.5		9.3	**72.5**	**28**	9.3
Sasolburg Provincial Hospital	80.6	55.4	4.9	20.4	1.0	42.4		3.6	**42.4**	1	3.6
Moredou Old Age Home	82.9	59.5	4.8	20.7	1.0	37.8		3.3	37.8		3.3
Ons Gryse Jeug Old Age Home	82.1	58.1	4.9	20.3	1.0	39.6		3.5	39.6		3.5
Noord Primere Skool	82.2	57.9	4.9	20.4	1.0	40.2		3.6	**40.2**	1	3.6
Sasolburg High School	80.3	58.0	4.8	20.1	1.0	40.0		3.4	40.0		3.4
Sakhubusa Secondary School	86.8	56.8	5.0	22.9	1.0	45.0		4.0	**45.0**	1	4.0

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Bekezela Primary School	88.0	52.7	5.0	23.1	1.0	50.9		4.6	**50.9**	1	4.6
Isaac Mhlambi Primary	82.1	55.9	4.9	21.4	1.0	49.9		4.1	**49.9**	1	4.1
Refenkgotso Primary School	103.3	46.7	6.9	33.8	1.7	45.9		4.8	**45.9**	1	4.8
Deneysville Primary School	106.4	45.6	7.1	34.3	1.8	38.1		4.5	38.1		4.5
Netcare Vaalpark Hospital	81.2	63.1	4.9	20.3	1.0	53.3		4.7	**53.3**	1	4.7
Vaalpark Articon Secondary School	80.1	64.1	5.0	20.1	1.0	55.9		5.1	**55.9**	1	5.1
Mediclinic Emfuleni	74.2	47.5	4.5	17.3	0.9	46.2		3.7	**46.2**	1	3.7
Jeugland Old Age Home	75.2	52.2	4.5	17.4	0.9	40.7		3.6	**40.7**	1	3.6
Herfsoord Huis Old Age Home	73.8	48.0	4.5	17.3	0.9	41.3		3.4	**41.3**	1	3.4
Huis Prinscilla	72.7	45.5	4.5	17.2	0.9	39.8		3.3	39.8		3.3
Laerskool Emfulenipark	79.1	56.0	4.8	18.6	0.9	52.8		4.5	**52.8**	1	4.5
Nw University_Vaal Campus	78.1	51.6	4.8	19.0	0.9	62.6		5.8	**62.6**	2	5.8
Emfuleni Primary School	71.3	43.6	4.3	16.4	0.8	36.7		3.0	36.7		3.0
Mediclinic Vereeniging	76.7	49.7	4.8	17.4	1.0	49.5		4.7	**49.5**	1	4.7
Kopanong Provincial Hospital (Duncanville)	76.8	46.4	4.9	17.9	1.0	33.2		3.0	33.2		3.0
Avondrus Eventide Old Age Home	77.7	47.0	4.9	18.2	1.0	34.4		3.1	34.4		3.1
Riviera On Vaal Resort	76.9	50.6	4.9	17.4	1.0	56.6		5.4	**56.6**	1	5.4
Sedibeng Tvet College	77.6	50.7	4.9	17.4	1.0	58.5		5.5	**58.5**	1	5.5
General Smuts High School	78.4	51.1	4.9	17.8	1.0	49.4		4.7	**49.4**	1	4.7
Eureuka School & Selbourne Primary	78.4	53.0	4.8	17.9	1.0	48.8		4.5	**48.8**	1	4.5
Midvaal Private Hospital (Three Rivers)	85.1	57.2	5.3	20.1	1.1	57.5		5.0	**57.5**	1	5.0
Three Rivers Retirement Village	85.6	55.0	5.4	20.4	1.1	48.3		4.2	**48.3**	1	4.2
Drie Riviere Aftreeoord Old Age Home	86.2	57.9	5.3	20.5	1.1	41.8		3.8	**41.8**	1	3.8
Riverside High School	97.0	54.4	5.8	25.2	1.3	65.0		4.9	**65.0**	3	4.9
Risiville Primary School	90.0	49.7	5.4	21.6	1.1	39.9		3.7	39.9		3.7
Sebokeng Hospital	71.7	49.0	4.3	17.2	0.8	29.8		2.5	29.8		2.5
Clinix-Naledzi Private Hospital	71.5	50.2	4.4	17.2	0.8	31.2		2.6	31.2		2.6
Mohloli Secondary School	75.6	52.1	4.7	17.4	0.9	48.7		4.4	**48.7**	1	4.4
Tshirela Primary School (Boipatong)	72.3	49.1	4.5	17.3	0.9	35.3		3.2	35.3		3.2
Tsoaranang Primary School (Thepiso)	74.2	56.2	4.7	17.4	0.9	40.6		3.7	**40.6**	1	3.7
Thepiso Primary School	73.5	52.9	4.6	17.2	0.9	40.2		3.3	**40.2**	1	3.3

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Emmanuel Primary School	74.1	57.2	4.7	17.4	0.9	43.8		4.0	**43.8**	1	4.0
Rust Ter Vaal Combined School	71.6	47.6	4.7	17.3	0.9	26.6		2.5	26.6		2.5
Roshnee Primary School	70.3	47.1	4.6	17.3	0.9	25.5		2.4	25.5		2.4
Roshnee High School	71.0	47.4	4.6	17.3	0.9	26.3		2.5	26.3		2.5
Hoerskool Dr Malan	78.7	44.6	5.0	19.7	1.0	29.4		2.7	29.4		2.7
Laerskool Voorwaarts	92.2	49.0	5.7	24.8	1.2	32.6		3.1	32.6		3.1
Meyerton Secondary School	79.1	46.8	5.1	19.5	1.0	28.2		2.8	28.2		2.8
Ratasetjhaba Primary School	73.7	45.2	4.8	18.9	0.9	25.7		2.5	25.7		2.5
Meyerton Primary School	76.2	44.1	5.0	19.3	1.0	28.8		2.6	28.8		2.6
Oprah Leadership Academy	80.1	43.2	5.1	20.9	1.0	28.7		2.6	28.7		2.6
Henley River Retirement Village	80.4	43.9	5.2	21.1	1.0	27.0		2.7	27.0		2.7
Henley High & Preparatory School	76.0	42.7	5.1	20.3	1.0	26.1		2.6	26.1		2.6
Randvaal Clinic	73.6	43.8	5.0	19.7	1.0	25.8		2.5	25.8		2.5
Laerskool Japie Greyling	72.4	44.0	4.9	19.4	1.0	24.6		2.5	24.6		2.5
Thomas Nhlapo Primary	73.9	43.2	5.0	19.5	1.0	25.3		2.5	25.3		2.5
Randvaal Old Age Home	71.5	45.0	4.9	19.5	1.0	24.6		2.4	24.6		2.4
Laerskool Ag Visser	71.0	41.4	5.9	18.2	1.2	26.2		2.9	26.2		2.9
Lethaba Siyangobe	71.1	41.9	6.0	18.9	1.2	26.3		2.9	26.3		2.9
Shalimar Ridge Primary School	70.1	43.4	5.9	18.3	1.1	26.5		2.9	26.5		2.9
Jw Luckoff High School	71.2	41.4	6.1	18.9	1.3	26.6		3.0	26.6		3.0
Heidelberg Hospital	70.9	43.8	5.9	18.6	1.2	26.9		2.9	26.9		2.9
Thulatsatsi Operation (Rensburg)	70.8	41.4	5.9	18.3	1.2	26.2		2.9	26.2		2.9
Silwer Akker Tehuis	70.3	43.2	5.8	18.2	1.1	26.5		2.9	26.5		2.9
Riversands Retirement Village	70.7	44.1	5.9	18.8	1.2	26.9		2.9	26.9		2.9
Qhaqholla Primary School	72.0	41.6	5.9	19.1	1.2	25.5		2.9	25.5		2.9
Ratanda Primary School	73.4	40.8	5.9	19.6	1.2	25.7		2.9	25.7		2.9
Boneha Primary School	72.2	41.9	5.9	19.1	1.2	25.4		2.9	25.4		2.9
Sithokomele Primary School	72.2	42.0	5.9	19.2	1.2	25.4		2.9	25.4		2.9
Ratanda Bertha Gxowa Primary School	71.5	42.2	6.0	19.1	1.2	26.3		2.9	26.3		2.9
Khanya Lesedi Secondary School	72.5	40.9	5.9	19.4	1.2	25.5		2.9	25.5		2.9
Ratanda Secondary School	72.3	41.5	5.9	19.3	1.2	25.5		2.9	25.5		2.9

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
New Ratanda Secondary School	71.3	42.0	6.0	18.7	1.2	26.1		2.9	26.1		2.9
Kgoro Ya Thuto Secondary School	71.3	42.0	6.0	18.7	1.2	26.1		2.9	26.1		2.9
Ekurhuleni School For The Deaf	67.3	40.8	5.0	17.2	0.9	23.7		2.4	23.7		2.4
Pholosong Hospital	72.4	47.5	5.9	19.9	1.2	26.5		2.9	26.5		2.9
Tsakane Home For Aged	72.2	48.1	5.9	20.7	1.2	26.6		2.9	26.6		2.9
Mmuso Primary School	74.5	48.0	6.2	21.3	1.3	27.2		3.1	27.2		3.1
Michael Zulu Primary School	73.9	48.1	6.0	20.4	1.2	26.6		3.0	26.6		3.0
Nkabinde Primary School (Thembilisha)	73.7	48.6	5.8	19.4	1.2	26.5		3.0	26.5		3.0
Nigel Clinic	72.5	45.3	6.1	19.1	1.2	27.2		3.2	27.2		3.2
Tehuis Vir Bejaardes	73.1	44.0	6.1	19.0	1.2	27.4		3.2	27.4		3.2
Hoerskool John Vorster	72.9	44.2	6.1	18.8	1.2	27.4		3.2	27.4		3.2
Laerskool Hannes Visagie	72.7	44.3	6.2	18.8	1.2	27.6		3.3	27.6		3.3
Nigel Secondary School	74.0	42.8	6.3	19.3	1.3	27.9		3.4	27.9		3.4
Laerskool Dunnottar	73.5	47.5	6.0	20.5	1.2	27.4		3.1	27.4		3.1
Springs Retirement Village	72.1	47.7	5.7	18.9	1.1	26.4		3.1	26.4		3.1
Life Springs Parkland Hospital	72.0	48.7	5.8	19.3	1.1	26.4		3.0	26.4		3.0
Netcare N17 Hospital (Springs)	71.7	48.6	5.8	19.0	1.1	26.3		3.0	26.3		3.0
Springs Boys High School	73.6	48.1	5.9	19.5	1.2	26.8		3.1	26.8		3.1
Laerskool Selectionpark	72.0	47.4	5.8	19.1	1.1	26.7		3.1	26.7		3.1
Kwasa College Pre&Primary School	72.7	46.9	5.9	18.9	1.2	27.9		3.2	27.9		3.2
Edelweis Medical Centre	72.7	46.6	5.9	19.0	1.2	27.3		3.2	27.3		3.2
Laerskool Christiaan Beyers	71.1	47.9	5.8	18.8	1.1	26.6		3.1	26.6		3.1
Hoerskool Hugenote	71.7	46.9	5.7	18.3	1.1	27.1		3.0	27.1		3.0
Brakpan Primary School	71.2	48.3	5.6	18.9	1.1	26.2		2.8	26.2		2.8
Parkrand Primary School	68.1	48.0	5.3	18.0	1.0	24.6		2.5	24.6		2.5
Thabo Memorial Hospital	65.5	47.1	5.1	17.9	1.0	23.8		2.4	23.8		2.4
Sunward Park Hospital	67.2	46.7	5.2	17.7	1.0	24.3		2.5	24.3		2.5
Alberton High School	67.5	41.7	4.8	17.9	0.9	22.9		2.2	22.9		2.2
Netcare Clinton Hospital	66.1	42.5	4.8	17.6	0.9	22.8		2.2	22.8		2.2
Alberton Tuiste Vir Bejaardes	67.5	42.4	4.8	17.9	0.9	22.8		2.2	22.8		2.2
Bertha Gxowa Hospital	67.8	47.3	5.1	19.0	1.0	23.4		2.2	23.4		2.2

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Linmed Hospital	66.6	47.1	5.3	18.8	1.1	25.6		2.6	25.6		2.6
Hoerskool Brandwag (Airfield)	67.5	47.6	5.4	18.5	1.1	25.2		2.6	25.2		2.6
Thepiso Noto Intermediate School	73.3	51.9	5.7	19.1	1.1	30.3		3.4	30.3		3.4
Laerskool Bredell	64.7	48.0	4.9	16.7	0.9	25.5		2.5	25.5		2.5
Sibonelo Primary School (Daveyton)	69.6	50.5	5.5	18.2	1.1	27.8		3.1	27.8		3.1
Petit High School (Kempton Park Nu)	67.8	49.5	5.3	18.7	1.0	27.2		2.8	27.2		2.8
Arwyp Medical Centre	65.0	45.1	4.8	17.5	0.9	24.8		2.3	24.8		2.3
Hoerskool Birchleigh	64.0	43.8	4.6	15.7	0.8	24.2		2.2	24.2		2.2
Curro Serengeti Acadamy	62.7	47.1	4.6	15.5	0.8	25.4		2.4	25.4		2.4
South Rand Hospital	74.1	50.3	5.2	22.5	1.1	23.1		2.1	23.1		2.1
Chris Hani Baragwanath Hospital	64.6	42.3	4.2	18.1	0.8	22.0		1.8	22.0		1.8
Thulani Primary School	58.8	41.0	3.8	17.0	0.7	20.2		1.7	20.2		1.7
University of Witwatersrand	74.0	48.1	5.0	23.7	1.1	22.5		2.0	22.5		2.0
Milpark Hospital	71.1	48.2	4.8	22.1	1.0	22.2		1.9	22.2		1.9
Charlotte Maxixe Academic Hospital	72.8	48.1	4.9	22.9	1.0	22.5		2.0	22.5		2.0
Thembisa West Secondary School (Thembisa)	60.4	42.3	4.2	13.8	0.7	23.6		2.0	23.6		2.0
Lenmed Zamokuhle Private Hospital (Thembisa)	62.0	43.9	4.2	14.6	0.7	24.2		2.1	24.2		2.1
Ikusasa Comprehensive School	62.4	44.5	4.4	15.0	0.8	25.0		2.2	25.0		2.2
Gem Village Old Age Home	63.3	44.8	3.9	13.6	0.6	24.3		2.0	24.3		2.0
Rustoord Old Age Home	63.0	42.4	3.8	13.6	0.6	23.2		1.9	23.2		1.9
Cornwell Hill College (Irene)	64.1	44.0	4.0	13.6	0.6	24.3		2.0	24.3		2.0
Kleinfontein Sorg Sentrum Old Age Home (Donkerhoek)	70.8	45.2	4.4	15.6	0.7	26.5		2.4	26.5		2.4
Valtaki AH (Rayton)	72.4	45.9	4.5	16.2	0.8	28.6		2.6	28.6		2.6
Laerskool Rayton (Rayton)	64.9	39.3	4.0	12.9	0.6	26.0		2.2	26.0		2.2
Tierkop AH	73.7	50.1	4.7	17.3	0.8	28.7		2.7	28.7		2.7
Redford House The Hills Private School (Mooikloof Glen)	72.6	47.3	4.5	16.8	0.8	26.9		2.4	26.9		2.4
Rietvlei View Country Estate	72.7	48.6	4.6	16.8	0.8	27.7		2.5	27.7		2.5

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Hazeldean Curro School (Tyger Valley)	63.5	40.9	3.8	12.8	0.6	23.4		2.0	23.4		2.0
Tyger Valley College	65.0	41.3	4.0	13.9	0.6	24.2		2.1	24.2		2.1
Pretoria East Hospital (Moreletapark)	66.8	42.6	4.1	14.9	0.7	24.8		2.1	24.8		2.1
Groenkloof Old Age Home	60.6	42.6	3.7	13.3	0.6	22.5		1.8	22.5		1.8
Steve Biko Academic Hospital	58.8	42.8	3.4	11.7	0.5	21.3		1.6	21.3		1.6
Willow Ridge High School (Wilgers)	61.0	41.3	3.7	12.4	0.6	23.3		1.9	23.3		1.9
Hoerskool Waterkloof	66.5	44.5	4.1	14.9	0.7	24.9		2.0	24.9		2.0
Hoerskool Garsfontein	63.9	40.9	3.9	14.1	0.6	24.2		2.0	24.2		2.0
Afrikaanse Hoer Seunskool	60.6	42.3	3.6	12.8	0.6	22.2		1.7	22.2		1.7
Huis Silversig SAVF Old Age Home (Silverton)	59.7	42.3	3.5	11.2	0.5	22.8		1.7	22.8		1.7
Laersekool Meyerspark (Meyerspark)	60.2	41.6	3.6	11.2	0.5	23.1		1.8	23.1		1.8
Curro Academy Mamelodi	56.6	35.8	3.4	10.1	0.5	21.9		1.7	21.9		1.7
Impendulo Primary School	59.3	36.5	3.6	11.0	0.5	22.6		1.8	22.6		1.8
Nellmapius Ext 6 Primary School	59.2	39.5	3.5	10.6	0.5	22.3		1.8	22.3		1.8
Mamelodi Home For Aged	58.4	35.8	3.5	10.6	0.5	22.1		1.8	22.1		1.8

Predicted concentrations in µg/m³ at the sensitive receptors for Scenario B (2031), together with the limit value of the NAAQS and number of exceedances (NoE)

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Elsie Ballot Memorial Hospital	138.5	53.6	8.4	30.2	1.6	20.2		3.3	20.2		3.3
Laerskool Amersfoort	131.7	50.8	8.2	28.3	1.6	19.6		3.2	19.6		3.2
Embuzane Primary School	289.2	95.8	17.2	68.6	3.9	39.4		6.2	**39.4**	1	6.2
Sangqotho Primary School	74.9	35.1	7.0	20.2	1.4	20.0		3.5	20.0		3.5
Amersfoort Combined School	126.6	54.8	8.1	27.9	1.6	18.9		3.3	18.9		3.3
Injubuko Primary School	77.7	33.5	6.8	18.0	1.2	17.1		2.9	17.1		2.9
Daggakraal Primary School	131.1	47.7	10.7	28.7	2.1	20.9		3.4	20.9		3.4
Sizenzele Primary School	162.2	51.8	11.7	36.4	2.4	27.5		4.0	**27.5**	1	4.0
Seme Secondary School	120.1	44.3	10.6	26.6	2.1	23.2		3.6	23.2		3.6
Louwra Primary School	89.2	39.1	6.3	19.8	1.1	21.3		2.9	21.3		2.9
Perdekop Agricultural School	77.2	39.4	6.2	19.1	1.2	28.7		4.1	**28.7**	1	4.1
Vukuzenzele Combined School	81.7	41.6	6.4	19.7	1.2	28.3		4.1	**28.3**	1	4.1
Gunwana Primary School	78.0	38.6	5.9	17.6	1.1	18.8		2.8	18.8		2.8
Amajuba Memorial Hospital	70.1	32.5	5.2	14.5	0.9	16.9		2.4	16.9		2.4
Volksrust High School	68.2	34.8	5.1	14.5	0.9	17.0		2.4	17.0		2.4
Volksrust Municipal Clinic	67.8	33.5	5.0	13.8	0.8	15.9		2.3	15.9		2.3
C V O Skool Amajuba	67.9	34.2	5.1	14.2	0.9	16.4		2.3	16.4		2.3
Qhubulwazi Combined School	66.5	31.8	5.1	13.6	0.9	16.5		2.3	16.5		2.3
Volksrust Primary School	71.4	34.3	5.4	15.2	0.9	18.2		2.5	18.2		2.5
New Ermelo	49.5	25.7	6.2	12.3	1.2	15.8		2.5	15.8		2.5
Ermelo Christian School	50.7	26.7	6.4	13.1	1.3	15.7		2.5	15.7		2.5
SAVF Home For Aged	50.0	26.6	6.3	12.8	1.3	15.8		2.5	15.8		2.5
Ermelo Hospital	49.8	25.9	6.3	12.8	1.2	15.8		2.5	15.8		2.5
Mediclinic Ermelo	50.7	26.5	6.4	13.2	1.3	15.7		2.6	15.7		2.6
Hoerskool Ermelo	49.8	26.1	6.3	12.9	1.2	15.8		2.5	15.8		2.5
Ermelo Indian Combined School	49.7	25.6	6.3	12.8	1.2	15.7		2.6	15.7		2.6
Lungelo Combined School (Outside Town)	55.9	27.7	6.2	14.8	1.2	17.1		2.8	17.1		2.8
New Ermelo Primary School	49.8	25.8	6.3	12.5	1.2	15.7		2.5	15.7		2.5

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Kwashashe (Outside Town)	49.7	26.0	6.5	12.9	1.3	15.6		2.5	15.6		2.5
Hts Ligbron	50.2	26.4	6.4	13.0	1.3	15.7		2.6	15.7		2.6
Laerskool Ermelo	50.2	26.4	6.3	12.7	1.2	15.8		2.5	15.8		2.5
JJ Vd Merwe Pre-Primary School	50.4	26.1	6.4	13.2	1.3	15.8		2.6	15.8		2.6
Lindile Secondary School	49.6	25.5	6.3	12.7	1.2	15.8		2.5	15.8		2.5
Emthonjeni Clinic	49.6	25.6	6.3	12.7	1.3	15.8		2.5	15.8		2.5
Reggie Masuku Secondary School	49.5	25.8	6.4	12.6	1.3	15.9		2.5	15.9		2.5
Cebisa Secondary School	49.6	25.6	6.3	12.7	1.3	15.9		2.5	15.9		2.5
Camden	49.6	26.9	6.1	11.8	1.1	15.6		2.4	15.6		2.4
Camden Combined School	49.5	26.5	6.0	11.7	1.1	15.7		2.4	15.7		2.4
Camden School	49.6	27.0	6.1	11.9	1.1	15.6		2.5	15.6		2.5
Umzimvelo Secondary School (Rural Area)	44.9	22.6	5.9	10.1	1.0	14.6		2.3	14.6		2.3
Bhekimfundo Primary School (Rural Area)	52.7	28.9	6.5	14.7	1.3	16.1		2.7	16.1		2.7
Eshwileni Primary School (Rural Area)	58.4	26.9	6.3	14.7	1.2	16.7		2.8	16.7		2.8
Davel Combined School	61.1	29.0	7.1	18.0	1.7	21.3		3.4	21.3		3.4
Morgenzon Landbou Akademie	61.3	25.2	6.5	17.8	1.3	21.6		3.5	21.6		3.5
Nqobangolwazi Secondary School	61.3	25.3	6.4	18.1	1.3	21.4		3.5	21.4		3.5
Siqondekhaya Pre Primary School	60.8	25.6	6.3	18.0	1.3	23.5		3.6	23.5		3.6
Sizakhele Primary School	61.2	25.5	6.4	17.9	1.3	23.4		3.5	23.4		3.5
Phezukwentaba Primary School (South of Morgenzon)	60.9	26.4	6.5	17.7	1.2	22.6		3.6	22.6		3.6
Kwaggalaagte Primary School (North of Morgenzon)	71.6	31.9	6.6	22.9	1.5	23.3		3.7	23.3		3.7
Sizakhele Clinic/Hospital	61.2	25.4	6.4	17.9	1.3	23.1		3.5	23.1		3.5
Grootvlei	43.0	22.1	3.9	11.9	0.8	14.5		1.8	14.5		1.8
Olive Grove Country Lodge	43.9	21.5	3.9	12.2	0.8	14.6		1.8	14.6		1.8
Grootvlei Town (South of Power Station)	42.5	21.3	3.8	11.5	0.8	14.0		1.8	14.0		1.8
Laerskool Grootvlei	42.6	21.4	3.9	11.6	0.8	14.0		1.8	14.0		1.8
Tokoloho Primary School	42.3	21.5	3.8	11.3	0.8	14.1		1.8	14.1		1.8
Tshepeha Combined School	42.4	21.2	3.8	11.4	0.8	14.1		1.8	14.1		1.8
Warembo Lodge	40.7	20.9	3.8	10.6	0.7	14.7		1.9	14.7		1.9

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Balfour	43.0	24.8	3.9	11.4	0.8	17.2		2.0	17.2		2.0
Siyathemba	43.7	24.3	4.0	11.6	0.8	17.6		2.1	17.6		2.1
Bonukukhanya Primary (Siyathemba)	43.5	24.3	4.0	11.5	0.8	17.5		2.0	17.5		2.0
Qalabocha Primary School (Siyathemba)	43.6	24.8	4.0	11.6	0.8	17.5		2.1	17.5		2.1
Vusumuzi Primary School	44.0	24.4	4.1	11.9	0.8	17.6		2.1	17.6		2.1
Gekombineerde Skool Balfour	43.1	24.3	3.9	11.3	0.8	17.0		2.0	17.0		2.0
Im Manchu Secondary School	42.9	24.5	3.9	11.2	0.8	17.0		2.0	17.0		2.0
Isifisosethu Secondary School (Siyathemba)	43.9	24.3	4.1	11.9	0.8	17.6		2.1	17.6		2.1
Setsheng Secondary School (Siyathemba)	43.7	24.9	4.1	11.8	0.8	17.6		2.1	17.6		2.1
Dr Nieuwoudt And Dr Kok	43.4	24.4	3.9	11.2	0.8	16.9		2.0	16.9		2.0
Balfour Clinic	42.7	24.5	3.9	11.1	0.8	17.1		2.0	17.1		2.0
Siyathemba Clinic	43.0	24.7	4.0	11.5	0.8	17.3		2.0	17.3		2.0
Mondoro Lodge	42.8	23.3	3.9	11.9	0.8	15.8		1.9	15.8		1.9
Wegelegen Manor	43.4	24.7	3.9	11.5	0.8	17.2		2.1	17.2		2.1
The Stone Cellar	41.8	20.6	3.5	10.6	0.7	14.8		1.8	14.8		1.8
Greylingstad	45.5	25.8	4.4	11.1	0.8	16.9		2.3	16.9		2.3
Nthorwane	45.4	24.4	4.3	10.5	0.8	17.2		2.2	17.2		2.2
Laerskool Greylingstad	46.5	25.8	4.5	11.7	0.8	17.2		2.3	17.2		2.3
Nthoroane Secondary School	45.5	24.4	4.3	10.5	0.8	17.3		2.3	17.3		2.3
Badgarleur Bush Lodge	41.5	22.1	4.1	10.7	0.8	15.7		2.0	15.7		2.0
Matla Village	129.9	57.3	8.6	36.8	2.3	**135.3**	**16**	14.6	**135.3**	**143**	14.6
Sifundise Primary School	129.8	58.0	8.7	37.5	2.3	**127.0**	**14**	13.9	**127.0**	**129**	13.9
Matla Coal Health Centre	132.6	54.3	8.8	38.5	2.3	**87.5**	1	11.2	**87.5**	**92**	11.2
Gweda Primary School	177.9	62.9	10.3	75.3	3.3	**102.7**	9	18.7	**102.7**	**278**	**18.7**
Zithobe Primary School	106.0	41.7	6.6	33.1	1.7	56.3		9.0	**56.3**	**50**	9.0
Kwanala Primary School	153.1	58.5	11.1	66.3	3.5	**132.0**	**27**	14.6	**132.0**	**158**	14.6
Reedstream Park	123.1	47.6	10.2	38.3	2.8	46.3		7.0	**46.3**	11	7.0
Rietspruit Clinic	119.6	43.5	10.0	36.3	2.7	41.6		6.5	**41.6**	2	6.5
Lehlaka Combined School	119.1	44.7	10.0	36.3	2.7	41.5		6.6	**41.5**	1	6.6
Mbali Coal/Blesboklaagte Housing	136.7	46.8	10.1	34.9	2.7	36.9		5.7	**36.9**	1	5.7
Kinross	93.7	43.7	6.6	31.7	1.7	67.4		7.4	**67.4**	**44**	7.4

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Kinross Settlement	84.3	43.9	6.1	25.6	1.5	57.2		6.9	**57.2**	**18**	6.9
Kinross Municipal Clinic	93.2	42.5	6.5	31.2	1.6	61.9		7.1	**61.9**	**39**	7.1
Kriel	122.2	42.6	10.4	55.2	3.3	**87.7**	1	8.7	**87.7**	**48**	8.7
Eagles Nest Guest House	116.6	40.9	10.4	53.3	3.2	**79.0**	1	8.2	**79.0**	**45**	8.2
Merlin Park Primary School	109.3	40.6	9.9	46.5	2.9	63.5		7.1	**63.5**	**19**	7.1
Kriel Medical Centre	110.7	40.3	9.9	46.7	3.0	67.5		7.3	**67.5**	**23**	7.3
Laerskool Krielpark	116.3	42.0	10.1	49.7	3.1	**80.9**	1	7.9	**80.9**	**36**	7.9
Laerskool Onverwacht	112.7	41.9	10.0	48.3	3.0	58.5		7.1	**58.5**	**22**	7.1
Silwer Fleur Aftree Oord (Old Age Home)	115.5	43.0	10.1	49.0	3.0	62.1		7.3	**62.1**	**26**	7.3
Thubelihle	103.0	41.0	9.7	41.2	2.7	41.0		6.1	**41.0**	1	6.1
Sibongamandla Secondary School	98.6	38.9	9.6	38.8	2.7	39.1		6.2	**39.1**	1	6.2
Ga-Nala Clinic	115.7	43.4	10.1	48.8	3.0	52.5		6.6	**52.5**	**19**	6.6
Impilo Primary School	87.9	35.2	8.6	28.6	2.3	33.4		5.5	**33.4**	1	5.5
Bonginhlanhla Primary School	98.9	39.6	9.5	38.8	2.7	39.9		6.1	**39.9**	1	6.1
Sibongamandla Secondary School	98.4	38.9	9.6	38.7	2.7	39.1		6.2	**39.1**	1	6.2
Leandra	70.7	35.7	5.3	20.8	1.2	31.8		5.5	**31.8**	1	5.5
Eendracht	67.5	34.5	5.2	19.2	1.2	29.7		4.9	**29.7**	1	4.9
Sidingulwazi Primary School	68.8	34.8	5.3	20.0	1.2	30.6		5.1	**30.6**	1	5.1
Ss Mshayisa Primary School	71.0	36.3	5.3	20.2	1.2	31.1		5.3	**31.1**	1	5.3
Chief Ampie Mayisa Secondary School	68.7	34.9	5.3	20.3	1.2	30.5		5.1	**30.5**	1	5.1
Lebogang Clinic	69.0	35.6	5.3	20.7	1.2	30.7		5.2	**30.7**	1	5.2
Kleuterskool Haas Das	52.7	26.9	4.9	12.0	0.8	21.3		3.3	21.3		3.3
Standerton Primary School	52.4	27.5	4.9	12.0	0.8	21.4		3.3	21.4		3.3
Laerskool Jeugkrag	51.7	26.9	4.9	11.6	0.8	23.2		3.4	23.2		3.4
Laerskool Standerton	52.9	26.6	4.9	12.0	0.8	21.4		3.2	21.4		3.2
Laerskool Kalie De Haas	54.6	25.9	5.0	12.2	0.8	20.9		3.1	20.9		3.1
Hoerskool Standerton	52.3	27.5	4.9	12.0	0.8	21.4		3.3	21.4		3.3
Standerton Provincial Government Hospital	51.9	27.7	4.9	11.8	0.8	21.3		3.3	21.3		3.3
Mar-Peh Medicare Private Hospital	52.8	26.2	4.9	12.0	0.8	21.0		3.2	21.0		3.2
Standerton Retirement Home	52.8	26.0	4.9	11.9	0.8	21.0		3.2	21.0		3.2
Standerton Ouetehuis/Old Age Home	53.8	26.6	5.0	12.2	0.8	21.1		3.2	21.1		3.2

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Holmdene Secondary School	47.4	27.0	4.7	10.6	0.8	20.8		3.0	20.8		3.0
Cathuza Primary School (SE of Town)	62.1	30.9	5.4	14.6	1.0	25.5		3.6	**25.5**	1	3.6
Sizanani Pre Primary School	51.9	25.5	4.9	11.4	0.8	20.4		3.1	20.4		3.1
Hlobisa Primary School	50.2	26.0	4.8	10.8	0.8	19.9		3.0	19.9		3.0
Shukuma Primary School	50.0	26.2	4.8	10.8	0.8	19.6		3.0	19.6		3.0
Retsebile Primary School	50.8	25.7	4.8	11.0	0.8	21.2		3.1	21.2		3.1
Thuto-Thebe Secondary School	51.4	25.4	4.9	11.6	0.8	21.6		3.3	21.6		3.3
Jandrell Secondary School	50.7	25.8	4.8	11.0	0.8	20.3		3.1	20.3		3.1
Thobelani Secondary School	51.3	26.0	4.9	11.1	0.8	20.6		3.1	20.6		3.1
Standerton Tb Hospital	51.2	26.6	4.8	11.1	0.8	19.8		3.0	19.8		3.0
Thuthukani Pre Primary School	63.7	31.1	5.8	16.0	1.1	37.9		5.5	**37.9**	1	5.5
Ulwazi Primary School	63.4	31.6	5.8	15.9	1.1	36.0		5.3	**36.0**	1	5.3
Zikhetheleni Secondary School	63.0	30.8	5.8	15.8	1.1	36.3		5.3	**36.3**	1	5.3
Joubertsvlei Primary School (North of Tutuka)	62.8	27.6	5.8	18.2	1.2	23.8		4.3	23.8		4.3
Amalumgelo Primary School (NE of Tutuka)	68.3	27.6	6.9	20.0	1.4	45.4		5.7	**45.4**	8	5.7
Grootdraaidam Primary School	54.7	27.8	5.2	12.6	0.9	25.7		3.8	**25.7**	1	3.8
Laerskool Secunda	71.3	32.3	6.0	22.3	1.4	42.1		5.8	**42.1**	2	5.8
Laerskool Kruinpark	71.3	32.5	6.2	23.4	1.4	37.8		6.0	**37.8**	1	6.0
Laerskool Oranjegloed Primary	69.3	31.5	5.9	21.8	1.3	39.0		5.6	**39.0**	1	5.6
Curro Castle Combined School	68.1	32.3	5.8	20.5	1.3	38.1		5.4	**38.1**	1	5.4
Hoërskool Oosterland	71.8	32.8	6.1	22.8	1.4	39.6		6.0	**39.6**	1	6.0
Mediclinic Secunda (Hospital)	70.0	32.7	5.9	21.2	1.3	44.5		5.7	**44.5**	3	5.7
Mediclinic Highveld (Hospital_Trichardt, Secunda)	78.8	34.4	6.6	27.7	1.6	45.7		7.0	**45.7**	**17**	7.0
Daviescourt/Davieshof Old Age Home	71.3	32.1	6.0	22.5	1.4	40.7		5.8	**40.7**	1	5.8
Highveld Park High School	72.2	33.2	6.1	23.2	1.4	40.2		6.0	**40.2**	3	6.0
Hoerskool Secunda	70.4	32.0	6.0	22.1	1.3	41.1		5.7	**41.1**	1	5.7
Basizeni Special School	68.0	34.6	5.3	19.1	1.1	33.1		4.5	**33.1**	1	4.5
Maphala-Gulube Primary School	63.9	35.1	5.2	16.8	1.0	27.6		4.1	**27.6**	1	4.1
Shapeve Primary School	68.7	34.3	5.4	18.5	1.1	32.2		4.5	**32.2**	1	4.5

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Thomas Nhlabathi Secondary School	66.9	34.1	5.2	18.2	1.1	30.5		4.2	**30.5**	1	4.2
Embalenhle Hospital / Clinic	65.9	34.2	5.2	17.6	1.1	29.9		4.2	**29.9**	1	4.2
Vukuzithathe Primary School	64.3	33.0	5.2	16.7	1.0	27.8		4.1	**27.8**	1	4.1
K I Twala Secondary	64.4	32.6	5.2	16.5	1.0	28.0		4.0	**28.0**	1	4.0
Allan Makunga Primary School	67.6	34.2	5.3	18.1	1.1	31.3		4.4	**31.3**	1	4.4
Evander Hospital Arv Clinic	78.7	38.2	6.1	25.1	1.4	45.2		5.9	**45.2**	4	5.9
Laerskool Hoeveld	78.7	38.8	6.0	24.1	1.4	45.5		5.8	**45.5**	3	5.8
Hoerskool Evander	76.7	39.1	5.9	23.3	1.4	45.0		5.6	**45.0**	10	5.6
Bernice Samuel Hospital	57.5	33.0	3.9	14.9	0.8	27.1		3.4	**27.1**	1	3.4
Hoerskool Delmas	57.3	34.0	3.9	14.9	0.8	26.9		3.5	**26.9**	1	3.5
Laerskool Delmas	58.4	34.6	3.9	15.4	0.8	27.4		3.6	**27.4**	1	3.6
Kangela Primary School (North of Delpark)	59.6	34.4	4.0	16.2	0.8	29.6		3.8	**29.6**	1	3.8
Savf Ons Eie Ouetehuis / Old Age Home	58.3	35.0	3.9	15.5	0.8	27.6		3.6	**27.6**	1	3.6
Laerskool Eloff	52.8	32.0	3.7	13.6	0.7	24.2		3.0	24.2		3.0
Rietkol Primary School	53.0	31.7	3.7	13.6	0.7	24.2		3.0	24.2		3.0
Bazani Primary School	59.2	33.4	3.9	17.0	0.8	27.9		4.0	**27.9**	1	4.0
Phaphamani Secondary School	58.4	33.1	3.9	16.3	0.8	27.6		3.9	**27.6**	1	3.9
Vezimfundo Primary School	58.0	31.0	3.9	16.3	0.8	28.2		4.0	**28.2**	1	4.0
Arbor Primary School	87.7	51.1	5.6	36.8	1.6	71.4		11.6	**71.4**	**113**	11.6
Ogies Combined School	153.2	53.6	9.3	40.0	2.7	42.2		5.6	**42.2**	1	5.6
Ogies Tb Clinic	157.6	57.7	9.3	41.8	2.7	44.6		5.6	**44.6**	2	5.6
Ogies Police Station	157.6	57.7	9.3	41.8	2.7	44.6		5.6	**44.6**	2	5.6
Hlangu Phala Primary School	129.3	60.4	8.1	44.2	2.7	38.5		5.0	**38.5**	1	5.0
Sukumani Primary School	129.4	60.6	8.1	43.6	2.7	38.5		5.0	**38.5**	1	5.0
Thuthukani Primary School	129.4	57.6	8.2	42.5	2.6	38.5		4.9	**38.5**	1	4.9
Mehlwana Secondary School	119.3	55.3	8.0	44.3	2.7	42.3		5.1	**42.3**	1	5.1
Makause Combined School	119.7	56.0	8.0	43.0	2.7	39.6		5.0	**39.6**	1	5.0
Sibongindawo Primary School	124.2	53.4	8.5	69.8	3.5	67.5		7.5	**67.5**	**37**	7.5
Laerskool Balmoral	102.2	48.8	5.4	51.1	1.8	32.5		3.5	**32.5**	1	3.5
Clewer Primary School	83.4	38.3	6.1	27.8	1.7	31.3		3.8	**31.3**	1	3.8
Witbank High School	78.6	38.9	5.7	22.0	1.4	49.4		5.0	**49.4**	10	5.0

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Eden Park Retirement Village	81.0	38.9	5.9	23.3	1.5	55.8		6.4	**55.8**	**47**	6.4
Savf House Immergroen Old Age Home	76.3	38.3	5.6	21.8	1.4	40.8		4.5	**40.8**	1	4.5
Mthimkulu Housing For The Aged	75.6	38.5	5.5	22.3	1.4	33.5		3.7	**33.5**	1	3.7
Emalahleni Private Hospital	75.4	38.1	5.5	21.0	1.4	38.5		4.2	**38.5**	1	4.2
Life Cosmos Hospital	78.5	38.9	5.7	21.7	1.4	50.3		5.1	**50.3**	**20**	5.1
Duvha Primary School	85.6	37.2	6.3	25.5	1.7	50.0		6.1	**50.0**	**30**	6.1
Laerskool Taalfees	78.1	38.6	5.7	21.9	1.4	49.8		4.9	**49.8**	**13**	4.9
Witbank Provincial Hospital	76.9	38.2	5.6	21.0	1.4	45.4		4.5	**45.4**	4	4.5
Nancy Shiba Primary School (Vosman)	75.3	38.4	5.2	24.4	1.4	24.4		2.8	24.4		2.8
Wh De Klerk Skool	77.2	39.7	5.5	20.1	1.3	33.6		3.4	**33.6**	1	3.4
Laerskool Panorama	74.2	38.1	5.2	19.4	1.2	27.6		2.9	**27.6**	1	2.9
Laerskool Duvhapark	86.6	38.0	6.4	25.8	1.7	55.3		6.9	**55.3**	**51**	6.9
Laerskool Klipfontein	81.8	38.7	6.0	23.4	1.5	56.4		6.6	**56.4**	**59**	6.6
Cambridge Academy	79.9	40.4	5.9	22.5	1.5	55.6		5.8	**55.6**	**30**	5.8
Besilindile Primary School	74.4	38.7	4.9	23.5	1.2	22.7		2.6	22.7		2.6
Reynopark High School	81.6	35.9	6.1	24.5	1.6	72.9		8.2	**72.9**	**87**	8.2
Bakenveld Golf Estate	81.7	41.0	6.0	23.5	1.5	42.8		4.4	**42.8**	**13**	4.4
Allendale Secondary School	74.9	46.4	7.1	21.6	1.8	42.3		7.7	**42.3**	7	7.7
Khayalethu Primary School	75.6	38.4	5.4	22.1	1.4	32.7		3.6	**32.7**	1	3.6
Illanga Secondary School	76.0	58.7	7.0	21.5	1.8	**80.0**	1	17.0	**80.0**	**230**	**17.0**
Joy Creche (Duvha)	77.7	38.2	6.5	22.2	1.7	43.1		6.5	**43.1**	**20**	6.5
Linderus Old Age Home	69.8	40.8	4.7	16.2	0.9	20.6		2.0	20.6		2.0
Vergeet My Nie Old Age Home	72.5	42.4	4.7	16.3	0.9	20.3		2.1	20.3		2.1
Middleburg Frail Care Unit And Home For Elderly	66.0	39.5	4.4	13.9	0.8	18.7		1.8	18.7		1.8
Life Midmed Hospital	68.9	41.1	4.5	14.7	0.8	19.0		1.9	19.0		1.9
Middelburg Hospital	71.3	42.0	4.6	15.7	0.9	19.7		2.0	19.7		2.0
Makhathini Primary School	66.9	39.4	4.4	14.3	0.8	18.8		1.8	18.8		1.8
Laerskool Dennesig	63.7	38.9	4.3	13.4	0.8	18.8		1.8	18.8		1.8
Hoerskool Kanonkop	65.2	38.9	4.3	13.8	0.8	18.7		1.8	18.7		1.8
Laerskool Kanonkop	66.5	39.7	4.4	14.2	0.8	18.6		1.8	18.6		1.8

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Steelcrest High School	68.1	40.1	4.5	14.6	0.8	18.7		1.9	18.7		1.9
Middelburg Primary	71.2	42.0	4.6	16.0	0.9	20.1		2.0	20.1		2.0
Middleburg Ext 6 Clinic	69.6	39.4	4.7	15.8	0.9	27.3		2.4	**27.3**	1	2.4
Sofunda Secondary School	68.6	39.5	4.5	15.2	0.9	21.3		2.1	21.3		2.1
Mhluzi Primary School	68.2	39.2	4.5	14.8	0.8	19.4		1.9	19.4		1.9
Highlands Primary School	70.4	39.7	4.8	16.8	0.9	21.9		2.1	21.9		2.1
Blinkpan Primary School	77.7	34.1	7.8	23.7	2.0	40.3		5.7	**40.3**	3	5.7
Laerskool Koornfontein	75.2	34.3	7.8	22.5	1.9	40.7		5.5	**40.7**	2	5.5
Blinkpan	78.6	35.4	7.9	24.3	2.0	41.4		5.8	**41.4**	3	5.8
Laerskool Kragveld	64.4	30.7	6.9	18.1	1.6	30.6		3.5	**30.6**	1	3.5
Pullens Hope	63.7	31.7	6.9	17.8	1.6	30.0		3.5	**30.0**	1	3.5
Arnot Colliery Primary School	53.5	30.7	5.1	12.9	1.0	19.6		2.1	19.6		2.1
Laerskool Rietkuil	52.3	29.9	5.2	12.9	1.0	19.2		2.1	19.2		2.1
Beestepan Agricultural School	59.1	31.7	4.6	12.4	0.8	18.3		1.9	18.3		1.9
Gekombineerde Skool Hendrina	50.9	28.2	6.5	12.9	1.4	22.7		3.1	22.7		3.1
Hendrina Primary School	51.1	28.1	6.5	13.2	1.4	23.7		3.0	23.7		3.0
Kwazamokuhle Secondary School	51.2	27.9	6.5	13.2	1.4	23.6		3.0	23.6		3.0
Ubuhle Bolwai Secondary School	39.0	22.8	5.3	8.7	0.9	13.9		2.0	13.9		2.0
Lothair Primary School	39.2	22.2	5.4	8.8	0.9	14.0		2.1	14.0		2.1
Warburton Combined School	39.2	24.2	5.1	9.1	0.8	13.7		1.9	13.7		1.9
Warburton Town	39.3	24.7	5.1	9.2	0.8	13.8		1.9	13.8		1.9
Kwachibikhulu Clinic	42.0	24.4	5.7	9.6	1.0	15.0		2.2	15.0		2.2
Kwachibikhulu Primary School	41.8	24.6	5.7	9.7	1.0	15.0		2.2	15.0		2.2
Carolina Hospital	41.3	25.0	5.2	9.3	0.9	16.8		2.1	16.8		2.1
Zinikeleni Secondary School (Silobela)	41.4	25.2	5.2	9.3	0.9	17.0		2.1	17.0		2.1
Volkskool Carolina	41.3	24.8	5.1	9.3	0.9	16.5		2.0	16.5		2.0
Sobuza Primary School	40.8	25.1	5.2	9.4	0.9	17.0		2.1	17.0		2.1
Ons Eie Ouetehuis (Old Age Home)	41.3	24.9	5.2	9.3	0.9	16.5		2.0	16.5		2.0
Laerskool Breyten	45.8	25.3	6.2	11.8	1.3	16.3		2.4	16.3		2.4
Siyazi Primary School (Kwazanele)	46.0	25.6	6.3	12.0	1.3	16.4		2.4	16.4		2.4
Masizakhe Secondary School (Kwazanele)	46.1	25.5	6.2	11.9	1.3	16.3		2.4	16.3		2.4

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Belfast Rusoord (Old Age Home)	41.0	26.1	3.6	9.1	0.6	12.8		1.4	12.8		1.4
Belfast Hospital	41.0	26.3	3.7	9.6	0.6	12.8		1.4	12.8		1.4
Platorand School	41.3	25.9	3.7	9.9	0.7	12.8		1.4	12.8		1.4
Belfast Primary School (Siyathuthuka)	41.0	24.7	3.5	8.9	0.6	12.8		1.4	12.8		1.4
Siyathuthuka Clinic	40.9	24.8	3.5	8.9	0.6	12.8		1.4	12.8		1.4
Life Bethal Hospital	83.5	34.8	7.5	27.9	1.9	27.6		4.4	**27.6**	1	4.4
Hoerskool Hoogenhout	83.1	34.6	7.5	27.4	1.9	27.0		4.4	**27.0**	1	4.4
Jim Van Tonderskool	86.4	35.5	7.8	29.6	2.1	32.4		4.8	**32.4**	1	4.8
Bethal Independent Primary School	86.3	35.1	7.7	28.9	2.0	31.5		4.7	**31.5**	1	4.7
Laerskool Marietjie Van Niekerk	78.4	35.2	7.8	25.9	2.0	27.1		4.3	**27.1**	1	4.3
Laerskool Hm Swart	83.6	34.8	7.5	28.1	1.9	27.7		4.4	**27.7**	1	4.4
Sakhisizwe Primary School (Emzinoni)	88.2	35.7	7.2	30.5	1.8	32.8		4.8	**32.8**	1	4.8
Alpheus D Nkosi Secondary School (Emzinoni)	86.5	36.4	7.3	28.9	1.8	31.1		4.6	**31.1**	1	4.6
Silwerjare Old Age Home	83.5	35.2	7.4	27.6	1.9	28.7		4.4	**28.7**	1	4.4
Residentia Palm Oord	83.7	34.9	7.5	28.5	1.9	28.2		4.5	**28.2**	1	4.5
Bronkhorspruit Hospital	52.8	32.2	2.9	14.0	0.6	23.4		2.2	23.4		2.2
Cultura High School	58.7	34.2	3.2	17.2	0.7	27.7		2.6	**27.7**	1	2.6
Bronkhorspruit Primary School	53.5	32.7	3.0	14.9	0.6	24.1		2.2	24.1		2.2
Bronkhorspruit Dam	63.6	34.1	3.4	20.1	0.8	30.3		3.3	**30.3**	1	3.3
Hoerskool Erasmus	55.3	33.1	3.0	15.3	0.6	25.9		2.4	**25.9**	1	2.4
Althea Independent School	55.2	34.0	3.0	15.1	0.6	25.0		2.3	25.0		2.3
Kgoro Primary School (Zithobeni)	51.1	31.3	2.8	13.1	0.5	21.9		2.1	21.9		2.1
Zithobeni Secondary School (Zithobeni)	49.0	31.2	2.8	12.7	0.5	22.2		2.0	22.2		2.0
Vaal Power AH	72.6	34.2	4.0	23.4	1.0	64.0		8.3	**64.0**	**86**	8.3
Sasolburg Provincial Hospital	56.3	38.9	3.0	14.9	0.6	32.1		2.7	**32.1**	1	2.7
Moredou Old Age Home	53.4	36.2	2.9	13.4	0.6	28.3		2.4	**28.3**	1	2.4
Ons Gryse Jeug Old Age Home	53.9	35.4	3.0	13.5	0.6	30.6		2.6	**30.6**	1	2.6
Noord Primere Skool	53.4	36.5	3.0	13.8	0.6	31.2		2.7	**31.2**	1	2.7
Sasolburg High School	53.4	33.5	2.9	13.9	0.6	30.7		2.5	**30.7**	1	2.5
Sakhubusa Secondary School	57.3	34.3	3.0	14.0	0.6	37.8		3.0	**37.8**	1	3.0

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Bekezela Primary School	57.1	33.1	3.0	13.7	0.6	43.1		3.6	**43.1**	11	3.6
Isaac Mhlambi Primary	57.9	36.4	3.1	14.7	0.7	42.0		3.2	**42.0**	2	3.2
Refenkgotso Primary School	70.3	27.4	4.2	24.9	1.1	35.3		3.6	**35.3**	1	3.6
Deneysville Primary School	69.8	26.5	4.4	24.8	1.1	28.2		3.3	**28.2**	1	3.3
Netcare Vaalpark Hospital	56.1	39.4	3.0	13.9	0.6	43.2		3.8	**43.2**	12	3.8
Vaalpark Articon Secondary School	57.2	39.4	3.1	14.3	0.7	46.4		4.2	**46.4**	**19**	4.2
Mediclinic Emfuleni	49.1	30.1	2.7	10.9	0.5	35.4		2.8	**35.4**	1	2.8
Jeugland Old Age Home	49.7	31.1	2.7	11.2	0.5	32.1		2.8	**32.1**	1	2.8
Herfsoord Huis Old Age Home	48.6	29.3	2.7	10.7	0.5	31.7		2.6	**31.7**	1	2.6
Huis Prinscilla	47.0	27.1	2.6	10.5	0.5	29.9		2.5	**29.9**	1	2.5
Laerskool Emfulenipark	53.9	33.6	2.9	12.5	0.6	43.9		3.6	**43.9**	7	3.6
Nw University_Vaal Campus	52.5	36.2	3.0	12.2	0.6	53.2		4.9	**53.2**	**28**	4.9
Emfuleni Primary School	46.4	28.0	2.5	9.9	0.5	26.8		2.2	**26.8**	1	2.2
Mediclinic Vereeniging	48.7	28.7	2.9	10.8	0.6	40.0		3.8	**40.0**	10	3.8
Kopanong Provincial Hospital (Duncanville)	48.4	27.5	2.9	10.9	0.6	23.6		2.1	23.6		2.1
Avondrus Eventide Old Age Home	48.8	27.9	2.9	10.8	0.6	24.5		2.2	24.5		2.2
Riviera On Vaal Resort	48.5	31.3	2.9	11.0	0.6	46.5		4.5	**46.5**	**17**	4.5
Sedibeng Tvet College	49.3	30.4	2.9	11.0	0.6	49.9		4.6	**49.9**	**21**	4.6
General Smuts High School	48.7	33.9	2.9	10.6	0.6	39.2		3.8	**39.2**	9	3.8
Eureuka School & Selbourne Primary	48.5	32.2	2.8	10.5	0.6	39.5		3.6	**39.5**	4	3.6
Midvaal Private Hospital (Three Rivers)	54.6	34.2	3.3	12.9	0.7	49.3		4.1	**49.3**	**20**	4.1
Three Rivers Retirement Village	55.4	32.9	3.3	13.0	0.7	39.4		3.2	**39.4**	8	3.2
Drie Riviere Aftreeoord Old Age Home	54.9	32.4	3.3	12.9	0.7	33.6		2.8	**33.6**	1	2.8
Riverside High School	69.6	34.6	3.6	18.8	0.8	57.2		4.0	**57.2**	**17**	4.0
Risiville Primary School	58.1	34.0	3.3	13.8	0.7	31.8		2.8	**31.8**	1	2.8
Sebokeng Hospital	41.9	27.9	2.5	9.8	0.5	20.0		1.7	20.0		1.7
Clinix-Naledzi Private Hospital	42.0	28.8	2.5	10.0	0.5	20.3		1.8	20.3		1.8
Mohloli Secondary School	46.9	33.9	2.8	10.6	0.6	39.3		3.5	**39.3**	4	3.5
Tshirela Primary School (Boipatong)	45.5	31.7	2.6	9.9	0.5	25.8		2.3	**25.8**	1	2.3
Tsoaranang Primary School (Thepiso)	45.4	32.1	2.7	10.0	0.5	31.2		2.8	**31.2**	1	2.8
Thepiso Primary School	46.2	32.9	2.7	10.1	0.5	29.9		2.5	**29.9**	1	2.5

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Emmanuel Primary School	46.1	34.7	2.8	10.3	0.5	34.9		3.1	**34.9**	1	3.1
Rust Ter Vaal Combined School	44.6	26.6	2.7	10.2	0.5	18.2		1.6	18.2		1.6
Roshnee Primary School	42.6	26.1	2.6	10.3	0.5	16.4		1.5	16.4		1.5
Roshnee High School	42.6	26.3	2.7	10.4	0.5	17.6		1.6	17.6		1.6
Hoerskool Dr Malan	49.6	27.6	3.0	13.1	0.6	20.0		1.8	20.0		1.8
Laerskool Voorwaarts	58.5	28.4	3.4	16.7	0.8	23.5		2.1	23.5		2.1
Meyerton Secondary School	50.7	29.8	3.0	12.6	0.6	19.3		1.9	19.3		1.9
Ratasetjhaba Primary School	46.1	27.7	2.8	11.1	0.5	16.7		1.6	16.7		1.6
Meyerton Primary School	48.0	28.1	2.9	12.5	0.6	19.4		1.7	19.4		1.7
Oprah Leadership Academy	50.5	25.1	3.0	13.2	0.6	20.3		1.7	20.3		1.7
Henley River Retirement Village	51.4	25.5	3.1	13.0	0.6	18.4		1.7	18.4		1.7
Henley High & Preparatory School	48.9	24.4	3.0	12.6	0.6	17.7		1.6	17.7		1.6
Randvaal Clinic	47.1	26.0	2.9	11.9	0.6	17.1		1.6	17.1		1.6
Laerskool Japie Greyling	45.6	25.2	2.9	11.5	0.6	15.3		1.5	15.3		1.5
Thomas Nhlapo Primary	46.7	24.7	2.9	12.0	0.6	16.5		1.6	16.5		1.6
Randvaal Old Age Home	45.2	26.7	2.8	11.4	0.6	15.2		1.5	15.2		1.5
Laerskool Ag Visser	43.9	23.7	3.4	10.9	0.6	15.1		1.7	15.1		1.7
Lethaba Siyangobe	43.8	23.5	3.5	11.0	0.7	15.2		1.7	15.2		1.7
Shalimar Ridge Primary School	44.4	24.6	3.4	10.8	0.6	15.1		1.7	15.1		1.7
Jw Luckoff High School	44.4	23.6	3.5	11.4	0.7	15.2		1.8	15.2		1.8
Heidelberg Hospital	44.7	25.2	3.4	10.8	0.6	15.2		1.7	15.2		1.7
Thulatsatsi Operation (Rensburg)	43.8	23.8	3.4	10.9	0.6	15.1		1.7	15.1		1.7
Silwer Akker Tehuis	44.3	24.6	3.4	10.8	0.6	15.1		1.7	15.1		1.7
Riversands Retirement Village	44.4	25.5	3.4	10.9	0.7	15.2		1.7	15.2		1.7
Qhaqholla Primary School	44.5	23.8	3.4	11.2	0.7	15.0		1.7	15.0		1.7
Ratanda Primary School	44.6	22.8	3.4	11.6	0.7	15.0		1.7	15.0		1.7
Boneha Primary School	44.3	23.6	3.4	11.3	0.7	15.0		1.7	15.0		1.7
Sithokomele Primary School	44.0	23.4	3.4	11.4	0.7	15.0		1.7	15.0		1.7
Ratanda Bertha Gxowa Primary School	44.2	23.3	3.5	11.2	0.7	15.2		1.7	15.2		1.7
Khanya Lesedi Secondary School	43.8	23.1	3.4	11.5	0.7	14.9		1.7	14.9		1.7
Ratanda Secondary School	43.8	23.1	3.4	11.5	0.7	14.9		1.7	14.9		1.7

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
New Ratanda Secondary School	44.0	23.6	3.4	11.1	0.7	15.2		1.7	15.2		1.7
Kgoro Ya Thuto Secondary School	44.0	23.6	3.4	11.1	0.7	15.2		1.7	15.2		1.7
Ekurhuleni School For The Deaf	41.1	24.6	2.9	10.7	0.5	13.5		1.4	13.5		1.4
Pholosong Hospital	44.3	28.1	3.3	11.9	0.7	15.5		1.7	15.5		1.7
Tsakane Home For Aged	45.2	27.5	3.4	11.9	0.7	15.4		1.8	15.4		1.8
Mmuso Primary School	46.5	26.9	3.5	12.4	0.7	16.3		1.8	16.3		1.8
Michael Zulu Primary School	44.8	28.2	3.4	12.0	0.7	15.8		1.8	15.8		1.8
Nkabinde Primary School (Thembilisha)	44.0	28.5	3.3	11.4	0.6	16.0		1.8	16.0		1.8
Nigel Clinic	45.4	25.6	3.5	11.0	0.6	16.9		1.9	16.9		1.9
Tehuis Vir Bejaardes	45.9	25.6	3.5	10.9	0.6	17.1		2.0	17.1		2.0
Hoerskool John Vorster	45.1	25.5	3.5	10.9	0.6	16.9		1.9	16.9		1.9
Laerskool Hannes Visagie	45.3	25.3	3.5	11.1	0.7	17.3		2.0	17.3		2.0
Nigel Secondary School	46.1	26.7	3.6	11.4	0.7	18.2		2.0	18.2		2.0
Laerskool Dunnottar	46.1	26.8	3.4	11.9	0.7	16.3		1.9	16.3		1.9
Springs Retirement Village	44.0	29.6	3.2	11.2	0.6	17.2		1.9	17.2		1.9
Life Springs Parkland Hospital	44.0	28.4	3.3	11.3	0.6	16.8		1.9	16.8		1.9
Netcare N17 Hospital (Springs)	43.9	28.8	3.3	11.2	0.6	16.7		1.9	16.7		1.9
Springs Boys High School	45.2	28.7	3.3	11.4	0.6	16.8		1.9	16.8		1.9
Laerskool Selectionpark	44.3	28.0	3.3	11.2	0.6	17.1		1.9	17.1		1.9
Kwasa College Pre&Primary School	44.8	27.5	3.4	11.5	0.6	17.3		2.0	17.3		2.0
Edelweis Medical Centre	44.2	27.8	3.3	11.2	0.6	17.4		2.0	17.4		2.0
Laerskool Christiaan Beyers	43.9	28.8	3.2	11.3	0.6	17.3		2.0	17.3		2.0
Hoerskool Hugenote	44.6	28.7	3.2	11.2	0.6	17.0		1.9	17.0		1.9
Brakpan Primary School	43.5	27.3	3.2	11.3	0.6	15.7		1.7	15.7		1.7
Parkrand Primary School	41.5	27.6	3.0	11.3	0.6	14.1		1.5	14.1		1.5
Thabo Memorial Hospital	40.8	28.4	3.0	11.1	0.6	13.6		1.4	13.6		1.4
Sunward Park Hospital	41.1	27.3	3.0	10.9	0.6	13.7		1.5	13.7		1.5
Alberton High School	40.5	26.0	2.8	10.9	0.5	12.8		1.3	12.8		1.3
Netcare Clinton Hospital	39.8	26.6	2.8	10.8	0.5	12.7		1.3	12.7		1.3
Alberton Tuiste Vir Bejaardes	40.4	26.4	2.8	11.0	0.5	12.8		1.3	12.8		1.3
Bertha Gxowa Hospital	41.3	28.3	3.0	11.6	0.6	13.3		1.3	13.3		1.3

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Linmed Hospital	40.7	28.0	3.1	11.5	0.6	15.2		1.6	15.2		1.6
Hoerskool Brandwag (Airfield)	41.8	29.5	3.1	11.6	0.6	14.7		1.6	14.7		1.6
Thepiso Noto Intermediate School	44.9	29.1	3.2	11.9	0.6	19.4		2.2	19.4		2.2
Laerskool Bredell	38.4	28.5	2.8	10.2	0.5	15.2		1.5	15.2		1.5
Sibonelo Primary School (Daveyton)	44.1	28.8	3.1	11.0	0.6	17.2		2.0	17.2		2.0
Petit High School (Kempton Park Nu)	40.1	29.9	3.0	11.4	0.6	16.4		1.7	16.4		1.7
Arwyp Medical Centre	37.6	28.1	2.8	11.0	0.6	14.0		1.4	14.0		1.4
Hoerskool Birchleigh	38.6	26.4	2.7	9.7	0.5	14.2		1.3	14.2		1.3
Curro Serengeti Acadamy	38.4	27.1	2.7	9.5	0.5	15.5		1.5	15.5		1.5
South Rand Hospital	46.5	31.6	3.1	13.9	0.7	13.2		1.2	13.2		1.2
Chris Hani Baragwanath Hospital	39.3	25.3	2.5	10.5	0.5	12.1		1.1	12.1		1.1
Thulani Primary School	34.8	24.0	2.2	10.1	0.4	11.0		0.9	11.0		0.9
University of Witwatersrand	44.9	28.9	2.9	14.0	0.6	13.0		1.2	13.0		1.2
Milpark Hospital	42.4	27.6	2.8	13.0	0.6	12.9		1.1	12.9		1.1
Charlotte Maxixe Academic Hospital	43.5	28.7	2.9	13.4	0.6	13.0		1.2	13.0		1.2
Thembisa West Secondary School (Thembisa)	36.7	23.7	2.4	8.3	0.4	13.8		1.2	13.8		1.2
Lenmed Zamokuhle Private Hospital (Thembisa)	38.5	25.2	2.4	8.9	0.4	14.7		1.3	14.7		1.3
Ikusasa Comprehensive School	39.1	25.8	2.5	8.9	0.5	14.8		1.3	14.8		1.3
Gem Village Old Age Home	38.0	23.9	2.3	8.5	0.4	14.5		1.3	14.5		1.3
Rustoord Old Age Home	37.4	25.7	2.2	8.3	0.4	14.0		1.2	14.0		1.2
Cornwell Hill College (Irene)	38.2	24.8	2.3	8.7	0.4	14.5		1.3	14.5		1.3
Kleinfontein Sorg Sentrum Old Age Home (Donkerhoek)	44.0	25.7	2.5	10.7	0.4	16.7		1.6	16.7		1.6
Valtaki AH (Rayton)	45.8	26.2	2.6	11.0	0.5	18.7		1.7	18.7		1.7
Laerskool Rayton (Rayton)	39.7	25.0	2.3	8.8	0.4	16.3		1.4	16.3		1.4
Tierkop AH	45.3	29.9	2.8	11.2	0.5	17.9		1.8	17.9		1.8
Redford House The Hills Private School (Mooikloof Glen)	44.7	27.6	2.6	10.7	0.5	16.5		1.6	16.5		1.6
Rietvlei View Country Estate	45.0	28.4	2.7	10.9	0.5	16.6		1.6	16.6		1.6

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Hazeldean Curro School (Tyger Valley)	38.7	23.6	2.2	8.3	0.3	13.9		1.2	13.9		1.2
Tyger Valley College	40.1	24.4	2.3	8.9	0.4	14.4		1.3	14.4		1.3
Pretoria East Hospital (Moreletapark)	40.7	25.5	2.3	9.4	0.4	14.9		1.3	14.9		1.3
Groenkloof Old Age Home	37.2	27.0	2.1	8.5	0.3	13.0		1.1	13.0		1.1
Steve Biko Academic Hospital	35.4	23.7	2.0	7.5	0.3	12.6		1.0	12.6		1.0
Willow Ridge High School (Wilgers)	37.6	25.6	2.1	8.1	0.3	13.2		1.1	13.2		1.1
Hoerskool Waterkloof	40.0	26.4	2.3	9.6	0.4	14.6		1.3	14.6		1.3
Hoerskool Garsfontein	39.7	25.5	2.2	9.0	0.4	14.0		1.2	14.0		1.2
Afrikaanse Hoer Seunskool	36.7	25.3	2.1	8.1	0.3	12.7		1.1	12.7		1.1
Huis Silversig SAVF Old Age Home (Silverton)	36.4	24.8	2.0	7.3	0.3	12.8		1.0	12.8		1.0
Laersekool Meyerspark (Meyerspark)	36.6	24.4	2.0	7.4	0.3	13.0		1.1	13.0		1.1
Curro Academy Mamelodi	34.2	21.9	1.9	6.7	0.3	12.5		1.0	12.5		1.0
Impendulo Primary School	36.5	22.3	2.0	7.3	0.3	13.4		1.1	13.4		1.1
Nellmapius Ext 6 Primary School	36.5	22.5	2.0	6.7	0.3	13.0		1.1	13.0		1.1
Mamelodi Home For Aged	35.2	21.9	2.0	6.9	0.3	12.8		1.0	12.8		1.0

Predicted concentrations in µg/m³ at the sensitive receptors for Scenario C (2036), together with the limit value of the NAAQS and number of exceedances (NoE)

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Elsie Ballot Memorial Hospital	122.9	52.9	6.9	35.9	1.6	16.7		2.5	16.7		2.5
Laerskool Amersfoort	116.1	45.6	6.7	34.0	1.6	16.3		2.4	16.3		2.4
Embuzane Primary School	241.0	79.7	13.3	79.0	3.9	35.2		5.5	**35.2**	1	5.5
Sangqotho Primary School	69.0	32.2	5.8	16.5	1.3	16.1		2.6	16.1		2.6
Amersfoort Combined School	110.7	51.2	6.7	32.6	1.6	16.1		2.5	16.1		2.5
Injubuko Primary School	68.1	31.8	5.6	16.8	1.2	13.9		2.1	13.9		2.1
Daggakraal Primary School	116.3	40.3	8.8	36.6	2.3	17.9		2.7	17.9		2.7
Sizenzele Primary School	140.8	42.6	9.6	44.1	2.6	24.3		3.3	24.3		3.3
Seme Secondary School	107.1	38.0	8.6	32.8	2.2	20.2		2.9	20.2		2.9
Louwra Primary School	75.9	31.4	5.0	20.8	1.1	16.9		2.4	16.9		2.4
Perdekop Agricultural School	62.6	34.2	4.8	17.1	1.0	25.3		3.4	**25.3**	1	3.4
Vukuzenzele Combined School	64.3	36.8	4.8	18.1	1.1	24.9		3.4	24.9		3.4
Gunwana Primary School	62.9	32.0	4.6	18.5	1.0	15.5		2.3	15.5		2.3
Amajuba Memorial Hospital	55.3	23.5	4.1	15.2	0.8	12.7		1.9	12.7		1.9
Volksrust High School	55.0	24.1	4.0	14.5	0.8	13.0		1.9	13.0		1.9
Volksrust Municipal Clinic	54.2	22.2	3.9	14.4	0.8	11.9		1.8	11.9		1.8
C V O Skool Amajuba	53.8	22.9	4.0	14.7	0.8	12.6		1.8	12.6		1.8
Qhubulwazi Combined School	52.9	22.0	4.0	14.2	0.8	12.4		1.8	12.4		1.8
Volksrust Primary School	56.2	23.6	4.2	16.2	0.9	13.8		2.0	13.8		2.0
New Ermelo	32.8	17.7	3.7	9.5	0.8	11.1		1.5	11.1		1.5
Ermelo Christian School	33.6	18.2	3.8	10.1	0.8	11.0		1.6	11.0		1.6
SAVF Home For Aged	32.7	17.9	3.8	10.0	0.8	11.0		1.5	11.0		1.5
Ermelo Hospital	32.4	18.1	3.7	9.9	0.8	11.0		1.5	11.0		1.5
Mediclinic Ermelo	33.6	18.0	3.8	10.1	0.8	11.0		1.6	11.0		1.6
Hoerskool Ermelo	32.5	18.1	3.7	10.0	0.8	11.0		1.5	11.0		1.5
Ermelo Indian Combined School	32.4	18.3	3.7	9.8	0.8	10.9		1.5	10.9		1.5

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Lungelo Combined School (Outside Town)	39.8	19.0	4.0	10.3	0.8	11.8		1.7	11.8		1.7
New Ermelo Primary School	32.9	18.2	3.8	9.7	0.8	11.1		1.5	11.1		1.5
Kwashashe (Outside Town)	31.5	17.9	3.8	10.3	0.8	11.1		1.5	11.1		1.5
Hts Ligbron	33.2	17.9	3.8	10.1	0.8	11.0		1.5	11.0		1.5
Laerskool Ermelo	32.3	17.8	3.7	9.9	0.8	11.1		1.5	11.1		1.5
JJ Vd Merwe Pre-Primary School	32.7	18.1	3.8	10.2	0.8	11.0		1.6	11.0		1.6
Lindile Secondary School	32.0	18.3	3.7	9.7	0.8	10.8		1.5	10.8		1.5
Emthonjeni Clinic	32.0	18.3	3.7	9.9	0.8	10.8		1.5	10.8		1.5
Reggie Masuku Secondary School	31.2	18.3	3.7	10.0	0.8	10.4		1.5	10.4		1.5
Cebisa Secondary School	31.9	18.3	3.7	9.9	0.8	10.8		1.5	10.8		1.5
Camden	34.0	18.8	3.8	8.9	0.7	10.7		1.5	10.7		1.5
Camden Combined School	34.0	19.3	3.9	8.7	0.7	10.5		1.5	10.5		1.5
Camden School	34.2	18.8	3.8	9.0	0.8	10.8		1.5	10.8		1.5
Umzimvelo Secondary School (Rural Area)	30.5	18.7	3.7	8.1	0.7	10.2		1.5	10.2		1.5
Bhekimfundo Primary School (Rural Area)	35.8	18.9	4.0	10.4	0.9	11.3		1.6	11.3		1.6
Eshwileni Primary School (Rural Area)	46.8	21.2	4.7	10.9	1.0	11.3		1.8	11.3		1.8
Davel Combined School	33.6	17.1	3.7	12.4	0.9	11.9		1.7	11.9		1.7
Morgenzon Landbou Akademie	64.1	22.4	5.5	14.7	1.2	17.5		2.3	17.5		2.3
Nqobangolwazi Secondary School	63.5	23.3	5.3	14.6	1.1	17.3		2.3	17.3		2.3
Siqondekhaya Pre Primary School	63.7	23.9	5.3	14.7	1.1	19.0		2.3	19.0		2.3
Sizakhele Primary School	63.1	23.6	5.3	14.6	1.1	18.8		2.3	18.8		2.3
Phezukwentaba Primary School (South of Morgenzon)	61.5	22.0	5.7	14.6	1.2	17.9		2.5	17.9		2.5
Kwaggalaagte Primary School (North of Morgenzon)	43.4	21.0	4.0	13.2	0.9	13.6		1.9	13.6		1.9

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Sizakhele Clinic/Hospital	63.5	23.7	5.3	14.8	1.1	18.5		2.3	18.5		2.3
Grootvlei	36.6	17.5	3.0	8.9	0.6	10.1		1.3	10.1		1.3
Olive Grove Country Lodge	37.7	17.8	3.1	9.2	0.6	10.5		1.3	10.5		1.3
Grootvlei Town (South of Power Station)	35.7	16.7	3.0	8.8	0.6	10.4		1.3	10.4		1.3
Laerskool Grootvlei	36.3	16.8	3.0	8.9	0.6	10.5		1.3	10.5		1.3
Tokoloho Primary School	35.8	16.4	3.0	8.7	0.6	10.5		1.3	10.5		1.3
Tshepeha Combined School	35.7	16.8	3.0	8.8	0.6	10.4		1.3	10.4		1.3
Warembo Lodge	33.5	17.5	3.0	8.4	0.6	10.1		1.3	10.1		1.3
Balfour	31.9	16.1	2.8	8.8	0.5	10.3		1.4	10.3		1.4
Siyathemba	31.9	16.5	2.9	9.2	0.6	10.4		1.4	10.4		1.4
Bonukukhanya Primary (Siyathemba)	31.8	16.3	2.9	9.2	0.6	10.5		1.4	10.5		1.4
Qalabocha Primary School (Siyathemba)	31.8	16.5	2.9	9.1	0.6	10.4		1.4	10.4		1.4
Vusumuzi Primary School	31.9	16.6	2.9	9.3	0.6	10.5		1.4	10.5		1.4
Gekombineerde Skool Balfour	32.3	15.9	2.9	8.7	0.6	10.3		1.4	10.3		1.4
Im Manchu Secondary School	32.1	15.7	2.9	8.6	0.5	10.3		1.3	10.3		1.3
Isifisosethu Secondary School (Siyathemba)	32.1	16.5	2.9	9.5	0.6	10.6		1.4	10.6		1.4
Setsheng Secondary School (Siyathemba)	32.0	16.5	2.9	9.2	0.6	10.5		1.4	10.5		1.4
Dr Nieuwoudt And Dr Kok	32.5	15.6	2.9	8.7	0.6	10.2		1.4	10.2		1.4
Balfour Clinic	31.8	15.6	2.8	8.6	0.5	10.3		1.3	10.3		1.3
Siyathemba Clinic	31.6	16.1	2.8	8.9	0.5	10.4		1.4	10.4		1.4
Mondoro Lodge	32.3	14.6	2.8	9.0	0.5	10.0		1.3	10.0		1.3
Wegelegen Manor	31.2	15.4	2.8	8.7	0.5	10.6		1.4	10.6		1.4
The Stone Cellar	30.7	14.0	2.5	7.6	0.4	9.6		1.2	9.6		1.2
Greylingstad	31.9	17.9	3.2	9.3	0.6	11.2		1.5	11.2		1.5
Nthorwane	31.6	17.9	3.1	8.9	0.6	11.1		1.5	11.1		1.5

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Laerskool Greylingstad	32.3	17.8	3.2	9.7	0.6	11.2		1.6	11.2		1.6
Nthoroane Secondary School	31.5	17.6	3.1	8.8	0.6	11.1		1.5	11.1		1.5
Badgarleur Bush Lodge	31.8	19.6	3.1	8.6	0.6	10.5		1.4	10.5		1.4
Matla Village	49.4	18.7	3.9	32.4	1.5	30.5		3.6	**30.5**	1	3.6
Sifundise Primary School	49.2	19.0	3.9	32.4	1.5	29.8		3.6	**29.8**	1	3.6
Matla Coal Health Centre	49.8	18.5	3.9	32.5	1.5	29.1		3.6	**29.1**	1	3.6
Gweda Primary School	39.9	17.1	3.5	22.5	1.1	19.5		2.5	19.5		2.5
Zithobe Primary School	39.8	16.5	3.2	23.9	1.1	39.2		4.9	**39.2**	12	4.9
Kwanala Primary School	42.3	18.2	4.0	26.9	1.5	23.4		2.8	23.4		2.8
Reedstream Park	44.0	17.2	4.4	29.3	1.9	24.2		2.8	24.2		2.8
Rietspruit Clinic	42.0	17.3	4.3	27.4	1.9	21.9		2.6	21.9		2.6
Lehlaka Combined School	42.2	17.1	4.4	27.7	1.9	22.1		2.6	22.1		2.6
Mbali Coal/Blesboklaagte Housing	49.8	18.3	4.7	35.5	2.3	26.7		3.0	**26.7**	1	3.0
Kinross	35.5	15.7	3.2	17.9	0.9	21.3		2.9	21.3		2.9
Kinross Settlement	34.0	15.4	3.1	16.5	0.9	23.5		3.1	23.5		3.1
Kinross Municipal Clinic	34.6	15.7	3.2	17.4	0.9	20.4		2.8	20.4		2.8
Kriel	38.6	16.9	3.8	22.9	1.4	18.9		2.4	18.9		2.4
Eagles Nest Guest House	37.6	17.0	3.8	22.1	1.3	18.6		2.3	18.6		2.3
Merlin Park Primary School	37.4	16.5	3.8	22.6	1.4	17.7		2.3	17.7		2.3
Kriel Medical Centre	37.5	16.6	3.8	22.3	1.4	17.9		2.3	17.9		2.3
Laerskool Krielpark	38.2	16.6	3.8	22.8	1.4	18.2		2.3	18.2		2.3
Laerskool Onverwacht	37.6	16.5	3.8	22.9	1.4	17.8		2.3	17.8		2.3
Silwer Fleur Aftree Oord (Old Age Home)	37.9	16.5	3.8	22.9	1.4	18.1		2.3	18.1		2.3
Thubelihle	36.5	16.2	3.9	21.1	1.5	17.4		2.2	17.4		2.2
Sibongamandla Secondary School	35.7	16.2	3.9	20.6	1.5	17.3		2.1	17.3		2.1
Ga-Nala Clinic	37.8	16.4	3.8	23.5	1.4	17.5		2.3	17.5		2.3
Impilo Primary School	33.4	15.8	3.7	19.2	1.4	15.2		1.9	15.2		1.9

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Bonginhlanhla Primary School	35.6	16.3	3.8	20.4	1.5	17.2		2.1	17.2		2.1
Sibongamandla Secondary School	35.8	16.2	3.9	20.6	1.5	17.3		2.1	17.3		2.1
Leandra	32.8	16.5	3.0	15.6	0.8	23.9		3.4	23.9		3.4
Eendracht	32.6	17.1	3.0	16.1	0.8	22.2		3.1	22.2		3.1
Sidingulwazi Primary School	32.7	17.1	3.0	15.5	0.8	22.0		3.2	22.0		3.2
Ss Mshayisa Primary School	32.6	16.5	3.0	15.4	0.8	22.0		3.2	22.0		3.2
Chief Ampie Mayisa Secondary School	32.9	17.2	3.0	15.2	0.8	21.8		3.1	21.8		3.1
Lebogang Clinic	33.4	16.8	3.0	15.6	0.8	22.9		3.2	22.9		3.2
Kleuterskool Haas Das	50.4	24.2	3.9	12.4	0.7	17.4		2.4	17.4		2.4
Standerton Primary School	50.8	24.5	3.9	12.4	0.7	17.8		2.4	17.8		2.4
Laerskool Jeugkrag	50.0	26.7	3.9	12.6	0.7	19.3		2.5	19.3		2.5
Laerskool Standerton	50.3	24.3	3.9	12.5	0.7	17.3		2.4	17.3		2.4
Laerskool Kalie De Haas	52.2	24.8	4.0	12.9	0.7	16.5		2.3	16.5		2.3
Hoerskool Standerton	50.8	24.5	3.9	12.4	0.7	17.8		2.4	17.8		2.4
Standerton Provincial Government Hospital	50.0	24.0	3.9	12.3	0.7	17.6		2.4	17.6		2.4
Mar-Peh Medicare Private Hospital	50.6	23.6	3.9	12.5	0.7	16.8		2.4	16.8		2.4
Standerton Retirement Home	50.3	23.4	3.9	12.5	0.7	16.7		2.4	16.7		2.4
Standerton Ouetehuis/Old Age Home	51.1	23.8	3.9	12.7	0.7	17.3		2.4	17.3		2.4
Holmdene Secondary School	39.2	22.3	3.5	10.4	0.6	13.6		2.1	13.6		2.1
Cathuza Primary School (SE of Town)	58.2	24.8	4.4	14.6	0.9	19.5		2.7	19.5		2.7
Sizanani Pre Primary School	48.3	23.1	3.8	11.9	0.7	16.8		2.3	16.8		2.3
Hlobisa Primary School	47.2	22.8	3.8	11.6	0.7	15.9		2.2	15.9		2.2
Shukuma Primary School	46.3	22.1	3.8	11.5	0.7	14.7		2.2	14.7		2.2
Retsebile Primary School	48.3	23.3	3.8	11.8	0.7	17.7		2.3	17.7		2.3
Thuto-Thebe Secondary School	49.2	23.9	3.8	12.3	0.7	18.4		2.4	18.4		2.4
Jandrell Secondary School	47.5	22.5	3.8	11.7	0.7	16.8		2.3	16.8		2.3
Thobelani Secondary School	48.2	22.6	3.8	11.9	0.7	17.1		2.3	17.1		2.3

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Standerton Tb Hospital	47.1	22.2	3.8	11.8	0.7	15.2		2.2	15.2		2.2
Thuthukani Pre Primary School	50.1	38.8	4.3	14.0	0.9	33.9		4.1	**33.9**	1	4.1
Ulwazi Primary School	50.8	40.0	4.3	14.1	0.9	31.8		4.0	**31.8**	1	4.0
Zikhetheleni Secondary School	51.0	39.4	4.3	14.4	0.9	33.1		4.0	**33.1**	1	4.0
Joubertsvlei Primary School (North of Tutuka)	42.7	25.0	4.0	16.1	0.9	15.2		2.3	15.2		2.3
Amalumgelo Primary School (NE of Tutuka)	111.9	40.5	6.4	26.4	1.5	42.4		4.2	**42.4**	8	4.2
Grootdraaidam Primary School	55.8	27.1	4.2	13.8	0.8	21.6		2.8	21.6		2.8
Laerskool Secunda	35.0	16.5	3.3	15.5	0.8	17.1		2.3	17.1		2.3
Laerskool Kruinpark	34.9	16.0	3.4	15.7	0.9	16.5		2.2	16.5		2.2
Laerskool Oranjegloed Primary	34.7	16.9	3.3	15.0	0.8	16.7		2.2	16.7		2.2
Curro Castle Combined School	34.3	16.9	3.2	15.0	0.8	16.9		2.2	16.9		2.2
Hoërskool Oosterland	35.2	16.4	3.3	15.7	0.9	17.0		2.3	17.0		2.3
Mediclinic Secunda (Hospital)	34.4	16.5	3.2	15.5	0.8	17.3		2.3	17.3		2.3
Mediclinic Highveld (Hospital_Trichardt, Secunda)	35.8	15.5	3.4	17.1	0.9	16.7		2.3	16.7		2.3
Daviescourt/Davieshof Old Age Home	34.8	16.6	3.3	15.4	0.8	17.2		2.3	17.2		2.3
Highveld Park High School	34.6	16.4	3.3	15.7	0.8	17.2		2.3	17.2		2.3
Hoerskool Secunda	34.8	16.7	3.3	15.4	0.8	17.1		2.3	17.1		2.3
Basizeni Special School	33.3	17.4	3.0	12.5	0.7	16.4		2.3	16.4		2.3
Maphala-Gulube Primary School	33.6	17.7	3.1	11.8	0.7	15.2		2.2	15.2		2.2
Shapeve Primary School	32.9	17.5	3.1	12.7	0.7	16.7		2.3	16.7		2.3
Thomas Nhlabathi Secondary School	33.1	17.3	3.0	11.6	0.7	16.3		2.3	16.3		2.3
Embalenhle Hospital / Clinic	33.7	17.5	3.0	11.6	0.7	15.8		2.2	15.8		2.2
Vukuzithathe Primary School	33.7	17.0	3.1	11.6	0.7	15.7		2.2	15.7		2.2
K I Twala Secondary	34.0	17.1	3.1	11.6	0.7	15.6		2.2	15.6		2.2
Allan Makunga Primary School	33.2	17.4	3.1	12.5	0.7	16.3		2.3	16.3		2.3

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Evander Hospital Arv Clinic	33.7	16.4	3.2	15.9	0.8	18.5		2.6	18.5		2.6
Laerskool Hoeveld	33.6	16.4	3.2	15.6	0.8	18.8		2.6	18.8		2.6
Hoerskool Evander	33.3	16.3	3.1	14.9	0.8	19.1		2.5	19.1		2.5
Bernice Samuel Hospital	28.9	15.0	2.2	13.0	0.6	20.9		2.5	20.9		2.5
Hoerskool Delmas	29.2	14.9	2.2	13.0	0.6	20.8		2.5	20.8		2.5
Laerskool Delmas	29.8	15.1	2.3	13.6	0.6	21.1		2.6	21.1		2.6
Kangela Primary School (North of Delpark)	30.7	14.4	2.3	14.7	0.6	22.1		2.8	22.1		2.8
Savf Ons Eie Ouetehuis / Old Age Home	29.9	15.0	2.3	13.6	0.6	21.1		2.6	21.1		2.6
Laerskool Eloff	27.3	14.8	2.2	11.5	0.5	18.2		2.1	18.2		2.1
Rietkol Primary School	27.2	15.0	2.2	11.4	0.5	18.1		2.1	18.1		2.1
Bazani Primary School	29.6	14.9	2.2	14.5	0.6	21.6		3.0	21.6		3.0
Phaphamani Secondary School	29.2	15.0	2.2	13.9	0.6	21.1		3.0	21.1		3.0
Vezimfundo Primary School	29.8	14.8	2.2	14.5	0.6	21.7		3.0	21.7		3.0
Arbor Primary School	58.9	24.0	3.4	37.9	1.4	61.6		10.4	**61.6**	**98**	10.4
Ogies Combined School	61.2	23.0	4.9	42.3	2.5	34.9		3.4	**34.9**	1	3.4
Ogies Tb Clinic	64.7	23.1	4.9	44.5	2.5	36.3		3.6	**36.3**	2	3.6
Ogies Police Station	64.7	23.1	4.9	44.5	2.5	36.3		3.6	**36.3**	2	3.6
Hlangu Phala Primary School	72.1	25.8	5.0	49.2	2.6	32.3		3.5	**32.3**	1	3.5
Sukumani Primary School	70.7	24.7	5.0	48.5	2.6	32.2		3.5	**32.2**	1	3.5
Thuthukani Primary School	69.8	24.4	5.0	47.4	2.6	31.9		3.4	**31.9**	1	3.4
Mehlwana Secondary School	70.7	24.6	5.1	48.5	2.6	35.3		3.5	**35.3**	1	3.5
Makause Combined School	70.5	23.4	5.0	47.4	2.6	33.3		3.4	**33.3**	1	3.4
Sibongindawo Primary School	105.5	31.6	6.2	75.0	3.5	62.3		6.1	**62.3**	**34**	6.1
Laerskool Balmoral	84.9	34.1	3.8	55.1	1.7	28.0		2.5	**28.0**	1	2.5
Clewer Primary School	46.1	19.8	3.6	28.8	1.5	16.9		1.7	16.9		1.7
Witbank High School	36.0	18.1	3.0	19.7	1.1	14.7		1.4	14.7		1.4
Eden Park Retirement Village	36.3	18.1	3.1	20.4	1.1	14.8		1.4	14.8		1.4

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Savf House Immergroen Old Age Home	36.1	18.4	3.0	19.5	1.0	14.8		1.4	14.8		1.4
Mthimkulu Housing For The Aged	37.9	18.4	3.0	21.3	1.1	15.0		1.4	15.0		1.4
Emalahleni Private Hospital	35.9	18.2	2.9	19.2	1.0	14.5		1.4	14.5		1.4
Life Cosmos Hospital	35.5	18.0	3.0	19.3	1.0	14.5		1.4	14.5		1.4
Duvha Primary School	37.8	17.8	3.3	22.5	1.2	13.8		1.5	13.8		1.5
Laerskool Taalfees	35.8	18.2	3.0	19.4	1.0	14.8		1.4	14.8		1.4
Witbank Provincial Hospital	35.4	18.4	2.9	18.9	1.0	14.4		1.4	14.4		1.4
Nancy Shiba Primary School (Vosman)	43.5	20.7	3.1	25.8	1.2	15.2		1.4	15.2		1.4
Wh De Klerk Skool	33.4	18.1	2.8	17.3	0.9	13.0		1.3	13.0		1.3
Laerskool Panorama	33.4	18.2	2.7	16.6	0.9	13.2		1.2	13.2		1.2
Laerskool Duvhapark	36.1	17.7	3.2	21.2	1.2	13.3		1.4	13.3		1.4
Laerskool Klipfontein	36.1	18.0	3.1	20.4	1.1	14.7		1.4	14.7		1.4
Cambridge Academy	34.9	17.9	3.0	18.8	1.0	14.0		1.4	14.0		1.4
Besilindile Primary School	44.2	20.9	2.9	24.9	1.1	14.3		1.4	14.3		1.4
Reynopark High School	35.8	18.0	3.2	20.2	1.2	14.3		1.4	14.3		1.4
Bakenveld Golf Estate	32.1	17.1	2.9	17.1	1.0	11.8		1.3	11.8		1.3
Allendale Secondary School	30.4	16.8	3.1	16.9	1.1	12.2		1.3	12.2		1.3
Khayalethu Primary School	37.7	18.5	3.0	21.1	1.1	14.8		1.4	14.8		1.4
Illanga Secondary School	31.5	16.2	3.1	17.3	1.1	12.4		1.3	12.4		1.3
Joy Creche (Duvha)	32.4	16.5	3.2	18.3	1.1	12.6		1.4	12.6		1.4
Linderus Old Age Home	25.7	16.3	2.2	9.3	0.5	10.1		1.0	10.1		1.0
Vergeet My Nie Old Age Home	26.0	16.1	2.2	9.4	0.5	10.1		1.0	10.1		1.0
Middleburg Frail Care Unit And Home For Elderly	25.5	16.7	2.1	8.9	0.5	9.6		0.9	9.6		0.9
Life Midmed Hospital	25.7	16.8	2.1	9.0	0.5	9.8		1.0	9.8		1.0
Middelburg Hospital	25.9	16.4	2.2	9.3	0.5	10.0		1.0	10.0		1.0
Makhathini Primary School	26.1	16.7	2.1	9.2	0.5	9.7		0.9	9.7		0.9
Laerskool Dennesig	25.4	16.5	2.1	8.7	0.5	9.6		0.9	9.6		0.9

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Hoerskool Kanonkop	25.3	16.6	2.1	8.7	0.5	9.7		0.9	9.7		0.9
Laerskool Kanonkop	25.4	16.8	2.1	8.9	0.5	9.6		0.9	9.6		0.9
Steelcrest High School	25.5	16.6	2.1	8.9	0.5	9.7		0.9	9.7		0.9
Middelburg Primary	25.8	16.1	2.2	9.3	0.5	10.0		1.0	10.0		1.0
Middleburg Ext 6 Clinic	27.6	17.4	2.3	10.5	0.6	10.5		1.0	10.5		1.0
Sofunda Secondary School	27.0	17.1	2.2	9.9	0.5	10.2		1.0	10.2		1.0
Mhluzi Primary School	26.5	16.7	2.1	9.5	0.5	9.9		1.0	9.9		1.0
Highlands Primary School	25.8	15.6	2.2	9.4	0.5	10.1		1.0	10.1		1.0
Blinkpan Primary School	28.0	15.7	3.3	14.0	1.1	12.2		1.4	12.2		1.4
Laerskool Koornfontein	27.9	15.9	3.3	13.7	1.1	12.2		1.4	12.2		1.4
Blinkpan	28.1	15.6	3.3	14.3	1.1	12.3		1.4	12.3		1.4
Laerskool Kragveld	24.9	15.3	2.8	10.3	0.7	10.4		1.2	10.4		1.2
Pullens Hope	24.9	15.2	2.8	10.1	0.7	10.4		1.2	10.4		1.2
Arnot Colliery Primary School	22.4	14.6	2.4	7.7	0.5	9.5		1.0	9.5		1.0
Laerskool Rietkuil	22.4	15.0	2.4	7.5	0.5	9.4		1.1	9.4		1.1
Beestepan Agricultural School	21.8	13.2	2.2	7.0	0.5	9.0		1.0	9.0		1.0
Gekombineerde Skool Hendrina	25.3	15.0	3.0	9.5	0.8	10.2		1.3	10.2		1.3
Hendrina Primary School	25.0	14.4	2.9	9.4	0.7	10.0		1.3	10.0		1.3
Kwazamokuhle Secondary School	24.9	14.5	2.9	9.3	0.7	9.9		1.3	9.9		1.3
Ubuhle Bolwai Secondary School	25.2	15.6	3.1	6.8	0.6	9.7		1.3	9.7		1.3
Lothair Primary School	25.4	16.1	3.1	6.8	0.6	10.0		1.3	10.0		1.3
Warburton Combined School	22.9	14.5	2.8	7.0	0.5	9.6		1.2	9.6		1.2
Warburton Town	22.8	14.6	2.8	7.0	0.5	9.5		1.2	9.5		1.2
Kwachibikhulu Clinic	24.8	15.4	3.0	7.5	0.6	9.5		1.3	9.5		1.3
Kwachibikhulu Primary School	24.7	15.1	3.0	7.5	0.6	9.6		1.3	9.6		1.3
Carolina Hospital	21.7	14.2	2.6	6.8	0.5	9.3		1.1	9.3		1.1
Zinikeleni Secondary School (Silobela)	21.8	14.1	2.6	6.7	0.5	9.4		1.2	9.4		1.2
Volkskool Carolina	21.4	14.3	2.5	6.8	0.5	9.3		1.1	9.3		1.1

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Sobuza Primary School	21.7	14.0	2.6	6.8	0.5	9.3		1.1	9.3		1.1
Ons Eie Ouetehuis (Old Age Home)	21.6	14.2	2.6	6.9	0.5	9.3		1.1	9.3		1.1
Laerskool Breyten	25.5	15.9	3.2	9.6	0.8	9.9		1.3	9.9		1.3
Siyazi Primary School (Kwazanele)	26.0	16.3	3.3	10.1	0.8	10.0		1.4	10.0		1.4
Masizakhe Secondary School (Kwazanele)	25.9	16.5	3.3	10.0	0.8	10.0		1.4	10.0		1.4
Belfast Rusoord (Old Age Home)	18.2	12.0	1.9	6.8	0.4	7.2		0.8	7.2		0.8
Belfast Hospital	18.7	12.0	1.9	7.1	0.4	7.3		0.8	7.3		0.8
Platorand School	19.1	12.2	1.9	7.5	0.4	7.4		0.8	7.4		0.8
Belfast Primary School (Siyathuthuka)	17.9	12.3	1.8	6.6	0.4	7.1		0.8	7.1		0.8
Siyathuthuka Clinic	18.0	12.2	1.8	6.7	0.4	7.1		0.8	7.1		0.8
Life Bethal Hospital	34.8	17.7	3.6	14.1	1.0	13.1		1.8	13.1		1.8
Hoerskool Hoogenhout	34.4	17.6	3.6	14.3	1.0	12.9		1.8	12.9		1.8
Jim Van Tonderskool	34.5	17.4	3.6	15.1	1.0	13.4		1.9	13.4		1.9
Bethal Independent Primary School	34.5	17.5	3.6	14.7	1.0	13.2		1.8	13.2		1.8
Laerskool Marietjie Van Niekerk	35.0	17.2	3.7	14.4	1.0	13.1		1.8	13.1		1.8
Laerskool Hm Swart	34.6	17.6	3.6	14.2	1.0	13.1		1.8	13.1		1.8
Sakhisizwe Primary School (Emzinoni)	35.6	19.0	3.6	14.1	0.9	13.8		1.9	13.8		1.9
Alpheus D Nkosi Secondary School (Emzinoni)	34.4	18.9	3.6	13.8	0.9	13.3		1.9	13.3		1.9
Silwerjare Old Age Home	34.7	17.9	3.6	14.1	1.0	13.1		1.8	13.1		1.8
Residentia Palm Oord	34.6	17.7	3.6	14.1	1.0	13.2		1.8	13.2		1.8
Bronkhorspruit Hospital	28.8	16.6	1.7	12.4	0.4	17.1		1.5	17.1		1.5
Cultura High School	32.1	19.3	1.9	15.2	0.5	21.1		1.9	21.1		1.9
Bronkhorspruit Primary School	29.3	16.7	1.8	13.0	0.4	17.7		1.5	17.7		1.5
Bronkhorspruit Dam	33.4	18.9	2.1	16.5	0.6	22.6		2.4	22.6		2.4
Hoerskool Erasmus	30.5	17.4	1.8	13.8	0.5	18.7		1.7	18.7		1.7
Althea Independent School	29.9	17.2	1.8	13.2	0.5	18.3		1.6	18.3		1.6

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Kgoro Primary School (Zithobeni)	27.7	18.0	1.7	10.8	0.4	15.5		1.4	15.5		1.4
Zithobeni Secondary School (Zithobeni)	26.9	18.2	1.7	10.0	0.4	15.3		1.4	15.3		1.4
Vaal Power AH	63.1	27.8	3.0	16.4	0.7	61.1		7.9	**61.1**	**86**	7.9
Sasolburg Provincial Hospital	41.2	29.9	2.2	9.8	0.4	27.8		2.3	**27.8**	1	2.3
Moredou Old Age Home	36.7	25.7	2.1	8.4	0.4	24.2		2.1	24.2		2.1
Ons Gryse Jeug Old Age Home	38.0	27.9	2.1	9.0	0.4	25.7		2.3	**25.7**	1	2.3
Noord Primere Skool	38.5	27.3	2.2	9.1	0.4	26.6		2.3	**26.6**	1	2.3
Sasolburg High School	39.0	27.9	2.1	9.2	0.4	25.3		2.1	**25.3**	1	2.1
Sakhubusa Secondary School	39.7	25.5	2.2	9.0	0.4	33.2		2.7	**33.2**	1	2.7
Bekezela Primary School	41.1	25.7	2.2	8.9	0.4	39.8		3.3	**39.8**	11	3.3
Isaac Mhlambi Primary	42.0	26.0	2.2	9.4	0.5	38.6		2.8	**38.6**	2	2.8
Refenkgotso Primary School	68.9	22.5	3.4	18.2	0.7	32.1		3.2	**32.1**	1	3.2
Deneysville Primary School	68.4	22.5	3.6	18.2	0.8	25.0		2.9	25.0		2.9
Netcare Vaalpark Hospital	40.2	30.9	2.2	9.1	0.5	39.4		3.4	**39.4**	11	3.4
Vaalpark Articon Secondary School	41.8	34.3	2.3	9.4	0.5	43.6		3.9	**43.6**	**19**	3.9
Mediclinic Emfuleni	32.3	25.6	1.9	7.8	0.4	31.8		2.5	**31.8**	1	2.5
Jeugland Old Age Home	32.7	26.2	1.9	7.9	0.4	28.2		2.4	**28.2**	1	2.4
Herfsoord Huis Old Age Home	31.7	24.9	1.8	7.8	0.4	27.9		2.2	**27.9**	1	2.2
Huis Prinscilla	29.4	25.0	1.8	7.7	0.4	26.6		2.1	**26.6**	1	2.1
Laerskool Emfulenipark	36.7	32.5	2.1	8.4	0.4	40.2		3.3	**40.2**	7	3.3
Nw University_Vaal Campus	35.4	31.8	2.1	8.2	0.4	49.1		4.6	**49.1**	**28**	4.6
Emfuleni Primary School	29.9	22.1	1.7	7.3	0.3	23.2		1.9	23.2		1.9
Mediclinic Vereeniging	32.2	24.4	2.0	7.6	0.4	37.0		3.5	**37.0**	10	3.5
Kopanong Provincial Hospital (Duncanville)	33.9	24.1	2.1	7.5	0.4	20.3		1.7	20.3		1.7
Avondrus Eventide Old Age Home	33.9	24.5	2.1	7.7	0.4	21.0		1.8	21.0		1.8
Riviera On Vaal Resort	33.2	27.6	2.1	7.7	0.4	43.1		4.1	**43.1**	**17**	4.1
Sedibeng Tvet College	33.2	27.2	2.1	7.7	0.4	46.8		4.3	**46.8**	**20**	4.3

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
General Smuts High School	32.2	29.3	2.0	7.8	0.4	36.2		3.5	**36.2**	9	3.5
Eureuka School & Selbourne Primary	32.0	28.2	2.0	7.6	0.4	36.6		3.2	**36.6**	4	3.2
Midvaal Private Hospital (Three Rivers)	40.3	30.8	2.4	8.8	0.5	45.7		3.7	**45.7**	**20**	3.7
Three Rivers Retirement Village	41.2	28.7	2.4	9.1	0.5	36.1		2.9	**36.1**	7	2.9
Drie Riviere Aftreeoord Old Age Home	41.5	27.4	2.4	9.3	0.5	30.2		2.5	**30.2**	1	2.5
Riverside High School	59.2	32.4	2.7	13.8	0.6	53.6		3.6	**53.6**	**17**	3.6
Risiville Primary School	45.7	29.3	2.4	9.9	0.5	28.2		2.4	**28.2**	1	2.4
Sebokeng Hospital	27.6	18.7	1.7	7.6	0.3	16.5		1.3	16.5		1.3
Clinix-Naledzi Private Hospital	27.2	18.2	1.7	7.5	0.3	15.8		1.4	15.8		1.4
Mohloli Secondary School	31.5	28.9	2.0	7.4	0.4	35.9		3.1	**35.9**	5	3.1
Tshirela Primary School (Boipatong)	29.0	22.8	1.8	7.5	0.4	22.1		2.0	22.1		2.0
Tsoaranang Primary School (Thepiso)	29.4	23.2	1.9	7.4	0.4	27.9		2.5	**27.9**	1	2.5
Thepiso Primary School	29.6	21.6	1.8	7.5	0.4	26.7		2.1	**26.7**	1	2.1
Emmanuel Primary School	29.7	24.2	1.9	7.3	0.4	30.8		2.8	**30.8**	1	2.8
Rust Ter Vaal Combined School	29.2	19.1	1.8	7.8	0.4	14.4		1.3	14.4		1.3
Roshnee Primary School	28.5	19.5	1.8	7.7	0.3	12.5		1.1	12.5		1.1
Roshnee High School	28.9	19.5	1.8	7.7	0.4	13.8		1.2	13.8		1.2
Hoerskool Dr Malan	39.0	21.0	2.1	9.0	0.4	15.8		1.4	15.8		1.4
Laerskool Voorwaarts	49.6	23.4	2.5	11.8	0.5	19.8		1.7	19.8		1.7
Meyerton Secondary School	39.5	22.7	2.1	8.9	0.4	15.4		1.5	15.4		1.5
Ratasetjhaba Primary School	32.2	18.5	1.9	8.4	0.4	12.7		1.2	12.7		1.2
Meyerton Primary School	36.4	19.6	2.0	8.9	0.4	15.3		1.3	15.3		1.3
Oprah Leadership Academy	39.3	18.9	2.1	9.4	0.4	16.2		1.3	16.2		1.3
Henley River Retirement Village	39.2	19.2	2.2	9.2	0.4	14.3		1.3	14.3		1.3
Henley High & Preparatory School	36.6	17.3	2.1	9.0	0.4	13.8		1.2	13.8		1.2
Randvaal Clinic	33.7	17.0	2.0	9.0	0.4	13.1		1.2	13.1		1.2
Laerskool Japie Greyling	32.8	15.9	2.0	8.5	0.4	11.6		1.1	11.6		1.1
Thomas Nhlapo Primary	35.2	16.3	2.0	8.9	0.4	12.9		1.2	12.9		1.2

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Randvaal Old Age Home	31.9	15.7	1.9	8.8	0.4	11.2		1.1	11.2		1.1
Laerskool Ag Visser	31.4	15.4	2.3	7.6	0.4	9.8		1.2	9.8		1.2
Lethaba Siyangobe	31.8	15.5	2.3	7.9	0.4	9.9		1.2	9.9		1.2
Shalimar Ridge Primary School	31.1	15.4	2.3	7.7	0.4	10.1		1.2	10.1		1.2
Jw Luckoff High School	32.2	14.9	2.4	8.2	0.5	10.2		1.2	10.2		1.2
Heidelberg Hospital	30.7	15.6	2.3	7.8	0.4	10.0		1.2	10.0		1.2
Thulatsatsi Operation (Rensburg)	31.4	15.2	2.3	7.6	0.4	9.9		1.2	9.9		1.2
Silwer Akker Tehuis	30.9	15.3	2.3	7.6	0.4	10.2		1.2	10.2		1.2
Riversands Retirement Village	30.8	15.6	2.3	8.0	0.4	10.0		1.2	10.0		1.2
Qhaqholla Primary School	33.7	15.9	2.3	7.9	0.4	10.3		1.2	10.3		1.2
Ratanda Primary School	35.1	15.4	2.4	8.3	0.5	10.6		1.2	10.6		1.2
Boneha Primary School	33.6	15.8	2.4	8.0	0.4	10.1		1.2	10.1		1.2
Sithokomele Primary School	33.8	15.8	2.4	8.1	0.4	10.1		1.2	10.1		1.2
Ratanda Bertha Gxowa Primary School	32.4	15.6	2.4	8.1	0.5	10.0		1.2	10.0		1.2
Khanya Lesedi Secondary School	35.0	15.7	2.4	8.2	0.4	10.3		1.2	10.3		1.2
Ratanda Secondary School	34.7	15.7	2.4	8.2	0.4	10.2		1.2	10.2		1.2
New Ratanda Secondary School	32.1	15.6	2.3	7.9	0.4	9.9		1.2	9.9		1.2
Kgoro Ya Thuto Secondary School	32.1	15.6	2.3	7.9	0.4	9.9		1.2	9.9		1.2
Ekurhuleni School For The Deaf	28.8	15.6	1.9	8.2	0.4	9.3		1.0	9.3		1.0
Pholosong Hospital	27.3	14.8	2.1	8.7	0.4	10.9		1.1	10.9		1.1
Tsakane Home For Aged	27.9	14.8	2.1	8.6	0.4	10.7		1.1	10.7		1.1
Mmuso Primary School	28.9	15.4	2.2	8.6	0.5	10.9		1.2	10.9		1.2
Michael Zulu Primary School	27.8	14.9	2.1	8.8	0.4	10.8		1.2	10.8		1.2
Nkabinde Primary School (Thembilisha)	26.5	13.8	2.0	8.7	0.4	11.1		1.2	11.1		1.2
Nigel Clinic	27.7	15.8	2.2	7.8	0.4	11.1		1.3	11.1		1.3
Tehuis Vir Bejaardes	27.6	15.6	2.2	7.7	0.4	11.3		1.3	11.3		1.3
Hoerskool John Vorster	27.7	15.8	2.2	7.8	0.4	11.2		1.3	11.2		1.3
Laerskool Hannes Visagie	27.8	15.6	2.2	7.8	0.4	11.5		1.3	11.5		1.3

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Nigel Secondary School	28.5	15.8	2.3	8.2	0.4	11.9		1.3	11.9		1.3
Laerskool Dunnottar	27.7	15.1	2.1	8.5	0.4	11.1		1.2	11.1		1.2
Springs Retirement Village	25.3	12.8	2.0	8.6	0.4	11.8		1.3	11.8		1.3
Life Springs Parkland Hospital	25.7	13.1	2.0	8.8	0.4	11.6		1.2	11.6		1.2
Netcare N17 Hospital (Springs)	25.8	13.3	2.0	8.8	0.4	11.6		1.2	11.6		1.2
Springs Boys High School	26.5	13.5	2.1	8.8	0.4	11.4		1.2	11.4		1.2
Laerskool Selectionpark	26.1	13.4	2.0	8.6	0.4	11.6		1.2	11.6		1.2
Kwasa College Pre&Primary School	26.4	13.7	2.1	8.5	0.4	12.0		1.3	12.0		1.3
Edelweis Medical Centre	26.3	13.6	2.0	8.5	0.4	11.8		1.3	11.8		1.3
Laerskool Christiaan Beyers	25.7	13.1	2.0	8.3	0.4	11.9		1.3	11.9		1.3
Hoerskool Hugenote	24.8	13.1	2.0	8.8	0.4	11.6		1.3	11.6		1.3
Brakpan Primary School	25.1	13.7	2.0	9.0	0.4	10.8		1.1	10.8		1.1
Parkrand Primary School	26.4	14.7	1.9	9.0	0.4	9.5		1.0	9.5		1.0
Thabo Memorial Hospital	26.2	14.6	1.9	9.0	0.4	9.1		1.0	9.1		1.0
Sunward Park Hospital	26.5	14.6	1.9	8.8	0.4	9.4		1.0	9.4		1.0
Alberton High School	27.0	14.8	1.8	9.1	0.4	8.7		0.9	8.7		0.9
Netcare Clinton Hospital	26.8	14.9	1.8	9.0	0.4	8.7		0.9	8.7		0.9
Alberton Tuiste Vir Bejaardes	26.9	14.9	1.8	9.2	0.4	8.7		0.9	8.7		0.9
Bertha Gxowa Hospital	26.8	14.8	1.9	10.0	0.5	8.9		0.9	8.9		0.9
Linmed Hospital	25.7	14.0	1.9	9.7	0.5	10.3		1.1	10.3		1.1
Hoerskool Brandwag (Airfield)	25.6	14.0	1.9	9.6	0.5	10.1		1.0	10.1		1.0
Thepiso Noto Intermediate School	25.9	13.9	1.9	10.3	0.5	13.4		1.5	13.4		1.5
Laerskool Bredell	23.6	13.9	1.8	8.5	0.4	10.0		1.0	10.0		1.0
Sibonelo Primary School (Daveyton)	24.7	13.8	1.9	9.2	0.4	12.1		1.3	12.1		1.3
Petit High School (Kempton Park Nu)	25.4	13.8	1.9	10.1	0.5	11.1		1.1	11.1		1.1
Arwyp Medical Centre	24.6	14.8	1.8	8.9	0.4	9.6		0.9	9.6		0.9
Hoerskool Birchleigh	24.4	14.7	1.7	8.2	0.4	9.6		0.9	9.6		0.9
Curro Serengeti Acadamy	23.2	14.5	1.7	7.8	0.4	9.7		1.0	9.7		1.0

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
South Rand Hospital	28.8	15.9	1.9	11.7	0.5	8.5		0.8	8.5		0.8
Chris Hani Baragwanath Hospital	24.5	14.3	1.6	8.7	0.4	7.7		0.7	7.7		0.7
Thulani Primary School	22.6	14.1	1.4	7.6	0.3	7.4		0.6	7.4		0.6
University of Witwatersrand	28.9	15.9	1.8	11.2	0.5	8.2		0.8	8.2		0.8
Milpark Hospital	27.7	15.2	1.7	10.2	0.4	8.2		0.8	8.2		0.8
Charlotte Maxixe Academic Hospital	28.5	15.2	1.8	10.7	0.5	8.3		0.8	8.3		0.8
Thembisa West Secondary School (Thembisa)	22.7	13.7	1.6	6.6	0.3	9.1		0.8	9.1		0.8
Lenmed Zamokuhle Private Hospital (Thembisa)	23.0	13.8	1.6	6.9	0.3	9.3		0.9	9.3		0.9
Ikusasa Comprehensive School	23.2	13.9	1.6	7.3	0.3	9.5		0.9	9.5		0.9
Gem Village Old Age Home	21.3	14.7	1.4	6.2	0.3	9.2		0.8	9.2		0.8
Rustoord Old Age Home	20.8	13.7	1.4	6.4	0.3	8.8		0.8	8.8		0.8
Cornwell Hill College (Irene)	21.3	14.5	1.4	6.5	0.3	9.3		0.8	9.3		0.8
Kleinfontein Sorg Sentrum Old Age Home (Donkerhoek)	22.2	14.9	1.5	8.2	0.3	11.4		1.0	11.4		1.0
Valtaki AH (Rayton)	23.8	15.6	1.5	8.7	0.3	12.3		1.1	12.3		1.1
Laerskool Rayton (Rayton)	21.0	13.9	1.4	6.6	0.3	10.5		0.9	10.5		0.9
Tierkop AH	24.0	15.5	1.7	8.8	0.4	11.7		1.2	11.7		1.2
Redford House The Hills Private School (Mooikloof Glen)	23.5	15.4	1.6	8.2	0.4	11.1		1.0	11.1		1.0
Rietvlei View Country Estate	23.5	15.7	1.6	8.2	0.4	11.3		1.1	11.3		1.1
Hazeldean Curro School (Tyger Valley)	20.7	13.9	1.3	6.5	0.3	9.2		0.8	9.2		0.8
Tyger Valley College	21.1	15.0	1.4	6.9	0.3	9.5		0.8	9.5		0.8
Pretoria East Hospital (Moreletapark)	21.8	14.8	1.4	7.2	0.3	9.6		0.9	9.6		0.9
Groenkloof Old Age Home	19.9	14.5	1.3	6.5	0.3	8.4		0.7	8.4		0.7
Steve Biko Academic Hospital	19.4	14.1	1.2	5.6	0.2	7.8		0.6	7.8		0.6
Willow Ridge High School (Wilgers)	20.4	14.6	1.3	6.1	0.2	8.9		0.7	8.9		0.7

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Hoerskool Waterkloof	21.7	14.7	1.4	7.4	0.3	9.6		0.8	9.6		0.8
Hoerskool Garsfontein	21.2	15.0	1.4	7.0	0.3	9.4		0.8	9.4		0.8
Afrikaanse Hoer Seunskool	19.9	14.5	1.3	6.4	0.3	8.1		0.7	8.1		0.7
Huis Silversig SAVF Old Age Home (Silverton)	19.9	13.7	1.2	5.5	0.2	8.4		0.7	8.4		0.7
Laersekool Meyerspark (Meyerspark)	20.0	13.8	1.2	5.6	0.2	8.6		0.7	8.6		0.7
Curro Academy Mamelodi	19.0	12.2	1.2	4.9	0.2	8.3		0.7	8.3		0.7
Impendulo Primary School	19.9	12.8	1.2	5.5	0.2	8.7		0.7	8.7		0.7
Nellmapius Ext 6 Primary School	20.2	12.6	1.2	5.4	0.2	8.6		0.7	8.6		0.7
Mamelodi Home For Aged	19.5	12.4	1.2	5.0	0.2	8.4		0.7	8.4		0.7

Predicted concentrations in µg/m³ at the sensitive receptors for Scenario D (MES), together with the limit value of the NAAQS and number of exceedances (NoE)

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Elsie Ballot Memorial Hospital	37.5	16.0	2.7	35.9	1.6	11.4		1.9	11.4		1.9
Laerskool Amersfoort	35.7	14.4	2.6	34.0	1.6	11.1		1.9	11.1		1.9
Embuzane Primary School	74.2	25.2	4.6	79.0	3.9	30.3		4.9	**30.3**	1	4.9
Sangqotho Primary School	25.4	10.9	2.4	16.5	1.3	12.9		2.1	12.9		2.1
Amersfoort Combined School	34.4	16.2	2.6	32.6	1.6	10.8		1.9	10.8		1.9
Injubuko Primary School	23.2	10.2	2.3	16.8	1.2	9.4		1.6	9.4		1.6
Daggakraal Primary School	35.6	13.4	3.2	36.6	2.3	13.5		2.1	13.5		2.1
Sizenzele Primary School	44.3	14.3	3.5	44.1	2.6	20.4		2.7	20.4		2.7
Seme Secondary School	33.1	13.1	3.2	32.8	2.2	15.8		2.3	15.8		2.3
Louwra Primary School	25.9	11.8	2.0	20.8	1.1	13.3		1.9	13.3		1.9
Perdekop Agricultural School	23.7	11.8	2.0	17.1	1.0	21.0		2.9	21.0		2.9
Vukuzenzele Combined School	24.7	12.1	2.0	18.1	1.1	20.4		2.9	20.4		2.9
Gunwana Primary School	23.7	11.4	1.9	18.5	1.0	10.9		1.8	10.9		1.8
Amajuba Memorial Hospital	20.6	9.9	1.7	15.2	0.8	9.9		1.5	9.9		1.5
Volksrust High School	20.5	10.6	1.6	14.5	0.8	10.1		1.4	10.1		1.4
Volksrust Municipal Clinic	20.1	9.7	1.6	14.4	0.8	9.1		1.4	9.1		1.4
C V O Skool Amajuba	20.2	10.2	1.6	14.7	0.8	9.7		1.4	9.7		1.4
Qhubulwazi Combined School	20.1	9.8	1.6	14.2	0.8	9.5		1.4	9.5		1.4
Volksrust Primary School	21.2	10.3	1.7	16.2	0.9	10.8		1.6	10.8		1.6
New Ermelo	17.7	8.6	2.0	9.5	0.8	7.1		1.1	7.1		1.1
Ermelo Christian School	18.3	8.8	2.0	10.1	0.8	7.3		1.2	7.3		1.2
SAVF Home For Aged	18.2	8.8	2.0	10.0	0.8	7.3		1.1	7.3		1.1
Ermelo Hospital	18.2	8.9	2.0	9.9	0.8	7.4		1.1	7.4		1.1
Mediclinic Ermelo	18.3	8.7	2.0	10.1	0.8	7.4		1.2	7.4		1.2
Hoerskool Ermelo	18.3	8.8	2.0	10.0	0.8	7.4		1.1	7.4		1.1
Ermelo Indian Combined School	18.2	8.6	2.0	9.8	0.8	7.4		1.1	7.4		1.1
Lungelo Combined School (Outside Town)	18.4	8.6	2.0	10.3	0.8	8.0		1.3	8.0		1.3
New Ermelo Primary School	18.1	8.6	2.0	9.7	0.8	7.2		1.1	7.2		1.1

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Kwashashe (Outside Town)	18.8	8.9	2.1	10.3	0.8	7.2		1.1	7.2		1.1
Hts Ligbron	18.2	8.8	2.0	10.1	0.8	7.3		1.2	7.3		1.2
Laerskool Ermelo	18.3	8.7	2.0	9.9	0.8	7.3		1.1	7.3		1.1
JJ Vd Merwe Pre-Primary School	18.3	8.8	2.0	10.2	0.8	7.5		1.2	7.5		1.2
Lindile Secondary School	18.1	8.6	2.0	9.7	0.8	7.4		1.1	7.4		1.1
Emthonjeni Clinic	18.4	8.6	2.0	9.9	0.8	7.3		1.1	7.3		1.1
Reggie Masuku Secondary School	18.7	8.8	2.0	10.0	0.8	7.1		1.1	7.1		1.1
Cebisa Secondary School	18.6	8.5	2.0	9.9	0.8	7.3		1.1	7.3		1.1
Camden	16.8	8.8	1.9	8.9	0.7	7.0		1.1	7.0		1.1
Camden Combined School	16.6	9.0	1.9	8.7	0.7	7.0		1.1	7.0		1.1
Camden School	16.8	8.8	1.9	9.0	0.8	7.1		1.1	7.1		1.1
Umzimvelo Secondary School (Rural Area)	15.2	8.2	1.9	8.1	0.7	6.5		1.1	6.5		1.1
Bhekimfundo Primary School (Rural Area)	18.8	9.0	2.1	10.4	0.9	7.6		1.2	7.6		1.2
Eshwileni Primary School (Rural Area)	18.9	8.6	2.2	10.9	1.0	8.1		1.4	8.1		1.4
Davel Combined School	21.5	9.7	2.2	12.4	0.9	8.8		1.3	8.8		1.3
Morgenzon Landbou Akademie	22.5	10.0	2.4	14.7	1.2	14.1		1.9	14.1		1.9
Nqobangolwazi Secondary School	22.3	9.9	2.3	14.6	1.1	13.8		1.9	13.8		1.9
Siqondekhaya Pre Primary School	22.6	9.7	2.3	14.7	1.1	15.6		1.9	15.6		1.9
Sizakhele Primary School	22.6	9.7	2.3	14.6	1.1	15.3		1.9	15.3		1.9
Phezukwentaba Primary School (South of Morgenzon)	21.9	9.1	2.4	14.6	1.2	14.7		2.1	14.7		2.1
Kwaggalaagte Primary School (North of Morgenzon)	22.7	9.7	2.1	13.2	0.9	9.6		1.5	9.6		1.5
Sizakhele Clinic/Hospital	22.6	9.7	2.3	14.8	1.1	15.0		1.9	15.0		1.9
Grootvlei	14.6	7.8	1.3	8.9	0.6	7.3		1.0	7.3		1.0
Olive Grove Country Lodge	14.6	7.9	1.3	9.2	0.6	7.4		1.0	7.4		1.0
Grootvlei Town (South of Power Station)	14.6	7.9	1.3	8.8	0.6	7.0		1.0	7.0		1.0
Laerskool Grootvlei	14.8	7.9	1.3	8.9	0.6	7.1		1.0	7.1		1.0
Tokoloho Primary School	14.6	7.9	1.3	8.7	0.6	7.1		1.0	7.1		1.0
Tshepeha Combined School	14.6	7.9	1.3	8.8	0.6	7.1		1.0	7.1		1.0
Warembo Lodge	14.2	8.6	1.3	8.4	0.6	7.1		1.0	7.1		1.0

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Balfour	15.6	9.3	1.3	8.8	0.5	8.1		1.1	8.1		1.1
Siyathemba	16.3	9.8	1.4	9.2	0.6	8.2		1.1	8.2		1.1
Bonukukhanya Primary (Siyathemba)	16.2	9.7	1.4	9.2	0.6	8.1		1.1	8.1		1.1
Qalabocha Primary School (Siyathemba)	16.3	9.7	1.4	9.1	0.6	8.2		1.1	8.2		1.1
Vusumuzi Primary School	16.5	10.0	1.4	9.3	0.6	8.2		1.1	8.2		1.1
Gekombineerde Skool Balfour	15.3	9.2	1.3	8.7	0.6	7.8		1.1	7.8		1.1
Im Manchu Secondary School	15.3	9.0	1.3	8.6	0.5	7.8		1.1	7.8		1.1
Isifisosethu Secondary School (Siyathemba)	16.5	10.1	1.4	9.5	0.6	8.2		1.1	8.2		1.1
Setsheng Secondary School (Siyathemba)	16.5	9.9	1.4	9.2	0.6	8.3		1.1	8.3		1.1
Dr Nieuwoudt And Dr Kok	15.3	9.2	1.3	8.7	0.6	7.7		1.1	7.7		1.1
Balfour Clinic	15.4	9.0	1.3	8.6	0.5	7.8		1.0	7.8		1.0
Siyathemba Clinic	15.8	9.4	1.3	8.9	0.5	8.1		1.1	8.1		1.1
Mondoro Lodge	15.5	8.0	1.3	9.0	0.5	7.5		1.0	7.5		1.0
Wegelegen Manor	16.0	9.5	1.3	8.7	0.5	8.3		1.1	8.3		1.1
The Stone Cellar	14.1	7.4	1.1	7.6	0.4	7.3		0.9	7.3		0.9
Greylingstad	17.1	9.7	1.5	9.3	0.6	8.7		1.2	8.7		1.2
Nthorwane	16.7	9.2	1.4	8.9	0.6	8.4		1.2	8.4		1.2
Laerskool Greylingstad	17.6	9.7	1.5	9.7	0.6	8.7		1.2	8.7		1.2
Nthoroane Secondary School	16.7	9.2	1.4	8.8	0.6	8.5		1.2	8.5		1.2
Badgarleur Bush Lodge	15.3	8.1	1.4	8.6	0.6	7.5		1.1	7.5		1.1
Matla Village	48.2	15.6	2.8	32.4	1.5	26.8		3.3	**26.8**	1	3.3
Sifundise Primary School	48.2	15.3	2.8	32.4	1.5	26.1		3.3	**26.1**	1	3.3
Matla Coal Health Centre	48.8	16.3	2.9	32.5	1.5	25.4		3.3	**25.4**	1	3.3
Gweda Primary School	36.5	12.8	2.4	22.5	1.1	16.3		2.2	16.3		2.2
Zithobe Primary School	36.4	14.2	2.2	23.9	1.1	35.7		4.6	**35.7**	12	4.6
Kwanala Primary School	41.1	15.1	3.0	26.9	1.5	20.4		2.5	20.4		2.5
Reedstream Park	43.1	14.2	3.4	29.3	1.9	21.2		2.5	21.2		2.5
Rietspruit Clinic	40.9	13.5	3.4	27.4	1.9	19.3		2.3	19.3		2.3
Lehlaka Combined School	41.2	13.6	3.4	27.7	1.9	19.6		2.4	19.6		2.4
Mbali Coal/Blesboklaagte Housing	49.3	15.5	3.8	35.5	2.3	24.2		2.8	24.2		2.8
Kinross	29.5	10.7	2.0	17.9	0.9	18.1		2.5	18.1		2.5

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Kinross Settlement	27.4	11.6	2.0	16.5	0.9	20.2		2.8	20.2		2.8
Kinross Municipal Clinic	28.7	10.6	2.0	17.4	0.9	17.2		2.5	17.2		2.5
Kriel	36.6	13.5	2.7	22.9	1.4	15.7		2.1	15.7		2.1
Eagles Nest Guest House	35.8	13.4	2.7	22.1	1.3	15.5		2.0	15.5		2.0
Merlin Park Primary School	35.2	12.1	2.8	22.6	1.4	14.7		2.0	14.7		2.0
Kriel Medical Centre	35.3	12.4	2.8	22.3	1.4	14.8		2.0	14.8		2.0
Laerskool Krielpark	36.3	13.1	2.8	22.8	1.4	15.0		2.0	15.0		2.0
Laerskool Onverwacht	35.3	12.3	2.8	22.9	1.4	14.7		2.0	14.7		2.0
Silwer Fleur Aftree Oord (Old Age Home)	36.2	12.6	2.8	22.9	1.4	15.0		2.0	15.0		2.0
Thubelihle	34.4	11.9	2.9	21.1	1.5	14.5		1.9	14.5		1.9
Sibongamandla Secondary School	33.4	12.0	2.9	20.6	1.5	14.4		1.8	14.4		1.8
Ga-Nala Clinic	36.6	12.7	2.8	23.5	1.4	14.3		2.0	14.3		2.0
Impilo Primary School	31.3	11.5	2.8	19.2	1.4	12.4		1.6	12.4		1.6
Bonginhlanhla Primary School	33.5	12.0	2.8	20.4	1.5	14.3		1.8	14.3		1.8
Sibongamandla Secondary School	33.4	12.0	2.9	20.6	1.5	14.4		1.8	14.4		1.8
Leandra	26.6	12.9	1.9	15.6	0.8	21.1		3.1	21.1		3.1
Eendracht	26.3	13.4	1.8	16.1	0.8	19.5		2.8	19.5		2.8
Sidingulwazi Primary School	26.1	12.7	1.8	15.5	0.8	19.3		2.9	19.3		2.9
Ss Mshayisa Primary School	26.1	12.5	1.8	15.4	0.8	19.4		2.9	19.4		2.9
Chief Ampie Mayisa Secondary School	25.7	12.2	1.8	15.2	0.8	19.2		2.9	19.2		2.9
Lebogang Clinic	26.1	12.5	1.8	15.6	0.8	20.2		2.9	20.2		2.9
Kleuterskool Haas Das	19.5	8.9	1.7	12.4	0.7	13.6		2.0	13.6		2.0
Standerton Primary School	19.5	9.0	1.7	12.4	0.7	14.1		2.0	14.1		2.0
Laerskool Jeugkrag	19.8	9.4	1.7	12.6	0.7	15.2		2.1	15.2		2.1
Laerskool Standerton	19.5	8.9	1.7	12.5	0.7	13.5		2.0	13.5		2.0
Laerskool Kalie De Haas	19.6	9.1	1.7	12.9	0.7	12.8		1.9	12.8		1.9
Hoerskool Standerton	19.5	9.0	1.7	12.4	0.7	14.1		2.0	14.1		2.0
Standerton Provincial Government Hospital	19.5	8.9	1.7	12.3	0.7	13.8		2.0	13.8		2.0
Mar-Peh Medicare Private Hospital	19.2	8.8	1.7	12.5	0.7	13.1		1.9	13.1		1.9
Standerton Retirement Home	19.3	8.8	1.7	12.5	0.7	12.9		1.9	12.9		1.9
Standerton Ouetehuis/Old Age Home	19.4	8.8	1.7	12.7	0.7	13.5		1.9	13.5		1.9

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Holmdene Secondary School	17.9	9.5	1.6	10.4	0.6	10.1		1.7	10.1		1.7
Cathuza Primary School (SE of Town)	21.2	9.7	1.9	14.6	0.9	15.6		2.2	15.6		2.2
Sizanani Pre Primary School	18.9	8.8	1.7	11.9	0.7	12.8		1.9	12.8		1.9
Hlobisa Primary School	18.7	8.9	1.6	11.6	0.7	11.9		1.8	11.9		1.8
Shukuma Primary School	18.4	8.7	1.6	11.5	0.7	10.9		1.8	10.9		1.8
Retsebile Primary School	18.8	8.9	1.6	11.8	0.7	13.5		1.9	13.5		1.9
Thuto-Thebe Secondary School	19.4	9.0	1.7	12.3	0.7	14.2		2.0	14.2		2.0
Jandrell Secondary School	18.7	9.0	1.6	11.7	0.7	12.7		1.9	12.7		1.9
Thobelani Secondary School	18.9	8.8	1.7	11.9	0.7	13.0		1.9	13.0		1.9
Standerton Tb Hospital	19.0	8.8	1.6	11.8	0.7	11.3		1.8	11.3		1.8
Thuthukani Pre Primary School	22.4	13.5	1.9	14.0	0.9	29.6		3.7	**29.6**	1	3.7
Ulwazi Primary School	22.1	12.9	1.9	14.1	0.9	27.6		3.6	**27.6**	1	3.6
Zikhetheleni Secondary School	22.4	13.2	1.9	14.4	0.9	28.8		3.6	**28.8**	1	3.6
Joubertsvlei Primary School (North of Tutuka)	25.5	9.1	2.0	16.1	0.9	11.8		1.9	11.8		1.9
Amalumgelo Primary School (NE of Tutuka)	34.7	12.9	2.7	26.4	1.5	38.5		3.8	**38.5**	8	3.8
Grootdraaidam Primary School	21.5	9.5	1.8	13.8	0.8	17.9		2.4	17.9		2.4
Laerskool Secunda	25.8	9.0	1.9	15.5	0.8	14.1		2.0	14.1		2.0
Laerskool Kruinpark	26.1	8.9	2.0	15.7	0.9	13.3		1.9	13.3		1.9
Laerskool Oranjegloed Primary	25.4	8.9	1.9	15.0	0.8	13.4		1.9	13.4		1.9
Curro Castle Combined School	25.2	9.0	1.9	15.0	0.8	13.7		1.9	13.7		1.9
Hoërskool Oosterland	26.4	9.1	2.0	15.7	0.9	13.8		1.9	13.8		1.9
Mediclinic Secunda (Hospital)	25.6	9.0	1.9	15.5	0.8	14.3		2.0	14.3		2.0
Mediclinic Highveld (Hospital_Trichardt, Secunda)	27.8	9.5	2.1	17.1	0.9	13.6		2.0	13.6		2.0
Daviescourt/Davieshof Old Age Home	25.9	9.0	1.9	15.4	0.8	14.1		1.9	14.1		1.9
Highveld Park High School	26.4	9.2	2.0	15.7	0.8	14.0		1.9	14.0		1.9
Hoerskool Secunda	25.5	8.9	1.9	15.4	0.8	14.1		1.9	14.1		1.9
Basizeni Special School	22.5	9.8	1.7	12.5	0.7	13.4		2.0	13.4		2.0
Maphala-Gulube Primary School	22.0	9.4	1.7	11.8	0.7	12.1		1.9	12.1		1.9
Shapeve Primary School	22.6	9.8	1.7	12.7	0.7	13.6		2.0	13.6		2.0

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Thomas Nhlabathi Secondary School	22.0	9.7	1.7	11.6	0.7	13.3		1.9	13.3		1.9
Embalenhle Hospital / Clinic	22.2	9.6	1.7	11.6	0.7	12.7		1.9	12.7		1.9
Vukuzithathe Primary School	22.1	9.4	1.7	11.6	0.7	12.6		1.9	12.6		1.9
K I Twala Secondary	21.7	9.5	1.7	11.6	0.7	12.6		1.9	12.6		1.9
Allan Makunga Primary School	22.2	9.8	1.7	12.5	0.7	13.3		2.0	13.3		2.0
Evander Hospital Arv Clinic	26.3	9.9	1.9	15.9	0.8	15.5		2.2	15.5		2.2
Laerskool Hoeveld	25.9	10.0	1.9	15.6	0.8	15.9		2.2	15.9		2.2
Hoerskool Evander	25.0	10.2	1.8	14.9	0.8	16.2		2.2	16.2		2.2
Bernice Samuel Hospital	23.1	11.3	1.4	13.0	0.6	17.8		2.2	17.8		2.2
Hoerskool Delmas	23.2	11.4	1.4	13.0	0.6	17.7		2.3	17.7		2.3
Laerskool Delmas	24.3	11.8	1.4	13.6	0.6	18.0		2.4	18.0		2.4
Kangela Primary School (North of Delpark)	25.5	12.2	1.4	14.7	0.6	18.8		2.6	18.8		2.6
Savf Ons Eie Ouetehuis / Old Age Home	24.3	11.8	1.4	13.6	0.6	18.0		2.4	18.0		2.4
Laerskool Eloff	20.2	10.3	1.3	11.5	0.5	15.1		1.9	15.1		1.9
Rietkol Primary School	20.4	10.0	1.3	11.4	0.5	14.9		1.9	14.9		1.9
Bazani Primary School	25.8	11.9	1.4	14.5	0.6	18.5		2.8	18.5		2.8
Phaphamani Secondary School	25.2	11.3	1.4	13.9	0.6	17.9		2.7	17.9		2.7
Vezimfundo Primary School	24.9	12.2	1.4	14.5	0.6	18.7		2.8	18.7		2.8
Arbor Primary School	57.9	21.5	2.6	37.9	1.4	59.4		10.2	**59.4**	**98**	10.2
Ogies Combined School	59.3	19.0	4.1	42.3	2.5	32.2		3.2	**32.2**	1	3.2
Ogies Tb Clinic	63.0	19.9	4.1	44.5	2.5	33.6		3.3	**33.6**	2	3.3
Ogies Police Station	63.0	19.9	4.1	44.5	2.5	33.6		3.3	**33.6**	2	3.3
Hlangu Phala Primary School	70.5	23.5	4.2	49.2	2.6	29.8		3.3	**29.8**	1	3.3
Sukumani Primary School	69.2	22.1	4.2	48.5	2.6	29.7		3.3	**29.7**	1	3.3
Thuthukani Primary School	67.7	22.0	4.2	47.4	2.6	29.4		3.2	**29.4**	1	3.2
Mehlwana Secondary School	69.8	20.4	4.3	48.5	2.6	32.7		3.3	**32.7**	1	3.3
Makause Combined School	69.1	20.1	4.3	47.4	2.6	30.7		3.2	**30.7**	1	3.2
Sibongindawo Primary School	105.2	29.4	5.4	75.0	3.5	59.9		5.8	**59.9**	**34**	5.8
Laerskool Balmoral	80.9	31.8	3.1	55.1	1.7	25.2		2.3	**25.2**	1	2.3
Clewer Primary School	44.5	15.3	2.8	28.8	1.5	13.9		1.4	13.9		1.4
Witbank High School	33.3	12.3	2.2	19.7	1.1	12.0		1.2	12.0		1.2

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Eden Park Retirement Village	33.9	13.1	2.3	20.4	1.1	12.0		1.2	12.0		1.2
Savf House Immergroen Old Age Home	33.6	12.8	2.2	19.5	1.0	12.1		1.2	12.1		1.2
Mthimkulu Housing For The Aged	35.8	13.4	2.3	21.3	1.1	12.1		1.2	12.1		1.2
Emalahleni Private Hospital	33.4	12.6	2.2	19.2	1.0	11.8		1.1	11.8		1.1
Life Cosmos Hospital	32.7	12.2	2.2	19.3	1.0	11.8		1.1	11.8		1.1
Duvha Primary School	35.6	13.7	2.5	22.5	1.2	10.8		1.2	10.8		1.2
Laerskool Taalfees	33.0	12.4	2.2	19.4	1.0	12.1		1.2	12.1		1.2
Witbank Provincial Hospital	32.6	12.5	2.2	18.9	1.0	11.7		1.1	11.7		1.1
Nancy Shiba Primary School (Vosman)	41.8	16.7	2.3	25.8	1.2	12.1		1.2	12.1		1.2
Wh De Klerk Skool	30.6	12.1	2.0	17.3	0.9	10.4		1.0	10.4		1.0
Laerskool Panorama	30.4	11.9	2.0	16.6	0.9	10.4		1.0	10.4		1.0
Laerskool Duvhapark	33.8	12.4	2.4	21.2	1.2	10.5		1.2	10.5		1.2
Laerskool Klipfontein	33.8	12.9	2.3	20.4	1.1	11.8		1.2	11.8		1.2
Cambridge Academy	32.0	12.8	2.2	18.8	1.0	11.3		1.1	11.3		1.1
Besilindile Primary School	41.1	17.0	2.2	24.9	1.1	11.7		1.2	11.7		1.2
Reynopark High School	33.6	13.0	2.4	20.2	1.2	11.4		1.2	11.4		1.2
Bakenveld Golf Estate	29.2	11.5	2.1	17.1	1.0	8.9		1.0	8.9		1.0
Allendale Secondary School	27.1	11.1	2.3	16.9	1.1	9.4		1.1	9.4		1.1
Khayalethu Primary School	35.8	13.4	2.2	21.1	1.1	11.8		1.2	11.8		1.2
Illanga Secondary School	28.4	11.0	2.3	17.3	1.1	9.6		1.1	9.6		1.1
Joy Creche (Duvha)	29.6	11.5	2.3	18.3	1.1	9.8		1.1	9.8		1.1
Linderus Old Age Home	21.0	10.5	1.5	9.3	0.5	7.1		0.7	7.1		0.7
Vergeet My Nie Old Age Home	21.1	10.6	1.5	9.4	0.5	7.2		0.7	7.2		0.7
Middleburg Frail Care Unit And Home For Elderly	20.3	10.7	1.4	8.9	0.5	6.8		0.7	6.8		0.7
Life Midmed Hospital	20.4	10.7	1.4	9.0	0.5	6.8		0.7	6.8		0.7
Middelburg Hospital	20.9	10.6	1.5	9.3	0.5	7.1		0.7	7.1		0.7
Makhathini Primary School	20.9	10.8	1.4	9.2	0.5	6.9		0.7	6.9		0.7
Laerskool Dennesig	20.3	10.8	1.4	8.7	0.5	6.8		0.7	6.8		0.7
Hoerskool Kanonkop	20.3	10.6	1.4	8.7	0.5	6.8		0.7	6.8		0.7
Laerskool Kanonkop	20.3	10.6	1.4	8.9	0.5	6.7		0.7	6.7		0.7

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Steelcrest High School	20.1	10.5	1.4	8.9	0.5	6.8		0.7	6.8		0.7
Middelburg Primary	20.9	10.5	1.5	9.3	0.5	7.1		0.7	7.1		0.7
Middleburg Ext 6 Clinic	22.4	10.8	1.5	10.5	0.6	7.5		0.8	7.5		0.8
Sofunda Secondary School	21.8	10.8	1.5	9.9	0.5	7.2		0.7	7.2		0.7
Mhluzi Primary School	21.3	10.8	1.5	9.5	0.5	7.0		0.7	7.0		0.7
Highlands Primary School	21.0	10.6	1.5	9.4	0.5	7.2		0.7	7.2		0.7
Blinkpan Primary School	24.0	10.0	2.3	14.0	1.1	9.2		1.1	9.2		1.1
Laerskool Koornfontein	23.6	9.8	2.3	13.7	1.1	9.3		1.1	9.3		1.1
Blinkpan	24.3	10.1	2.3	14.3	1.1	9.3		1.2	9.3		1.2
Laerskool Kragveld	19.6	9.9	1.9	10.3	0.7	7.6		0.9	7.6		0.9
Pullens Hope	19.7	9.9	1.9	10.1	0.7	7.6		0.9	7.6		0.9
Arnot Colliery Primary School	16.4	9.0	1.6	7.7	0.5	6.4		0.8	6.4		0.8
Laerskool Rietkuil	16.3	8.8	1.6	7.5	0.5	6.5		0.8	6.5		0.8
Beestepan Agricultural School	16.4	8.6	1.4	7.0	0.5	6.5		0.7	6.5		0.7
Gekombineerde Skool Hendrina	18.3	8.5	2.0	9.5	0.8	7.2		1.0	7.2		1.0
Hendrina Primary School	18.2	8.3	1.9	9.4	0.7	7.1		1.0	7.1		1.0
Kwazamokuhle Secondary School	18.0	8.5	1.9	9.3	0.7	7.1		1.0	7.1		1.0
Ubuhle Bolwai Secondary School	13.7	7.4	1.7	6.8	0.6	6.2		0.9	6.2		0.9
Lothair Primary School	13.8	7.4	1.7	6.8	0.6	6.3		0.9	6.3		0.9
Warburton Combined School	13.9	8.4	1.6	7.0	0.5	6.0		0.8	6.0		0.8
Warburton Town	14.2	8.1	1.6	7.0	0.5	6.0		0.8	6.0		0.8
Kwachibikhulu Clinic	15.0	8.6	1.7	7.5	0.6	6.3		0.9	6.3		0.9
Kwachibikhulu Primary School	15.1	8.7	1.7	7.5	0.6	6.3		0.9	6.3		0.9
Carolina Hospital	14.3	8.1	1.6	6.8	0.5	6.3		0.8	6.3		0.8
Zinikeleni Secondary School (Silobela)	14.2	8.1	1.6	6.7	0.5	6.3		0.8	6.3		0.8
Volkskool Carolina	14.4	7.9	1.6	6.8	0.5	6.2		0.8	6.2		0.8
Sobuza Primary School	14.2	8.1	1.6	6.8	0.5	6.4		0.8	6.4		0.8
Ons Eie Ouetehuis (Old Age Home)	14.5	7.9	1.6	6.9	0.5	6.2		0.8	6.2		0.8
Laerskool Breyten	17.7	8.6	2.0	9.6	0.8	6.4		1.0	6.4		1.0
Siyazi Primary School (Kwazanele)	18.1	8.7	2.0	10.1	0.8	6.5		1.0	6.5		1.0
Masizakhe Secondary School (Kwazanele)	18.0	8.9	2.0	10.0	0.8	6.5		1.0	6.5		1.0

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Belfast Rusoord (Old Age Home)	14.0	8.2	1.2	6.8	0.4	5.2		0.6	5.2		0.6
Belfast Hospital	14.4	8.3	1.2	7.1	0.4	5.2		0.6	5.2		0.6
Platorand School	14.8	8.4	1.2	7.5	0.4	5.3		0.6	5.3		0.6
Belfast Primary School (Siyathuthuka)	14.0	8.4	1.2	6.6	0.4	5.1		0.6	5.1		0.6
Siyathuthuka Clinic	14.0	8.4	1.2	6.7	0.4	5.1		0.6	5.1		0.6
Life Bethal Hospital	24.9	11.3	2.2	14.1	1.0	10.3		1.5	10.3		1.5
Hoerskool Hoogenhout	24.8	11.4	2.2	14.3	1.0	10.0		1.5	10.0		1.5
Jim Van Tonderskool	26.0	12.1	2.3	15.1	1.0	10.6		1.5	10.6		1.5
Bethal Independent Primary School	25.8	12.0	2.3	14.7	1.0	10.4		1.5	10.4		1.5
Laerskool Marietjie Van Niekerk	25.0	10.9	2.3	14.4	1.0	10.1		1.5	10.1		1.5
Laerskool Hm Swart	24.7	11.4	2.2	14.2	1.0	10.2		1.5	10.2		1.5
Sakhisizwe Primary School (Emzinoni)	25.4	10.7	2.1	14.1	0.9	10.4		1.6	10.4		1.6
Alpheus D Nkosi Secondary School (Emzinoni)	24.4	10.7	2.2	13.8	0.9	9.9		1.5	9.9		1.5
Silwerjare Old Age Home	24.7	11.3	2.2	14.1	1.0	10.2		1.5	10.2		1.5
Residentia Palm Oord	24.9	11.4	2.2	14.1	1.0	10.4		1.5	10.4		1.5
Bronkhorspruit Hospital	24.9	13.0	1.1	12.4	0.4	14.5		1.3	14.5		1.3
Cultura High School	29.0	16.5	1.3	15.2	0.5	18.7		1.7	18.7		1.7
Bronkhorspruit Primary School	26.2	14.0	1.1	13.0	0.4	15.2		1.4	15.2		1.4
Bronkhorspruit Dam	30.6	16.4	1.4	16.5	0.6	19.9		2.2	19.9		2.2
Hoerskool Erasmus	26.7	14.0	1.2	13.8	0.5	16.2		1.5	16.2		1.5
Althea Independent School	26.4	14.8	1.2	13.2	0.5	15.6		1.4	15.6		1.4
Kgoro Primary School (Zithobeni)	23.8	14.1	1.1	10.8	0.4	12.8		1.2	12.8		1.2
Zithobeni Secondary School (Zithobeni)	22.9	13.7	1.1	10.0	0.4	12.6		1.2	12.6		1.2
Vaal Power AH	21.4	10.4	1.2	16.4	0.7	58.2		7.7	**58.2**	**86**	7.7
Sasolburg Provincial Hospital	16.7	11.2	1.0	9.8	0.4	24.4		2.1	24.4		2.1
Moredou Old Age Home	16.1	10.7	0.9	8.4	0.4	21.2		1.9	21.2		1.9
Ons Gryse Jeug Old Age Home	16.1	10.5	0.9	9.0	0.4	22.8		2.0	22.8		2.0
Noord Primere Skool	16.2	10.5	0.9	9.1	0.4	23.6		2.1	23.6		2.1
Sasolburg High School	16.1	10.7	0.9	9.2	0.4	22.5		1.9	22.5		1.9
Sakhubusa Secondary School	16.2	10.6	0.9	9.0	0.4	30.4		2.5	**30.4**	1	2.5

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Bekezela Primary School	16.6	10.6	0.9	8.9	0.4	37.0		3.0	**37.0**	11	3.0
Isaac Mhlambi Primary	16.8	11.1	1.0	9.4	0.5	35.7		2.6	**35.7**	2	2.6
Refenkgotso Primary School	21.5	8.7	1.3	18.2	0.7	29.5		3.0	**29.5**	1	3.0
Deneysville Primary School	21.2	9.1	1.3	18.2	0.8	22.5		2.6	22.5		2.6
Netcare Vaalpark Hospital	17.0	11.8	1.0	9.1	0.5	36.2		3.2	**36.2**	11	3.2
Vaalpark Articon Secondary School	16.8	12.2	1.0	9.4	0.5	39.8		3.6	**39.8**	**19**	3.6
Mediclinic Emfuleni	15.0	8.5	0.9	7.8	0.4	29.0		2.3	**29.0**	1	2.3
Jeugland Old Age Home	15.0	9.0	0.9	7.9	0.4	25.4		2.2	**25.4**	1	2.2
Herfsoord Huis Old Age Home	15.0	8.1	0.9	7.8	0.4	25.0		2.0	**25.0**	1	2.0
Huis Prinscilla	14.7	8.4	0.9	7.7	0.4	23.8		1.9	23.8		1.9
Laerskool Emfulenipark	16.1	11.0	0.9	8.4	0.4	37.0		3.1	**37.0**	7	3.1
Nw University_Vaal Campus	15.6	10.7	0.9	8.2	0.4	46.3		4.3	**46.3**	**28**	4.3
Emfuleni Primary School	14.2	8.4	0.8	7.3	0.3	20.1		1.7	20.1		1.7
Mediclinic Vereeniging	14.6	9.1	0.9	7.6	0.4	34.4		3.2	**34.4**	10	3.2
Kopanong Provincial Hospital (Duncanville)	14.7	8.7	0.9	7.5	0.4	17.8		1.5	17.8		1.5
Avondrus Eventide Old Age Home	14.7	9.2	0.9	7.7	0.4	18.5		1.6	18.5		1.6
Riviera On Vaal Resort	14.9	9.9	0.9	7.7	0.4	40.5		3.9	**40.5**	**17**	3.9
Sedibeng Tvet College	14.9	9.9	0.9	7.7	0.4	44.2		4.0	**44.2**	**20**	4.0
General Smuts High School	14.7	10.6	0.9	7.8	0.4	33.6		3.3	**33.6**	9	3.3
Eureuka School & Selbourne Primary	14.6	10.4	0.9	7.6	0.4	34.0		3.0	**34.0**	4	3.0
Midvaal Private Hospital (Three Rivers)	16.5	10.5	1.0	8.8	0.5	43.3		3.5	**43.3**	**20**	3.5
Three Rivers Retirement Village	16.5	10.0	1.0	9.1	0.5	33.4		2.6	**33.4**	7	2.6
Drie Riviere Aftreeoord Old Age Home	16.5	9.8	1.0	9.3	0.5	27.6		2.2	**27.6**	1	2.2
Riverside High School	20.2	10.3	1.1	13.8	0.6	51.2		3.3	**51.2**	**17**	3.3
Risiville Primary School	17.2	10.2	1.0	9.9	0.5	25.7		2.2	**25.7**	1	2.2
Sebokeng Hospital	13.8	8.0	0.8	7.6	0.3	13.5		1.1	13.5		1.1
Clinix-Naledzi Private Hospital	14.0	7.8	0.8	7.5	0.3	13.1		1.2	13.1		1.2
Mohloli Secondary School	14.5	9.5	0.9	7.4	0.4	33.4		2.9	**33.4**	5	2.9
Tshirela Primary School (Boipatong)	14.6	8.5	0.9	7.5	0.4	19.4		1.8	19.4		1.8
Tsoaranang Primary School (Thepiso)	14.0	9.1	0.9	7.4	0.4	25.3		2.3	**25.3**	1	2.3
Thepiso Primary School	14.2	8.5	0.9	7.5	0.4	24.1		1.9	24.1		1.9

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Emmanuel Primary School	14.2	9.4	0.9	7.3	0.4	28.1		2.5	**28.1**	1	2.5
Rust Ter Vaal Combined School	14.6	8.0	0.9	7.8	0.4	11.8		1.1	11.8		1.1
Roshnee Primary School	14.4	7.6	0.9	7.7	0.3	10.0		0.9	10.0		0.9
Roshnee High School	14.6	7.8	0.9	7.7	0.4	11.2		1.0	11.2		1.0
Hoerskool Dr Malan	15.5	8.4	1.0	9.0	0.4	13.5		1.2	13.5		1.2
Laerskool Voorwaarts	17.8	9.4	1.1	11.8	0.5	17.2		1.5	17.2		1.5
Meyerton Secondary School	15.6	8.8	1.0	8.9	0.4	13.0		1.3	13.0		1.3
Ratasetjhaba Primary School	15.0	8.4	0.9	8.4	0.4	10.3		1.0	10.3		1.0
Meyerton Primary School	15.3	8.2	0.9	8.9	0.4	12.9		1.1	12.9		1.1
Oprah Leadership Academy	15.7	7.8	1.0	9.4	0.4	13.9		1.1	13.9		1.1
Henley River Retirement Village	15.8	7.9	1.0	9.2	0.4	12.0		1.1	12.0		1.1
Henley High & Preparatory School	15.4	7.9	1.0	9.0	0.4	11.3		1.0	11.3		1.0
Randvaal Clinic	15.4	8.3	0.9	9.0	0.4	10.6		1.0	10.6		1.0
Laerskool Japie Greyling	15.0	8.1	0.9	8.5	0.4	9.1		0.9	9.1		0.9
Thomas Nhlapo Primary	15.1	8.0	1.0	8.9	0.4	10.3		0.9	10.3		0.9
Randvaal Old Age Home	15.2	8.1	0.9	8.8	0.4	8.8		0.9	8.8		0.9
Laerskool Ag Visser	14.2	7.8	1.1	7.6	0.4	7.4		0.9	7.4		0.9
Lethaba Siyangobe	14.2	8.1	1.1	7.9	0.4	7.5		0.9	7.5		0.9
Shalimar Ridge Primary School	14.1	8.0	1.1	7.7	0.4	7.8		0.9	7.8		0.9
Jw Luckoff High School	14.5	7.6	1.1	8.2	0.5	7.7		0.9	7.7		0.9
Heidelberg Hospital	14.1	8.2	1.1	7.8	0.4	7.6		0.9	7.6		0.9
Thulatsatsi Operation (Rensburg)	14.1	7.8	1.1	7.6	0.4	7.5		0.9	7.5		0.9
Silwer Akker Tehuis	14.0	8.0	1.1	7.6	0.4	7.8		0.9	7.8		0.9
Riversands Retirement Village	14.2	8.3	1.1	8.0	0.4	7.6		0.9	7.6		0.9
Qhaqholla Primary School	14.0	7.6	1.1	7.9	0.4	7.8		0.9	7.8		0.9
Ratanda Primary School	14.3	7.6	1.1	8.3	0.5	8.0		0.9	8.0		0.9
Boneha Primary School	14.0	7.6	1.1	8.0	0.4	7.6		0.9	7.6		0.9
Sithokomele Primary School	14.1	7.7	1.1	8.1	0.4	7.6		0.9	7.6		0.9
Ratanda Bertha Gxowa Primary School	14.5	8.2	1.1	8.1	0.5	7.6		0.9	7.6		0.9
Khanya Lesedi Secondary School	13.9	7.6	1.1	8.2	0.4	7.8		0.9	7.8		0.9
Ratanda Secondary School	13.9	7.6	1.1	8.2	0.4	7.7		0.9	7.7		0.9

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
New Ratanda Secondary School	14.3	8.0	1.1	7.9	0.4	7.5		0.9	7.5		0.9
Kgoro Ya Thuto Secondary School	14.3	8.0	1.1	7.9	0.4	7.5		0.9	7.5		0.9
Ekurhuleni School For The Deaf	14.9	8.3	1.0	8.2	0.4	6.5		0.8	6.5		0.8
Pholosong Hospital	16.1	8.7	1.1	8.7	0.4	7.3		0.9	7.3		0.9
Tsakane Home For Aged	15.7	8.2	1.1	8.6	0.4	7.2		0.9	7.2		0.9
Mmuso Primary School	15.8	8.2	1.1	8.6	0.5	7.6		1.0	7.6		1.0
Michael Zulu Primary School	16.3	8.4	1.1	8.8	0.4	7.3		0.9	7.3		0.9
Nkabinde Primary School (Thembilisha)	16.4	9.2	1.1	8.7	0.4	7.7		0.9	7.7		0.9
Nigel Clinic	14.8	8.3	1.1	7.8	0.4	8.2		1.0	8.2		1.0
Tehuis Vir Bejaardes	14.9	8.1	1.1	7.7	0.4	8.4		1.0	8.4		1.0
Hoerskool John Vorster	14.7	8.3	1.1	7.8	0.4	8.4		1.0	8.4		1.0
Laerskool Hannes Visagie	15.0	7.9	1.1	7.8	0.4	8.6		1.0	8.6		1.0
Nigel Secondary School	15.3	7.8	1.2	8.2	0.4	9.0		1.1	9.0		1.1
Laerskool Dunnottar	15.7	8.3	1.1	8.5	0.4	7.8		1.0	7.8		1.0
Springs Retirement Village	16.6	8.8	1.1	8.6	0.4	8.5		1.0	8.5		1.0
Life Springs Parkland Hospital	16.3	9.0	1.1	8.8	0.4	8.3		1.0	8.3		1.0
Netcare N17 Hospital (Springs)	16.4	9.1	1.1	8.8	0.4	8.2		1.0	8.2		1.0
Springs Boys High School	16.4	8.7	1.1	8.8	0.4	8.1		1.0	8.1		1.0
Laerskool Selectionpark	16.3	8.8	1.1	8.6	0.4	8.3		1.0	8.3		1.0
Kwasa College Pre&Primary School	16.0	8.6	1.1	8.5	0.4	9.0		1.1	9.0		1.1
Edelweis Medical Centre	16.4	8.5	1.1	8.5	0.4	8.6		1.1	8.6		1.1
Laerskool Christiaan Beyers	16.3	8.5	1.1	8.3	0.4	8.7		1.1	8.7		1.1
Hoerskool Hugenote	16.4	8.9	1.1	8.8	0.4	8.4		1.0	8.4		1.0
Brakpan Primary School	16.9	9.8	1.1	9.0	0.4	7.8		0.9	7.8		0.9
Parkrand Primary School	16.3	9.2	1.1	9.0	0.4	6.7		0.8	6.7		0.8
Thabo Memorial Hospital	16.1	8.9	1.0	9.0	0.4	6.3		0.8	6.3		0.8
Sunward Park Hospital	16.1	9.1	1.1	8.8	0.4	6.5		0.8	6.5		0.8
Alberton High School	15.9	8.5	1.0	9.1	0.4	5.9		0.7	5.9		0.7
Netcare Clinton Hospital	15.9	8.5	1.0	9.0	0.4	5.9		0.7	5.9		0.7
Alberton Tuiste Vir Bejaardes	16.0	8.7	1.0	9.2	0.4	5.9		0.7	5.9		0.7
Bertha Gxowa Hospital	17.1	9.6	1.1	10.0	0.5	6.0		0.7	6.0		0.7

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Linmed Hospital	17.2	10.6	1.1	9.7	0.5	7.2		0.9	7.2		0.9
Hoerskool Brandwag (Airfield)	17.2	9.5	1.1	9.6	0.5	7.1		0.8	7.1		0.8
Thepiso Noto Intermediate School	18.8	11.1	1.2	10.3	0.5	10.6		1.3	10.6		1.3
Laerskool Bredell	15.8	9.1	1.0	8.5	0.4	7.1		0.8	7.1		0.8
Sibonelo Primary School (Daveyton)	17.7	10.1	1.1	9.2	0.4	9.3		1.1	9.3		1.1
Petit High School (Kempton Park Nu)	18.4	10.4	1.1	10.1	0.5	8.1		0.9	8.1		0.9
Arwyp Medical Centre	16.2	9.7	1.0	8.9	0.4	6.4		0.7	6.4		0.7
Hoerskool Birchleigh	15.5	9.5	1.0	8.2	0.4	6.7		0.7	6.7		0.7
Curro Serengeti Acadamy	15.6	9.8	1.0	7.8	0.4	7.0		0.8	7.0		0.8
South Rand Hospital	19.1	10.9	1.1	11.7	0.5	6.0		0.7	6.0		0.7
Chris Hani Baragwanath Hospital	15.7	9.5	0.9	8.7	0.4	5.7		0.6	5.7		0.6
Thulani Primary School	14.0	9.0	0.8	7.6	0.3	5.5		0.5	5.5		0.5
University of Witwatersrand	18.9	11.6	1.1	11.2	0.5	6.0		0.6	6.0		0.6
Milpark Hospital	17.6	11.3	1.0	10.2	0.4	6.0		0.6	6.0		0.6
Charlotte Maxixe Academic Hospital	18.0	11.3	1.1	10.7	0.5	6.0		0.6	6.0		0.6
Thembisa West Secondary School (Thembisa)	14.2	9.1	0.9	6.6	0.3	6.3		0.6	6.3		0.6
Lenmed Zamokuhle Private Hospital (Thembisa)	15.2	9.9	0.9	6.9	0.3	6.7		0.7	6.7		0.7
Ikusasa Comprehensive School	15.0	9.7	0.9	7.3	0.3	6.7		0.7	6.7		0.7
Gem Village Old Age Home	14.9	8.6	0.8	6.2	0.3	6.9		0.7	6.9		0.7
Rustoord Old Age Home	14.6	8.7	0.8	6.4	0.3	6.6		0.6	6.6		0.6
Cornwell Hill College (Irene)	14.7	8.9	0.8	6.5	0.3	7.1		0.7	7.1		0.7
Kleinfontein Sorg Sentrum Old Age Home (Donkerhoek)	17.4	10.5	0.9	8.2	0.3	8.8		0.9	8.8		0.9
Valtaki AH (Rayton)	19.7	11.7	1.0	8.7	0.3	10.0		1.0	10.0		1.0
Laerskool Rayton (Rayton)	16.7	9.7	0.8	6.6	0.3	8.3		0.7	8.3		0.7
Tierkop AH	18.6	11.2	1.0	8.8	0.4	9.3		1.0	9.3		1.0
Redford House The Hills Private School (Mooikloof Glen)	17.9	11.3	1.0	8.2	0.4	8.6		0.9	8.6		0.9
Rietvlei View Country Estate	17.9	11.1	1.0	8.2	0.4	8.8		0.9	8.8		0.9

	SO_2			NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Hazeldean Curro School (Tyger Valley)	15.4	9.2	0.8	6.5	0.3	6.7		0.6	6.7		0.6
Tyger Valley College	15.5	9.3	0.8	6.9	0.3	6.9		0.7	6.9		0.7
Pretoria East Hospital (Moreletapark)	16.2	9.7	0.9	7.2	0.3	7.2		0.7	7.2		0.7
Groenkloof Old Age Home	14.6	8.8	0.8	6.5	0.3	6.3		0.6	6.3		0.6
Steve Biko Academic Hospital	13.8	9.3	0.7	5.6	0.2	5.8		0.5	5.8		0.5
Willow Ridge High School (Wilgers)	14.6	8.7	0.8	6.1	0.2	6.4		0.6	6.4		0.6
Hoerskool Waterkloof	16.1	9.9	0.9	7.4	0.3	7.3		0.7	7.3		0.7
Hoerskool Garsfontein	15.4	9.4	0.8	7.0	0.3	6.9		0.7	6.9		0.7
Afrikaanse Hoer Seunskool	14.4	8.9	0.8	6.4	0.3	6.1		0.5	6.1		0.5
Huis Silversig SAVF Old Age Home (Silverton)	14.0	8.7	0.7	5.5	0.2	6.0		0.5	6.0		0.5
Laersekool Meyerspark (Meyerspark)	14.2	8.7	0.7	5.6	0.2	6.2		0.5	6.2		0.5
Curro Academy Mamelodi	13.8	8.4	0.7	4.9	0.2	5.9		0.5	5.9		0.5
Impendulo Primary School	14.7	9.3	0.7	5.5	0.2	6.3		0.6	6.3		0.6
Nellmapius Ext 6 Primary School	14.4	8.3	0.7	5.4	0.2	6.2		0.5	6.2		0.5
Mamelodi Home For Aged	14.3	8.8	0.7	5.0	0.2	5.9		0.5	5.9		0.5

ANNEXURE 3: NEMA REGULATION – APPENDIX 6

Specialist Reports as per the NEMA EIA Regulations, 2014 (as amended), must contain the information outlined in According to Appendix 6 (1) of the Regulations. Table A1 indicates where this information is included in the AIR.

Table A1: Prescribed contents of the Specialist Reports (Appendix 6 of the EIA Regulations, 2014)

Relevant section in GNR. 982	Requirement description	Relevant section in this report
(a) details of—	(i) the specialist who prepared the report; and	Section 2.7
	(ii) the expertise of that specialist to compile a specialist report including a curriculum vitae;	Section 2.7 & Annexure 2
(b)	a declaration that the specialist is independent in a form as may be specified by the competent authority;	Section 12
(c)	an indication of the scope of, and the purpose for which, the report was prepared;	Section 1, 2.1 & 3.2
(cA)	an indication of the quality and age of base data used for the specialist report;	Section 5 & 6
(cB)	a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	Section 6.1
(d)	the duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment;	Site investigation not applicable
(e)	a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;	Section 5 & 6.2
(f)	details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives;	Section 6.3 & 6.4
(g)	an identification of any areas to be avoided, including buffers;	None identified
(h)	a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Section 6.3.2
(i)	a description of any assumptions made and any uncertainties or gaps in knowledge; Note: Uncertainties should be qualified within the report – there will always be uncertainties due to gaps in knowledge should also be qualified – a gap is to record that not all knowledge can be obtained for a study.	Section 2.9
(j)	a description of the findings and potential implications of such findings on the impact of the proposed activity or activities;	Section 6.4
(k)	any mitigation measures for inclusion in the EMPr;	Section 9

Relevant section in GNR. 982	Requirement description	Relevant section in this report
	Note: We need to include whether these mitigation measures (excluding ongoing monitoring) can be practically implemented prior to commencement or not.	
(l)	any conditions for inclusion in the environmental authorisation;	Section 9
(m)	any monitoring requirements for inclusion in the EMPr or environmental authorisation;	Section 9
(n) a reasoned opinion—	(i) whether the proposed activity, activities or portions thereof should be authorised;	Section 10
	(iA) regarding the acceptability of the proposed activity or activities; and	Section 10
	(ii) if the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan; Note: We need to include whether these mitigation measures (excluding ongoing monitoring) can be practically implemented prior to commencement or not.	Section 10
(o)	a description of any consultation process that was undertaken during the course of preparing the specialist report;	Section 1
(p)	a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	Addressed in April 2021 AIR
(q)	any other information requested by the competent authority.	Addressed in April 2021 AIR
(2)	Where a government notice gazetted by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply.	Section 1 & 6.2.1

ANNEXURE 4: CURRICULUM VITAE

MARK ZUNCKEL



Firm	:	uMoya-NILU (Pty) Ltd
Profession	:	Air quality consultant
Specialization	:	Air quality assessment, air quality management planning, air dispersion modelling, boundary layer meteorology, project management
Position in Firm	:	Managing director and senior consultant
Years with Firm	:	Since 1 August 2007
Nationality	:	South African
Year of Birth	:	1959
Language Proficiency	:	English and Afrikaans

EDUCATION AND PROFESSIONAL STATUS

Qualification	Institution	Year
National Diploma (Meteorology)	Technikon Pretoria	1980
BSc (Meteorology)	Univ. of Pretoria	1984
BSc Hons (Meteorology)	Univ. of Pretoria	1988
MSc	Univ. of Natal	1992
PhD	Univ. Witwatersrand	1999

Registered Natural Scientist: South African Society for Natural Scientific Professionals
Ex-Council Member: National Association for Clean Air
Member: National Association for Clean Air

EMPLOYMENT AND EXPERIENCE RECORD

Period	**Organisation details and responsibilities/roles**
1976 – May 1992	South African Weather Bureau : Observer, junior forecaster, senior forecast, researcher, assistant director
June 1992 – July 2007	CSIR: Consultant and researcher, Research group Leader: Atmospheric Impacts
August 2007 to present	uMoya-NILU Consulting: Managing Director and senior air quality consultant

Key and Recent Project Experience:

1996	Project leader & Principal researcher: Atmospheric impact assessment for the proposed Mozal aluminium smelter in Maputo, Mozambique.

1996 Project leader & Principal researcher: Dry sulphur deposition during the Ben MacDhui High Altitude Trace Gas and Transport Experiment (BATTEX) in the Eastern Cape.

1997 Project leader & Principal researcher: Atmospheric impact assessment of the proposed capacity expansion project for Alusaf in Richards Bay.

1997 Project leader & Principal researcher: The Uruguayan ambient air quality project with LATU.

1997 Principal researcher on the Air quality specialist study for the Strategic Environmental Assessment on the industrial and urban hinterland of Richards Bay.

1997 Project leader & Principal researcher: Feasibility study for the implementation of a fog detection system in the Cape Metropolitan area: Meteorological aspects.

2001 Project leader & Principal researcher: Air quality specialist study for the Environmental Impact Assessment for the proposed expansion of the Hillside Aluminium Smelter, Richards Bay.

2001-03 Researcher: The Cross Border air Pollution Impact (CAPIA) project. A 3-year modelling and impacts study in the SADC region.

2002 Project leader & Principal researcher: Air quality assessment specialist study for the proposed Pechiney Smelter at Coega.

2002 Project leader & Principal researcher: Air quality assessment specialist study for the proposed N2 Wild Coast Toll Road.

2002-05 Project leader on the NRF project – development of a dynamic air pollution prediction system

2004 Project leader on the specialist study for expansion at the Natal Portland Cement plant at Simuma, KwaZulu-Natal.

2004-05 Researcher: National Air Quality Management Plan implementation project for Department Environmental Affairs and Tourism.

2005 Researcher in the assessment of air quality impacts associated with the expansion of the Natal Portland Cement plant at Port Shepstone.

2006-07 Project team leader of a multi-national team to develop the National Framework for Air Quality Management for the Department of Environment Affairs and Tourism

2007 Air quality assessment for Mutla Early Production System in Uganda for ERM Southern Africa on behalf of Tullow Oil.

2007-10 Lead consultant on the development of a dust mitigation strategy fro the Bulk Terminal Saldanha and an ambient guideline for Fe_2O_3 dust for Transnet Projects and on-going monitoring.

2008 Lead consultant on the Air quality status quo assessment and scoping for the EIA for the Sonangol Refinery

2008-09 Lead consultant on the development of the air quality management plan for the Western Cape Provincial. Department of Environmental Affairs and Development Planning.

2008-10 Lead consultant on the development of the Highveld Priority Area air quality management plan for the Department of Environmental Affairs and Tourism.

2008 Lead consultant in the development of an odour management and implementation strategy for eThekwini, focussing on Wastewater Treatment Works and odourous industrial sources

2008&10	Lead consultant on the Air Quality Specialist Study for the EIA for the proposed Kalagadi Manganese Smelter at Coega
2008	Lead consultant on the Air Quality Assessment for the Proposed Construction and Operation of a Second Cement Mill at NPC-Cimpor, Simuma near Port Shepstone.
2008	Lead consultant on the Air Quality Specialist Study Report for the New Multi-Purpose Pipeline Project (NMPP) for Transnet Pipelines.
2008	Lead consultant on the Air quality assessment for the proposed UTE Power Plant and RMDZ coal mine at Moatize, Mozambique for Vale.
2008-09	Lead consultant on the Dust source apportionment study for the Coedmore region in Durban for NPC-Cimpor.
2009	Consultant on the Air quality specialist study for the upgrade of the Kwadukuza Landfill, KwaZulu-Natal
2009-10	Lead consultant on the Audit of ambient air quality monitoring programme and air quality training for air quality personnel at PetroSA
2010	Lead consultant on the Qualitative assessment of impact of dust on solar power station at Saldanha Bay
2010	Lead consultant on the Air quality specialist study for the EIA for the Kalagadi Manganese Smelter at Coega
2009-10	Lead consultant on the Air quality specialist study for the Environmental Management Framework for the Port of Richards Bay
2010	Lead consultant on the Air quality status quo assessment and abatement planning at Idwala Carbonates, Port Shepstone
2010	Lead consultant on the Air quality status quo assessment and abatement planning at Sappi Tugela, Mandeni
2010–11	Air quality status quo assessment and revision of the Air Quality Management Plan for City of Johannesburg
2010	Lead consultant on the Air quality status quo assessment and abatement planning at First Quantum Mining's Bwana Mkubwa and Kansanshi mines, Zambia
2010–11	Lead consultant on the Air quality specialist study for the EIA for the Alternative Fuel and Resources Project at Simuma, Port Shepstone
2010–11	Lead consultant on the Air quality specialist study for the EIA for the Coke Oven re-commissioning at ArcelorMittal Newcastle
2010	Qualitative air quality assessment for the EIA for the Mozpel sugar to ethanol project , Mozambique
2011	Development of the South African Air Quality Information System – Phase II The National Emission Inventory
2011	Ambient baseline monitoring for Riversdale's Zambezi Coal Project in Tete, Mozambique
2010-11	Ambient quality baseline assessment for the Ncondeze Coal Project, Tete Mozambique
2011-12	Air quality assessment for the mining and processing facilities at Longmin Platinum in Marikana
2012	Air quality assessment for the proposed LNG and OLNG power stations in Mozambique
2012	Modelling study in Abu Dhabi for the transport and deposition of radio nuclides
2012	Air quality assessment for the proposed manganese ore terminal at the Ngqura Port

2012-13 Air quality management plan development for Stellenbosch Municipality
2012-12 Air quality management plan development for the Eastern Cape Province
2013 Air quality specialist for Tullow Oil Waraga-D and Kinsinsi environmental audit in Uganda
2013 Air quality specialist study for the EIA for the Thabametsi IPP station
2013 Air quality management plan for the Ugu District Municipality
2013-14 Air quality specialist study for the application for postponement of the minimum emission standards for 9 Eskom power stations
2014 Air quality specialist study for the application for postponement applications of the minimum emission standards for the Engen Refinery in Merebank, Durban
2014-15 Baseline assessment and AQMP development for the uThungulu District Municipality
2013-15 Baseline assessment, AQMP and Threat Assessment for the Waterberg-Bojanala Priority Area
2014-15 Review of the 2007 AQMP for eThekwini Municipality, including metropolitan emission inventory development for all sectors, i.e. industrial, transport, waste management, biomass burning, residential fuel burning, dispersion modelling and strategy development
2014-14 Dispersion modelling study for Richards Bay Minerals
2015 Air quality assessment for Rainbow Chickens at Hammersdale
2015 Air quality status quo assessment and planning for TNPA ports in South Africa
2016- 7 Lead author of the National State of Air Report for 2005 to 2015, including national emission inventory development for all sectors, i.e. industrial, transport, waste management, biomass burning, residential fuel burning
2016 Air quality assessment for Kanshansi Mine, Solwesi, Zambia
2016 Assessment of air quality impacts associated with activities at the Venetia Mine, Limpopo Province
2016 Assessment of air quality impacts associated with activities at the Komati Anthracite Mine, Mpumalanga Province
2016 Air quality assessment for the proposed Powership Project at the Port of Nacala, Mozambique
2016 Air quality assessment for the proposed Richards Bay Gas to Power Project
2017 Baseline assessment and review of the 2009 AQMP for Gauteng Province, including emission inventory development for all sectors, i.e. industrial, transport, waste management, biomass burning, residential fuel burning, and dispersion modelling
2017 Baseline assessment and air quality management plan for Northern Cape Province
2017 Air quality assessment for the EIA for the Thabametsi Power Station in Limpopo Province
2017 Air quality assessment for the EIA for the proposed Tshivasho Power Station in Limpopo Province
2018 Air quality assessment for the EIA for the proposed Bellmall Thermal Plant in Ekurhuleni
2018 Air quality assessment for the EIA for the proposed Simba Oil mini Refinery in Tororo, Uganda
2018-19 Air dispersion modelling for input to the Atmospheric Reports for the postponement application for 14 Eskom power stations

2019	Air quality impact assessment for the proposed NamPower expansion project in Walvis Bay
2019	Air quality assessment for the mine expansion project at the Akanani Mine
2019	Air quality impact assessment for the proposed power plant at Nacala, Mozambique
2020	AIR for the KarpowershipSA proposal in the Ports of Ngqura, Richards Bay and Saldanha Bay
2020	AIR for the Coega Development Corporation gas-to-power project at 4 sites in the CDC
2020	AIRs for 10 Eskom coal-fired power power stations on the Highveld to support their postponement application
2020	AIR for the proposed Azure Power gas-to-power project in the Western Cape
2021	Air quality assessment for the proposed optimisation project at Beeshoek Iron Ore Mine, Postmasburg, Northern Cape
2021	AIR for the proposed Frontier Power Gas-to-Power project at Saldanha Bay, Western Cape
2021	AIR for the 2021 shutdown and start-up at Engen Refinery in Merebank
2021	AIR for the proposed expansion of the Swartkops Ore handling facility in Port Elizabeth, Eastern Cape
2016-21	AEL compliance monitoring for Joseph Grieveson, Durban, including dust fallout monitoring and reporting
2018-21	Dust fallout and HF monitoring and reporting for Hulamin, Richards Bay
2018-21	Dust fallout and H_2S monitoring and reporting for at KwaDukuza Landfill for Dolphin Coast Landfill Management (DCLM)
2019-21	AEL compliance monitoring for Umgeni Iron and Steel Foundry, including dust fallout monitoring and reporting

PUBLICATIONS

Author and co-author of 34 articles in scientific journals, chapters in books and conference proceedings. Author and co-author of more than 300 technical reports and presented 47 papers at local and international conferences.

ATHAM RAGHUNANDAN



Firm	:	uMoya-NILU Consulting (Pty) Ltd
Profession	:	Air Quality Consultant
Specialization	:	Meteorological and Atmospheric Dispersion Modelling, Air Quality Specialist Studies, Project Management, Data Processing, Emission Inventories
Position in Firm	:	Senior Air Quality Consultant
Years with Firm	:	14 years (appointed in 2008)
Nationality	:	South African

Year of Birth : 1977
Language Proficiency :English (mother tongue), Afrikaans (fair)

EDUCATION AND PROFESSIONAL STATUS

Qualification	**Institution**	**Year**
M.A. (Atmospheric Sciences)	University of Natal, Durban	2003
B.A. Hons. (Environmental Sciences)	University of Durban–Westville	2001
B.Paed. (Education)	University of Durban–Westville	2000

Memberships:

- National Association for Clean Air (NACA)
- South African Society for Atmospheric Sciences (SASAS)
- South African Council of Educators (SACE)

EMPLOYMENT AND EXPERIENCE RECORD

Period	Organisation details and responsibilities/roles
Jan 2003 – Oct 2008	CSIR: Consultant/Researcher in Air Quality Group, Research Group Leader – Air Quality Research Group
Nov 2008 – present	uMoya-NILU: Senior Air Quality Consultant

Key and Recent Project Experience:

2003	Baseline air dispersion modelling study for Natal Portland Cement (Pty) Ltd – Simuma Plant, Port Shepstone – Modelling and Reporting
2004	Air Quality Screening Study for MOZAL 3 – Modelling and Reporting
2005	Air Quality Specialist Study for the Proposed Kudu Combined Cycle Gas Turbine Power Station at Oranjemund, Namibia (Site D) – Modelling and Reporting
2005	Air Quality Specialist Study for the Proposed Kudu Combined Cycle Gas Turbine Power Plant at Uubvlei, Namibia – Modelling and Reporting
2005	Air Quality Specialist Study for a Proposed Cement Milling, Storage and Packaging Facility and a Second Clinker Kiln at Natal Portland Cement (Pty) Ltd – Simuma Plant, Port Shepstone – Modelling and Reporting
2005	Technology Review: Air quality specialist study for the Coega Aluminium Smelter at Coega, Port Elizabeth – Modelling and Reporting
2005	Assessment of Development Scenarios for Hillside Aluminium using Sulphur Dioxide (SO_2) as an Ambient Air Quality Indicator – Modelling and Reporting
2005	Air Quality Scoping Study for Eskom's Proposed Open Cycle Gas Turbine Power Station at Atlantis – Modelling and Reporting

2005 Air Quality Specialist Study for Eskom's Proposed Open Cycle Gas Turbine Power Station at Atlantis, Western Cape – Modelling and Reporting

2005 Air Quality Specialist Study for the Proposed Tata Steel Ferrochrome Project at Richards Bay – Alton North Site – Modelling and Reporting

2005 Air Quality Audit for the Amathole District Municipality - Compilation of detailed emissions inventory

2006 A Regional Scale Air Dispersion Modelling Study for Northeastern Uruguay – Modelling and Reporting

2006 Air Dispersion Modelling Study for Natal Portland Cement (Pty) Ltd for the Proposed AFR Programme at the Simuma Plant, Port Shepstone – Modelling and Reporting

2007 Development of an air quality management strategy for particulate matter at the Bulk Terminal Saldanha - Project Leader and Reporting

2007 Air Quality and Human Health Specialist Study for the Proposed Coega Integrated LNG to Power Project (CIP) within the Coega Industrial Zone, Port Elizabeth, South Africa - Project Leader, Modelling and Reporting

2008 Dispersion Modelling for the Proposed Coega Aluminium Smelter (CAL) at Port Elizabeth - Project Leader, Modelling and Reporting

2008 Modelled and Measured Vertical Ozone Profiles over Southern Africa (as part of the Young Researcher Establishment Fund (2005-2008)) - Project Leader

2008 Air Quality Specialist Study for the Proposed N2 Wild Coast Toll Highway - Project Leader, Modelling and Reporting

2008 Initial Air Quality Impact Assessment for the Proposed Illovo Ethanol Plant in Mali, West Africa - Project Leader, Modelling and Reporting

2008 Modelling Mercury Stack Emissions from South African Coal-fired Power Power stations – Modelling and Reporting

2009 Air Quality Management Plan for the Western Cape Province – Baseline Assessment – Modelling

2009 Proposed Exxaro AlloyStream™ Manganese Project in the Coega Industrial Development Zone: Air Quality Impact Assessment – Modelling and Reporting

2009 Air Quality Specialist Study for the Kalagadi Manganese Smelter at Coega, Eastern Cape – Modelling and Reporting

2009 Qualitative Air Quality Impact Assessment for the Wearne Platkop Quarry – Modelling and Reporting

2009 Specialist Air Quality Study for the Vopak Terminal Durban Efficiency Project – Modelling

2009 Qualitative Air Quality Impact Assessment for the Proposed ETA STAR Coal Mine at Moatize, Mozambique – Modelling and Reporting

2009 Specialist Air Quality Study for the Kwadukuza Landfill Upgrade Project – Modelling and Reporting

2010 Ambient dust assessment at Saldanha Bay for the period October 2006 to September 2009 for Transnet Bulk Terminal Saldanha – Reporting

2010 Dust Impact Assessment for the Proposed Saldanha Bay Pilot PV plant – Reporting

2010 Modelling Particulate Emission Concentration Scenarios for Eskom's Kriel Power Station – Modelling and Reporting

2010 Air Quality Dispersion Modelling for MOZAL, Mozambique – Modelling and Reporting

2010 Air Quality Management Plan for the Highveld Priority Area – Air Quality Baseline Assessment for the Highveld Priority Area – Modelling

2010 Ambient Air Quality Modelling and Monitoring at Sappi, Mandeni – Modelling and Reporting

2010 Dust Impact Study at Idwala Carbonates – Modelling and Reporting

2010 Air quality specialist study for the EIA for the proposed re-commissioning of an existing coke oven battery at ArcelorMittal South Africa, Newcastle Works – Modelling

2010 Air quality specialist study for the proposed storage and utilisation of alternative fuels and resources at NPC-Cimpor's Simuma facility, Port Shepstone, KwaZulu-Natal – Modelling and Reporting

2010 Air quality status quo assessment and abatement planning at First Quantum Mining's Bwana Mkubwa and Kansanshi mines, Zambia – Modelling

2010 Air quality specialist study for the proposed briquetting plant at the Mafube Colliery – Modelling and Reporting

2011 Air quality modelling study for the Copeland reactor at Sappi Stanger – Modelling and Reporting

2011 Air quality modelling study for the Copeland reactor at Sappi Tugela – Modelling and Reporting

2011 Air quality monitoring and modelling study for the Copeland reactor at Mpact Paper, Piet Retief – Modelling and Reporting

2011 Air Quality Study for the Basic Environmental Assessment for the Proposed Biomass Co-Firing Facility at the Arnot Power Station – Modelling and Reporting

2011 Assessment of Scenarios for Developing and Implementing a Sulphur Dioxide Emissions Licensing Strategy for Hillside Aluminum – Modelling and Reporting

2011-12 Air quality assessment for the mining and processing facilities at Lonmin Platinum in Marikana – Modelling and Reporting

2012 Development of an Air Quality Management Plan for Anglo's Mafube Colliery in Mpumalanga – Modelling and Reporting

2012 Air quality assessment for the proposed manganese ore terminal at the Ngqura Port – Modelling and Reporting

2012 Air Quality Impact Assessment for NPC Cimpor – Modelling and Reporting

2013 Air Quality Impact Assessment for Proposed AfriSam Plant in Coega – Modelling

2013 Air quality assessment for the Orion Engineered Carbons Co-Gen Plant – Modelling

2013 Air quality assessment for the Orion Engineered Carbons - Main Boiler – Modelling

2013 Air quality assessment for the EIA for the Sekoko Coal Mine – Modelling and Reporting

2013 Air quality specialist study for the EIA for the Thabametsi IPP station – Modelling and Reporting

2013 Air quality specialist study for the EIA for the Mamathwane Common User facility – Modelling and Reporting

2013-14 Air quality specialist study for the application for postponement of the minimum emission standards for 16 Eskom power stations: Acacia, Arnot, Camden, Duvha, Grootvlei, Hendrina, Kendal, Komati, Kriel, Lethabo,

Majuba, Matimba, Matla, Madupi, Tutuka, Port Rex – Modelling and Reporting

2014 Air quality specialist study for the application for postponement of the minimum emission standards for the Engen Refinery in Merebank, Durban – Modelling and Reporting

2013-14 Baseline assessment and air quality management plan for the Waterberg-Bojanala Priority Area – Modelling

2013 Air Quality Specialist Study for the EIA for the Pandora Platinum Mine Joint Venture – Modelling and Reporting

2013 Air Quality Specialist Study for the EIA for the Proposed New Tailings Storage Facility (TD8) and Associated Infrastructure at Lonmin's Western Platinum Mine and Eastern Platinum Mine – Modelling and Reporting

2015 Waterberg-Bojanala Priority Area Air Quality Management Plan and Threat Assessment – Modelling

2015 Air Quality Management Plan for eThekwini Municipality – Modelling and Reporting

2015 Air Quality Management Plan for the uThungulu District Municipality – Modelling and Reporting

2015 Dispersion Modelling for Richards Bay Minerals – Modelling and Reporting

2015 Atmospheric Impact Report in support of Sancryl Chemicals's application for a verification to the existing AEL as a result of the introduction of Ethyl Acrylate and Vinyl Acetate, Prospecton – Modelling and Reporting

2016 Dispersion Modelling Study for the City of Johannesburg – Modelling and Reporting

2016 Air Quality Specialist Study for the Department of Energy's Emergency Power IPP Project at Richards Bay and Saldanha Bay – Modelling and Reporting

2016 Atmospheric Impact Report in support of the EIA for the Proposed Gas to Power Plant in Zone 1F of the Richards Bay IDZ – Modelling and Reporting

2016 Atmospheric Impact Report for the EIA for the proposed Tshivhaso Coal-fired Power Plant, Lephalale – Modelling and Reporting

2016 TNPA Air Quality Study – Dispersion Modelling for 8 Ports in South Africa: Port of Richards Bay, Durban, East London, Ngqura, Port Elizabeth, Mossel Bay, Cape Town and Saldanha Bay – Modelling and Reporting

2016 Atmospheric Impact Report for Durran's Calcination Plant – Modelling and Reporting

2016 Air Quality Assessment for the EIA for the Floating Power Plant in Nacala, Mozambique – Modelling and Reporting

2016 Ambient Air Quality Assessment for 2016 for Kansanshi Mining Plc – Modelling and Reporting

2016 Air Quality Impact Assessment for the EIA for the Proposed Hilli FLNG Project in Cameroon – Modelling and Reporting

2016 Kansanshi Smelter and TSF1 Modelling Scenarios for Kansanshi Mining Plc – Modelling and Reporting

2016 Air Quality Assessment the Proposed Accommodation Facility at the Venetia Mine in Limpopo – Modelling and Reporting

2016 Atmospheric Impact Report in support of the EIA for the Proposed Optimisation of the Process Plant at Nkomati Anthracite Mine – Modelling and Reporting

2017 Atmospheric Impact Report in support of the DRDAR Atmospheric Emission License (AEL) application for the proposed replacement and use of an incinerator at their State Veterinary Laboratories located in Grahamstown, Middelburg and Queesntown in the Eastern Cape – Modelling and Reporting

2017 Baseline Assessment and Review of the 2009 AQMP for Gauteng Province, including emission inventory development for all sectors, i.e. industrial, transport, waste management, biomass burning, residential fuel burning, and dispersion modelling – Modelling and Reporting

2017 Baseline Assessment and Air Quality Management Plan for Northern Cape Province – Modelling and Reporting

2017 Atmospheric Impact Report in support of Maloka Machaba Surfacing's application for an Atmospheric Emission License (AEL) for a proposed asphalt plant located in Polokwane – Modelling and Reporting

2017 Assessment of modelling scenarios involving an increase in the open area of the cone on the Common Stack for the pretreater, reformer and CHD furnaces at Engen Refinery – Modelling and Reporting

2017 Atmospheric Impact Report in support of the Atmospheric Emission License (AEL) application and stack-height assessment for the proposed Thabametsi Power Plant near Lephalale, Limpopo – Modelling and Reporting

2017 Dispersion Modelling Study for the Beeshoek Mine, near Postmasburg, Northern Cape – Modelling and Reporting

2018 Air quality assessment for the EIA for the proposed Bellmall Thermal Plant in Ekurhuleni – Modelling and Reporting

2018 Air quality assessment for the EIA for the proposed Simba Oil mini Refinery in Tororo, Uganda – Modelling and Reporting

2018-19 Air dispersion modelling for input to the Atmospheric Reports for the postponement application for 14 Eskom power stations – Modelling and Reporting

2019 Air quality impact assessment for the proposed NamPower expansion project in Walvis Bay – Modelling and Reporting

2019 Air quality assessment for the mine expansion project at the Akanani Mine – Modelling and Reporting

2019 Air quality impact assessment for the proposed power plant at Nacala, Mozambique – Modelling and Reporting

2019 Atmospheric Impact Report in Support of the Atmospheric Emission License (AEL) Amendment Application and Basic Assessment for Dow Southern Africa - New Germany – Modelling and Reporting

2019 Atmospheric Impact Report in support of Tau-Pele Construction's application for an Atmospheric Emission License (AEL) for a proposed emulsion and asphalt plant located in Indwe, Eastern Cape – Modelling and Reporting

2019 Atmospheric Impact Report in Support of the EIA for the Proposed Material Source and Processing Sites Along the N3 Between Durban and Hilton, KwaZulu-Natal: RCL1, RCL9 and Harrison's Quarry – Modelling and Reporting

2019 Atmospheric Impact Report in Support of the Atmospheric Emission License (AEL) Amendment Application and Basic Assessment for the Vopak Efficiency (Growth 4) Expansion Project, Durban, South Africa – Modelling and Reporting

2020 AIR for the KarpowershipSA proposal in the Ports of Ngqura, Richards Bay and Saldanha Bay – Modelling and Reporting
2020 AIR for the Coega Development Corporation gas-to-power project at 4 sites in the CDC – Modelling and Reporting
2020 AIRs for 10 Eskom coal-fired power power stations on the Highveld to support their postponement application – Modelling and Reporting
2020 AIR for the proposed Azura Power gas-to-power project in the Western Cape – Modelling and Reporting
2020 Atmospheric Impact Report for the proposed 315 MW LPG Power Plant at Saldanha Bay – Modelling and Reporting
2021 Air quality assessment for the proposed optimisation project at Beeshoek Iron Ore Mine, Postmasburg, Northern Cape – Modelling and Reporting
2021 Air quality assessment for the proposed expansion at Akanani Mine in Limpopo – Modelling and Reporting
2021 AIR for the proposed Frontier Power Gas-to-Power project at Saldanha Bay, Western Cape
2021 AIR for the 2021 shutdown and start-up at Engen Refinery in Merebank – Modelling and Reporting
2021 AIR for the proposed expansion of the Swartkops Ore handling facility in Port Elizabeth, Eastern Cape – Modelling and Reporting
2021 Atmospheric Impact Report in support of the Proposed 200 MW Engie CB Hybrid Power Project in the Coega Special Economic Zone (SEZ) – Modelling and Reporting
2021 Air Quality Impact Assessment for the proposed Mining of TSF-1 at the Stibium Mopani Mine near Gravelotte, Limpopo Province – Modelling and Reporting
2021 Addendum to the Atmospheric Impact Report in support of the proposed Mulilo-Total 200 MW Gas-fired Power Station, Coega Special Development Zone, Eastern Cape – Reporting
2021 Air Quality Assessment for the EIA for the Tete 1 400 MW Coal-Fired Power Plant, Tete Province, Mozambique – Modelling and Reporting
2021 Atmospheric Impact Report in support of Tugela Asphalt's application for an Atmospheric Emission License (AEL) for a proposed asphalt plant located in Mandini, KwaZulu-Natal – Modelling
2021 Atmospheric Impact Report for Nkomati Mine – Modelling and Reporting
2022 Emission Inventory for Lanxess for 2021 – Reporting
2022 Annual Report for Puregas: Atmospheric Emission License - Submission to the City of Ekurhuleni in compliance with the Atmospheric Emission Licence of the facility for the Reporting Period Year 2021 – Reporting
2022 Emission Inventory for Puregas for 2021 – Reporting
2022 Emission Inventory for Dow Advanced Materials for 2020 – Reporting
2022 Atmospheric Impact Report for the Engen Cape Town Terminal – Modelling and Reporting

PUBLICATIONS

Author and co-author of 5 articles in scientific journals and conference proceedings. Author and co-author of more than 200 technical reports for external contract clients. Presented 4 papers at local conferences. A full list of publications, conference papers and contract reports

is available on request.

NOPASIKA XULU



Firm	:	uMoya-NILU (Pty) Ltd
Profession	:	Senior Air Quality Consultant
Specialization	:	Air Quality Assessment, Air Dispersion Modelling; Project Management; Data Analysis; Report Writing and Reviews
Position in Firm	:	Senior Air Quality Consultant
Years with Firm	:	Since 27 March 2023
Nationality	:	South African
Year of Birth	:	1985
Language Proficiency	:	English and IsiZulu (read, write. Speak)

EDUCATION AND PROFESSIONAL STATUS

Qualification	Institution	Year
BSc. Environmental Studies	Univ. of Witwatersrand	2011
BSc Hons (Env. Studies)	Univ. of Witwatersrand	2012
BSc MSc (Env Sciences)	NWU Potchefstroom	2017

EMPLOYMENT AND EXPERIENCE RECORD

Period	Organisation details and responsibilities/roles
Oct 2016 – Dec 2018	Gondwana Environmental Solutions (Pty) Ltd: Air Quality Management Plans; Report Writing; Business Development and Marketing, Researcher,
July 2019 – March 2023	Rayten Engineering Solutions (Pty) Ltd: Air Quality Consultant, Project Management; Report Writing and Review; Data Analysis; Dispersion Modelling and Air Quality Impact Assessment; Research; Compiling Atmospheric Emission License (AEL) Applications; Populating National Atmospheric Emissions Inventory System; AEL Compliance Auditing; Dust Emission Reduction Plans; Greenhouse Gas Emissions Inventory Reporting; Facilitating/ Attending meetings; Liaising with Clients and Suppliers.

March 2023 – Present: uMoya – Nilu Consulting (Pty) Ltd Senior Air Quality Consultant, Dispersion Modelling and Air Quality Impact Assessments; Project Management

Key Project Experience:

2019 – 2023: Project Leader: Air Quality Impact Assessment projects (Harmony Moab Khotsong; EzeeTile Bloemfontein, EzeeTile Mokopane; Transvaal Galvanizers; Duho Drying; Lingaro Drying; Nama Copper Pty Ltd) Project Leader: AEL Applications and Reporting (Harmony Kopanang Operations;

Harmony Mponeng Operations; Sibanye Gold Mines; Sibanye Platinum Mines; TotalEnergies Marketing; Matt Cast Supplies CC; Independent Crematorium SA; City of Tshwane Crematorium; Buffalo City Municipality Crematorium; Wahl Industries; Transvaal Galvanizers)

2014 – 2017: Researcher: Air Quality Assessment in low-income residential areas in the Highveld

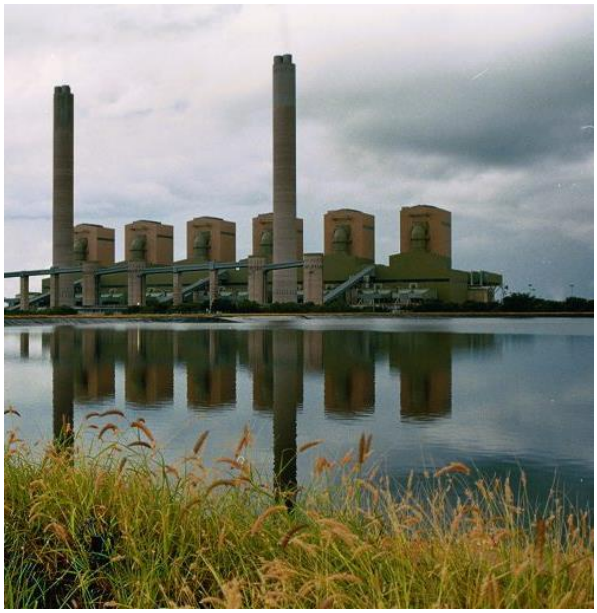
Publications: Author: Xulu, N.A., Piketh, S.J. Feig,G.T., Lack, D.A and Garland,R.M., (2020).Characterizing Light Absorbing Aerosols in a Low –Income Settlement in South Africa. Aerosol Air Quality Aerosol Air Quality Research. https://doi.org/10.4209/aaqr.2019.09.004

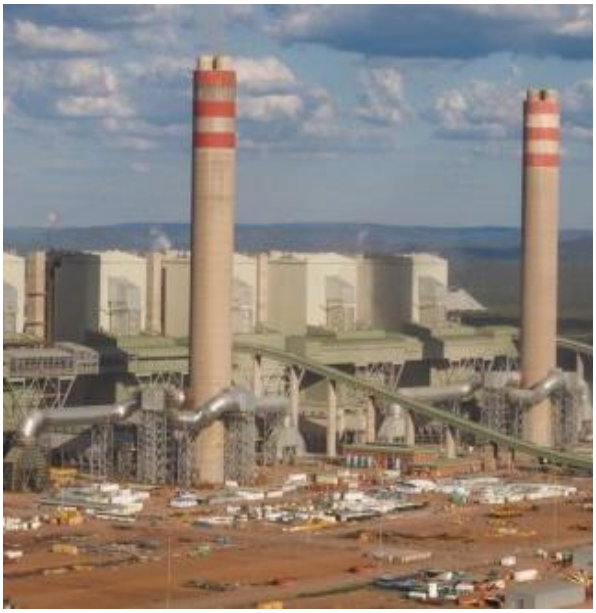
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ATMOSPHERIC IMPACT REPORT IN SUPPORT OF THE APPLICATION FOR EXEMPTION FROM THE MINIMUM EMISSION STANDARDS FOR ESKOM'S COAL-FIRED POWER STATIONS IN THE WATERBERG (A CUMULATIVE ASSESSMENT)





Final
4 November 2024

Report issued by:

uMoya-NILU Consulting (Pty) Ltd
P O Box 20622
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Report issued to:

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Report Details

Client:	WSP Group Africa (Pty) Ltd
Report title:	Atmospheric Impact Report in Support of the Application for Exemption from the Minimum Emission Standards for Eskom's Coal-Fired Power Stations in the Waterberg (A Cumulative Assessment)
Project:	uMN920-24
Report number:	uMN219-24
Version:	Final 4 November 2024
Prepared by:	uMoya-NILU Consulting (Pty) Ltd, P O Box 20622, Durban North 4016, South Africa
Authors:	Mark Zunckel, Atham Raghunandan and Nopasika Xulu

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Front page picture credit: https://www.eskom.co.za/eskom-divisions/gx/coal-fired-power-stations/

EXECUTIVE SUMMARY

Eskom operates a fleet of 14 coal-fired power stations, collectively generating more than 39 000 MW of electricity. The combustion of coal to generate steam for the generation of electricity is a Listed Activity in terms of the National Environmental Management: Air Quality Act (Act No. 39 of 2004). As such, Eskom holds Atmospheric Emission Licenses (AEL) for the respective power stations and is obligated to operate these power stations according to conditions specified in the respective AELs. Minimum Emission Standards (MES) for Listed Activities were published in 2010 (DEA, 2010) including compliance timeframes for existing and new plants had to comply with the MES for new plants by 30 April 2020.

Between 2018 and 2020, Eskom submitted applications to the Department of Forestry, Fisheries and the Environment (DFFE) based on an internally approved Emission Reduction Plan, which defined which power stations would have emission reduction technology installed and when. The National Air Quality Officer (NAQO) made decisions on these applications in 2019, which were not in favour of Eskom. Eskom appealed the NAQO's decision, and the Minister established the National Environmental Consultative and Advisory (NECA) Forum to advise her on the issue. The Minister ruled on the Eskom appeals on 22 May 2024 and granted the suspension of the Minimum Emission Standards (MES) at five (5) power stations on the Highveld up to 31 March 2030, namely Arnot, Camden, Grootvlei, Hendrina and Kriel. She further directed Eskom to submit an application in terms of Section 59 of the National Environmental Management: Air Quality Act for the exemption of the MES for eight (8) power stations that will continue to operate post 2030. These are Duvha, Kendal, Lethabo, Majuba, Matla and Tutuka on the Highveld and Medupi and Matimba in the Waterberg.

In terms the Minister's ruling Eskom Holdings SOC Ltd appointed WSP Group Africa (Pty) Ltd to prepare the necessary applications. WSP sub-contracted uMoya-NILU Consulting (Pty) Ltd to prepare the associated Atmospheric Impact Reports (AIRs) to support the applications. In response, AIRs have been prepared to support the exemption applications for the individual power stations. This AIR collectively assesses the two power stations in the Waterberg-Bojanala Priority Area, i.e. Medupi and Matimba, to provide further supporting information for the exemption applications. They are relatively close together in the Lephalale Local Municipality, just west of the town of Lephalale.

Eskom intends to systematically reduce emissions resulting from the fleet of coal-burning power stations. Three emission reduction trajectories from Eskom's financial ERP models are described here and illustrated in Figure E1 for NO_X, SO_2 and PM.

ERP 2024 A: Eskom continue as planned, which includes all PM and NOx abatement projects and FGD at Kusile – This is why ERP 2024 A = B = C for NOx & PM (only security of supply differs) – by the time Grootvlei, Kriel, Arnot, Hendrina, Camden, Duvha and Matla are shutdown, Eskom will be fully compliant with NO_X and PM MES through the fleet.

ERP 2024 B: 2024 A as above, but also FGD at Medupi, DSI at Majuba, and FGD at Kendal, hence the improvement from 2036 in SO_2 for ERP 2024 B. This is Eskom's middle-ground scenario; doing more than 2024 A, but not doing 2024 C.

ERP 2024 C: All of 2024 A and 2024 B above, but also FGD at Lethabo and Tutuka. Although this shows big improvement in SO_2 vs ERP 2024 B, this is a combination of Lethabo & Tutuka FGD, and actually probably more from shutdown of Duvha & Matla – station shutdowns have bigger impact on SO_2 reduction than FGD. When you look at the modelling results, ERP 2024 B already well within NAAQS (this is our model Scenario C), so enforcing ERP 2024 C not really justifiable, especially considering all the other negative impacts of FGD (age of Tutuka & Lethabo, costs, waste, water etc.).

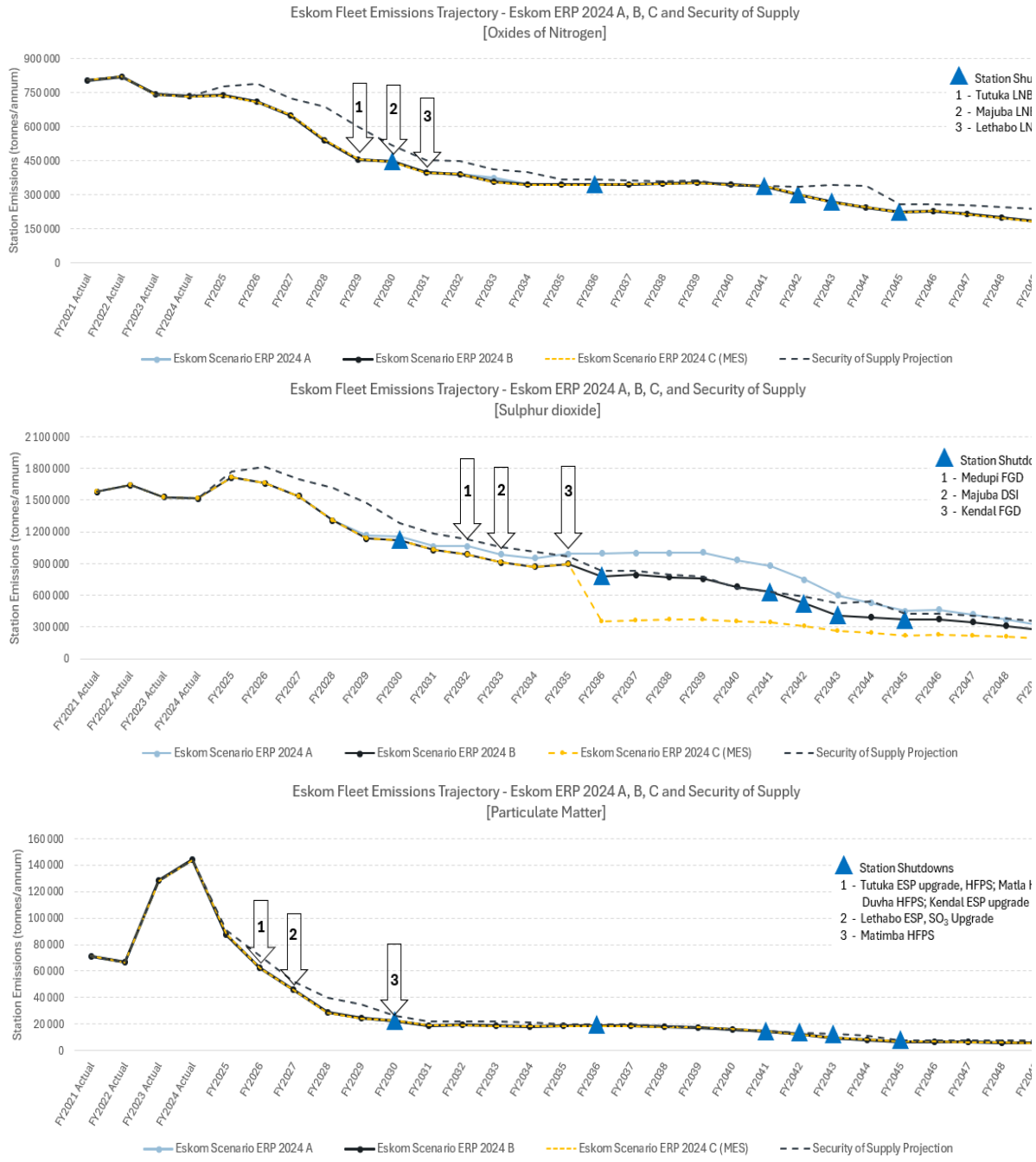
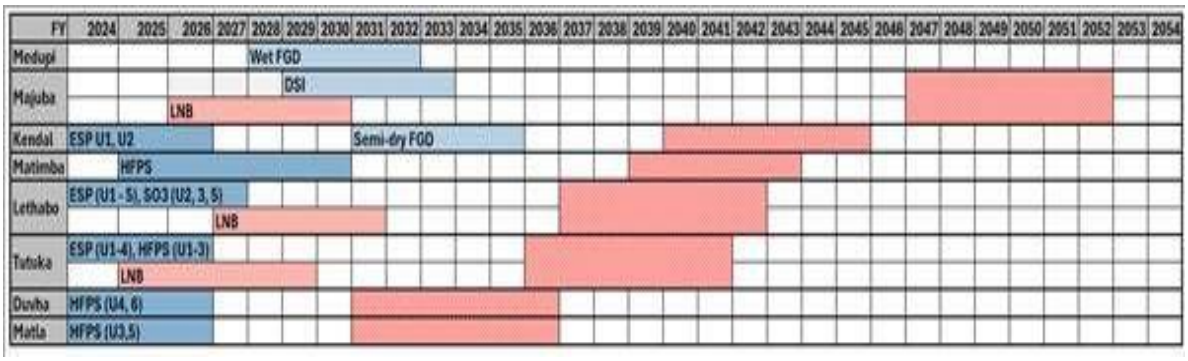


Figure E-1: Eskom's fleet emission trajectory NO_x (top), SO_2 (middle) and PM (bottom)

The proposed schedule for the installation of NO_X, PM and SO_2 emission reduction technologies and the shutdown schedule for power stations is shown in Figure E-2.



FGD: flue gas desulphurisation
DSI: Dry Sorbent Injection
LNB: low NO_X Burner
HFPS: high frequency power supply
ESP: Electrostatic precipitator
DHP: Dust Handling Plant
Station Shutdown

Figure E-2: Emission reduction installation schedule and the planned shutdown of power stations

This AIR for the Waterberg power stations collectively assesses Medupi and Matimba to provide supporting information for the exemption applications for the two individual power stations. In so do doing, 5 emission scenarios are assessed for the two power stations. These are:

Scenario 1 (Current): The baseline scenario using actual monthly stack emissions for 2021-2023 and fugitive emissions from the coal stockyards and the ash dumps (No FGD installed).

Scenario A (2025): Eskom's planned 2025 stack emissions, representing anticipated station performance between 2025 – 2030, including fugitive emissions from the coal stockyards and the ash dumps (No FGD installed).

Scenario B (2031): Eskom's planned 2031 stack emissions, representing anticipated station performance between 2031 – 2035, including fugitive emissions from the coal stockyards and the ash dumps (No FGD installed but load reduction).

Scenario C (2036): Eskom's planned 2036 stack emissions, representing anticipated station performance from 2036 onwards, including fugitive emissions from the coal stockyards and the ash dumps (FGD installed at Medupi).

Scenario D (MES): Full compliance with the MES, including fugitive emissions from the coal stockyards and the ash dumps (FGD installed at Medupi and Matimba).

The annual average SO_2, NO_X and PM emission rates in tonnes per annum and the equivalent emission concentrations in mg/Nm^3 for Medupi and Matimba for the five scenarios are presented in Table E-1.

Table E-1: Annual emissions from the Matimba and Medupi Power Stations and the corresponding emission concentrations

Scenario	Stack	Emission rate (tonnes/annum)			Emission concentration @ 10% O_2 and average load (mg/Nm^3)		
		NO_X	SO_2	PM	NO_x	SO_2	PM
		Medupi Power Station					
1[a]	Stack 1	25 577	123 502	1 314	257	1 343	13
	Stack 2	25 577	123 502	1 314	257	1 343	13
A	Stack 1	34 716	134 340	1 663	522	2 020	25
	Stack 2	34 716	134 340	1 663	522	2 020	25
B	Stack 1	20 770	80 374	1 273	522	2 020	32
	Stack 2	20 770	80 374	1 273	522	2 020	32
C	Stack 1	23 447	31 263	1 438	375	500	23
	Stack 2	23 447	31 263	1 438	375	500	23
D	Stack 1	23 447	31 263	1 438	375	500	23
	Stack 2	23 447	31 263	1 438	375	500	23
		Matimba Power Station					
1[a]	Stack 1	28 921	150 457	2 648	291	1 514	27
	Stack 2	28 921	150 457	2 648	291	1 514	27
A	Stack 1	28 346	150 830	1 820	545	2 900	35
	Stack 2	28 346	150 830	1 820	545	2 900	35
B	Stack 1	18 118	103 026	1 243	510	2 900	35
	Stack 2	18 118	103 026	1 243	510	2 900	35
C	Stack 1	20 872	112 752	1 432	510	2 755	35
	Stack 2	20 872	112 752	1 432	510	2 755	35
D	Stack 1	20 872	33 825	1 432	510	827	35
	Stack 2	20 872	33 825	1 432	510	827	35
MES					**750**	**1000**	**50**

(a): Average from actual monthly emissions

Fugitive emissions of particulates result from coal storage and handling, and from ashing activities at the power stations. The estimated annual PM_{10} emission rates are shown in Table E-2. These are assumed to be the same for all five scenarios.

Table E-2: Fugitive sources of PM_{10} at the Medupi and Matimba Power Stations

Power station	Source name	Emission (tonnes/year)
		PM_{10}
Medupi	Coal Yard	86.6
	Excess Coal Yard	30.4
	Ash Dump	1 951
Matimba	Coal Yard	22.7
	Ash Dump	6 066

The CALPUFF dispersion model is used to predict ambient concentrations of SO_2, NO_2, PM_{10} and $PM_{2.5}$ resulting from Medupi and Matimba operating together. The dispersion modelling simulates the stack emissions (PM, SO_2, NO_X) and fugitive emissions (PM) from the coal stock yard and the ash dump for the five scenarios. While the focus of the assessment is on the stack emissions, the inclusion of fugitive PM emissions provides a holistic understanding of the contribution of the two power stations to ambient PM_{10} and $PM_{2.5}$

concentrations. Modelling is done according to the modelling regulations and 3-years of hourly surface and upper air meteorological data is used.

The PM emissions from the stacks and fugitive sources are not speciated into PM_{10} and $PM_{2.5}$. Rather all PM emitted is assumed to be firstly PM_{10} in the modelling and assesses against the National Ambient Air Quality Standards (NAAQS) for PM_{10}. Secondly, all PM emitted is assumed to be $PM_{2.5}$ in the modelling and assesses against the NAAQS for $PM_{2.5}$. The predicted PM_{10} and $PM_{2.5}$ concentrations also include the formation of secondary particulates from SO_2 and NO_2 stack emissions. Together, this represents a worse-case environmental scenario for PM_{10} and $PM_{2.5}$. The stack emissions generally have an effect some distance from the source as they are released well above ground level and are buoyant. Fugitive emissions are released close to ground level and without any buoyancy they have an effect close to the source.

In the body of the report the predicted ambient SO_2, NO_2, PM_{10} and $PM_{2.5}$ concentrations are presented as isopleth maps over the modelling domain. The predicted concentrations at 51 identified receptor points in the study area are included Appendix 2 of this report. In this executive summary the maximum predicted annual SO_2, NO_2, PM_{10} and $PM_{2.5}$ concentrations and the 99th percentile concentration of the 24-hour and 1-hour predicted concentrations in the modelling domain are discussed below.

For SO_2, the predicted concentrations are attributed only to the stack emissions. The maximum predicted annual average concentrations for the 5 scenarios are low relative to the limit values of the respective NAAQS. The predicted the 99th percentile of the 24-hour SO_2 concentrations and the predicted 1-hour concentrations exceeded the limit value of the NAAQS in Scenario A (2025) Scenario B, (2031) and in Scenario C (2036). The predicted maximum SO_2 concentration occur within 15 km to the southwest of the two power stations. Noteworthy is the compliance with actual emissions in Scenario 1 (Current) and Scenario D (MES) which assumes that the MES are attained.

For NO_2, the predicted concentrations are attributed only to the stack emissions. The predicted maximum annual concentration and predicted 99th percentile of the 24-hour concentrations are low relative to the limit values of the respective NAAQS for the 5 scenarios. The predicted maximum NO_2 concentration also occur within 15 km to the southwest of the two power stations.

For PM_{10} and $PM_{2.5}$, the maximum predicted annual average concentrations exceed the limit values of the respective NAAQS in all scenarios. Similarly, the predicted 99th percentile of the 24-hour PM_{10} and $PM_{2.5}$ concentrations exceeds the limit value of the NAAQS. The predicted maximum PM_{10} and $PM_{2.5}$ concentrations occur within 10 km southwest of the two power stations.

The predicted ambient concentrations of SO_2 and NO_2 resulting from power station stack emissions are lower than the concentrations measured at the respective AQMS in the Waterberg. This is to be expected since AQMS are exposed to all sources of SO_2 and NO_2 while the model includes only the power station stack emissions. At the monitoring stations, the predicted and monitored SO_2 and NO_2 concentrations comply with the respective NAAQS.

For PM_{10} and $PM_{2.5}$ the predicted ambient concentrations result from the power station stack emissions and the fugitive low-level sources, i.e. the coal stock yard and the ash dumps at each power station. At the Marapong and Lephalale AQMS the modelled concentrations are considerably lower than the monitored concentrations. This is to be expected since AQMS are exposed to all sources of PM_{10} and $PM_{2.5}$. The difference between the predicted concentrations and the measured concentrations provides an indication of the contribution of other emission sources at the respective AQMS.

At the Medupi AQMS however the modelled PM_{10} and $PM_{2.5}$ concentrations are generally higher than the monitored concentrations, contrary to expectation as the AQMS is exposed to more sources. Noteworthy is the poor data recovery at the Medupi AQMS, especially in 2022 and 2023. In these years for PM_{10} it was only 56% and 62%, and for $PM_{2.5}$ it was 35% and 28%. Data is deemed acceptable if recovery is 90% or more. In this data of 50% or more was used, so the results need to be viewed with caution, otherwise that data was not used in averaging.

The predicted SO_2 and NO_2 concentrations are below the respective limit values of the NAAQS for all averaging period in all 5 emission scenarios at all sensitive receptors. Similarly, the predicted annual average PM_{10} and $PM_{2.5}$ concentrations are below the limit values of the NAAQS at all sensitive receptor points in all five scenarios.

Exceedance of the 24-hour limit value of the NAAQS for PM_{10} and $PM_{2.5}$ are predicted in all five scenarios at several of sensitive receptor points. For Scenario A (2025) the exceedances of the limit value for PM_{10} occur at most sensitive receptor points. For $PM_{2.5}$, the limit value of the NAAQS changes from 40 $\mu g/m^3$ to 25 $\mu g/m^3$ in 2030, resulting in an increase in the number of receptor points where the limit value is exceeded. The reader is reminded that PM is assumed to be $PM_{2.5}$ is compared to the stringent NAAQS for $PM_{2.5}$.

Noteworthy findings from the modelling results may be summarised as:

i) Ambient SO_2 and NO_2 concentrations are attributed to the stack emissions only, while ambient PM_{10} and $PM_{2.5}$ concentrations are attributed to the stack emissions and the low-level fugitive sources. The stack emissions generally have an effect some distance from the source, while low-level emissions have an effect close to the source.

ii) The predicted ambient concentrations are lower than the monitored concentrations for all pollutants at all AQMS, except at the Medupi AQMS where predicted and measured are higher in general. It is expected that measured concentrations will be higher than modelled since AQMS are exposed to all sources of the pollutants while the modelled concentrations result from power station emission only.

    The difference between the modelled concentrations and the measured concentrations are indicative of the contribution of other sources at the respective AQMS.

    The PM_{10} and $PM_{2.5}$ data recovery rate at the Medupi AQMS in 2022 and 2023 was poor so it is likely that the reported averages are unreliable.

iii) For Scenario 1 (Current):
    a. Predicted SO_2 and NO_2 concentrations comply with the NAAQS for all averaging periods throughout the modelling domain.

b. Predicted PM_{10} and $PM_{2.5}$ concentrations comply with the NAAQS, except close to the power stations where the limit value of the 24-hour NAAQS are exceeded as a result of the fugitive sources. Exceedances of the limit value for PM_{10} are predicted once at 2 sensitive receptor points respectively and thereof compliant with the NAAQS. For $PM_{2.5}$ exceedances of the limit value were predicted at 17 sensitive receptor points, at 10 of which the limit value was exceeded more than 12 times, hence non-compliant with the NAAQS.

iv) For Scenario A (2025):

a. Predicted annual and 1-hour SO_2 concentrations comply with the NAAQS throughout the modelling domain, but exceedances of the 24-hour limit value are predicted at 10 sensitive receptor points.
b. Predicted NO_2 concentrations comply with the NAAQS for all averaging periods throughout the modelling domain.
c. Predicted PM_{10} and $PM_{2.5}$ concentrations comply with the NAAQS, except close to the power stations where the limit value of the 24-hour NAAQS are exceeded as a result of the fugitive sources. Exceedances of the limit value for PM_{10} are predicted once at 5 sensitive receptor points respectively and thereof compliant with the NAAQS. For $PM_{2.5}$ exceedances of the limit value were predicted at 17 sensitive receptor points, at 10 of which the limit value was exceeded more than 12 times, hence non-compliant with the NAAQS.

v) For Scenario B (2031):

a. Predicted annual and 1-hour SO_2 concentrations comply with the NAAQS throughout the modelling domain, but exceedances of the 24-hour limit value are predicted at 10 sensitive receptor points.
b. Predicted NO_2 concentrations comply with the NAAQS for all averaging periods throughout the modelling domain.
c. Predicted PM_{10} and $PM_{2.5}$ concentrations comply with the NAAQS, except close to the power stations where the limit value of the 24-hour NAAQS are exceeded as a result of the fugitive sources. The number of predicted exceedances for PM_{10} decrease to 2, while the number of exceedances for $PM_{2.5}$ increase to 27 sensitive receptor points. The increase corresponds to the more stringent $PM_{2.5}$ limit value of 25 $\mu g/m^3$ which is implemented in 2030. At 14 of these points limit value was exceeded more than 12 times, hence non-compliant with the NAAQS.

vi) For Scenario C: (2036):

a. Predicted annual and 1-hour SO_2 concentrations comply with the NAAQS throughout the modelling domain, but exceedances of the 24-hour limit value are predicted at 9 sensitive receptor points.
b. Predicted NO_2 concentrations comply with the NAAQS for all averaging periods throughout the modelling domain.
c. Predicted PM_{10} and $PM_{2.5}$ concentrations comply with the NAAQS, except close to the power stations where the 24-hour limit value of the NAAQS for $PM_{2.5}$ are exceeded as a result of the fugitive sources. Exceedances of the limit value for $PM_{2.5}$ are predicted at 25 sensitive receptor points. At 14 of these points limit value was exceeded more than 12 times, hence non-compliant with the NAAQS.

vii) For Scenario D:

a. Predicted SO_2 and NO_2 concentrations comply with the NAAQS for all averaging periods throughout the modelling domain.

b. Predicted PM_{10} and $PM_{2.5}$ concentrations comply with the NAAQS, except close to the power stations where the 24-hour limit value of the NAAQS for $PM_{2.5}$ are exceeded as a result of the fugitive sources. Exceedances of the limit value for $PM_{2.5}$ are predicted at 25 sensitive receptor points. At 14 of these points limit value was exceeded more than 12 times, hence non-compliant with the NAAQS.

Given the conservative approach to the fugitive emission source simulations, and that this has provided an absolute worst-case emission scenario, and based on recommendations received from uMoya-Nilu, Eskom will be undertaking an additional modelling scenario, assessing only PM, SO_2, and NO_X stack emissions. NO_X and SO_2 emissions will be included in this scenario to ensure secondary particulate formation is accounted for. This will provide improved insight to impacts directly related to stack emissions, which are the focus of this exemption application.

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GLOSSARY OF TERMS AND ACRONYMS

AEL	Atmospheric Emission Licence
AIR	Atmospheric Impact Report
DEA	Department of Environmental Affairs
DFFE	Department of Forestry, Fisheries and the Environment
EIA	Environmental Impact Assessment
FGD	Flue-gas desulfurisation
g/s	Grams per second
kPa	Kilo Pascal
MES	Minimum Emission Standards
mg/Nm^3	Milligrams per normal cubic meter refers to emission concentration, i.e. mass per volume at normal temperature and pressure, defined as air at 20°C (293.15 K) and 1 atm (101.325 kPa)
NAAQS	National Ambient Air Quality Standards
NAQO	National Air Quality Officer
NECA	National Environmental Consultative and Advisory
NEM-AQA	National Environment Management: Air Quality Act, 2004 (Act No. 39 of 2004)
NEMA	National Environmental Management Act, 1998 (Act No. 107 of 1998)
USEPA	United States Environmental Protection Agency
µm	Micro meter (1 µm = 10^{-6} m)

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1. INTRODUCTION

Eskom operates a fleet of 14 coal-fired power stations in South Africa, collectively generating more than 39 000 MW of electricity. The combustion of coal to generate steam for the generation of electricity is a Listed Activity in terms of the National Environmental Management: Air Quality Act (Act No. 39 of 2004). Eskom holds Atmospheric Emission Licenses (AEL) for the respective power stations and is obligated to operate these power stations according to conditions specified in the respective AELs. Minimum Emission Standards (MES) for Listed Activities were published in 2010 (DEA, 2010) including compliance timeframes for existing and new plants. Existing activities had to comply with the MES for new plant by 30 April 2020.

Between 2018 and 2020, Eskom submitted applications to the Department of Forestry, Fisheries and the Environment (DFFE) based on an internally approved Emission Reduction Plan, which defined which power stations would have emission reduction technology installed and when. The National Air Quality Officer (NAQO) made decisions on these applications in 2019, which were not in favour of Eskom. Eskom appealed the NAQO's decision, and the Minister established the National Environmental Consultative and Advisory (NECA) Forum to advise her on the issue. The Minister ruled on the Eskom appeals on 22 May 2024 and granted the suspension of the Minimum Emission Standards (MES) at five (5) power stations on the Highveld up to 31 March 2030, namely Arnot, Camden, Grootvlei, Hendrina and Kriel. The Minister further directed Eskom to submit an application in terms of Section 59 of the National Environmental Management: Air Quality Act for the exemption of the MES for eight (8) power stations that will continue to operate post 2030. These are Duvha, Kendal, Lethabo, Majuba, Matla and Tutuka on the Highveld and Medupi and Matimba in the Waterberg.

In terms the Minister's ruling Eskom Holdings SOC Ltd appointed WSP Group Africa (Pty) Ltd to prepare the necessary applications. WSP Group Africa (Pty) Ltd sub-contracted uMoya-NILU Consulting (Pty) Ltd to prepare the associated Atmospheric Impact Reports (AIRs) (DEA, 2013a) to support the applications. While AIRs have been prepared to support the respective suspension and exemption applications for the individual power stations, this AIR collectively assesses the two coal-fired power stations in the in the Waterberg-Bojanala Priority Area, i.e. Medupi and Matimba. The intention of this cumulative AIR is to provide further supporting information for the exemption applications for the two individual power stations. Both Medupi and Matimba with valid AEL's (Table 1-1) with information regarding their respective AELs and proposed shutdown dates.

Table 1-1: AEL information

Power Station	Installed capacity	AEL	Dates	Shutdown date
Medupi	4 760 MW	H16/1/13-AEL/M1/R1	Expire: 01 Dec 2025	2071
Matimba	3 990MW	H16/1/13-WDM05	Expire: 27 Sept 2027	2043

2. ENTERPRISE DETAILS

2.1 Enterprise Details

Eskom enterprise details are summarised in Table 2-1.

Table 2-1: Enterprise information

Entity Name:	Eskom Holdings SOC Limited
Type of Enterprise, e.g. Company/Close Corporation/Trust, etc.:	State Owned Company
Company Registration Number:	2002/015527/30
Registered Address:	Megawatt Park, Maxwell Drive, Sunninghill, Sandton
Postal Address:	P. O. Box 1091, Johannesburg, 2000
Telephone Number (General):	+27 11 800 3861
Fax Number (General):	
Company Website:	www.eskom.co.za
Industry Type/Nature of Trade:	Electricity Generation
Land Use Zoning as per Town Planning Scheme:	Agricultural/Heavy industry
Land Use Rights if outside Town Planning Scheme:	Not applicable

2.2 Location and extent of the power stations

Medupi and Matimba are located in the Waterberg-Bojanala Priority Area, in the Waterberg District Municipality and are about 6 km apart, west-southwest and west and of the town of Lephalale respectively. Medupi is on the Farm Naauwontkomen about 16 km from Lephalale. Matimba is on the Farm Grootestryd about 13 km from Lephalale. Their relative location is illustrated in Figure 2-1.

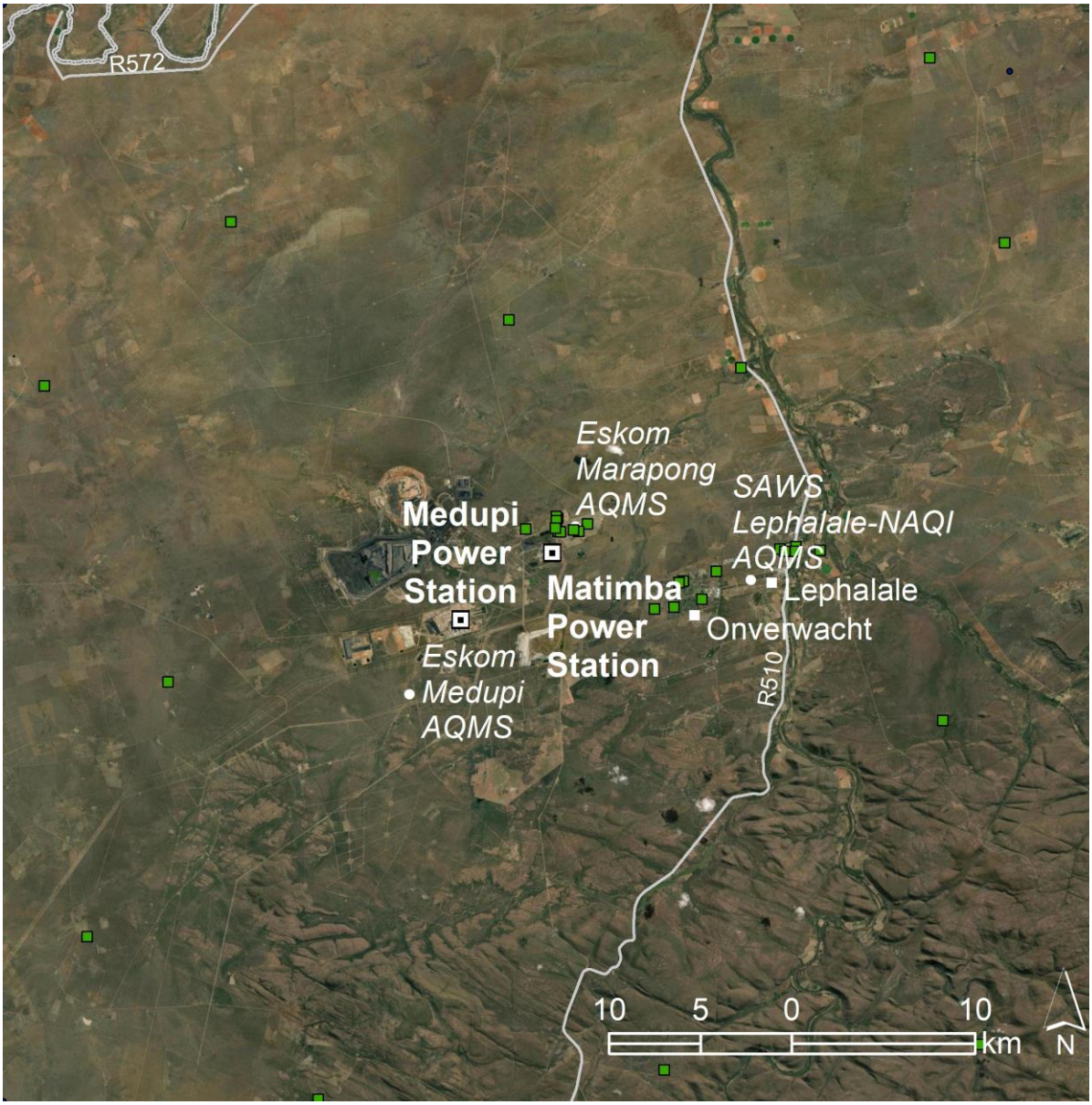


Figure 2-1: Relative location of the Medupi and Matimba coal-fired Power Stations in the modelling domain shown by white squares, with sensitive receptors shown by green squares

2.3 Description of surrounding land use

The Code of Practice for Air Dispersion Modelling in Air Quality Management in South Africa (DEA, 2014a) recommends the Land Use Procedure as sufficient for determining the urban/rural status of a modelling domain. The classification of the study area as urban or rural is based on the Auer method (Auer, 1978), as specified in the USEPA guideline on air dispersion models (USEPA, 2005). From the Auer's method, areas typically defined as rural include residences with grass lawns and trees, large estates, metropolitan parks and golf courses, agricultural areas, undeveloped land and water surfaces. An area is defined as urban if it has less than 35% vegetation coverage or it falls into one of the use types in Table 2-2.

Table 2-2: Land types, use and structures and vegetation cover

Type	Use and Structures	Vegetation
I1	Heavy industrial	Less than 5 %
I2	Light/moderate industrial	Less than 5 %
C1	Commercial	Less than 15 %
R2	Dense single / multi-family	Less than 30 %
R3	Multi-family, two-story	Less than 35 %

Generally the individual power stations are located in rural areas where the surrounding land use is primarily agriculture and includes coal mining. The surrounding land-use includes amongst others, urban areas with residential, commercial and recreational areas, industrial areas, agriculture, mining, forestry, undeveloped areas and conservation areas.

The US Environmental Protection Agency (USEPA, 2024) recognise Sensitive Receptors as areas which include, but are not limited to, hospitals, schools, daycare facilities, elderly housing and convalescent facilities or specialised healthcare facilities. These are areas where the occupants are more susceptible to the adverse effects of exposure to toxic chemicals, pesticides and other pollutants. The California Air Resources Board (CARB, 2024) identify Sensitive Receptors as children, elderly, asthmatics and others who are at a heightened risk of negative health outcomes due to exposure to air pollution.

The locations where these sensitive receptors congregate are considered sensitive receptor locations and therefore include hospitals, schools and day care centres, and other such locations. Three ambient air quality monitoring stations (AQMS) and 51 sensitive receptor points were identified within 30 km of Medupi and Matimba (Table 2-3).

Table 2-3: Sensitive receptors in the Waterberg

Receptor	UTMx	UTMy
Eskom Marapong AQMS - Monitoring Station	564.044	7383.715
Eskom Medupi AQMS - Monitoring Station	554.985	7374.552
SAWS Lephalale-NAQI AQMS - Monitoring Station	573.617	7380.786
Phegelelo Senior Secondary	563.060	7384.177
Contractors Village	561.293	7383.583
Ditheku Primary School	562.976	7384.275
Ditheko Primary School	564.691	7383.858
Marapong Training Centre	563.087	7383.465
Marapong Clinic	564.193	7383.463
Tielelo Secondary School	562.969	7384.035
Grootegeluk Medical Centre - Community Center	563.210	7383.420
Lephalale College	569.911	7380.730
Nelsonskop Primary School	563.913	7383.542
Hansie en Grietjie Pre-Primary School	569.673	7380.666
Sedibeng Special School for the Deaf and Disabilities	570.930	7379.738
Kings College	568.333	7379.207
Bosveld Primary School	569.400	7379.308
Lephalale Medical Hospital	562.938	7383.633
Ellisras Hospital	571.713	7381.272
Laerskool Ellisras Primary School	576.067	7382.619

Receptor	UTMx	UTMy
Hoerskool Ellisras Secondary School	575.189	7382.497
Marlothii Learning Academy	575.455	7382.359
Hardekool Akademie vir C.V.O	577.372	7382.411
Lephalale Clinic	576.044	7382.374
Ons Hoop	573.075	7392.408
Woudend	573.771	7422.152
Ramabara's	584.098	7373.114
Ga-Shongoane	608.321	7391.282
Bulge River	570.571	7332.998
Kaingo Mountain Lodge	582.064	7338.855
Community	557.518	7338.134
Kiesel	517.256	7348.639
Kremetartpan	537.357	7361.299
Mbala Private Camp	549.972	7352.418
Steenbokpan	541.767	7375.229
Receptor	535.001	7391.410
Sandbult	528.616	7377.834
Hardekraaltjie	526.176	7399.999
Receptor	560.399	7395.005
Receptor	545.208	7400.388
Receptor	559.690	7413.300
Receptor	583.382	7409.353
Receptor	587.468	7399.237
Ditaung	605.602	7401.960
Letlora	592.779	7416.528
Receptor	526.899	7365.394
Glenover	516.500	7360.781
Oxford Safaris	510.472	7376.086
Receptor	518.190	7387.978
Tholo Bush Estate	586.073	7355.406
Receptor	568.868	7354.021
Receptor	599.331	7360.083
Cheetah Safaris	537.952	7340.196
Rhinoland Safaris	607.228	7376.566

2.4 Atmospheric Emission License (AEL) and Other Authorisations

Medupi and Matimba have valid Atmospheric Emissions Licence (AEL) issued by the Waterberg District Municipality. The AEL numbers, issue dates and expiry dates are listed in Table 2-4. Both AELs concern three Listed Activities.

Table 2-4: Current authorisations related to air quality

Power Station	Atmospheric Emission License	Expiry Date	Listed Activity		Listed Activity Process Description
			Category	Sub-category	
Medupi	H16/1/13-AEL/M1/R1	01 Dec 2025	1	1.1	Solid Fuel Combustion Installations
Matimba	H16/1/13-WDM05	27 Sep 2027	2	2.4	Storage and Handling of Petroleum Products
			5	5.1	Storage and Handling of Ore and Coal

2.5 Modelling contractor

The dispersion modelling for this AIR is conducted by:

Company: uMoya-NILU Consulting (Pty) Ltd
Modellers: Dr Mark Zunckel, Atham Raghunandan, Nopasika Xulu
Contact details: Tel: 031 262 3265
Cell: 083 690 2728
email: mark@umoya-nilu.co.za
atham@umoya-nilu.co.za
nopasika@umoya-nilu.co.za

See Annexure 2 for abridged CV's

2.6 Terms of Reference

The terms of reference for this AIR are to assesses the cumulative effect of the two coal-fired power in the Waterberg (Medupi and Matimba) to provide support for the applications for the individual power stations. In so do doing, 5 emission scenarios are assessed for the two power stations. These scenarios are:

Scenario 1 (Current): The baseline scenario using actual monthly stack emissions for 2021-2023 and fugitive emissions from the coal stockyards and the ash dumps (No FGD installed).

Scenario A (2025): Eskom's planned 2025 stack emissions, representing anticipated station performance between 2025 – 2030, including fugitive emissions from the coal stockyards and the ash dumps (No FGD installed).

Scenario B (2031): Eskom's planned 2031 stack emissions, representing anticipated station performance between 2031 – 2035, including fugitive emissions from the coal stockyards and the ash dumps (No FGD installed but load reduction).

Scenario C (2036): Eskom's planned 2036 stack emissions, representing anticipated station performance from 2036 onwards, including fugitive emissions from the coal stockyards and the ash dumps (FGD installed at Medupi).

Scenario D (MES): Full compliance with the MES, including fugitive emissions from the coal stockyards and the ash dumps (FGD installed at Medupi and Matimba).

2.7 Assumptions

The following assumptions are relevant to this AIR:

a) No ambient monitoring is done in this assessment, rather available ambient air quality data is used.
b) The assessment of potential human health impacts is based on predicted (modelled) ambient concentrations of SO_2, NO_2, PM_{10} and $PM_{2.5}$ and the health-based National Ambient Air Quality Standards (NAAQS).
c) Emissions data used in this AIR have been provided by Eskom and are deemed to be accurate and representative of operating conditions in the respective scenarios.
d) The PM emissions are not speciated into PM_{10} and $PM_{2.5}$, rather all PM emitted is assumed to be PM_{10}, and all PM emitted is assumed to be $PM_{2.5}$. This represents a worse-case emission scenario for PM_{10} and $PM_{2.5}$.
e) Assumptions regarding emissions from the coal yards and ash dumps are included in Section 4.4

3. NATURE OF THE PROCESS

3.1 Listed Activity or Activities

As a measure to reduce emissions from industrial sources and to improve ambient air quality, Listed Activities and associated Minimum Emission Standards (MES) were initially published in 2010 in Government Notice 248 (DEA, 2010) with the most recent revision applicable in 2020 (Government Notice 421, DEA, 2020).

The Listed Activities relevant to all the coal-fired power stations are listed in Table 3-1.

Table 3-1: Details of the Listed Activity for coal-fired power stations according to GN 248 (DEA, 2010) and its revisions (DEA, 2013b, 2019 2020)

Category of Listed Activities	Sub-category of Listed Activity	Description of Listed Activity	Description and Application of the Listed Activity
1: Combustion Installations	1.1: Solid Fuel Combustion Installations	Solid fuels combustion installations used primarily for steam raising or electricity generation.	All installations with design capacity equal to or greater than 50 MW heat input per unit, based on the lower calorific value of the fuel used.
2: Petroleum Industry, the production of gaseous and liquid fuels as well as petrochemicals from crude oil, coal, gas or biomass	2.4: Storage and handling of petroleum products	Petroleum products storage tanks and product transfer facilities.	All permanent immobile liquid storage facilities at a single site with a combined storage capacity of greater than 1 000 cubic metres.
5: Mineral Processing, Storage and Handling	5.1: Storage and Handling of Ore and Coal	Storage and handling of ore and coal not situated on the premises of a mine or works as defined in the Mines Health and Safety Act 29/1996.	Locations designed to hold more than 100 000 tons.

3.2 Process Description

Eskom Holdings SOC Limited is a South African utility that generates, transmits and distributes electricity. The bulk of that electricity is generated by large coal-fired power stations that are situated close to the sources of coal. Medupi and Matimba are such power stations with a base load generation capacity of 4 584 MW and 3 990 MW, respectively.

The generic process is that coal is received at the power station's coal stockyard from nearby mines It is milled to pulverised fuel and fed to the boilers. Combustion of the coal in the boilers heats water to superheated steam, which drives the turbines. In turn, the turbines drive the generators which generate electricity. Medupi and Matimba each have six generation units.

Typical process units at a coal-fired power station are listed in Table 3-2.

Table 3-2: Unit processes at a coal-fired power station

Unit Process	Function of Unit Process	Batch or Continuous Process
Boiler Unit 1	Generation of electricity from coal	Continuous
Boiler Unit 2	Generation of electricity from coal	Continuous
Boiler Unit 3	Generation of electricity from coal	Continuous
Boiler Unit 4	Generation of electricity from coal	Continuous
Boiler Unit 5	Generation of electricity from coal	Continuous
Boiler Unit 6	Generation of electricity from coal	Continuous
Coal stockyard	Storage of coal	Continuous
Fuel oil storage tanks	Storage of fuel oil	Continuous
Ashing facility	Storage of ash	Continuous

3.3 Air pollutants resulting from the process

3.3.1 Air pollutants

Atmospheric emissions depend on the fuel composition and rate of consumption, boiler design and operation, and the efficacy of pollution control devices. Emissions from the boilers are emitted via two stacks and include sulphur dioxide (SO_2), oxides of nitrogen ($NO + NO_2 = NO_X$) and Particulate Matter (PM).

SO_2 is produced from the combustion of sulphur bound in coal. The stoichiometric ratio of SO_2 to sulphur dictates that 2 kg of SO_2 are produced from every kilogram of sulphur combusted. The coal used by the Matimba Power Station has a sulphur content (wt %) of less than 1 %. NO_X is produced from thermal fixation of atmospheric nitrogen in the combustion flame and from oxidation of nitrogen bound in the coal. The quantity of NO_X produced is directly proportional to the temperature of the flame.

The non-combustible portion of the fuel remains as solid waste. The coarser, heavier waste is called 'bottom ash' and is extracted from the boiler, and the lighter, finer portion is 'fly ash' and is usually suspended in the flue gas, and in the absence of any emission control would be emitted as PM through the stack. The coal used at Matimba has an ash content of between 30 and 40%.

3.3.2 National Ambient Air Quality Standards

National Ambient Air Quality Standards (NAAQS) (DEA, 2009, 2012) apply to the pollutants emitted by Medupi and Matimba. The NAAQS consists of a 'limit' value and a permitted frequency of exceedance. The limit value is the fixed concentration level aimed at reducing the harmful effects of a pollutant. The permitted frequency of exceedance represents the acceptable number of exceedances of the limit value expressed as the 99th percentile. Compliance with the ambient standard implies that the frequency of exceedance of the limit value does not exceed the permitted tolerance. The NAAQS for SO_2, NO_2, PM_{10} and $PM_{2.5}$ are presented in Table 3-3.

Table 3-3: NAAQS for pollutants relevant to Medupi and Matimba

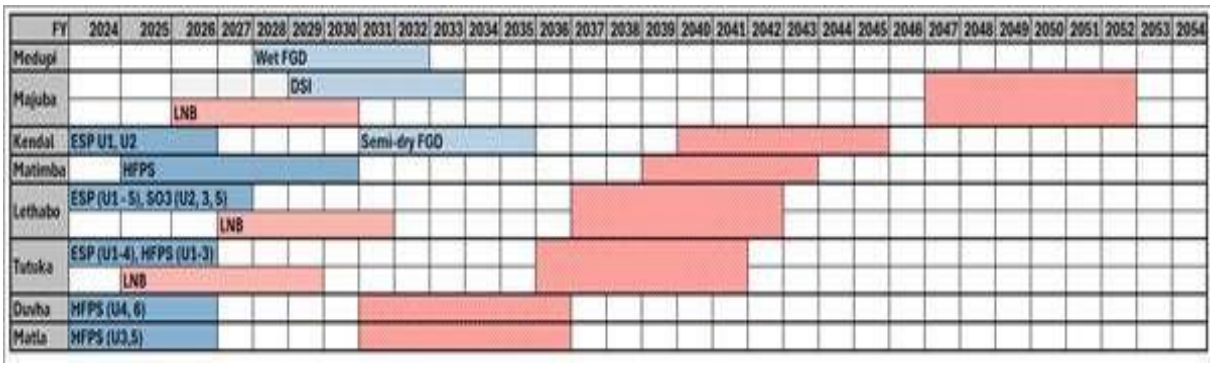
Pollutant	Averaging period	Limit value (µg/m^3)	Tolerance
SO_2	1 hour	350	88
	24 hour	125	4
	1 year	50	0
NO_2	1 hour	200	88
	1 year	40	0
PM_{10}	24 hour	75	4
	1 year	40	0
$PM_{2.5}$	24 hour	40 (25[a])	4
	1 year	20 (15 [a])	0

[(a)]: Applicable from 01 January 2030

4. ATMOSPHERIC EMISSIONS

4.1 Point Source Emission Rates (Emission scenarios)

Eskom intends to systematically reduce emissions resulting from the fleet of coal-burning power stations. This includes the systematic introduction of emission reduction technologies, and the shutdown of power stations by 2045. The proposed schedule to 2050 for the installation of NO_X, PM and SO_2 emission reduction technologies and the shutdown schedule for power stations is shown in Figure 4-1. The key planned intervention for Medupi is the installation of wet-FGD.



FGD: flue gas desulphurisation

DSI: Dry Sorbent Injection

LNB: low NO_X Burner

HFPS: high frequency power supply

ESP: Electrostatic precipitator

DHP: Dust Handling Plant

Station Shutdown

Figure 4-1: Emission reduction installation schedule and the planned shutdown of power stations

Shutdown of Matimba is planned from 2039 to 2043, while Medupi will remain operational until at least 2071. The total NO_X, SO_2 and PM emission resulting from operational coal-fired power stations at selected milestones from current emissions to 2050 are compared in Table 4-1.

Table 4-1: Total NO_X, SO_2 and PM emissions in tonnes from all operational fleet of coal-fired power stations at selected milestones

Years	NO_X	SO_2	PM
2025	108 743	570 139	6 924
2031	77 663	355 778	4 916
2036	89 267	289 280	5 650
2045	61 177	80 949	3 671
2050	61 889	83 753	3 714

Three emission reduction trajectories from Eskom's financial ERP models are described here and illustrated in Figure 4-2 to Figure 4-4 for NOx, SO_2 and PM:

ERP 2024 A: Eskom continue as planned, which includes all PM and NOx abatement projects and FGD at Kusile – This is why ERP 2024 A = B = C for NOx & PM (only security of supply differs) – by the time Grootvlei, Kriel, Arnot, Hendrina, Camden, Duvha and Matla are shutdown, Eskom will be fully compliant with NO_X and PM MES through the fleet.

ERP 2024 B: 2024 A as above, but also FGD at Medupi, DSI at Majuba, and FGD at Kendal, hence the improvement from 2036 in SO_2 for ERP 2024 B. This is Eskom's middle-ground scenario; doing more than 2024 A, but not doing 2024 C.

ERP 2024 C: All of 2024 A and 2024 B above, but also FGD at Lethabo and Tutuka. Although this shows big improvement in SO_2 vs ERP 2024 B, this is a combination of Lethabo & Tutuka FGD, and actually probably more from shutdown of Duvha & Matla – station shutdowns have bigger impact on SO_2 reduction than FGD. When you look at the modelling results, ERP 2024 B already well within NAAQS (this is our model Scenario C), so enforcing ERP 2024 C not really justifiable, especially considering all the other negative impacts of FGD (age of Tutuka & Lethabo, costs, waste, water etc.).

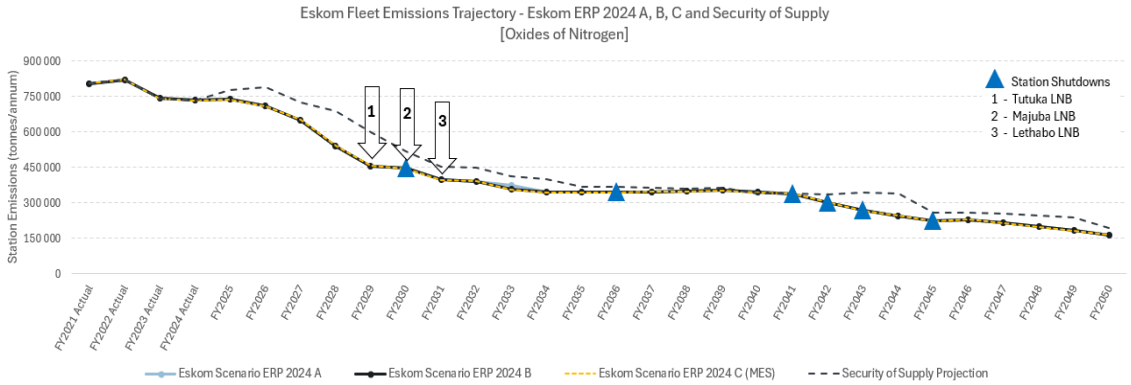


Figure 4-2: Eskom's fleet emission trajectory for NO_X

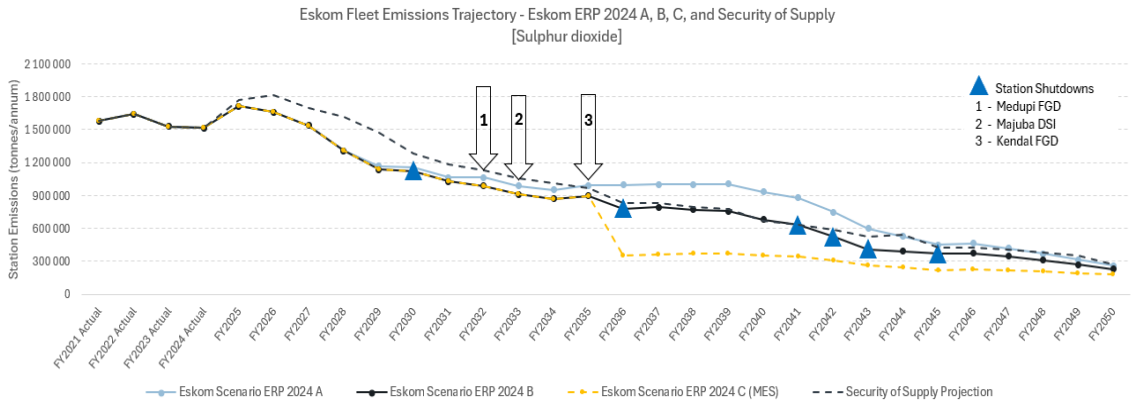


Figure 4-3: Eskom's fleet emission trajectory for SO_2

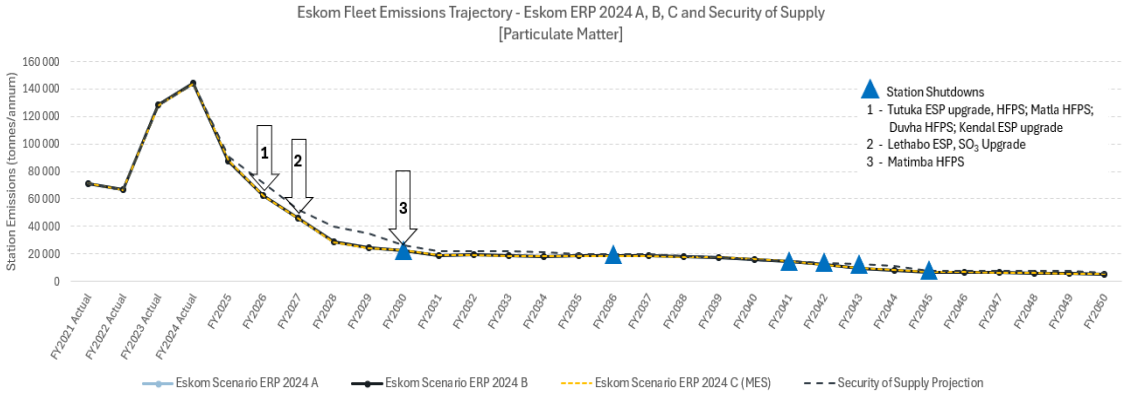


Figure 4-4: Eskom's fleet emission trajectory for PM

4.2 Point Source Parameters

Stack parameters for the individual power stations are not provided here, but are included in the respective AIRs (uMoya-NILU, 2024a, uMoya-NILU, 2024b).

The estimated emission rates and equivalent emission concentrations that are used in the dispersion modelling for the two stacks are shown in Table 4-2. The maximum anticipated emissions during each period are used for simulation in the model. The boiler units are assumed to operate continuously, i.e. 24 hours a day. Since each future scenario is a snapshot of period of operation (e.g. Scenario A = 2025 to 2030), the maximum anticipated emissions during that period, in a single year was selected for simulation in the model.

Table 4-2: Annual emissions from the Matimba and Medupi Power Stations and the corresponding emission concentrations

Scenario	Stack	Emission rate (tonnes/annum)			Emission concentration @ 10% O_2 and average load (mg/Nm^3)		
		NO_x	SO_2	PM	NO_x	SO_2	PM
		Medupi Power Station					
1[a]	Stack 1	25 577	123 502	1 314	257	1 343	13
	Stack 2	25 577	123 502	1 314	257	1 343	13
A	Stack 1	34 716	134 340	1 663	522	2 020	25
	Stack 2	34 716	134 340	1 663	522	2 020	25
B	Stack 1	20 770	80 374	1 273	522	2 020	32
	Stack 2	20 770	80 374	1 273	522	2 020	32
C	Stack 1	23 447	31 263	1 438	375	500	23
	Stack 2	23 447	31 263	1 438	375	500	23
D	Stack 1	23 447	31 263	1 438	375	500	23
	Stack 2	23 447	31 263	1 438	375	500	23
		Matimba Power Station					
1[a]	Stack 1	28 921	150 457	2 648	291	1 514	27
	Stack 2	28 921	150 457	2 648	291	1 514	27
A	Stack 1	28 346	150 830	1 820	545	2 900	35
	Stack 2	28 346	150 830	1 820	545	2 900	35
B	Stack 1	18 118	103 026	1 243	510	2 900	35
	Stack 2	18 118	103 026	1 243	510	2 900	35
C	Stack 1	20 872	112 752	1 432	510	2 755	35
	Stack 2	20 872	112 752	1 432	510	2 755	35
D	Stack 1	20 872	33 825	1 432	510	827	35
	Stack 2	20 872	33 825	1 432	510	827	35
MES					**750**	**1000**	**50**

(a): Average from actual monthly emissions

4.3 Point Source Maximum Emission Rates (Start Up, Shut-Down, Upset and Maintenance Conditions)

All power stations are required to conduct continuous emission measurements. Emissions include maximum emissions during start-up, shut-down, maintenance or upset conditions are accounted for in the actual monthly emissions used in Scenario 1 (Current) in this assessment.

4.4 Fugitive Emissions

The methodology to estimate emission rates of particulates from the coal stockyard and ash dumping activities for the power stations is described in this section.

A general equation for emission estimation is: E = A x EF x (1-ER/100)

where: E = emissions;
A = activity rate;
EF = emission factor; and
ER = overall emission reduction efficiency (%)

An emission factor is a representative value that relates the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of the pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant (e.g., kg of particulate emitted per tonne of coal crushed). Such factors facilitate estimation of emissions from various sources of air pollution. In most cases, these factors are simply averages of all available data of acceptable quality and are generally assumed to be representative of long-term averages for all facilities in the source category (USEPA, 2024b).

The emission factors used for the calculation of particulates in this study are the most recent factors published in the United States Environmental Protection Agency (US EPA), AP 42, Fifth Edition, Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources, Chapter 13: Section 13.2.4 Aggregate Handling and Storage Piles; Section 13.2.5 Industrial Wind Erosion; (USEPA, 2024b).

Wind entrainment of dust and PM_{10} from the coal stockpile and ash dump is a function of the physical size of the facility and the nature of the exposed surface, i.e. the moisture content, silt content, amount of vegetation cover, size of the particles on the surface and wind speed. Characteristics of the coal stockpile and ash dump at the power station is shown in Table 4-3.

As a mitigation measure, water is sprayed onto the coal stockpiles occasionally to reduce dust generation. In this assessment, the coal stockpile is assessed under worst case conditions (e.g. drought conditions), where it is assumed that no water will be sprayed onto the coal stockpile and 100% of the area is exposed to wind erosion.

The ash dump, by nature, is generally in a damp state depending on rainfall conditions, and if the ash is pumped onto the ash dump in a fluid state or trucked in. Rising green walls will provide vegetation cover on the sides and it is expected that most of the ash dump area exposed at the top will include a wet beach area. These initiatives, together with occasional wetting will reduce the amount of dust entrainment from the ash dump.

In this assessment, the ash dumps are modelled under worst case conditions (e.g. drought conditions), where it is assumed that it is mostly dry and 80% of the surface area is exposed to wind erosion, providing a worst-case (environmentally conservative) scenario. The annual emission rates for the coal stockpiles and ash dumps are shown in Table 4-4.

Table 4-3: Characteristics of the coal stockpile and ash dumps at the Medupi and Matimba Power Stations

	Medupi Power Station			Matimba Power Station	
Parameter	**Coal stockpile**	**Excess Coal stockpile**	**Ash dump**	**Coal stockpile**	**Ash dump**
Quantity of material stored (tonnes/year)	2 814 200	14 420 972	19 290 207	1 999 239	3 966 084
Moisture content (%)	4.5	4.5	27	4.5	27
Silt content (%)	2.2	2.2	80	2.2	80
Exposed surface area (m^2)	379 867	1 042 153	698 447	283 538	2 172 869
Height (m)	20	30.7	46.44	18	64
Dry area (%)	100	100	80	100	80
Dust abatement method	Wetting - Water	Wetting - Water	Spraying of dust using water during operation, top soil and vegetation coverage at incremental heights	Wetting - Water	Spraying of dust using water during operation, top soil and vegetation coverage at incremental heights
Material transfer method and ashing system	Conveyors (front end loaders in case of emergency)	Conveyors (front end loaders in case of emergency)	Dry (delivered by truck)	Conveyors (front end loaders in case of emergency)	Dry (delivered by trucks)

Table 4-4: Fugitive sources of PM_{10} at the Medupi and Matimba Power Stations

Power station	**Source name**	**Emission (tonnes/year)**
		PM_{10}
Medupi	Coal Yard	86.6
	Excess Coal Yard	30.4
	Ash Dump	1 951
Matimba	Coal Yard	22.7
	Ash Dump	6 066

5. BASELINE CONDITIONS

The description of the baseline conditions of the area provides an understanding on the receiving atmospheric environment so that changes as a result of the application for exemption of the MES can be assessed. The baseline description therefore includes an overview of the climatology and meteorology of the area, and an assessment of ambient air quality over the last three years measured at monitoring stations in the area. Other sources of air pollution in the area are also discussed.

5.1 Climate and meteorology

5.1.1 Temperature and rainfall

The climate of a given location is affected by its latitude, terrain and altitude, as well as nearby water bodies and their currents. Climates are classified according to the average and the typical ranges of different variables, most commonly temperature and precipitation.

The Waterberg experiences a hot semi-arid (BSh) climate according to the Köppen Climate Classification. Summer days are generally hot with maximum temperatures often exceeding 31 °C, and summer nights are mild. Winter days are mild and nights are cold. The average daily temperatures at Lephalale are illustrated in Figure 5-1. The area receives an average of 383 mm of rainfall annually, with nearly 90% of the rainfall occurring in the summer months between October and March (Figure 5-1). Rainfall seldom occurs in winter.

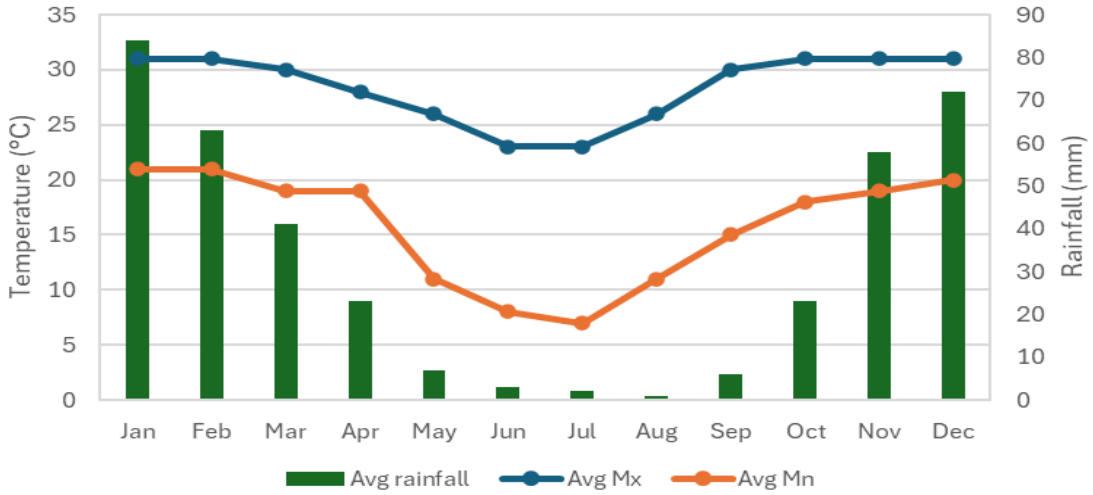


Figure 5-1: Average monthly maximum and minimum temperatures and average monthly rainfall at Lephalale (https://www.meteoblue.com/en/weather/historyclimate/climatemodelled/lephalale_south-africa_7730334)

5.1.2 Wind

Windroses illustrate the frequency of hourly wind from the 16 cardinal wind directions, with wind indicated from the direction it blows, i.e. easterly winds blow from the east. It also illustrates the frequency of average hourly wind speed in six wind speed classes.

The annual windrose at Marapong is presented in Figure 5-2 for the 3-year period, 2021 to 2023. At Medupi the wind is generally light with wind speeds seldom reaching more than 6 m/s (Figure 5-2). The wind is almost exclusively from the sector northeast to easterly, except in the winter when they tend to the east-southeast (Figure 5-3). A high frequency of calm winds occur (nearly 24 %).

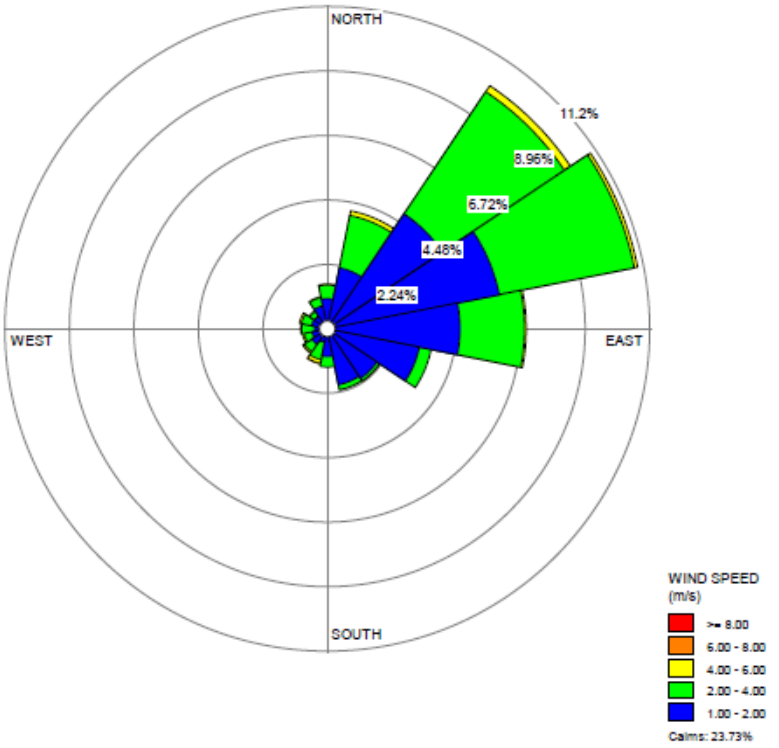


Figure 5-2: Annual windrose at the Marapong AQMS

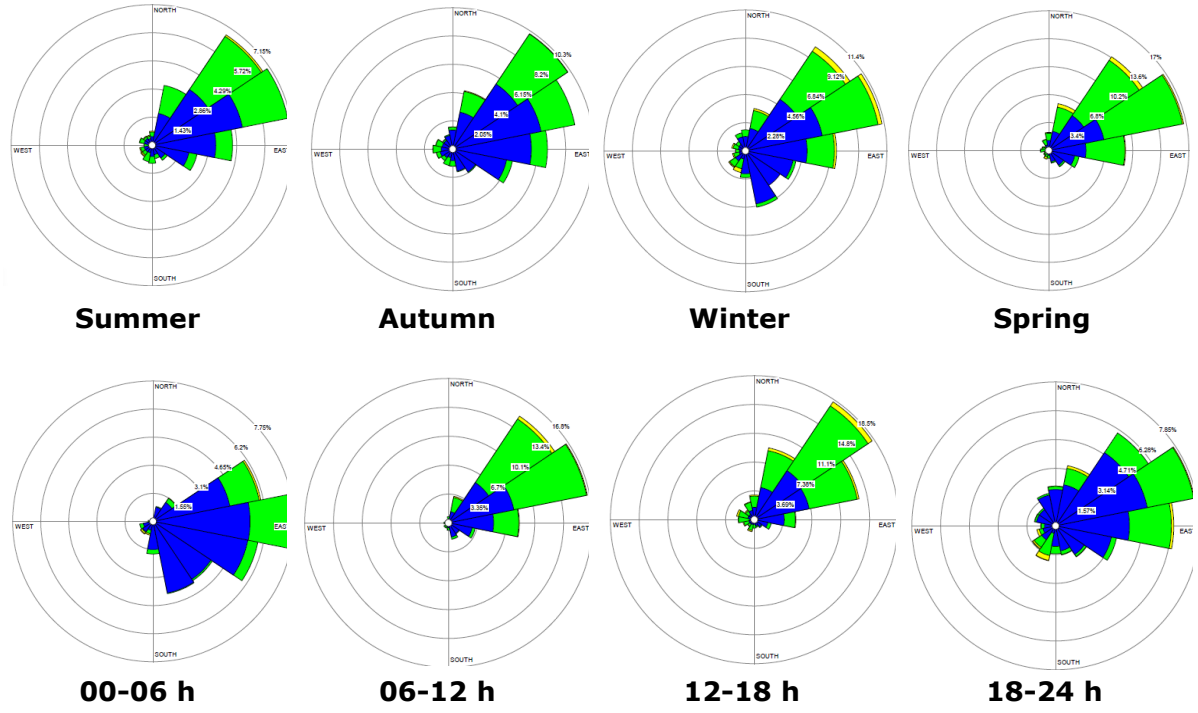


Figure 5-3: Seasonal (top) and diurnal (bottom) windroses at the Marapong AQMS

5.1.3 Air Pollution Dispersion Potential

The air pollution dispersion of an area refers to the ability of atmospheric processes, or meteorological mechanisms, to disperse and remove pollutants from the atmosphere. Dispersion comprises both vertical and horizontal components of motion. The vertical component is defined by the stability of the atmosphere and the depth of the surface mixing layer. The horizontal dispersion of pollution in the boundary layer is primarily a function of the wind field and atmospheric stability. The wind speed determines the rate of downwind transport and wind direction and the variability in wind direction determines the general path of the pollutant. Atmospheric stability, or instability, determines the ability of the atmosphere to mix and dilute pollutants. Stability is a function of solar radiation (thermal turbulence) and wind speed and surface roughness, which induce mechanical turbulence. The dispersion potential of an area therefore experiences diurnal and seasonal changes.

By day, with strong insolation (in-coming solar radiation) and stronger winds, the dispersion potential is generally efficient through vertical dilution and horizontal dispersion. The dispersion potential is generally better on summer days than winter days. At night, as the surface temperature inversion develops, the lowest layer of the atmosphere becomes more stable, reaching a maximum at sunrise. As a result, the dispersion potential typically becomes less efficient during the night and the poorest conditions generally occur at sunrise. Thermal turbulence disappears when the sun sets, and mechanical turbulence decreases as the wind speeds drops at night. Pollutants tend to accumulate near the point of release under these conditions, particularly if these are released close to ground level. The dispersion potential is generally poorer on winter nights than summer nights.

In the Matimba study area the dispersion potential is expected to be relatively good during the day in summer and winter as a result of daytime temperatures and a relatively high frequency of moderate winds. Summer rainfall is an important removal mechanism for air pollutants. Night-time surface temperature inversions are prevalent in winter and tend to trap pollutants that are released at or near ground level. Generally, there is better air pollution dispersion in summer when air pollutants disperse easily, compared with winter when pollutants can accumulate in stable night-time conditions. The tall power station stacks together with hot buoyant emissions ensure that pollutants are released above the surface inversion.

5.2 Ambient air quality

Agricultural and mining activities, as well as residential areas, are the key land use activities surrounding Medupi and Matimba. There are three relatively large residential areas, namely Marapong, Onverwacht and Lephalale. Marapong arcs from the north-northeast to the east-northeast and is less than 1 km from Matimba Power Station and 8 km northeast of Medupi. Lephalale is 18 km to the east of Medupi and between them is the Onverwacht residential area, 13 km from Medupi. The Matimba Power Station (industry) is 6 km northeast of Medupi and the Grootegeluk Coal Mine (mining) is 4 km north-northwest of Medupi.

Three ambient air quality monitoring stations (AQMS) are located relatively close to Medupi and Matimba. These are the Eskom Marapong AQMS (Maragpong AQMS) which is 2.2 km northeast of Medupi, Eskom Medupi AQMS (Medupi AQMS) which is 10.6 km southwest of Medupi, and the South African Weather Service (SAWS) Lephalale AQMS (Lephalale AQMS) which is 11.3 km east-southeast of Medupi.

Ambient air quality at the three AQMS will be influenced by local (nearby) sources, but ambient concentrations measured at these AQMS will also be influenced by emissions from the two power stations. Local sources of air pollution near the three AQMS include agricultural activities, domestic fuel and waste burning, vehicle emissions, mining and power generation. The Exxarro Grootegeluk Mine and Afrimat Kuipesbult Quarry are significant mining activities.

Pollutant concentrations measured at the three AQMS for 2021 to 2023 are presented here and are referenced against the respective NAAQS (Table 3-3).

5.2.1 Data recovery

Data recovery for the Marapong AQMS was relatively low for all pollutants for all years and below the minimum requirement of 90% as stipulated by the SANAS TR 07-03 (SANAS, 2012). Data recovery for SO_2 (2021), NO_2 (2021 and 2022), PM_{10} (2021) and $PM_{2.5}$ (2021 and 2022) was between 50% and 89.9%. These data are included in this discussion but must be viewed with caution.

Data recovery for the Medupi AQMS was above 90% for SO_2 (2021), NO_2 (2022), PM_{10} (2021) and $PM_{2.5}$ (2021), meeting the minimum requirement of 90% (SANAS, 2012). Data recovery for SO_2 (2022 and 2023), NO_2 (2021 and 2023) and PM_{10} (2022 and 2023) was between 50% and 89.9%, which is below the minimum requirement. These data are included in this discussion but must be viewed with caution.

Data recovery for the Lephalale AQMS was above 90% for SO_2 (2021), however data recovery for SO_2 (2022 and 2023), NO_2 (2021 to 2023), PM_{10} (2021 and 2023) and $PM_{2.5}$ (2023) was between 50% and 89.9%. These data are included in this discussion but must be viewed with caution.

Pollutants with a data recovery below 50% in a single year were not considered in this baseline discussion. These are highlighted in bold in Table 5-1.

Table 5-1: Data recovery at the Marapong, Medupi and Lephalale AQMSs from 2021 to 2023

Year	Data recovery (%)			
	SO_2	**NO_2**	**PM_{10}**	**$PM_{2.5}$**
Marapong AQMS				
2021	59.5	50.4	71.9	67.6
2022	**38.9**	59.4	**43.9**	59.8
2023	**0**	**0**	**0**	**0**
Medupi AQMS				
2021	97.9	86.6	93.2	96.5
2022	75.2	90.4	56.5	**35.4**
2023	71.5	80.1	62.1	**27.8**
Lephalale AQMS				
2021	96.1	64.1	51.4	**48.9**
2022	73.2	71.0	**34.2**	**29.0**
2023	58.0	74.9	59.6	57.7
Note:	Data recovery for the Marapong and Medupi AQMSs are based on 10-minute average data, while the Lephalale AQMS is based on 1-hour average data.			

5.2.2 Sulphur Dioxide (SO_2)

Marapong AQMS

- The 10-min average (Figure 5-4) SO_2 concentrations exceeded the 10-min (500 µg/m³) NAAQS in 2021 (23 times), however remaining compliant as 526 exceedances of 10-min NAAQS are permitted per calendar year.
- The 1-hour average (Figure 5-5) SO_2 concentrations exceeded the 1-hour (350 µg/m³) NAAQS in 2021 (sixteen times), thus compliant with the respective NAAQS as 88 exceedances of the 1-hour NAAQS are permitted per calendar year.
- The 24-hour average (Figure 5-6) SO_2 concentrations exceeded the 24-hour (125 µg/m³) NAAQS in 2021 (one time), thus compliant with the respective NAAQS as four exceedances of the 24-hour NAAQS are permitted per calendar year.
- The annual average SO_2 concentrations for 2021 (13.9 µg/m³) remained below the annual average NAAQS (50 µg/m³), thus compliant with the respective NAAQS.

Medupi AQMS

- The 10-min average (Figure 5-4) SO_2 concentrations exceeded the 10-min (500 µg/m³) NAAQS in 2021 (34 times), 2022 (75 times) and 2023 (53 times), thus compliant with the respective NAAQS as 526 exceedances of 10-min NAAQS are permitted per calendar year.
- The 1-hour average Figure 5-5) SO_2 concentrations exceeded the 1-hour (350 µg/m³) NAAQS in 2021 (eighteen times), 2022 (27 times) and 2023 (21 times), thus compliant

with the respective NAAQS as 88 exceedances of the 1-hour NAAQS are permitted per calendar year.

- The 24-hour average (Figure 5-6) SO_2 concentrations exceeded the 24-hour (125 µg/m³) NAAQS in 2021 (one time), 2022 (one time) and 2023 (one time), thus compliant with the respective NAAQS as four exceedances of the 24-hour NAAQS are permitted per calendar year.
- The annual average SO_2 concentrations for 2021 (16.2 µg/m³), 2022 (27.0 µg/m³) and 2023 (34.6 µg/m³) remained below the annual average NAAQS (50 µg/m³), thus compliant with the respective NAAQS.

Lephalale AQMS

- The 1-hour average (Figure 5-5) SO_2 concentrations exceeded the 1-hour (350 µg/m³) NAAQS in 2023 (two times), thus compliant with the respective NAAQS as 88 exceedances of the 1-hour NAAQS are permitted per calendar year. The 1-hour average SO_2 concentrations remained below the 1-hour (350 µg/m³) NAAQS in 2021 and 2022, with no exceedances recorded, thus compliant with the respective NAAQS.
- The 24-hour average (Figure 5-6) SO_2 concentrations remained below the 24-hour (125 µg/m³) NAAQS between 2021 and 2023, with no exceedances recorded, thus compliant with the respective NAAQS.
- The annual average SO_2 concentrations for 2021 (5.4 µg/m³), 2022 (5.0 µg/m³) and 2023 (7.1 µg/m³) remained below the annual average NAAQS (50 µg/m³), thus compliant with the respective NAAQS.

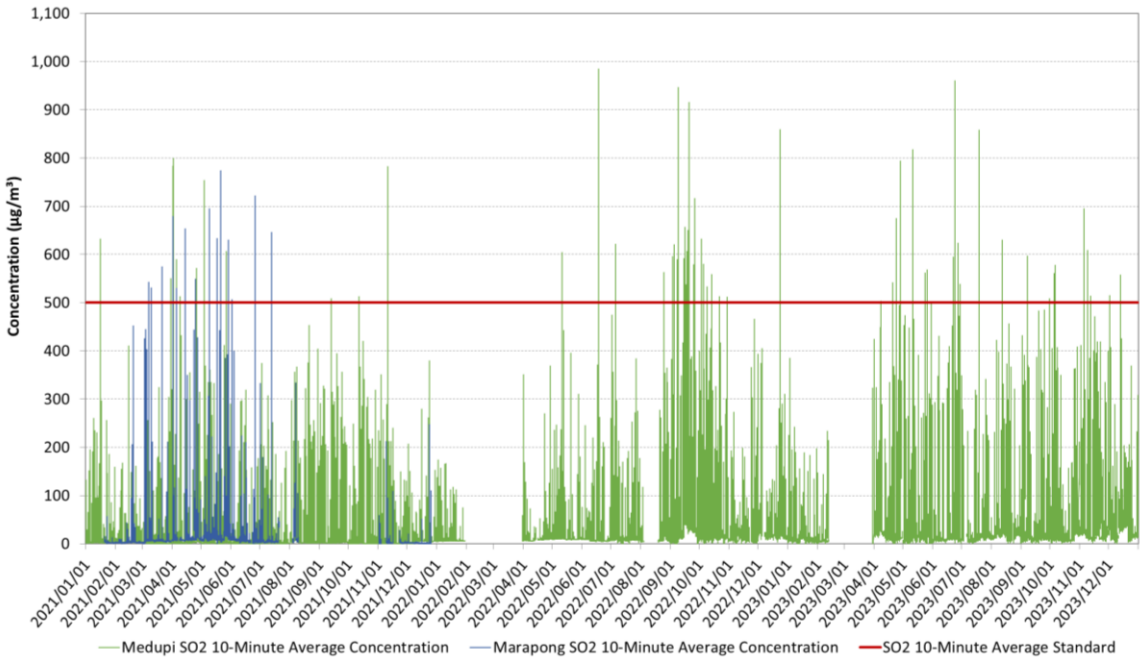


Figure 5-4: 10-minute average SO_2 concentrations at Marapong, Medupi and Lephalale AQMS for 2021 to 2023

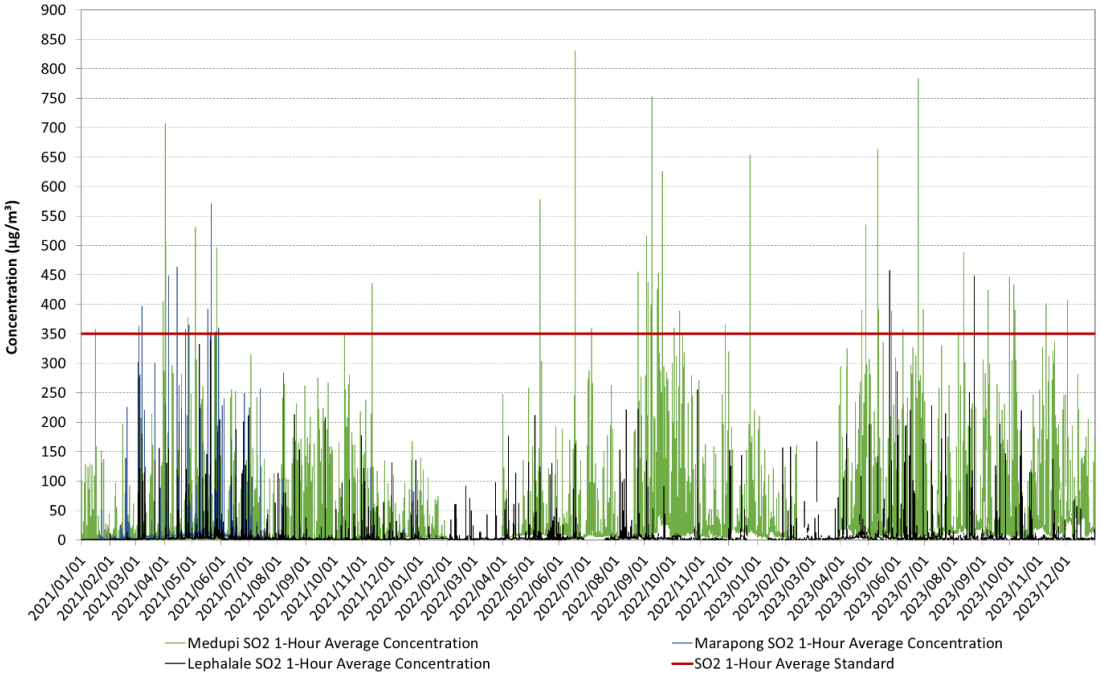


Figure 5-5: 1-hour average SO_2 concentrations at Marapong, Medupi and Lephalale AQMS for 2021 to 2023

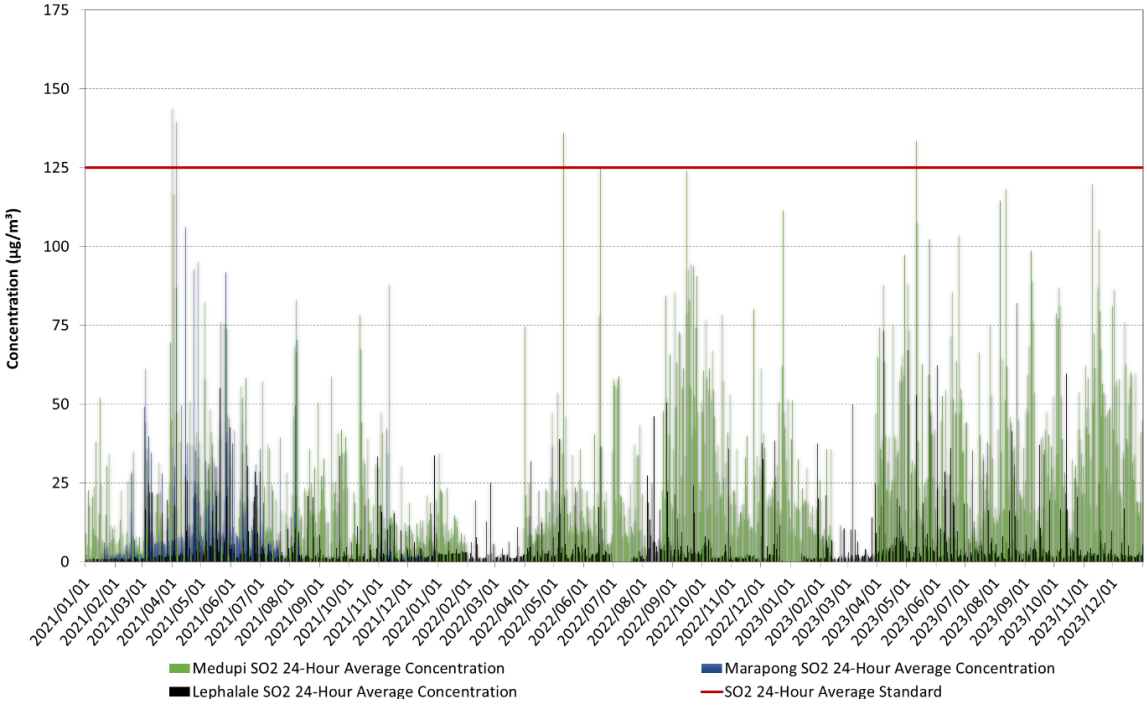


Figure 5-6: 24-hour average SO_2 concentrations at Marapong, Medupi and Lephalale AQMS for 2021 to 2023

5.2.3 Nitrogen Dioxide (NO_2)

Marapong AQMS

- The 1-hour average (Figure 5-7) NO_2 concentrations remained below the 1-hour NAAQS (200 µg/m³) for 2021 and 2022, with no exceedances recorded, thus compliant with the respective NAAQS.
- The annual average NO_2 concentrations for 2021 (16.4 µg/m³) and 2022 (17.3 µg/m³) remained below the annual average NAAQS (40 µg/m³), thus compliant with the respective NAAQS.

Medupi AQMS

- The 1-hour average (Figure 5-7) NO_2 concentrations remained below the 1-hour NAAQS (200 µg/m³) between 2021 and 2023, with no exceedances recorded, thus compliant with the respective NAAQS.
- The annual average NO_2 concentrations for 2021 (5.5 µg/m³), 2022 (10.4 µg/m³) and 2023 (11.3 µg/m³) remained below the annual average NAAQS (40 µg/m³), thus compliant with the respective NAAQS.

Lephalale AQMS

- The 1-hour average Figure 5-7) NO_2 concentrations remained below the 1-hour NAAQS (200 µg/m³) between 2021 and 2023, with no exceedances recorded, thus compliant with the respective NAAQS.
- The annual average NO_2 concentrations for 2021 (10.8 µg/m³), 2022 (12.8 µg/m³) and 2023 (15.7 µg/m³) remained below the annual average NAAQS (40 µg/m³), thus compliant with the respective NAAQS.

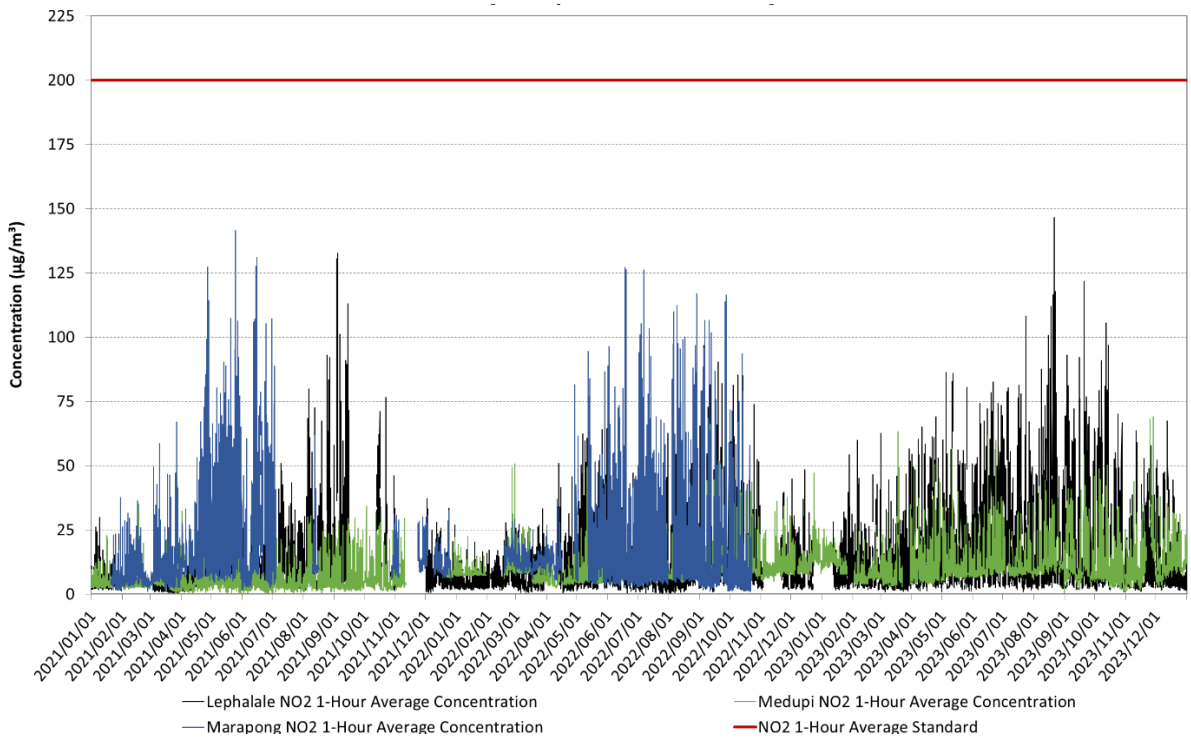


Figure 5-7: 1-hour average NO_2 concentrations at Marapong, Medupi and Lephalale AQMS for 2021 to 2023

5.2.4 Particulates (PM_{10} and $PM_{2.5}$)

Marapong AQMS

- The 24-hour average (Figure 5-8) PM_{10} concentrations exceeded the 24-hour average NAAQS (75 µg/m³) in 2021 (47 times), thus is non-compliant with the respective NAAQS as four exceedances per year are permitted.
- The annual average PM_{10} concentrations for 2021 (47.0 µg/m³) exceeded the annual average NAAQS (40 µg/m³), thus is non-compliant with the respective NAAQS.
- The 24-hour average (Figure 5-9) $PM_{2.5}$ concentrations exceeded the 24-hour average NAAQS (40 µg/m³) in 2021 (43 times) and 2022 (41 times), thus are non-compliant with the respective NAAQS as four exceedances per year are permitted.
- The annual average $PM_{2.5}$ concentrations for 2021 (25.8 µg/m³) and 2022 (30.2 µg/m³) exceeded the annual average NAAQS (20 µg/m³), thus are non-compliant with the respective NAAQS.

Medupi AQMS

- The 24-hour average (Figure 5-8) PM_{10} concentrations exceeded the 24-hour average NAAQS (75 µg/m³) in 2021 (12 times), 2022 (seven times) and 2023 (22 times), thus are non-compliant with the respective NAAQS as four exceedances per year are permitted.
- The annual average PM_{10} concentrations for 2021 (28.9 µg/m³), 2022 (28.4 µg/m³) and 2023 (37.5 µg/m³) remained below the annual average NAAQS (40 µg/m³), thus compliant with the respective NAAQS.
- The 24-hour average (Figure 5-9) $PM_{2.5}$ concentrations exceeded the 24-hour average NAAQS (40 µg/m³) in 2021 (eight times), thus is non-compliant with the respective NAAQS as four exceedances per year are permitted.
- The annual average $PM_{2.5}$ concentrations for 2021 (15.2 µg/m³) below the annual average NAAQS (20 µg/m³), thus compliant with the respective NAAQS.

Lephalale AQMS

- The 24-hour average (Figure 5-8) PM_{10} concentrations exceeded the 24-hour average NAAQS of 75 µg/m³ once in 2021, with no exceedances in 2023, , thus compliant with the respective NAAQS as four exceedances per year are permitted.
- The annual average PM_{10} concentrations for 2021 (37.3 µg/m³) and 2023 (17.4 µg/m³) remained below annual average NAAQS (40 µg/m³), thus compliant with the respective NAAQS.
- The 24-hour average (Figure 5-9) $PM_{2.5}$ concentrations in 2023 remained below the 24-hour average NAAQS (40 µg/m³) with no exceedances recorded, thus compliant with the respective NAAQS.
- The annual average $PM_{2.5}$ concentrations for 2023 (15.2 µg/m³) remained below the annual average NAAQS (20 µg/m³), thus compliant with the respective NAAQS.

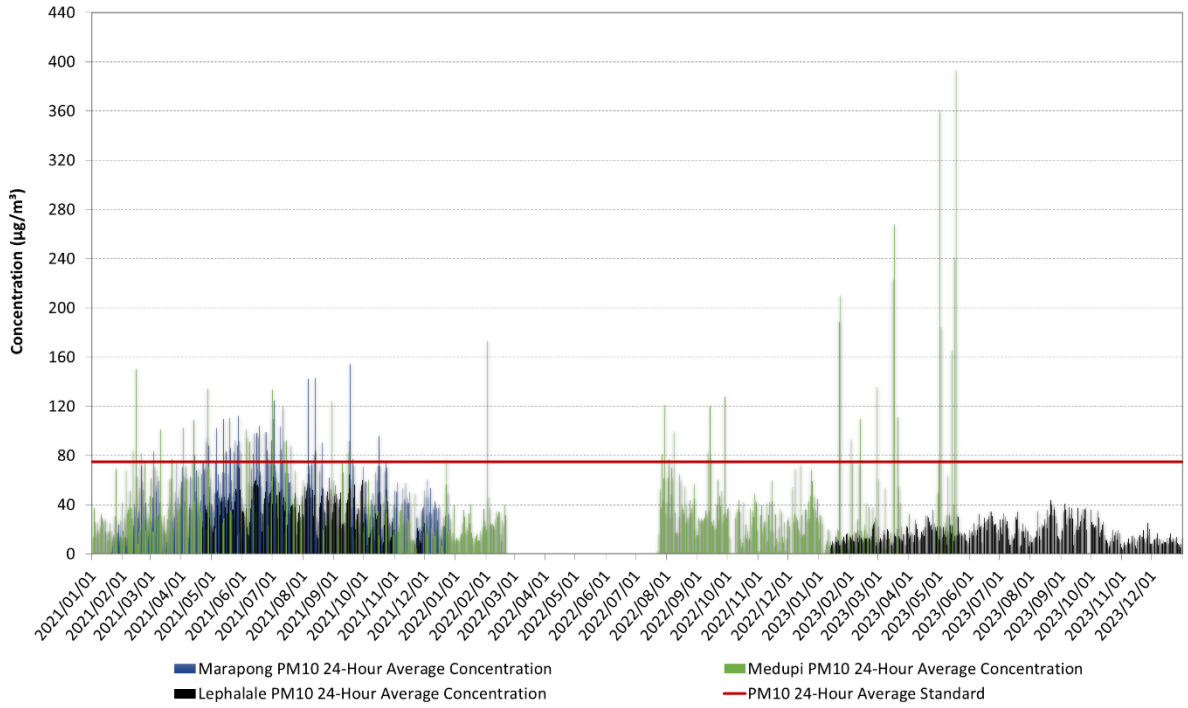


Figure 5-8: 24-hour average PM_{10} concentrations at Marapong, Medupi and Lephalale AQMS for 2021 to 2023

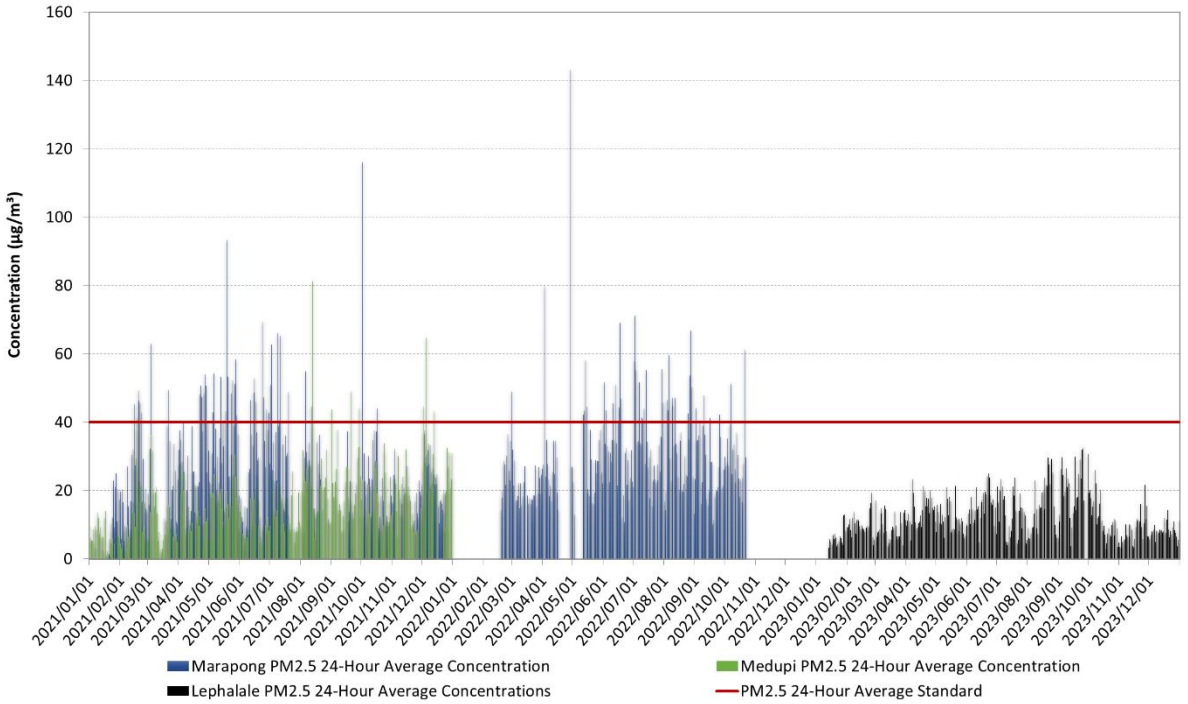


Figure 5-9: 24-hour average $PM_{2.5}$ concentrations at Marapong, Medupi and Lephalale AQMS for 2021 to 2023

5.2.5 Ambient pollutant summary

A summary of exceedances of the limit value of the NAAQS for all pollutants is presented in (Table 5-2).

Despite the proximity of several sources of SO_2 and NO_2 to the three monitoring sites, including Medupi and Matimba Power Station, no exceedances of the NAAQS for SO_2 and NO_2 were recorded during the period 2021 to 2023.

The key pollutants of concern however, are PM_{10} and $PM_{2.5}$. During the period 2021 to 2023 numerous exceedances of the NAAQS limit value for both the 24-hour and annual average for PM_{10} and $PM_{2.5}$ were recorded at the Marapong and Medupi AQMS. The exceedances are attributed to the proximity of sources of particulates to these monitoring sites, such as domestic fuel burning, wind and vehicle entrainment of dust, and mining.

Table 5-2: Pollutant exceedance summary at the Marapong, Medupi and Lephalale AQMS from 2021 to 2023

Pollutant	Averaging Period	Concentration	Permitted Number of Exceedances	2021	2022	2023
Marapong AQMS						
SO_2	10-min	500 µg/m³	526	23	- (1)	- (1)
	1-hour	350 µg/m³	88	16	- (1)	- (1)
	24-hour	125 µg/m³	4	1	- (1)	- (1)
	1-year	50 µg/m³	0	0	- (1)	- (1)
NO_2	1-hour	200 µg/m³	88	0	0	- (1)
	1-year	40 µg/m³	0	0	0	- (1)
PM_{10}	24-hour	75 µg/m³	4	47	- (1)	- (1)
	1-year	40 µg/m³	0	1	- (1)	- (1)
$PM_{2.5}$	24-hour	40 µg/m³	4	43	41	- (1)
	1-year	20 µg/m³	0	1	1	- (1)
Medupi AQMS						
SO_2	10-min	500 µg/m³	526	34	75	53
	1-hour	350 µg/m³	88	18	27	21
	24-hour	125 µg/m³	4	1	1	1
	1-year	50 µg/m³	0	0	0	0
NO_2	1-hour	200 µg/m³	88	0	0	0
	1-year	40 µg/m³	0	0	0	0
PM_{10}	24-hour	75 µg/m³	4	12	7	22
	1-year	40 µg/m³	0	0	0	0
$PM_{2.5}$	24-hour	40 µg/m³	4	8	- (1)	- (1)
	1-year	20 µg/m³	0	0	- (1)	- (1)
Lephalale AQMS						
SO_2	10-min	500 µg/m³	526	- (2)	- (2)	- (2)
	1-hour	350 µg/m³	88	0	0	2
	24-hour	125 µg/m³	4	0	0	0
	1-year	50 µg/m³	0	0	0	0
NO_2	1-hour	200 µg/m³	88	0	0	0
	1-year	40 µg/m³	0	0	0	0
PM_{10}	24-hour	75 µg/m³	4	1	- (1)	0
	1-year	40 µg/m³	0	0	- (1)	0
$PM_{2.5}$	24-hour	40 µg/m³	4	- (1)	- (1)	0
	1-year	20 µg/m³	0	- (1)	- (1)	0
Notes:	(1) Data recovery below 50%; thus, exceedances are not presented. (2) The Lephalale AQMS does not measure data in 10-minute intervals. Values in red indicate non-compliance against the respective standard.					

6. IMPACT OF ENTERPRISE ON THE RECEIVING ENVIRONMENT

6.1 Dispersion Modelling

6.1.1 Models used

A Level 3 air quality assessment must be conducted in situations where the purpose of the assessment requires a detailed understanding of the air quality impacts (time and space variation of the concentrations) and when it is important to account for causality effects, calms, non-linear plume trajectories, spatial variations in turbulent mixing, multiple source types and chemical transformations (DEA, 2014b). A Level 3 assessment may be used in situations where there is a need to evaluate air quality consequences under a permitting or environmental assessment process for large industrial developments that have considerable social, economic and potential environmental consequences. Under these circumstances, the assessment for Matimba and Medupi clearly demonstrates the need for a Level 3 assessment.

The CALPUFF suite of models are approved by the US EPA (http://www.src.com/calpuff/calpuff1.htm) and by the DEA for Level 3 assessments (DEA, 2014b). It consists of a meteorological pre-processor, CALMET, the dispersion model, CALPUFF, and the post-processor, CALPOST. It is an appropriate air dispersion model for the purpose of this assessment as it is well suited to simulate dispersion from several sources. It also has capability to simulate dispersion in the atmosphere's complex land-sea interface. More information about the model can be found in the User's Guide for the CALPUFF Dispersion Model (US EPA, 1995).

The Air Pollution Model (TAPM) (Hurley, 2000; Hurley et al., 2001; Hurley et al., 2002) is used to model surface and upper air metrological data for the study domain. TAPM uses global gridded synoptic-scale meteorological data with observed surface data to simulate surface and upper air meteorology at given locations in the domain, taking the underlying topography and land cover into account. The global gridded data sets that are used are developed from surface and upper air data that are submitted routinely by all meteorological observing stations to the Global Telecommunication System of the World Meteorological Organisation. TAPM has been used successfully in Australia where it was developed (Hurley, 2000; Hurley et al., 2001; Hurley et al., 2002). It is an ideal tool for modelling applications where meteorological data does not adequately meet requirements for dispersion modelling. TAPM modelled output data is therefore used to augment the site-specific surface meteorological data for input to CALPUFF.

6.1.2 TAPM and CALPUFF parameterisation

The TAPM diagnostic meteorological model is used to generate a 3-dimensional temporally and spatially continuous meteorological field for 2021, 2022 and 2023 in hourly increments for the modelling domain.

TAPM is set-up in a nested configuration of two domains, centred between Medupi and Matimba. The outer domain is 480 km by 480 km at a 12 km grid resolution and the inner

domain is 120 km by 120 km at a 3 km grid resolution (Figure 6-1). The nesting configuration ensures that topographical effects on meteorology are captured and that meteorology is well resolved and characterised across the boundaries of the inner domain. Twenty-seven vertical levels are modelled in each nest from 10 m to 5 000 m, with a finer resolution in the lowest 1 000 m. The subset of the entire TAPM model output in the form of pre-processed gridded surface meteorological data fields is input into the dispersion model.

The 3-dimensional TAPM meteorological output on the inner grid includes hourly wind speed and direction, temperature, relative humidity, total solar radiation, net radiation, sensible heat flux, evaporative heat flux, convective velocity scale, precipitation, mixing height, friction velocity and Obukhov length. The spatially and temporally resolved TAPM surface and upper air meteorological data is used as input to the CALPUFF meteorological pre-processor, CALMET.

The CALPUFF modelling domain covers an area of 11 664 km^2, where the domain extends 108 km (west-east) by 108 km (north-south). It consists of a uniformly spaced receptor grid with 1 km spacing, giving 11 664 grid cells (108 x 108 grid cells).

The topographical and land use for the respective modelling domains is obtained from the dataset accompanying the Commonwealth Scientific and Industrial Research Organisation (CSIRO) The Air Pollution Model (TAPM) modelling package (CSIRO, 2008). This dataset includes global terrain elevation and land use classification data on a longitude/latitude grid at 30-second grid spacing from the US Geological Survey, Earth Resources Observation Systems (EROS) Data Center.

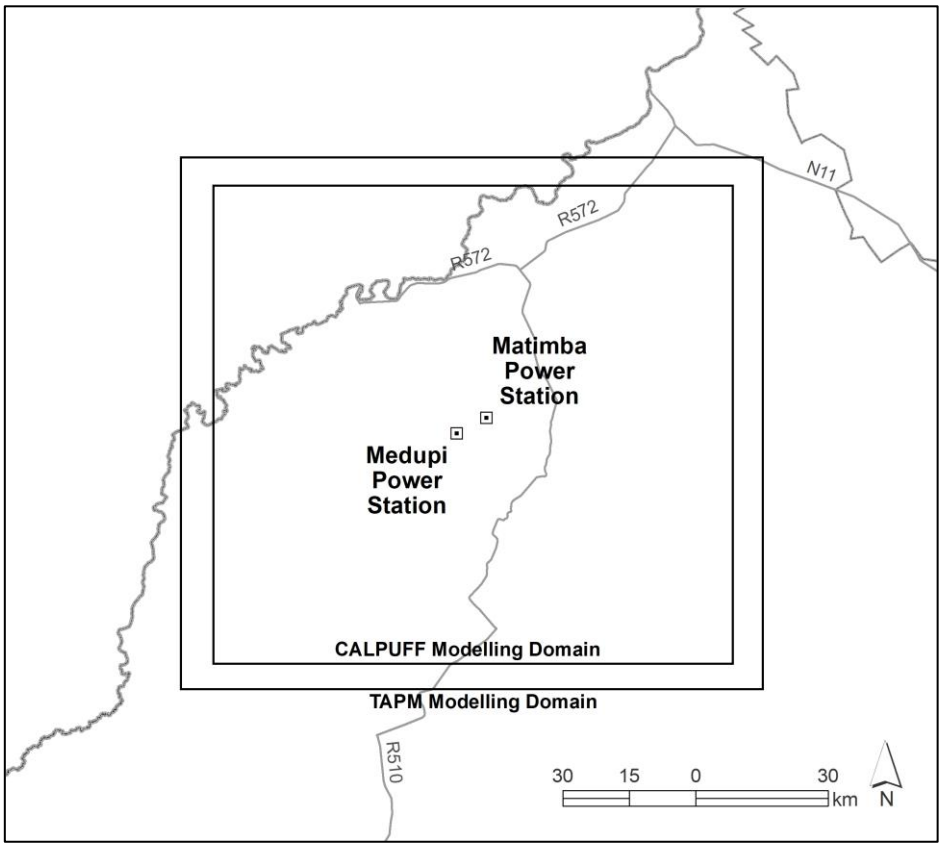


Figure 6-1: TAPM and CALPUFF modelling domains centred on Matimba

The parameterisation of key variables that will apply in CALMET and CALPUFF are indicated in Table 6-1 and Table 6-2 respectively.

Table 6-1: Parameterisation of key variables for CALMET

Parameter	Model value
12 vertical cell face heights (m)	0, 20, 40, 80, 160, 320, 640, 1000, 1500, 2000, 2500, 3000, 4000
Coriolis parameter (per second)	0.0001
Empirical constants for mixing height equation	Neutral, mechanical: 1.41 Convective: 0.15 Stable: 2400 Overwater, mechanical: 0.12
Minimum potential temperature lapse rate (K/m)	0.001
Depth of layer above convective mixing height through which lapse rate is computed (m)	200
Wind field model	Diagnostic wind module
Surface wind extrapolation	Similarity theory
Restrictions on extrapolation of surface data	No extrapolation as modelled upper air data field is applied
Radius of influence of terrain features (km)	5
Radius of influence of surface stations (km)	Not used as continuous surface data field is applied

Table 6-2: Parameterisation of key variables for CALPUFF

Parameter	Model value
Chemical transformation	Default NO_2 conversion factor is applied
Wind speed profile	Rural
Calm conditions	Wind speed < 0.5 m/s
Plume rise	Transitional plume rise, stack tip downwash, and partial plume penetration is modelled
Dispersion	CALPUFF used in PUFF mode
Dispersion option	Pasquill-Gifford coefficients are used for rural and McElroy-Pooler coefficients are used for urban
Terrain adjustment method	Partial plume path adjustment

6.1.3 Model accuracy

Air quality models attempt to predict ambient concentrations based on "known" or measured parameters, such as wind speed, temperature profiles, solar radiation and emissions. There are however, variations in the parameters that are not measured, the so-called "unknown" parameters as well as unresolved details of atmospheric turbulent flow. Variations in these "unknown" parameters can result in deviations of the predicted concentrations of the same event, even though the "known" parameters are fixed.

There are also "reducible" uncertainties that result from inaccuracies in the model, errors in input values and errors in the measured concentrations. These might include poor quality or unrepresentative meteorological, geophysical and source emission data, errors in the measured concentrations that are used to compare with model predictions and inadequate model physics and formulation used to predict the concentrations. "Reducible" uncertainties can be controlled or minimised. This is done by using accurate input data, preparing the input files correctly, checking and re-checking for errors, correcting for odd model behaviour, ensuring that the errors in the measured data are minimised and applying appropriate model physics.

Models recommended in the DEA dispersion modelling guideline (DEA, 2014b) have been evaluated using a range of modelling test kits (http://www.epa.gov./scram001). CALPUFF is one of the models that have been evaluated and it is therefore not mandatory to perform any modelling evaluations. Rather the accuracy of the modelling in this assessment is enhanced by every effort to minimise the "reducible" uncertainties in input data and model parameterisation.

6.1.4 Assessment scenarios

Five emission scenarios are assessed for Medupi and Matimba. These scenarios are:

Scenario 1 (Current): The baseline scenario using actual monthly stack emissions for 2021-2023 and fugitive emissions from the coal stockyards and the ash dumps (No FGD installed).

Scenario A (2025): Eskom's planned 2025 stack emissions, representing anticipated station performance between 2025 – 2030, including fugitive emissions from the coal stockyards and the ash dumps (No FGD installed).

Scenario B (2031): Eskom's planned 2031 stack emissions, representing anticipated station performance between 2031 – 2035, including fugitive emissions from the coal stockyards and the ash dumps (No FGD installed but load reduction).

Scenario C (2036): Eskom's planned 2036 stack emissions, representing anticipated station performance from 2036 onwards, including fugitive emissions from the coal stockyards and the ash dumps (FGD installed at Medupi).

Scenario D (MES): Full compliance with the MES, including fugitive emissions from the coal stockyards and the ash dumps (FGD installed at Medupi and Matimba).

6.2 Dispersion Modelling Results

The dispersion modelling results are compared with the NAAQS for SO_2, NO_2, PM_{10} and $PM_{2.5}$ (Table 3-3). It is not possible to apportion the PM_{10} and $PM_{2.5}$ portion of the total PM, so the PM emission is conservatively modelled as PM_{10} and $PM_{2.5}$. The CALPUFF modelling suite provides for the chemical conversion of SO_2 and NO_X to secondary particulates, i.e. sulphate and nitrate in the modelling results. The predicted PM_{10} and $PM_{2.5}$ concentrations presented here include direct emissions of PM plus secondary particulates formed from the power station emissions.

The 99th percentile predicted ambient SO_2, NO_2, PM_{10} and $PM_{2.5}$ concentrations from the dispersion modelling for Medupi and Matimba for the five emission scenarios are presented as isopleth maps over the modelling domain. The DEA (2012c) recommend the 99th percentile concentrations for short-term assessment with the NAAQS since the highest predicted ground-level concentrations can be considered outliers due to complex variability of meteorological processes. In addition, the limit value in the NAAQS is the 99th percentile.

6.2.1 Maximum predicted ambient concentrations

The maximum predicted annual SO_2, NO_2, PM_{10} and $PM_{2.5}$ concentrations and the 99th percentile of the 24-hour and 1-hour predicted concentrations in the modelling domain are discussed here and are listed in Table 6-3 for the 5 scenarios. Exceedances of the limit value of the NAAQS are shown in red font. Exceedance of the limit value does not automatically indicate non-compliance with the NAAQS as the standards provide a tolerance in the form of a permitted number of exceedances. The frequency of exceedances is discussed in Section 6.2.2.

For SO_2, the predicted concentrations are attributed only to the stack emissions. The maximum predicted annual average concentrations for the 5 scenarios are low relative to the limit values of the respective NAAQS. The predicted the 99th percentile of the 24-hour SO_2 concentrations and the predicted 1-hour concentrations exceeded the limit value of the NAAQS in Scenario A (2025) Scenario B (2031) and in Scenario C (2036). The predicted maximum SO_2 concentration occurs between 10 and 15 km southwest of Medupi and Matimba. Noteworthy is the compliance with the NAAQS with actual emissions (Scenario 1 (Current)) and Scenario D (MES).

For NO_2, the predicted concentrations are attributed only to the stack emissions. The predicted maximum and 99th percentile concentrations comply the respective NAAQS for the 5 scenarios. The predicted maximum NO_2 concentration occurs between 10 and 15 km southwest of Medupi and Matimba.

For PM_{10} and $PM_{2.5}$, the predicted concentrations are attributed to stack emissions, the low-level fugitive sources (coal stockyard and ash dump) and the contribution from secondary particulate formation. The total PM emissions are not speciated into PM_{10} or $PM_{2.5}$, rather all PM emitted is assumed to be firstly PM_{10}, and then all PM emitted is assumed to be $PM_{2.5}$.

For PM_{10} and $PM_{2.5}$, the maximum predicted annual average concentrations exceed the limit values of the respective NAAQS in all scenarios. Similarly, the 99th percentile of the

24-hour PM_{10} and $PM_{2.5}$ concentrations exceeds the limit value of the NAAQS. The predicted maximum PM_{10} and $PM_{2.5}$ concentrations occur within 10 km of Medupi and Matimba to the southwest.

Table 6-3: Maximum predicted ambient annual SO_2, NO_2 PM_{10}, and $PM_{2.5}$ concentrations in µg/m³ and the predicted 99th percentile concentrations for 24-hour and 1-hour averaging periods, with the NAAQS

Scenario and Pollutant	Averaging time		
Predicted maximum SO_2	**Annual**	**24-hour**	**1-hour**
Scenario 1 (Current)	15.6	123.2	316.9
Scenario A (2025)	24.7	**223.9**	**598.9**
Scenario B (2031)	26.7	**221.6**	**575.8**
Scenario C (2035)	17.9	**211.2**	**451.0**
Scenario D (MES)	6.7	64.9	156.6
NAAQS	50	125	350
Predicted maximum NO_2	**Annual**		**1-hour**
Scenario 1 (Current)	2.0		46.9
Scenario A (2025)	3.9		103.0
Scenario B (2031)	4.3		100.1
Scenario C (2035)	3.2		82.4
Scenario D (MES)	3.2		82.4
NAAQS	40		200
Predicted maximum PM_{10}	**Annual**	**24-hour**	
Scenario 1 (Current)	**77.9**	**277.2**	
Scenario A (2025)	**78.3**	**278.3**	
Scenario B (2031)	**78.2**	**276.2**	
Scenario C (2035)	**77.9**	**272.6**	
Scenario D (MES)	**77.6**	**270.0**	
NAAQS	40	75	
Predicted maximum $PM_{2.5}$	**Annual**	**24-hour**	
Scenario 1 (Current)	**77.9**	**277.2**	
Scenario A (2025)	**78.3**	**278.3**	
Scenario B (2031)	**78.2**	**276.2**	
Scenario C (2035)	**77.9**	**272.6**	
Scenario D (MES)	**77.6**	**270.0**	
NAAQS	**20**	**40**	Up to 31 Dec 2029
NAAQS	**15**	**25**	From 01 Jan 2030

6.2.2 Predicted concentrations at AQMS and sensitive receptors

The predicted annual SO_2, NO_2, PM_{10} and $PM_{2.5}$ concentrations and the 99th percentile of the 24-hour and 1-hour predicted concentrations at AQMS in the Waterberg modelling area are presented in Table 6-4 to Table 6-7. The measured annual averages in 2021,

2022 and 2023 presented with the modelled annual average concentration for Scenario 1: (Current).

For SO_2 and NO_2 the predicted ambient concentrations result from the respective power station stack emissions only. At all the AQMS the modelled concentrations are lower than the monitored concentrations. This is to be expected since AQMS are exposed to all sources of SO_2 and NO_2. The difference between the predicted concentrations and the measured concentrations provides an indication of the contribution of the power station stack emissions at the respective AQMS.

For PM_{10} and $PM_{2.5}$ the predicted ambient concentrations result from the respective power station stack emissions and the fugitive low-level sources, i.e. the coal stockyard and the ash dumps at each power station. At the Marapong and Lephalale AQMS the modelled concentrations are considerably lower than the monitored concentrations. This is to be expected since AQMS are exposed to all sources of PM_{10} and $PM_{2.5}$. The difference between the predicted concentrations and the measured concentrations provides an indication of the contribution of the power station stack emissions at the respective AQMS.

At the Medupi AQMS however the modelled PM_{10} and $PM_{2.5}$ concentrations are generally higher than the monitored concentrations, contrary to expectation as the AQMS is exposed to more sources. Noteworthy is the poor data recover at the Medupi AQMS, especially in 2022 and 2023. In these years for PM_{10} it was only 56% and 62%, and for $PM_{2.5}$ it was 35% and 28%. Data is deemed acceptable if recovery is 90% or more. In this data of 50% or more was used, so the results need to be viewed with caution, otherwise that data was not used in averaging.

Table 6-4: Measured annual average SO_2 concentration at the Waterberg AQMS compared with predicted concentrations in µg/m³

Receptor	2021	2022	2023	Modelled
Marapong AQMS	13.9	-	-	6.2
Medupi AQMS	16.2	27.0	34.6	10.9
Lephalale AQMS	5.4	5.0	7.1	5.4

Table 6-5: Measured annual average NO_2 concentration at the Waterberg AQMS compared with predicted concentrations in µg/m³

Receptor	2021	2022	2023	Modelled
Marapong AQMS	16.4	17.3	-	0.7
Medupi AQMS	5.5	10.4	11.3	1.4
Lephalale AQMS	10.8	12.8	15.7	0.5

Table 6-6: Measured annual average PM_{10} concentration at the Waterberg AQMS compared with predicted concentrations in µg/m³

Receptor	2021	2022	2023	Modelled
Marapong AQMS	47.0	-	-	5.7
Medupi AQMS	28.8	28.4	37.5	36.2
Lephalale AQMS	37.3	-	17.4	2.1

Table 6-7: Measured annual average $PM_{2.5}$ concentration at the Waterberg AQMS compared with predicted concentrations in µg/m³

Receptor	2021	2022	2023	Modelled
Marapong AQMS	25.8	30.2	-	5.7
Medupi AQMS	15.2	-	-	36.2
Lephalale AQMS	-	-	12.2	2.1

In the Waterberg study area 51 sensitive receptors were identified (Table 2-3). The predicted ambient SO_2 NO_2, PM_{10} and $PM_{2.5}$ concentrations at the sensitive receptors for the five scenarios are presented in Annexure 1 with the limit value of the NAAQS. The predicted concentrations at the sensitive receptors are discussed here. The NAAQS provides for 4 exceedances of the 24-hour limit value per year, implying that 12 or fewer exceedances of the limit value in the 3-year modelling period comply with the NAAQS. The number of exceedances are included in the tables in Appendix 1.

For SO_2, the predicted concentrations result from SO_2 emissions from the power station stacks. At all identified sensitive receptors the predicted annual and 1-hour SO_2 concentrations are below the respective NAAQS for all averaging periods. The highest predicted concentrations occur in Scenario A (2025) when exceedances of the 24-hour limit value of the NAAQS at 10 sensitive receptors are predicted. Exceedances are also predicted at 10 sensitive receptors in Scenario B (2031) and at 9 in Scenario C (2036). Noteworthy is that no exceedances are predicted for Scenario D (MES).

For NO_2, the predicted concentrations result from NO_X emissions from the power station stacks. At all identified sensitive receptors the predicted NO_2 concentrations are low and below the respective NAAQS for all averaging periods. The highest predicted concentration occur for the proposed Scenario A (2025) emissions.

For PM_{10} and $PM_{2.5}$, it must be remembered that the predicted concentrations are attributed to stack emissions and the low-level fugitive sources (coal stockyard and ash dump). Furthermore, the total PM emission is not speciated into PM_{10} and $PM_{2.5}$, but rather all PM emitted is assumed to be PM_{10}, and all PM emitted is assumed to be $PM_{2.5}$. In addition, the predicted PM_{10} and $PM_{2.5}$ concentrations account for the formation of secondary particulates from SO_2 and NO_2 stack emissions. This is a very conservative approach.

For PM_{10} and $PM_{2.5}$, the predicted annual average concentrations are below the limit values of the NAAQS at all sensitive receptor points in all five scenarios. Exceedance of the 24-hour limit value of the NAAQS for PM_{10} and $PM_{2.5}$ are predicted in all five scenarios at several sensitive receptor points (Table 6-8). For $PM_{2.5}$, the limit value of the NAAQS drops from 40 µg/m³ to 25 µg/m³ in 2030 resulting in an increase in the number of receptor points where the limit value is exceeded.

Table 6-8: Number of sensitive receptors where the limit value of the 24-hour NAAQS is exceeded

Scenario	Number of sensitive receptors	
	PM_{10}	$PM_{2.5}$
Scenario 1 (Current)	2	17
Scenario A (2025)	5	17
Scenario B (2031)	2	27
Scenario C (3036)	0	25
Scenario D (MES)	0	24

6.2.3 Isopleth maps

Isopleth maps of predicted ambient SO_2, NO_2, PM_{10} and $PM_{2.5}$ concentrations are presented in the following sections. The predicted concentrations are shown as isopleths, lines of equal concentration, in $\mu g/m^3$ for the respective NAAQS averaging periods. The isopleths are depicted as coloured lines on the various maps, corresponding to a particular predicted ambient concentration. Areas within red isopleths indicate an area where exceedances of the respective NAAQS limit value are predicted to occur. Sensitive receptors are represented by green squares and AQMS are represented by white dots.

The South African NAAQS permits 4 exceedances of the 24-hour or daily limit value per annum, implying 12 permitted exceedances in a three-year modelling period. For the 24-hour or daily isopleth maps, areas within burgundy isopleths indicate areas where more than 12 exceedances of the limit value are predicted over a 3-year period. The predicted 24-hour concentrations in these areas do not comply with the NAAQS.

The South African NAAQS also permits 88 exceedances of the 1-hour or hourly limit value per annum, implying 264 permitted exceedances in a three-year modelling period. For the 1-hour or hourly isopleth maps, areas within burgundy isopleths indicate areas where more than 264 exceedances of the limit value are predicted over a 3-year period. The predicted 1-hour concentrations in these areas do not comply with the NAAQS.

6.2.3.1 Sulphur dioxide (SO_2)

The isopleth maps showing the predicted annual average SO_2 concentrations clearly demonstrate the effect of the predominant northeasterly winds, with dispersion generally to the southwest of the power plant. In all scenarios the highest predicted annual average concentrations occur between 10 and 20 km of the two power stations and to the southwest. The predicted annual ambient concentrations are relatively low and are below the NAAQS in all scenarios throughout the Waterberg modelling domain.

For the annual, 24-hour and 1-hour predictions, the effect of the increase in SO_2 emissions at Medupi from Scenario 1 (Current) to Scenario A (2025) is shown in the modelled results by an increase in the affected area, and with predicted exceedances of the limit value of the 24-hour and 1-hour NAAQS in an area to the southwest of Medupi and Matimba. There is marginal decrease observed in concentrations from Scenario A (2025) to Scenario B (2031) as the total emission tonnage decreases. The reduction in SO_2 emissions at Medupi in Scenario C (2036) is seen by a marked reduction in the affected area for this scenario. Noteworthy is compliance with the NAAQS in Scenario D (MES).

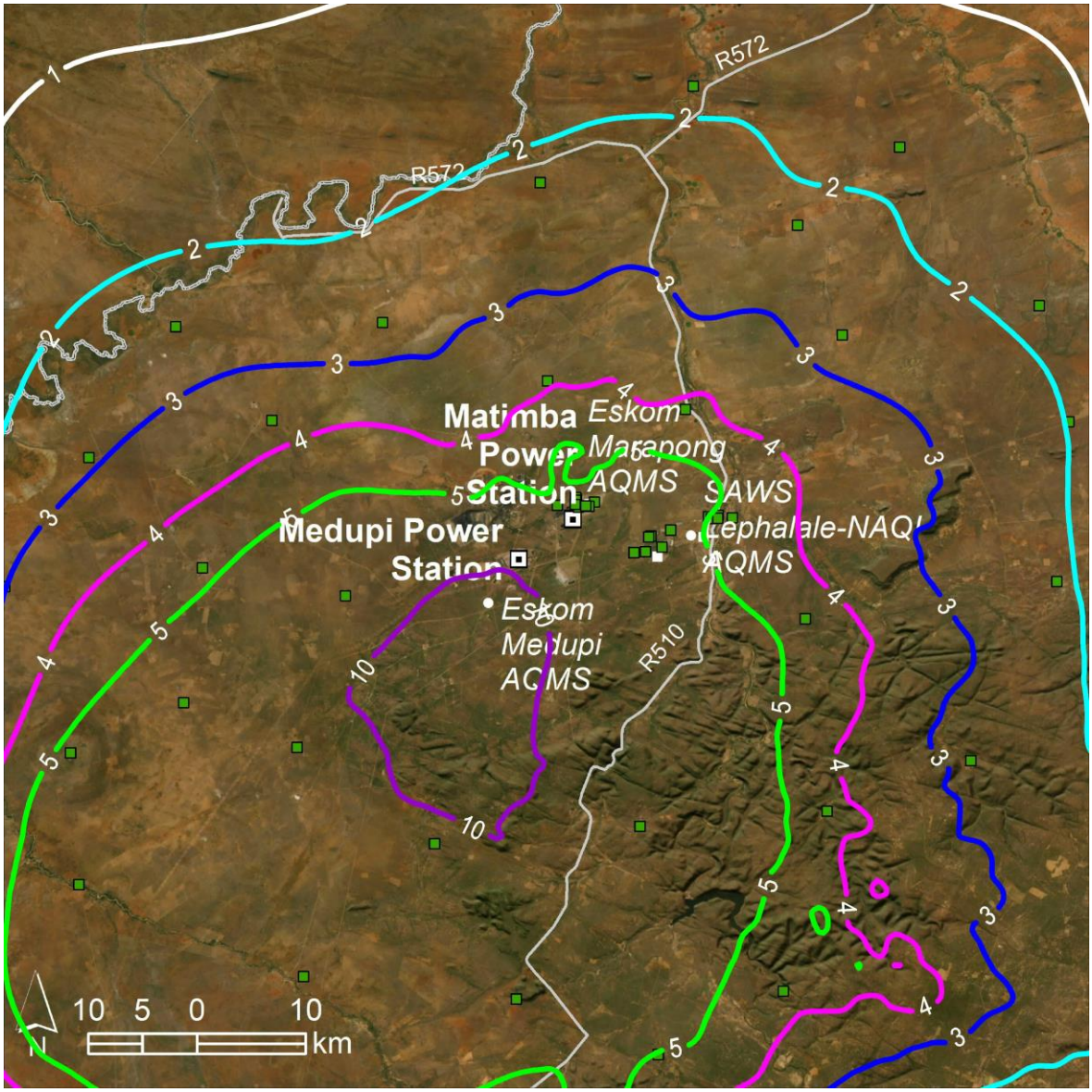


Figure 6-2: Predicted annual average SO_2 concentrations in µg/m³ for Scenario 1 (Current) (NAAQS Limit is 50 µg/m³)

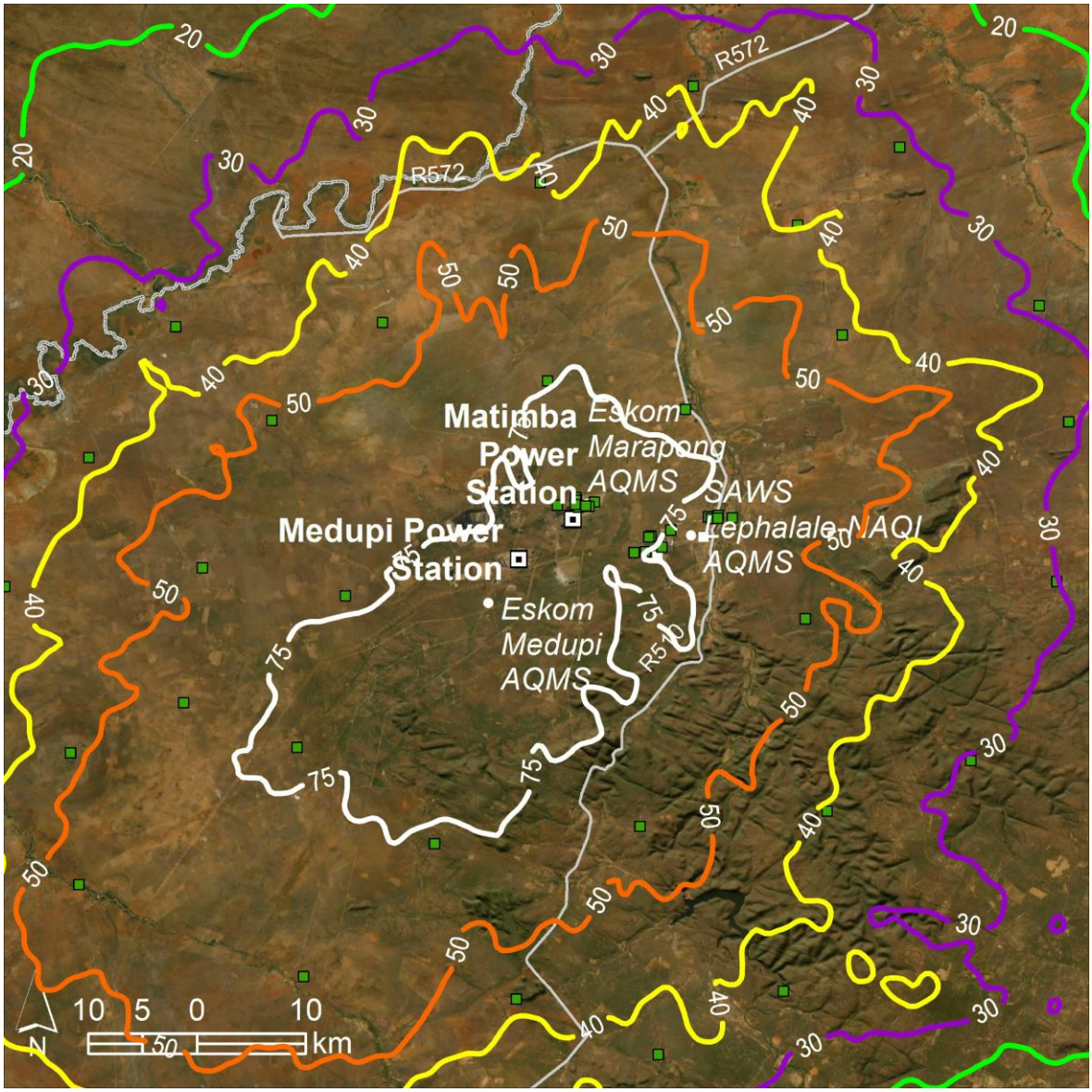


Figure 6-3: Predicted 99th percentile 24-hour SO_2 concentrations in µg/m³ for Scenario 1 (Current) (NAAQS Limit is 125 µg/m³)

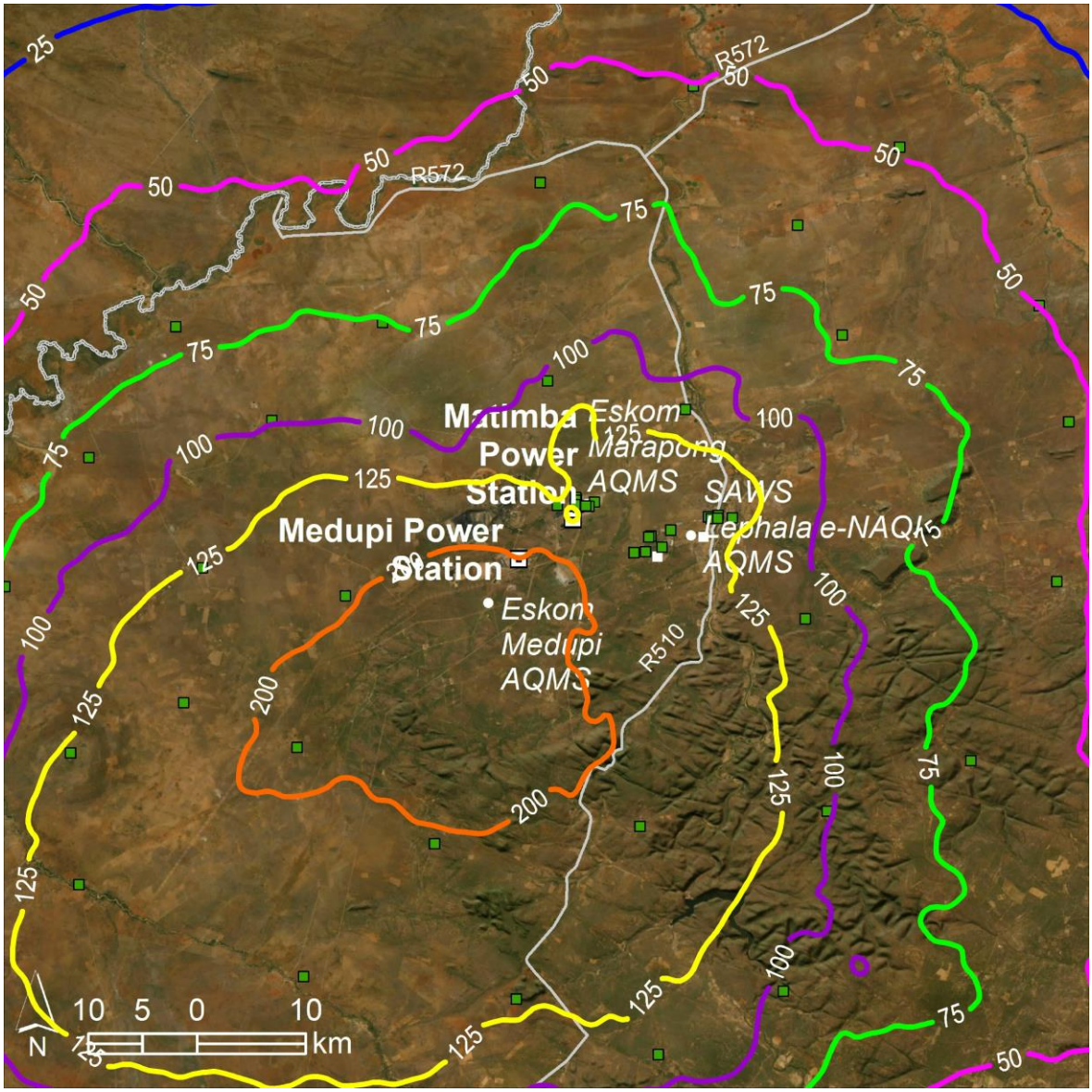


Figure 6-4: Predicted 99th percentile 1-hour SO_2 concentrations in µg/m³ for Scenario 1 (Current) (NAAQS Limit is 350 µg/m³)

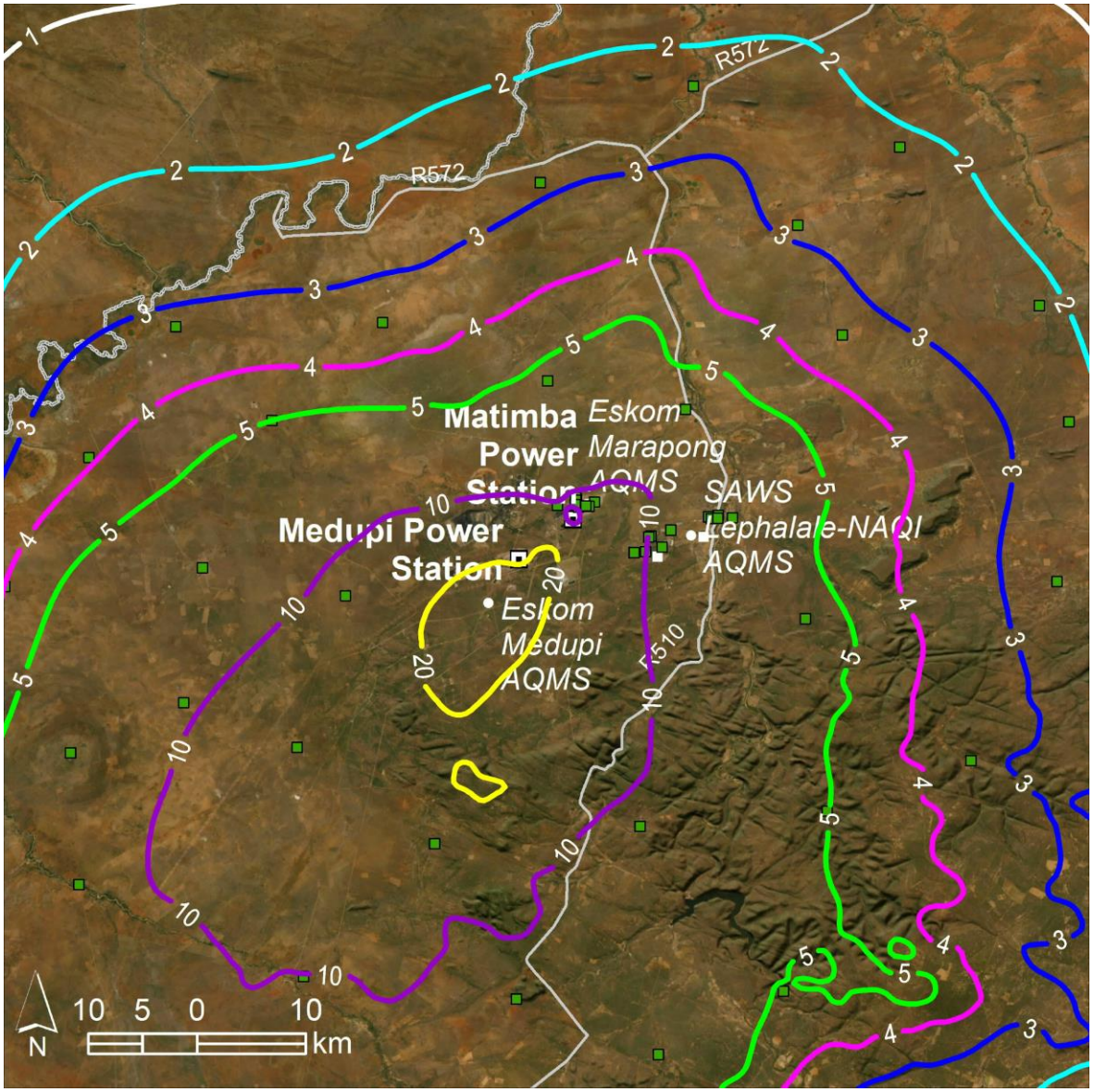


Figure 6-5: Predicted annual average SO_2 concentrations in µg/m³ for Scenario A (2025) (NAAQS Limit is 50 µg/m³)

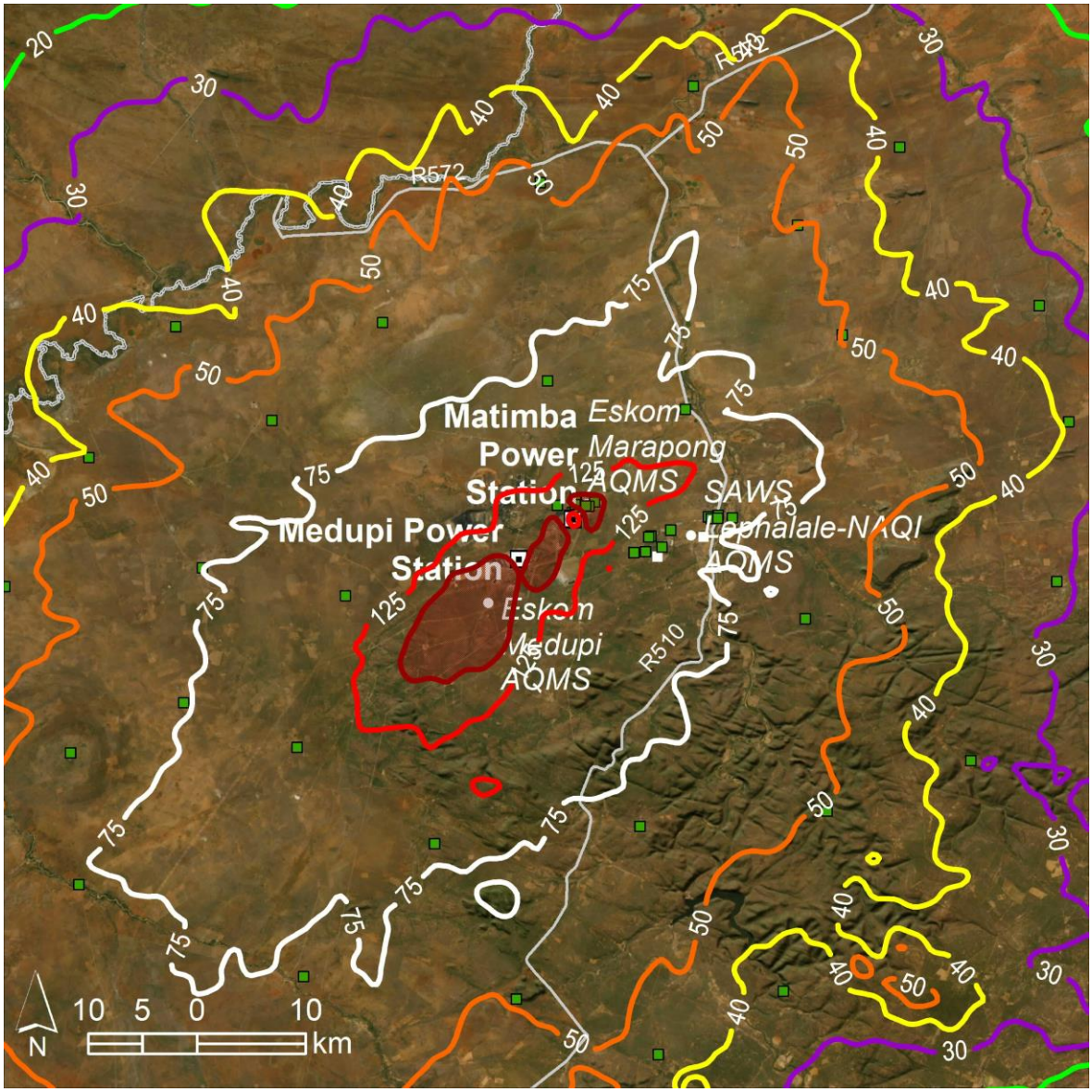


Figure 6-6: Predicted 99th percentile 24-hour SO_2 concentrations in µg/m³ for Scenario A (2025) (NAAQS Limit is 125 µg/m³)

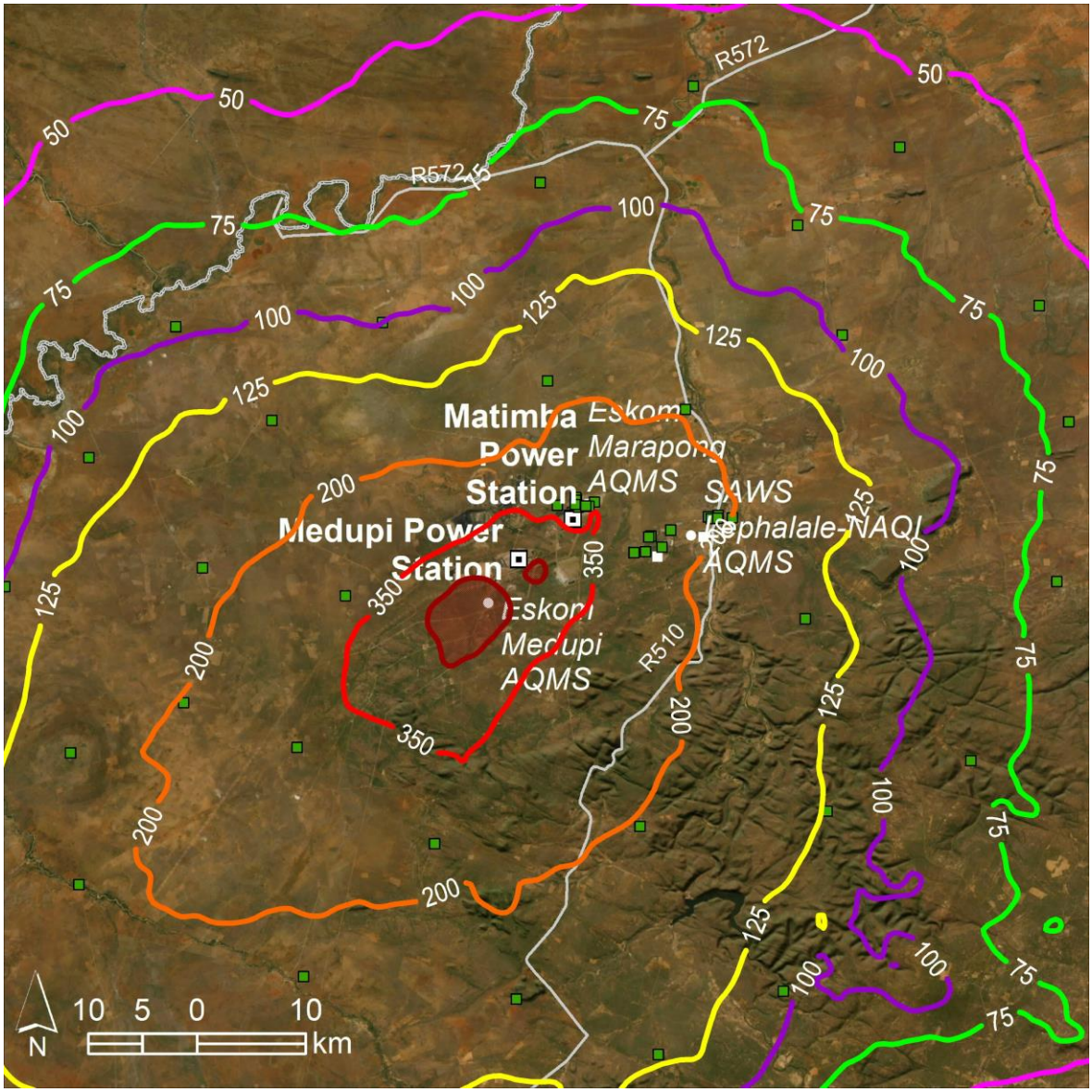


Figure 6-7: Predicted 99th percentile 1-hour SO_2 concentrations in µg/m³ for Scenario A (2025) (NAAQS Limit is 350 µg/m³)

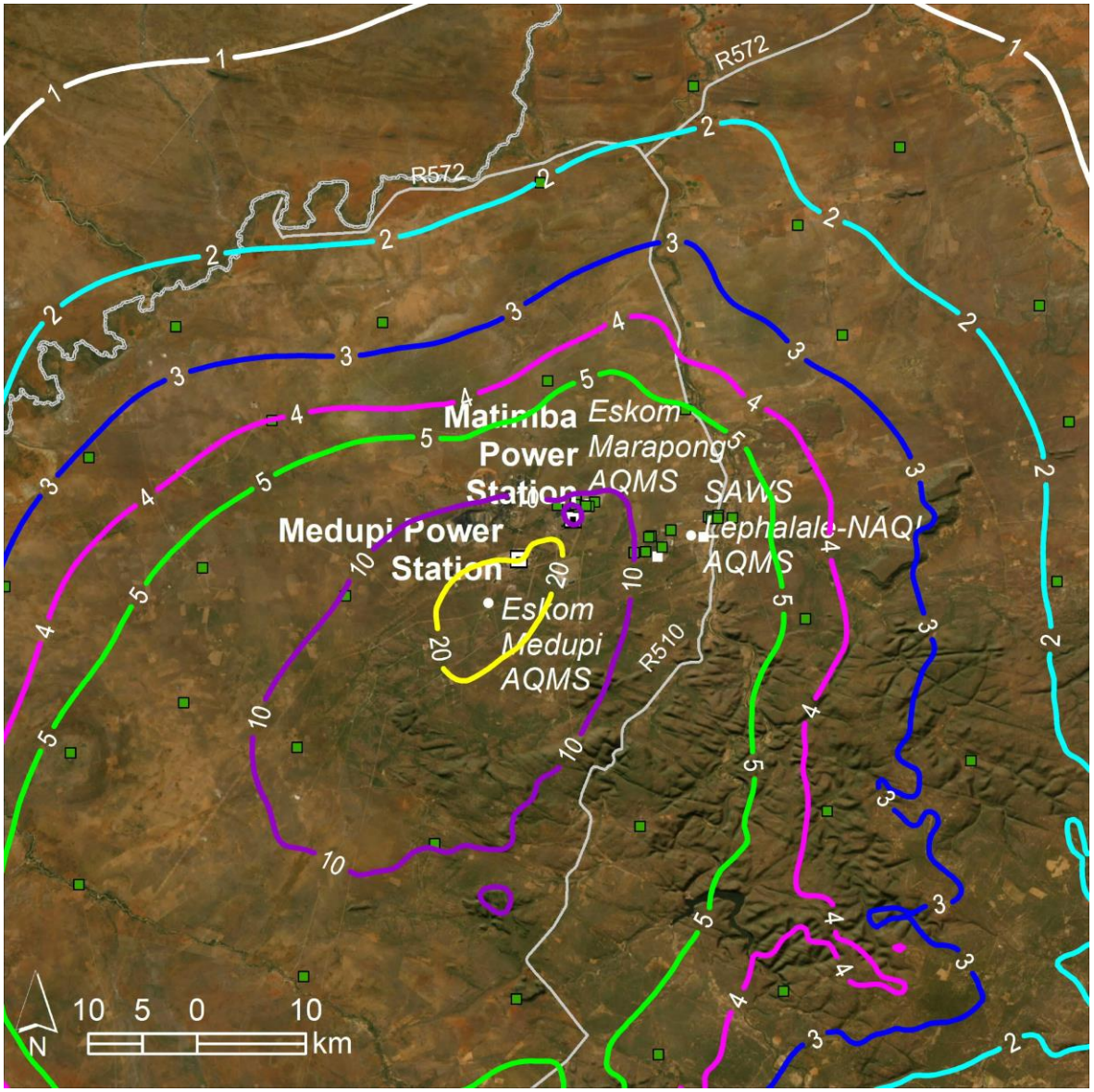


Figure 6-8: Predicted annual average SO_2 concentrations in µg/m³ for Scenario B (2031) (NAAQS Limit is 50 µg/m³)

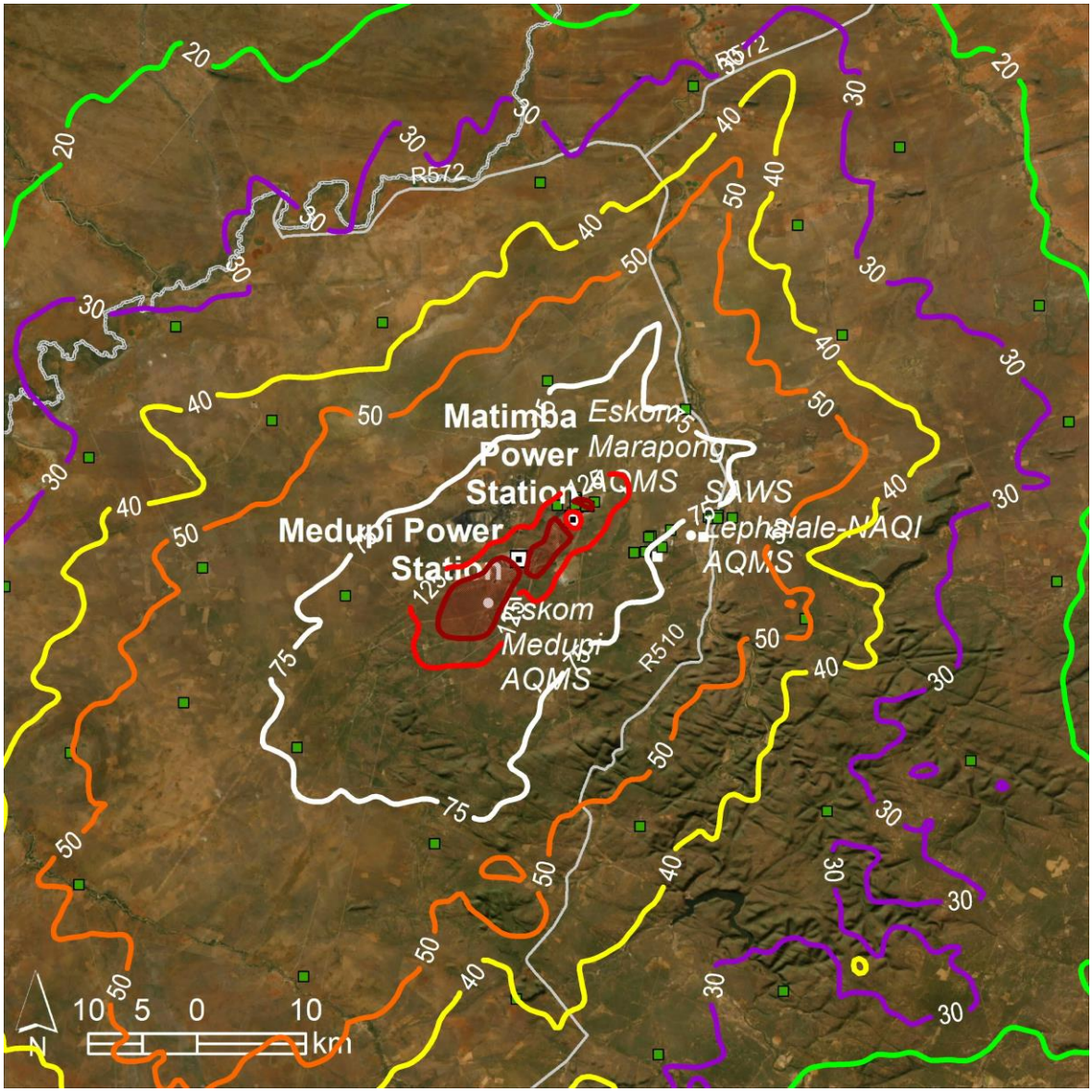


Figure 6-9: Predicted 99th percentile 24-hour SO_2 concentrations in µg/m³ for Scenario B (2031) (NAAQS Limit is 125 µg/m³)

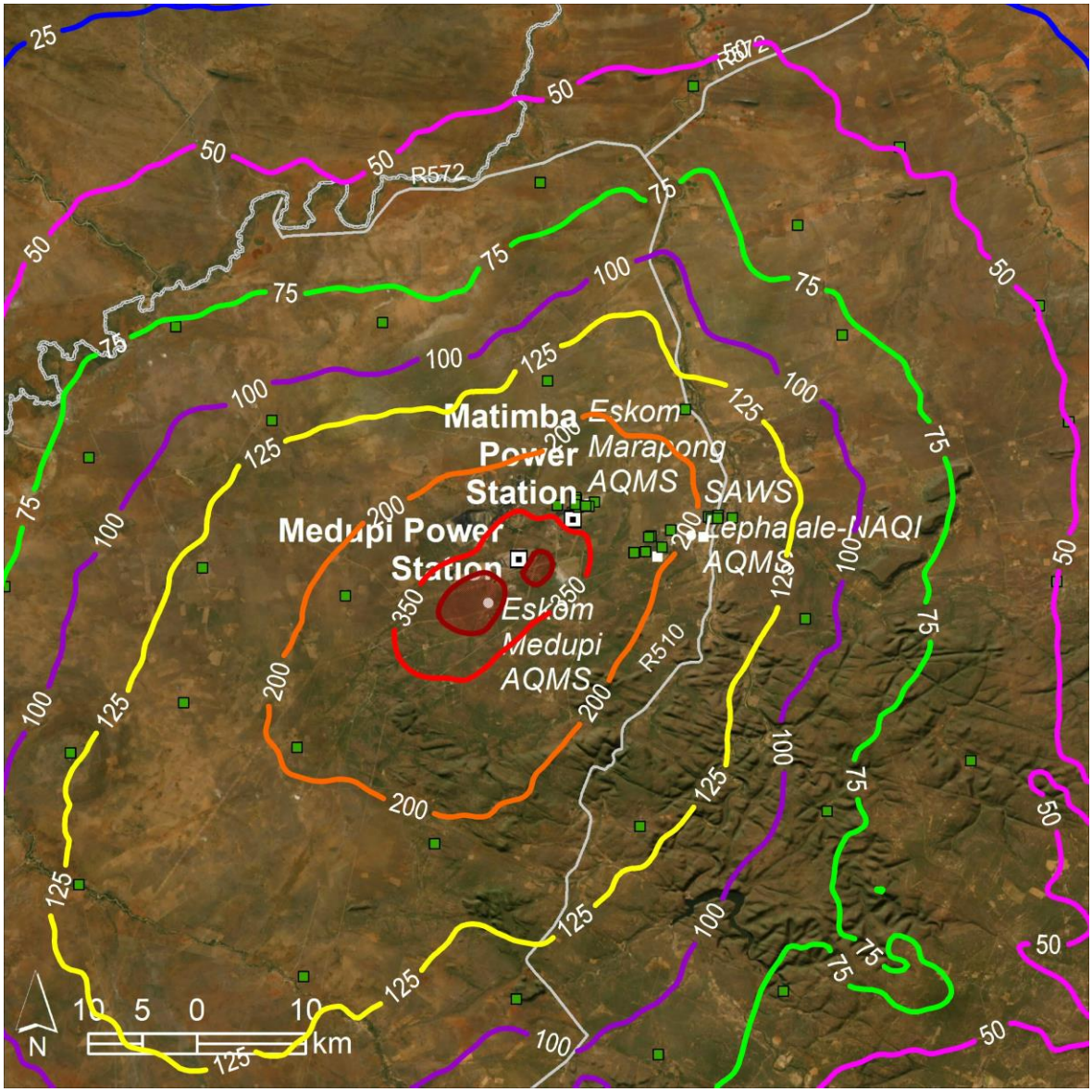


Figure 6-10: Predicted 99th percentile 1-hour SO_2 concentrations in µg/m³ for Scenario B (2031) (NAAQS Limit is 350 µg/m³)

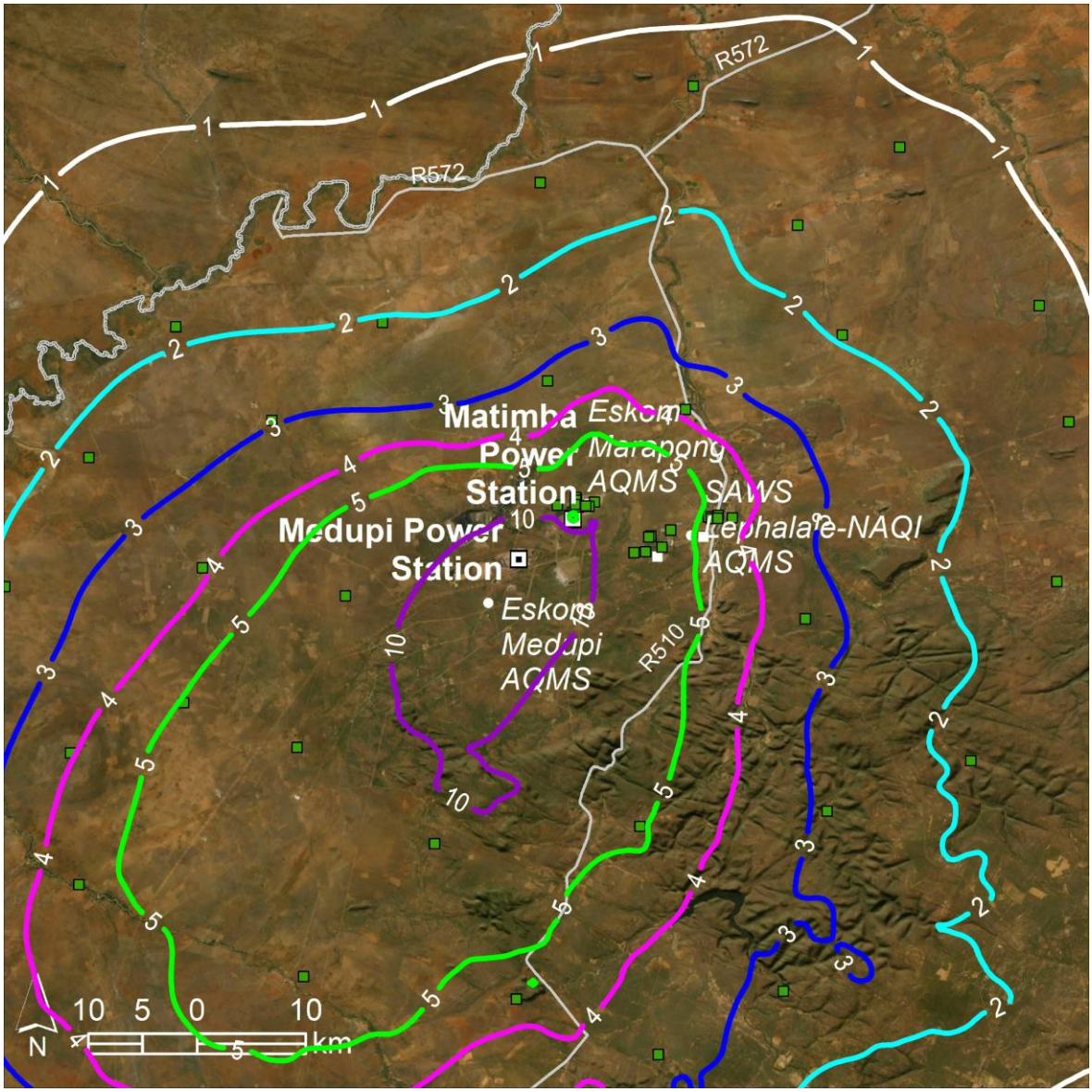


Figure 6-11: Predicted annual average SO_2 concentrations in µg/m³ for Scenario C (2036) (NAAQS Limit is 50 µg/m³)

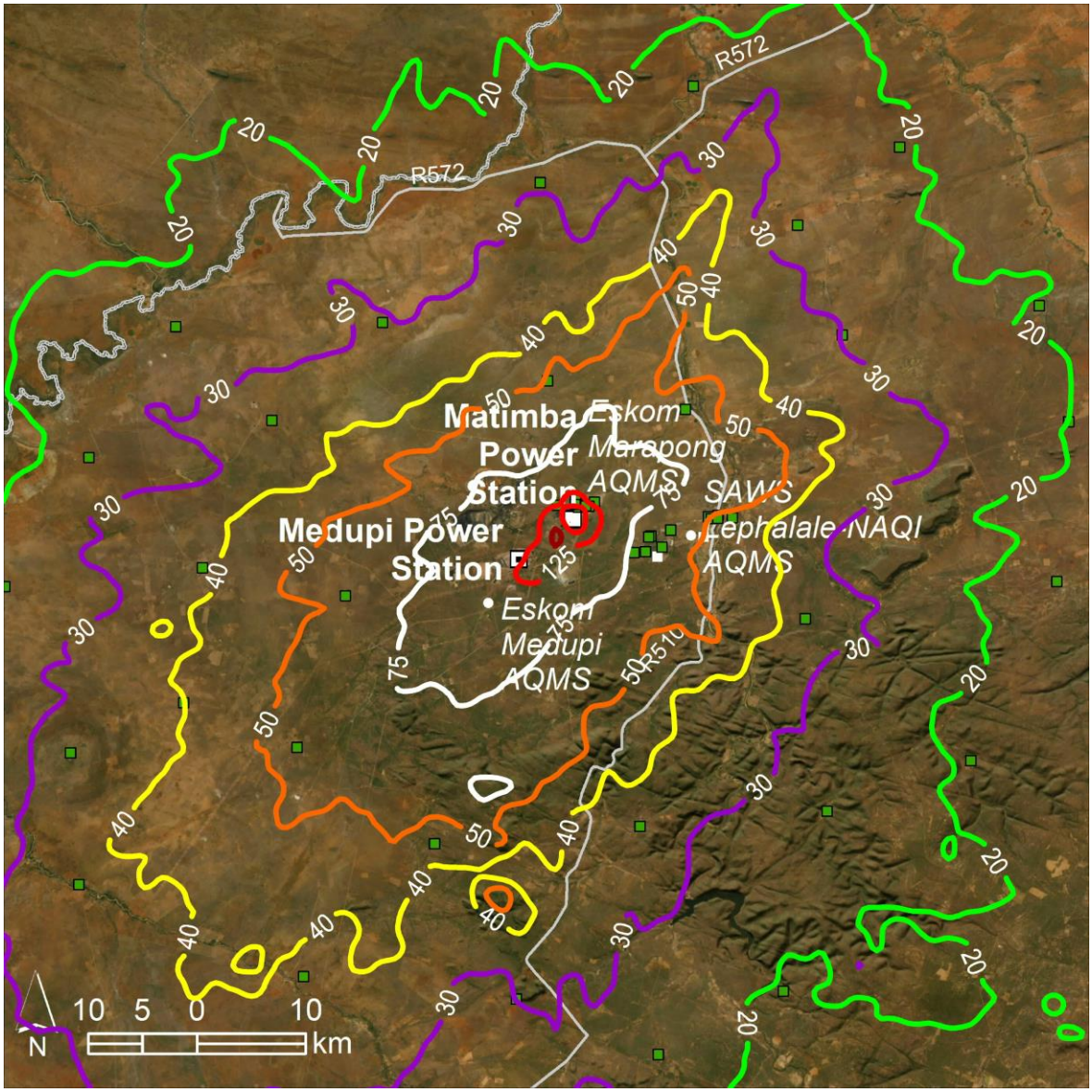


Figure 6-12: Predicted 99th percentile 24-hour SO_2 concentrations in µg/m³ for Scenario C (2036) (NAAQS Limit is 125 µg/m³)

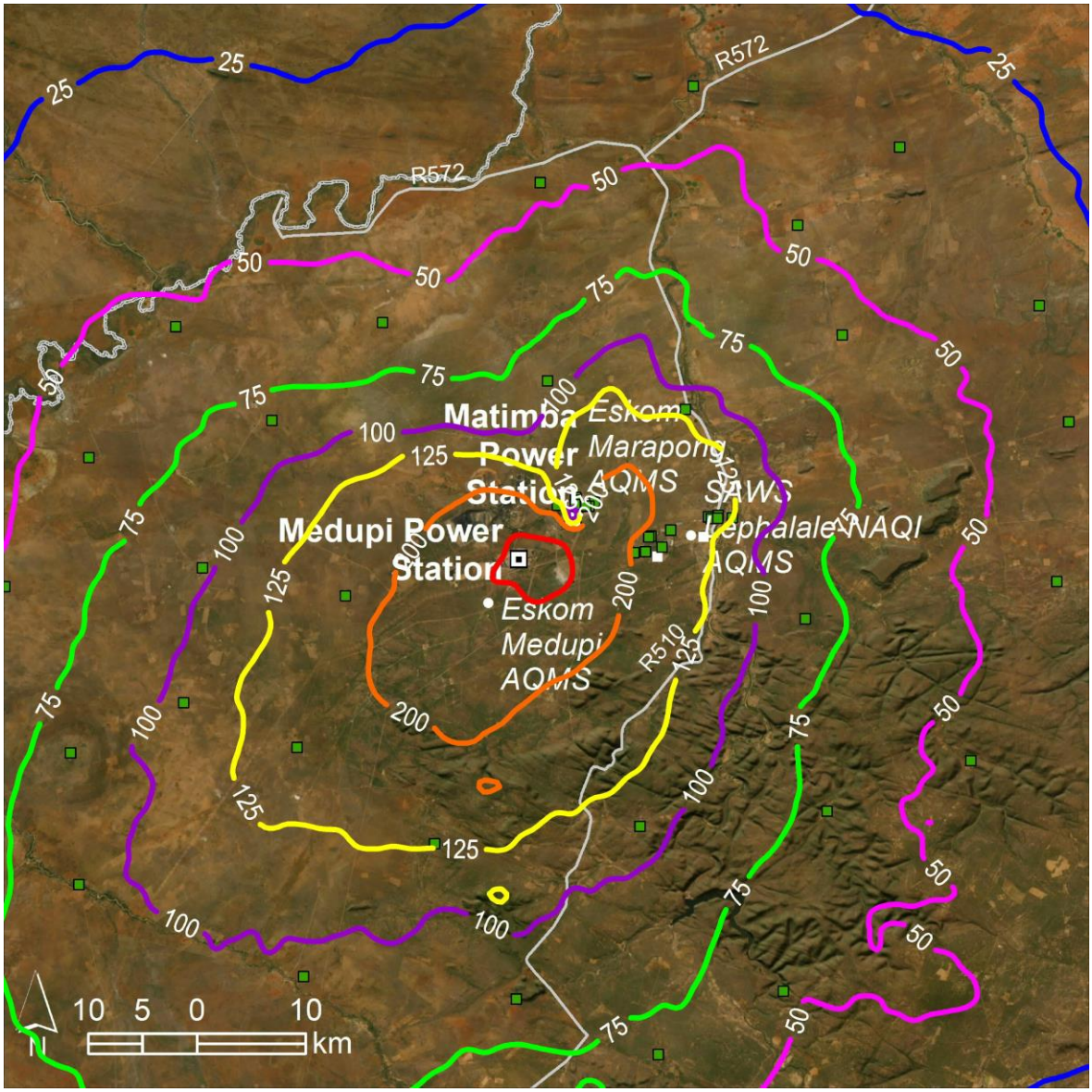


Figure 6-13: Predicted 99th percentile 1-hour SO_2 concentrations in µg/m³ for Scenario C (2036) (NAAQS Limit is 350 µg/m³)

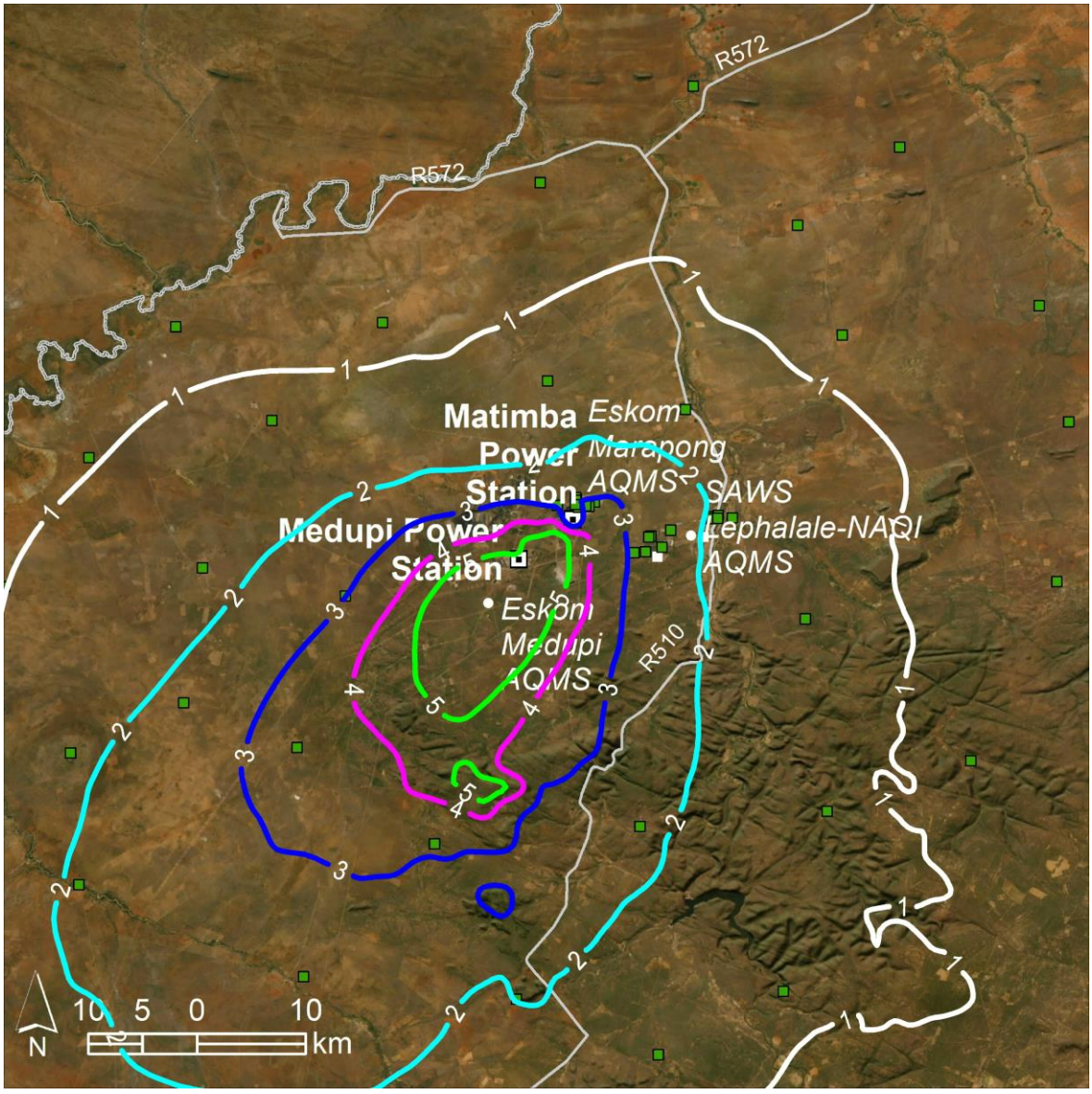


Figure 6-14: Predicted annual average SO_2 concentrations in µg/m³ for Scenario D (MES) (NAAQS Limit is 50 µg/m³)

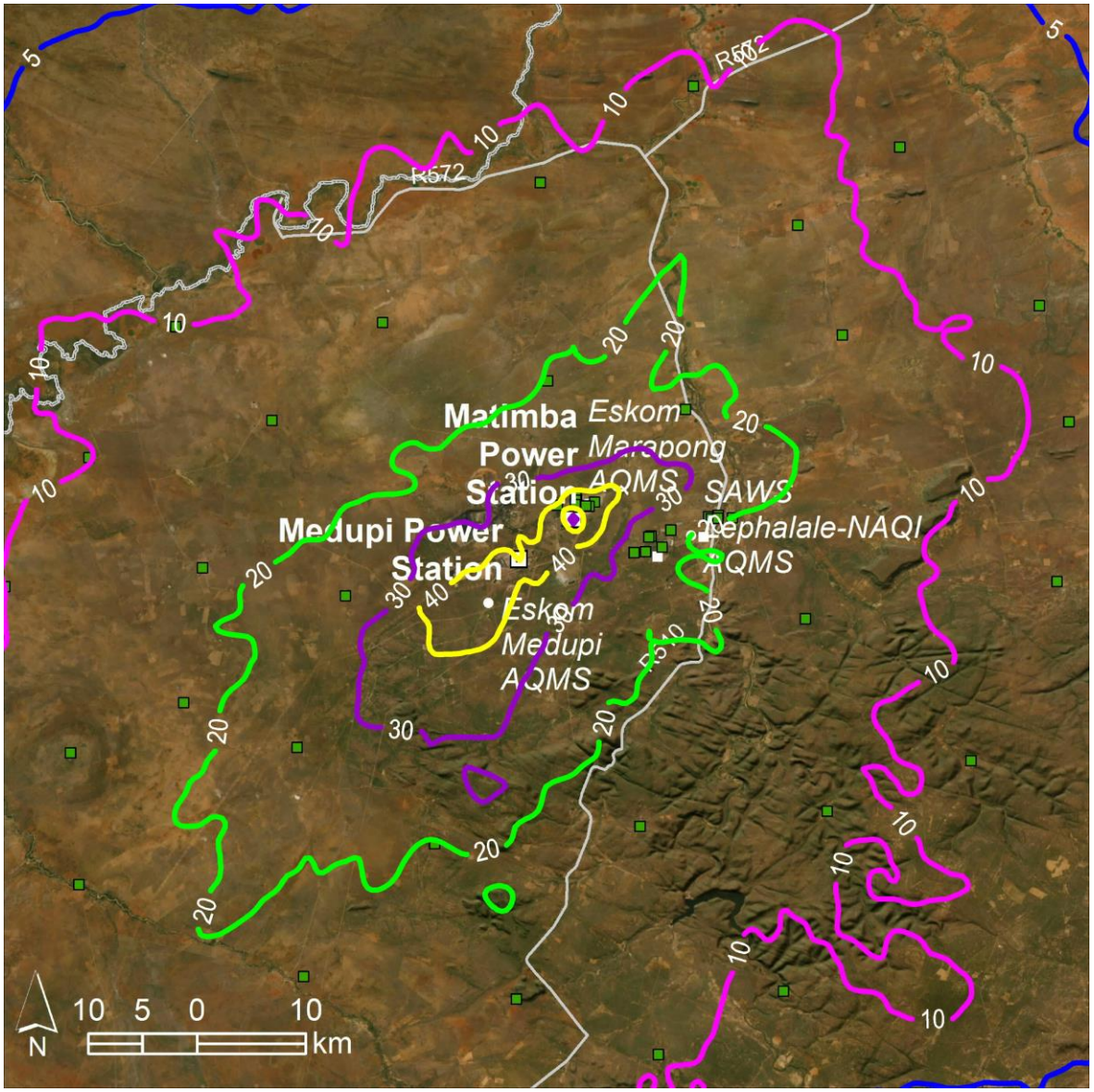


Figure 6-15: Predicted 99th percentile 24-hour SO_2 concentrations in µg/m³ for Scenario D (MES) (NAAQS Limit is 125 µg/m³)

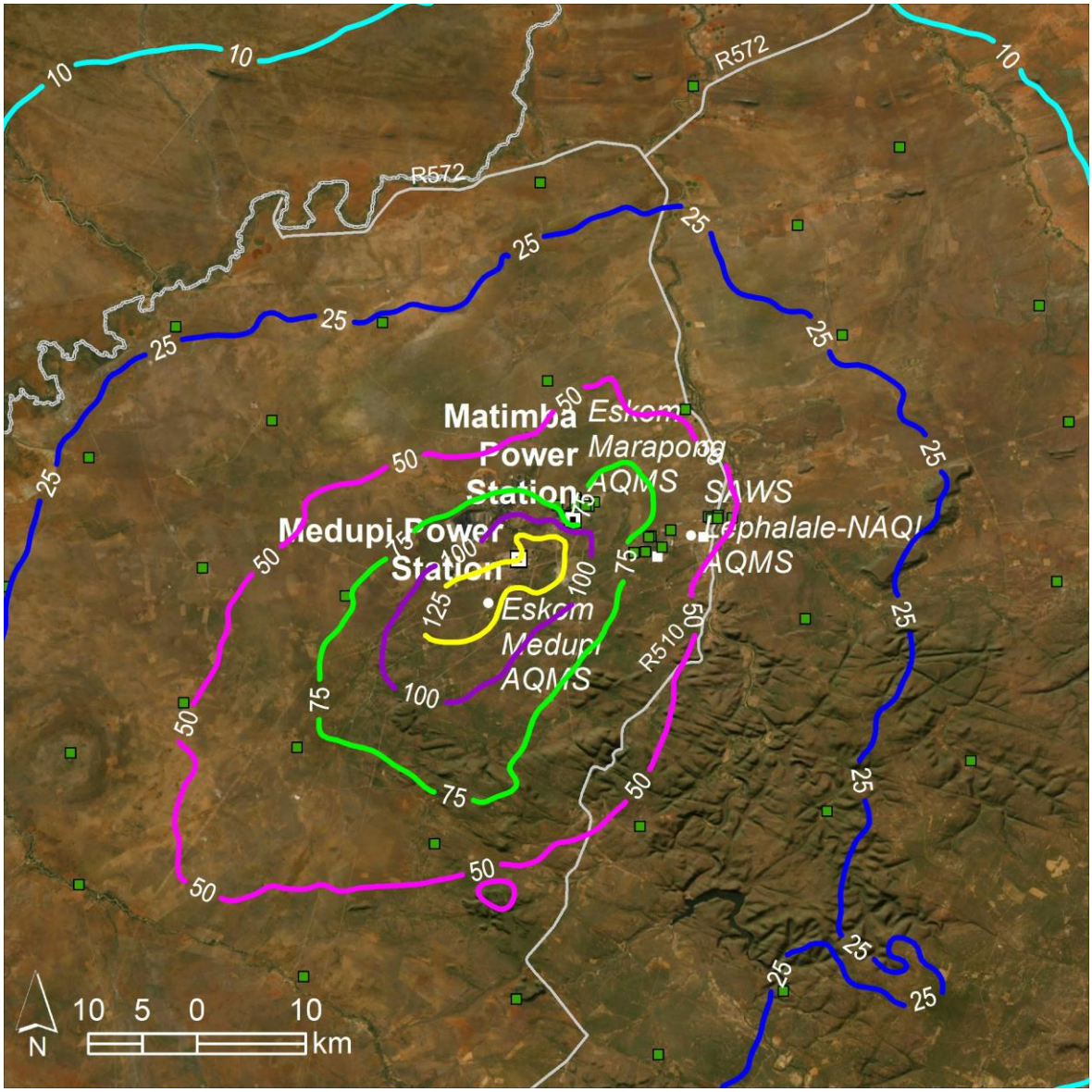


Figure 6-16: Predicted 99th percentile 1-hour SO_2 concentrations in µg/m³ for Scenario D (MES) (NAAQS Limit is 350 µg/m³)

6.2.3.2 Nitrogen dioxide (NO_2)

The isopleth maps showing the predicted annual average NO_2 concentrations clearly demonstrate the effect of the predominant northeasterly winds, with dispersion generally to the southwest of the power plant. In all scenarios the highest predicted annual average concentrations occur between 10 and 20 km to the southwest of the two power stations. The predicted ambient concentrations for all averaging periods are low and well below the NAAQS in all scenarios throughout the modelling domain.

For the annual 24-hour and 1-hour predictions, the effect of the increase in NO_2 emissions from Scenario 1 (Current) to Scenario A (2025) at Medupi is shown in the modelled results by an increase in the affected area. Similarly, the reduction in NO_2 emissions to Scenario B (2031) at both Medupi and Matimba is seen by a reduction in the affected area from the one scenario to the next. A small reduction in the affected is seen from Scenario B (2031) to Scenario C (2036). No further change is seen from Scenario C (2036) to Scenario D (MES).

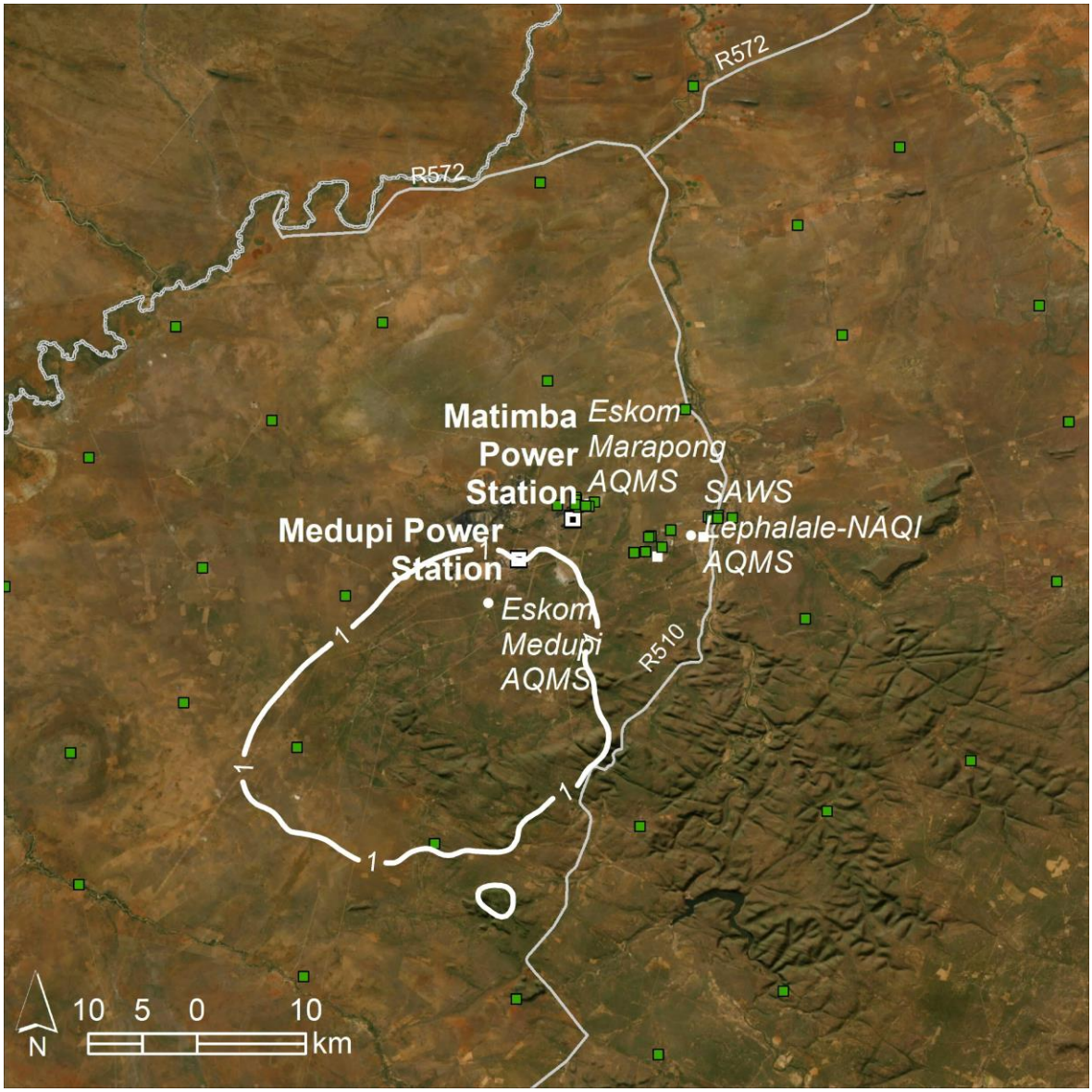


Figure 6-17: Predicted annual average NO_2 concentrations in µg/m³ for Scenario 1 (Current) (NAAQS Limit is 40 µg/m³)

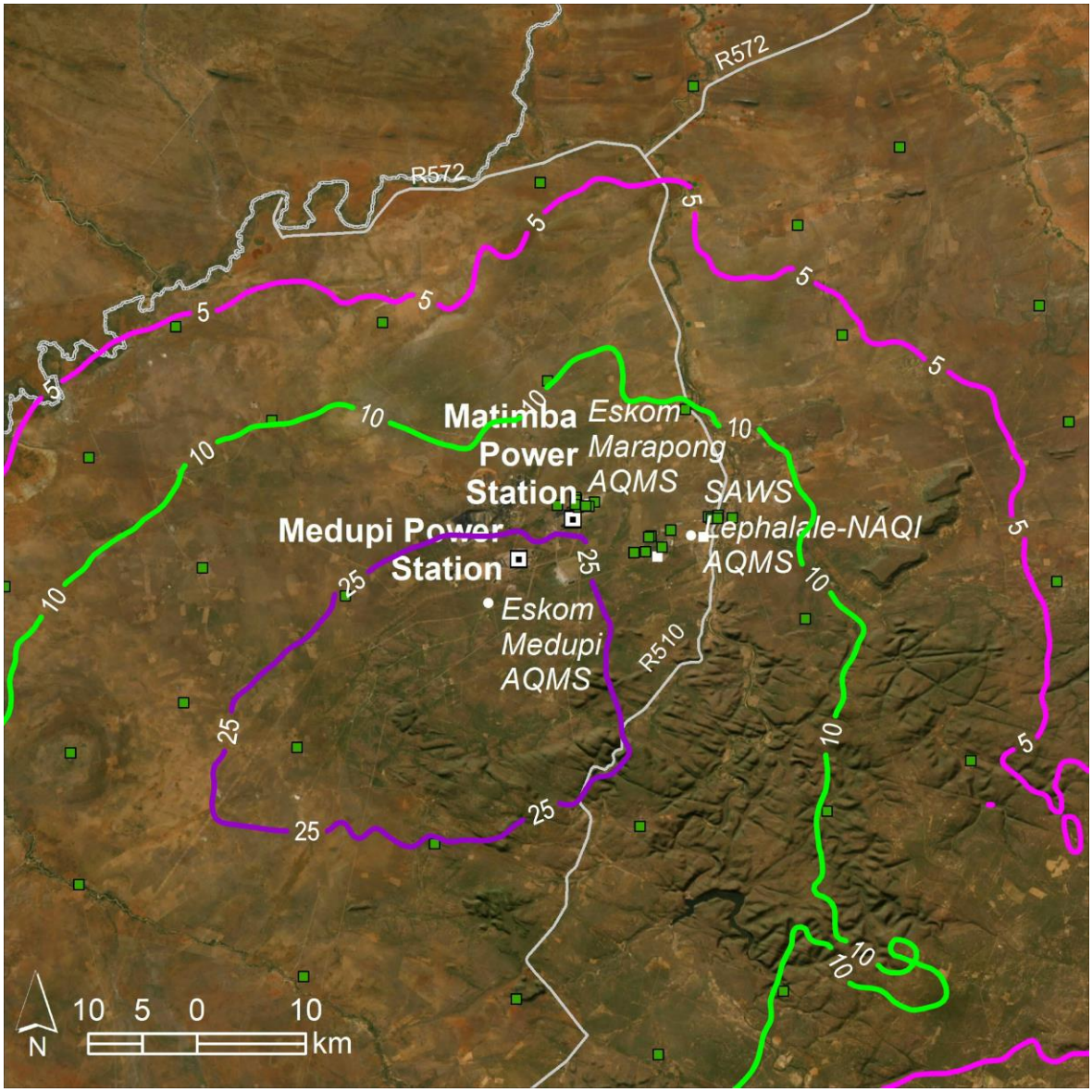


Figure 6-18: Predicted 99th percentile 1-hour NO_2 concentrations in µg/m³ for Scenario 1 (Current) (NAAQS Limit is 200 µg/m³)

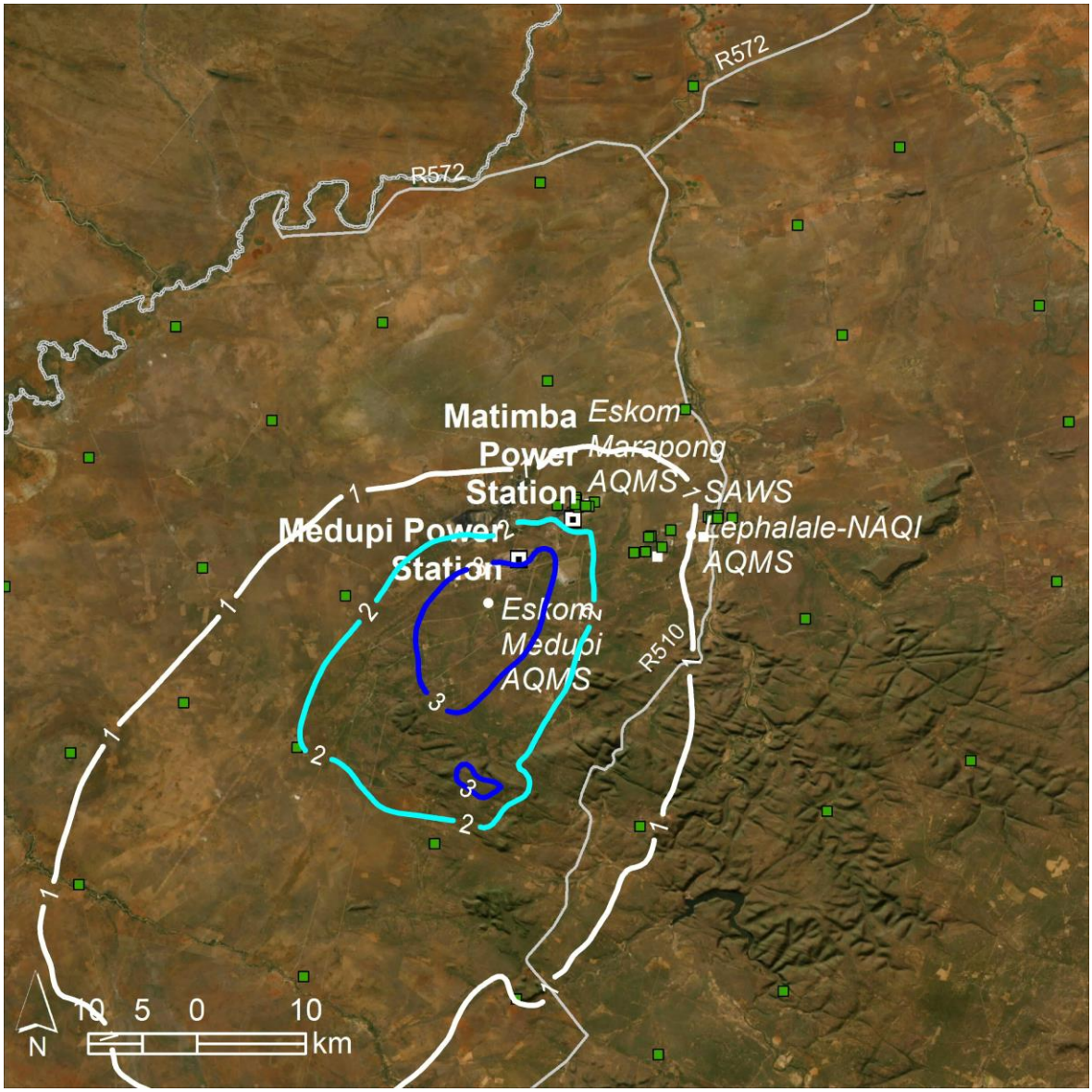


Figure 6-19: Predicted annual average NO_2 concentrations in µg/m³ for Scenario A (2025) (NAAQS Limit is 40 µg/m³)

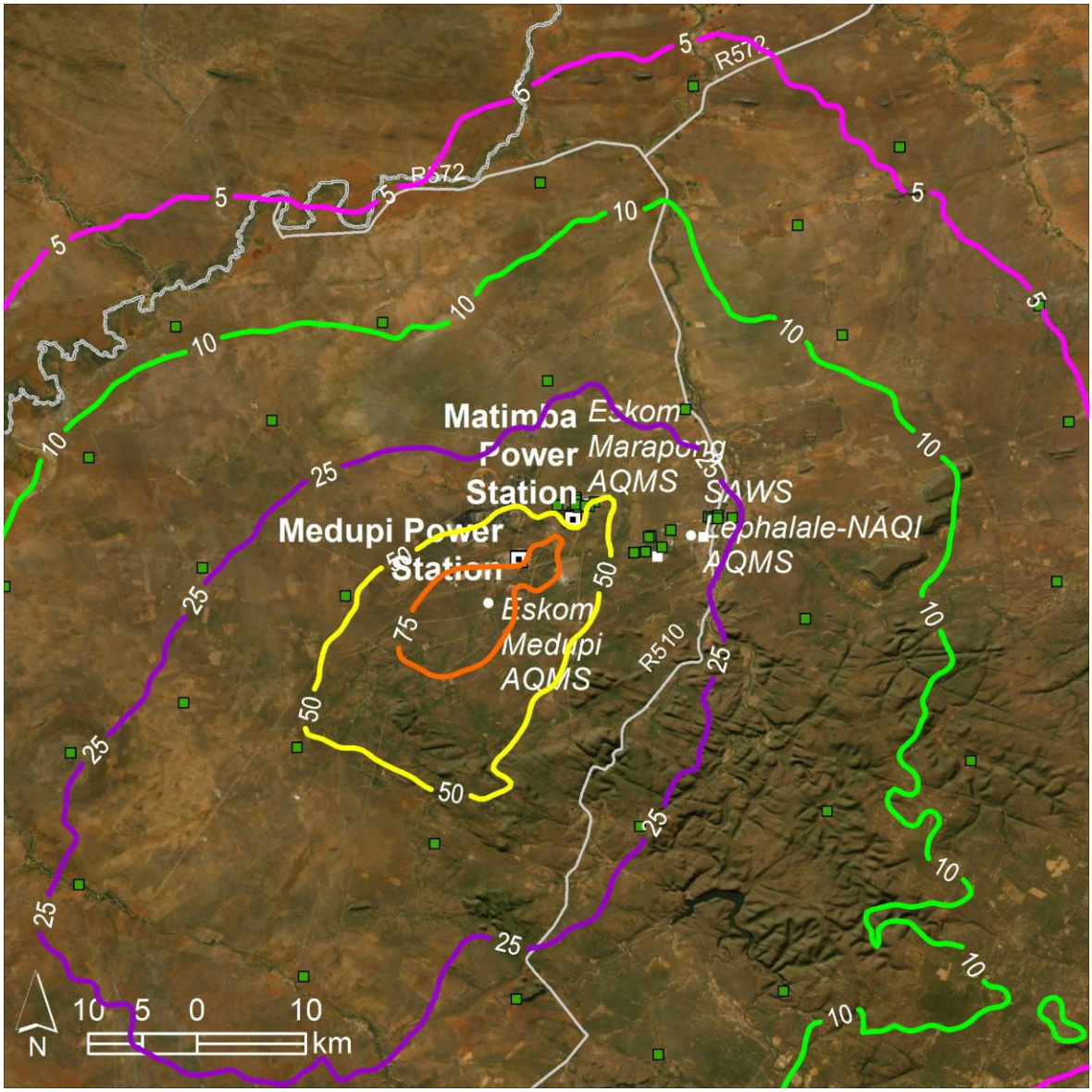


Figure 6-20: Predicted 99th percentile 1-hour NO_2 concentrations in µg/m³ for Scenario A (2025) (NAAQS Limit is 200 µg/m³)

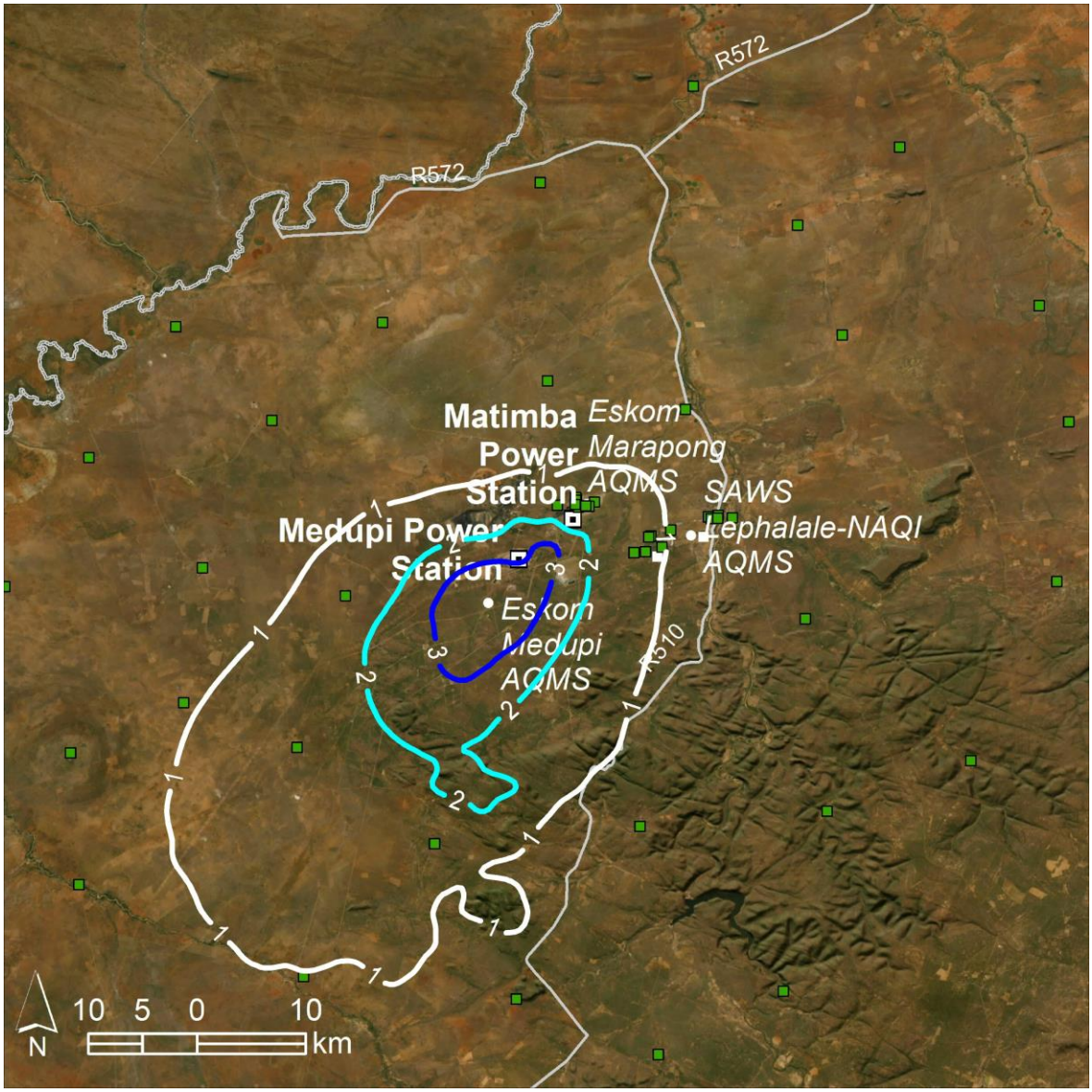


Figure 6-21: Predicted annual average NO_2 concentrations in µg/m³ for Scenario B (2031) (NAAQS Limit is 40 µg/m³)

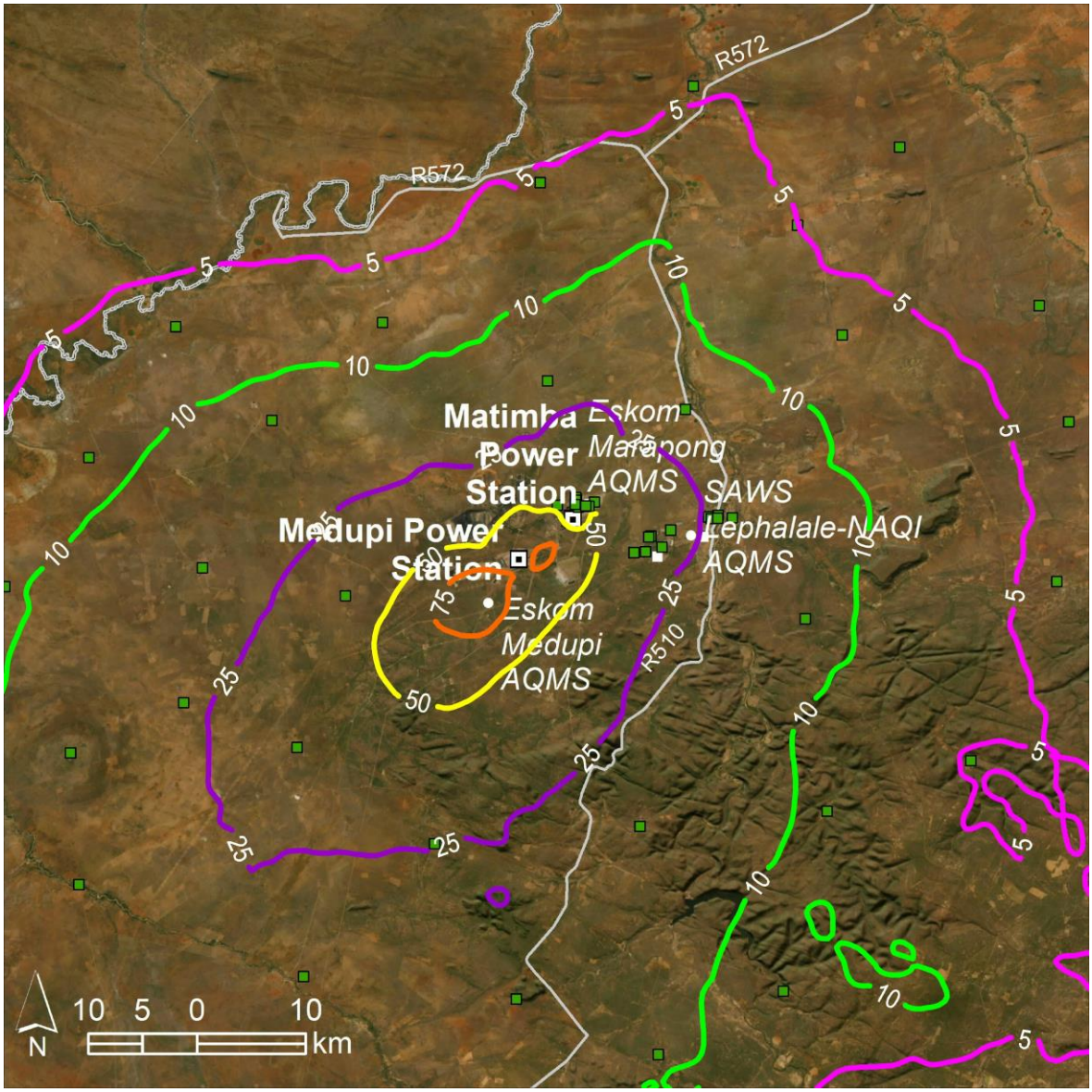


Figure 6-22: Predicted 99th percentile 1-hour NO_2 concentrations in µg/m³ for Scenario B (2031) (NAAQS Limit is 200 µg/m³)

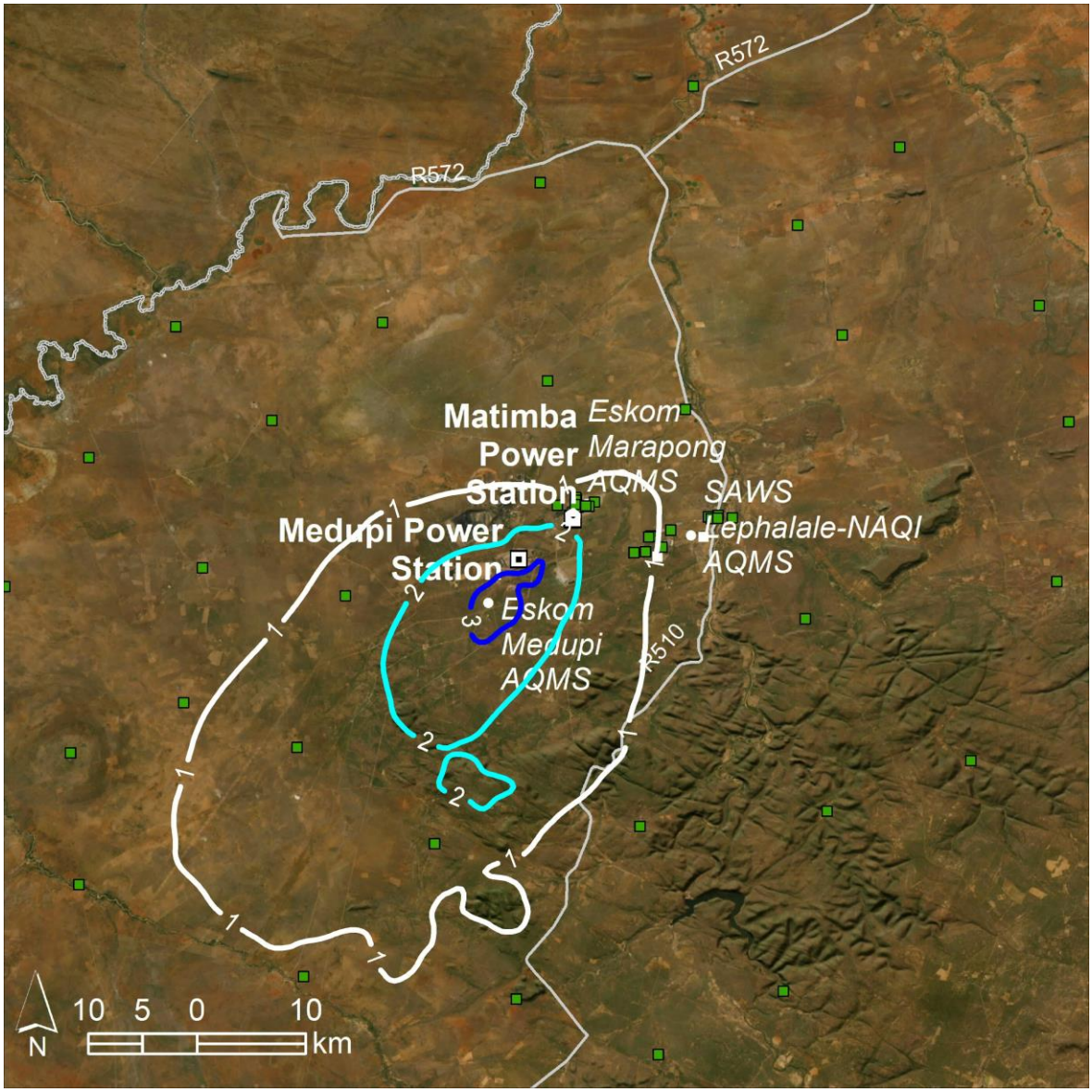


Figure 6-23: Predicted annual average NO_2 concentrations in µg/m³ for Scenario C (2036) (NAAQS Limit is 40 µg/m³)

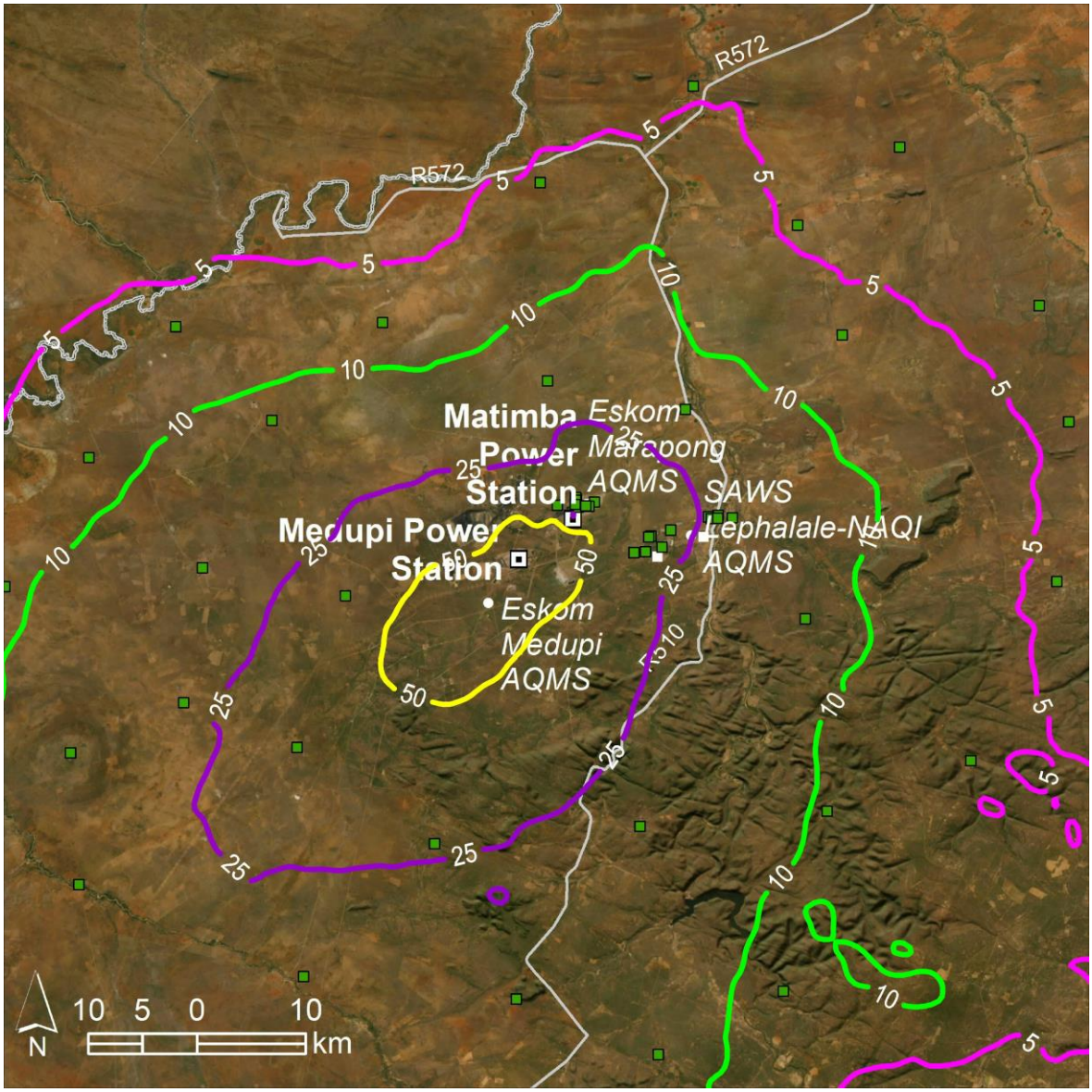


Figure 6-24: Predicted 99th percentile 1-hour NO_2 concentrations in µg/m³ for Scenario C (2036) (NAAQS Limit is 200 µg/m³)

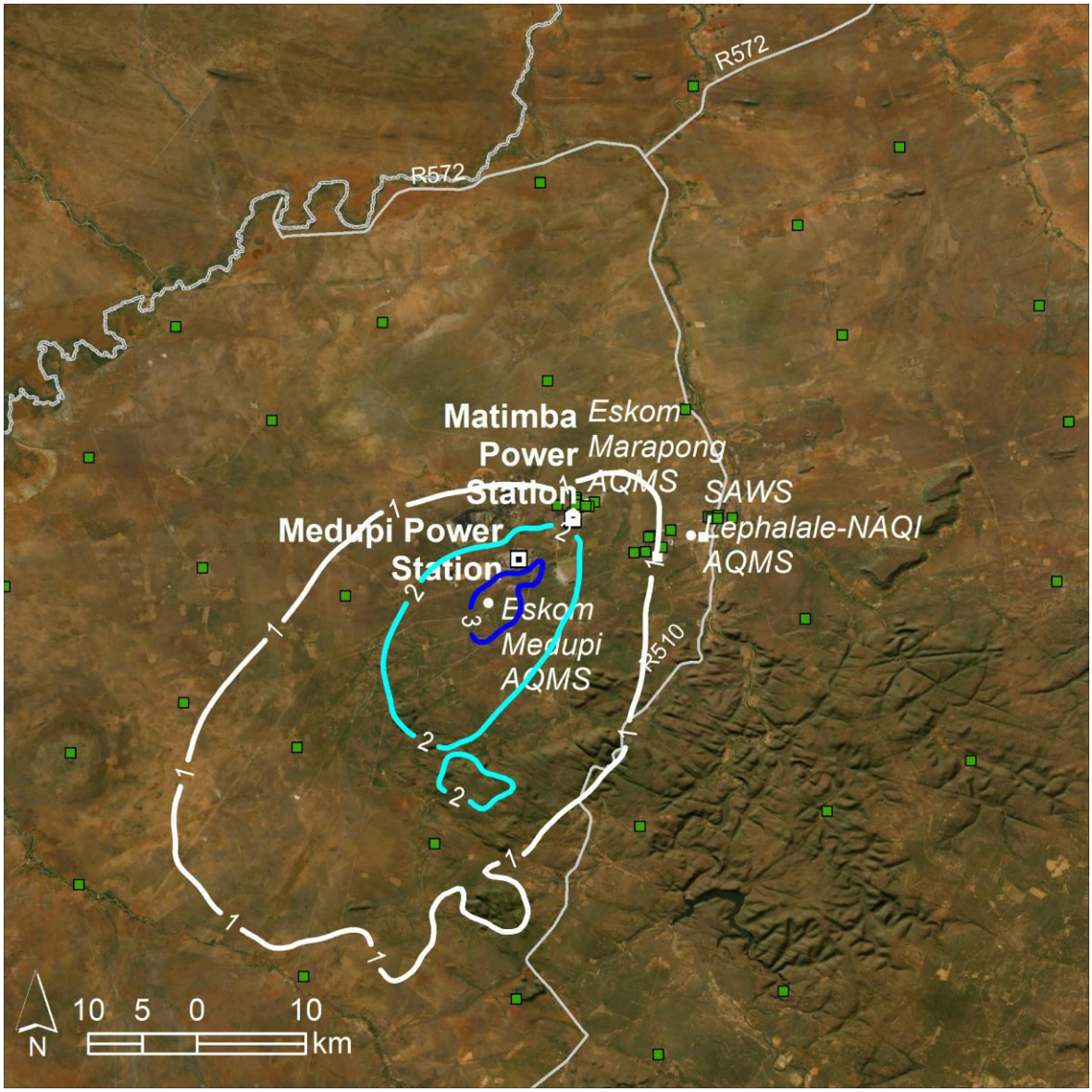


Figure 6-25: Predicted annual average NO_2 concentrations in µg/m³ for Scenario D (MES) (NAAQS Limit is 40 µg/m³)

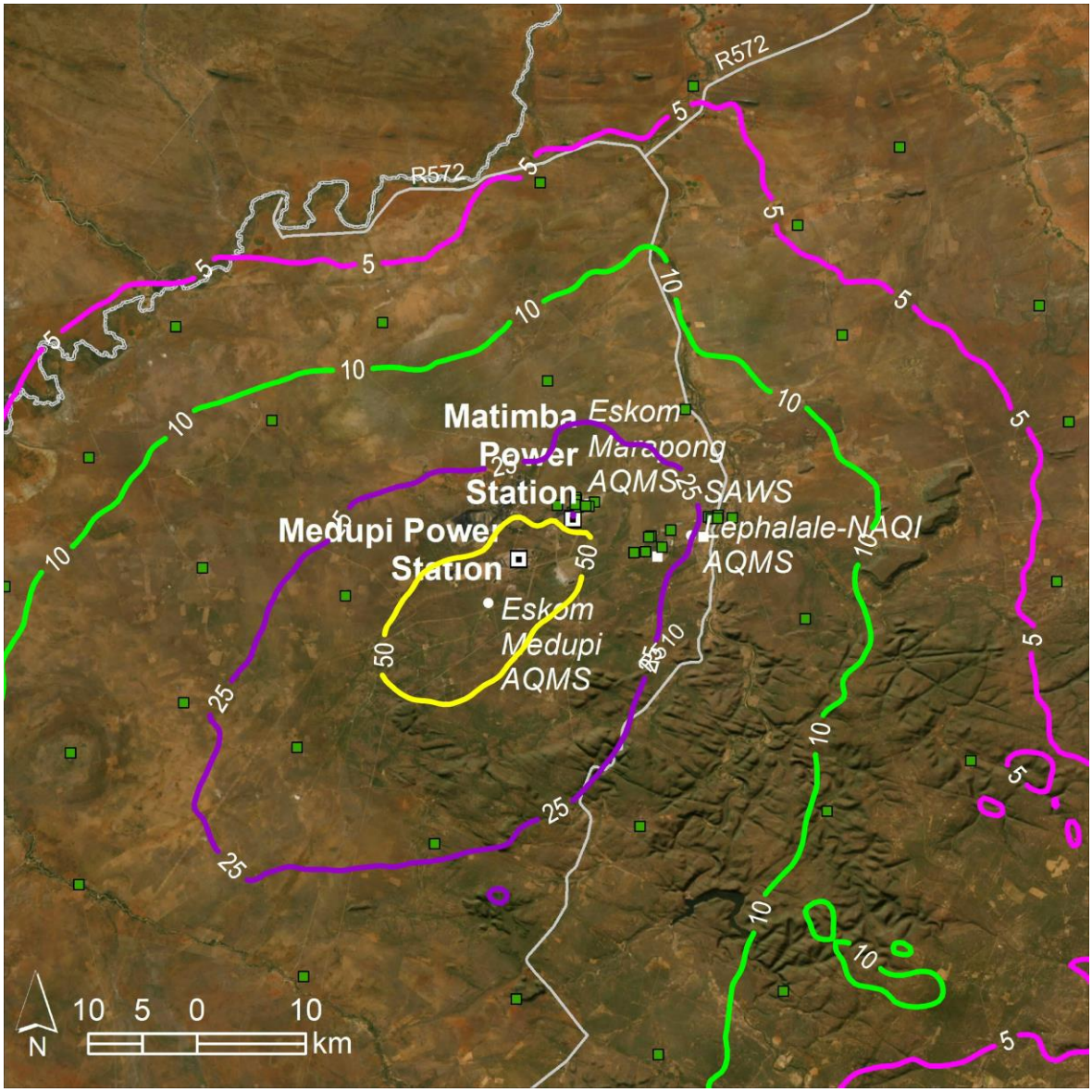


Figure 6-26: Predicted 99th percentile 1-hour NO_2 concentrations in µg/m³ for Scenario D (MES) (NAAQS Limit is 200 µg/m³)

6.2.3.3 Particulates (PM_{10})

The isopleth plots for PM_{10} are similar for all scenarios due to the significant contribution of the low-level fugitive sources to the ambient concentrations. The fugitive emission from the coal stockyard and the ash dump are the same for all scenarios, hence the similarity in the model results for the five scenarios. The effect on ambient PM_{10} concentrations of relatively small changes in the stack PM emissions is masked in the model output by the effect of the fugitive sources.

The predicted annual average concentrations exceed the NAAQS of 40 $\mu g/m^3$ in a small area immediately to the southwest of the two power stations. The area where the predicted 24-hour concentrations exceed the limit value of 75 $\mu g/m^3$ (shaded area) extends up to 10 km to the southwest of the two power station.

Exceedances of the 24-hour limit value of 75 $\mu g/m^3$ is exceeded once in the 3-year modelling period at 2 sensitive receptor points in Scenario 1 (Current) and Scenario B (2031), and once at 5 sensitive receptor points in Scenario A (2025). As 12 exceedances are permitted in the 3-year modelling period these predictions comply with the NAAQS.

It must be remembered that the predictions are conservative given the assumption that TPM = PM_{10} = $PM_{2.5}$. Remembering too that the fugitive emission have the greatest effect on ambient concentrations close to the source, while the effect of the stack emissions is generally further from the power station.

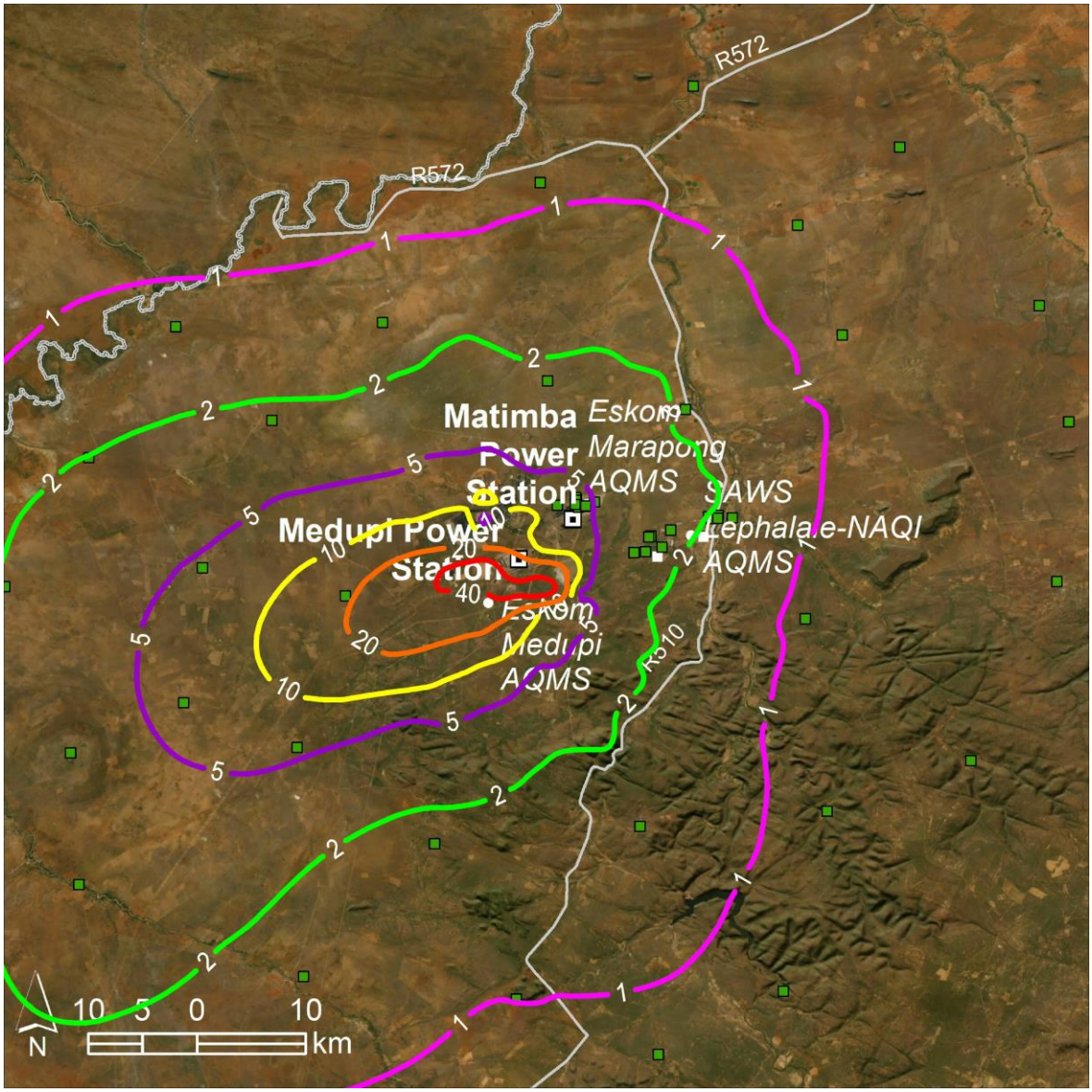


Figure 6-27: Predicted annual average PM_{10} concentrations in µg/m³ for Scenario 1 (Current) (NAAQS Limit is 40 µg/m³)

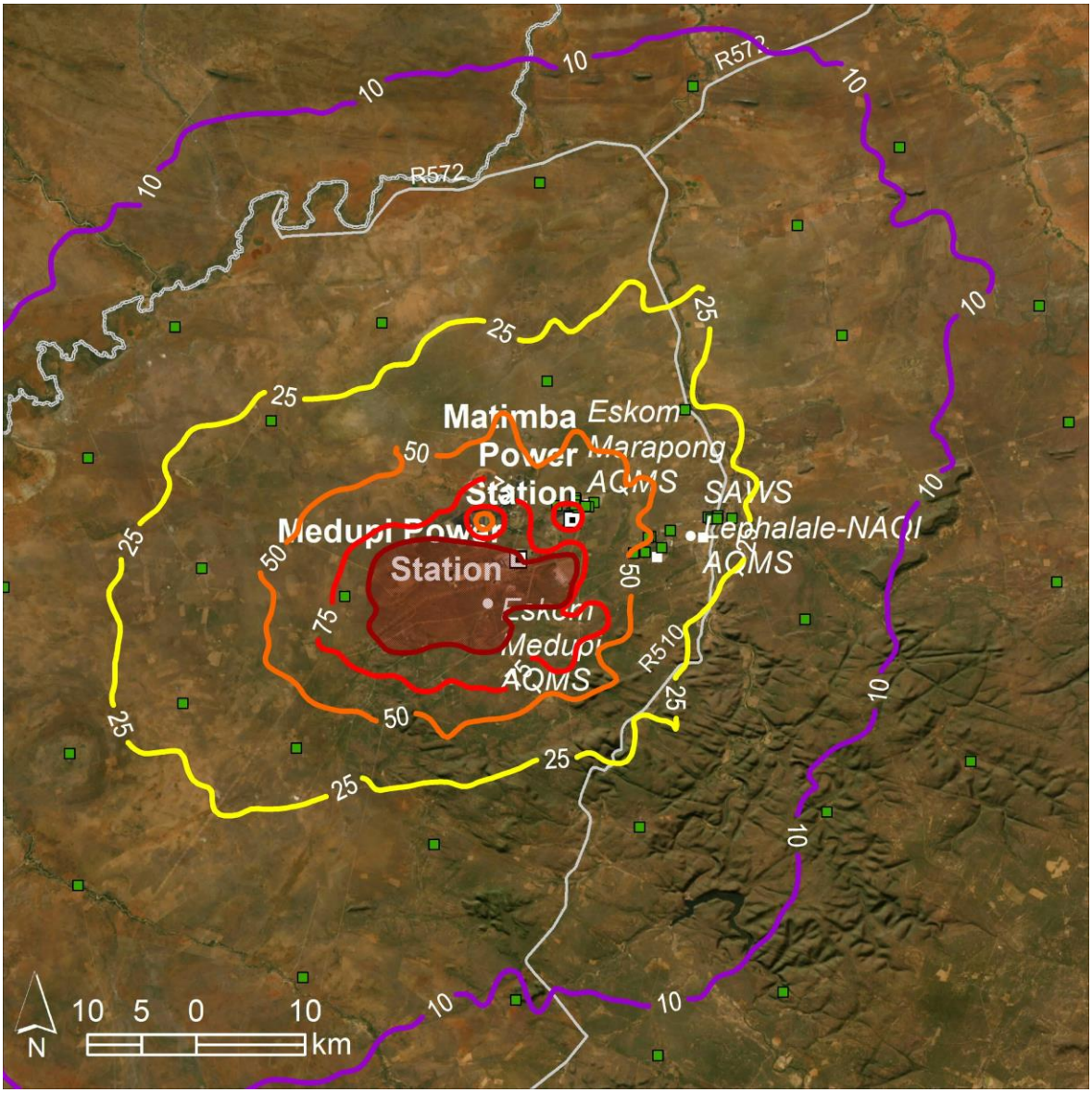


Figure 6-28: Predicted 99th percentile of the 24-hour PM_{10} concentrations in µg/m³ for Scenario 1 (Current) (NAAQS Limit is 75 µg/m³)

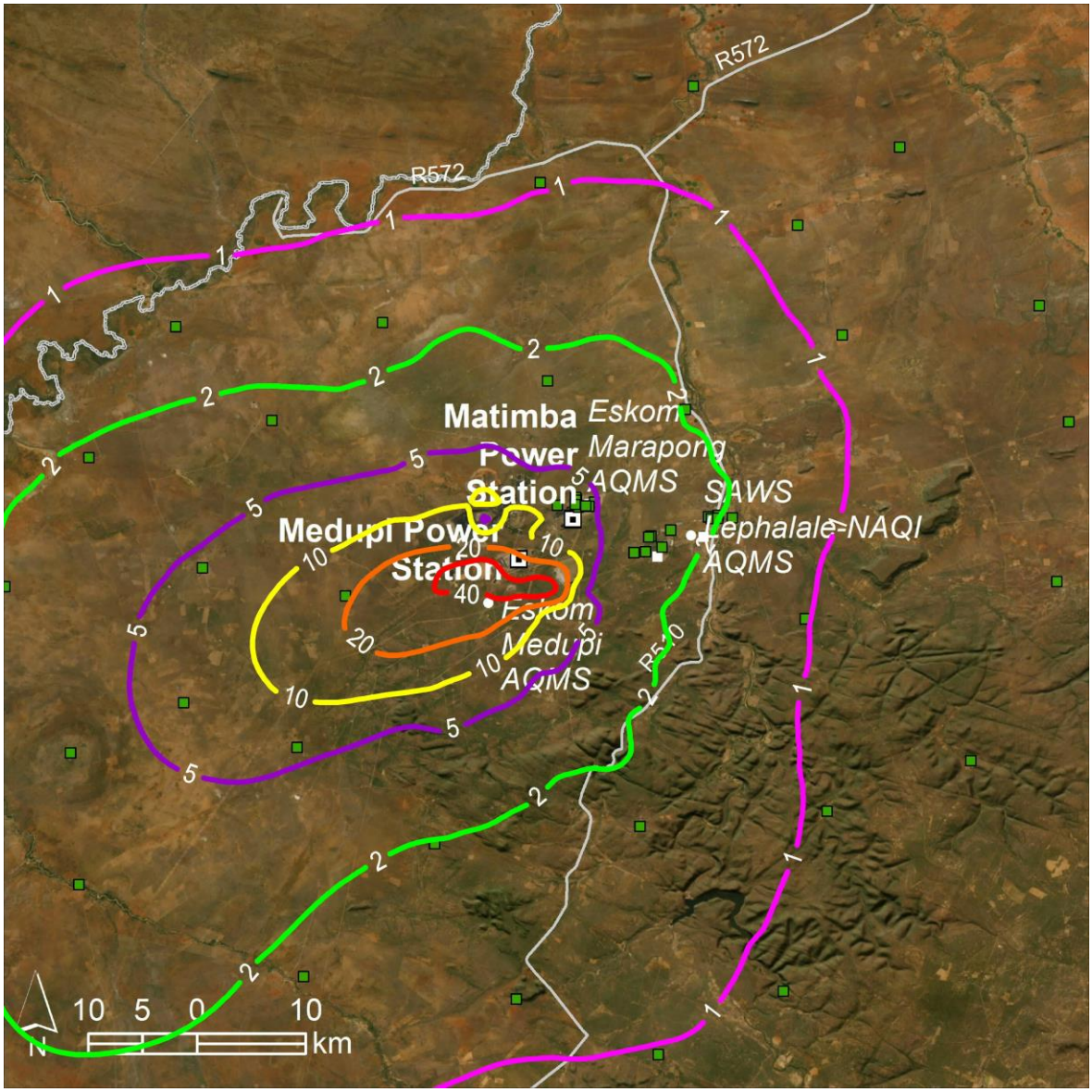


Figure 6-29: Predicted annual average PM_{10} concentrations in µg/m³ for Scenario A (2025) (NAAQS Limit is 40 µg/m³)

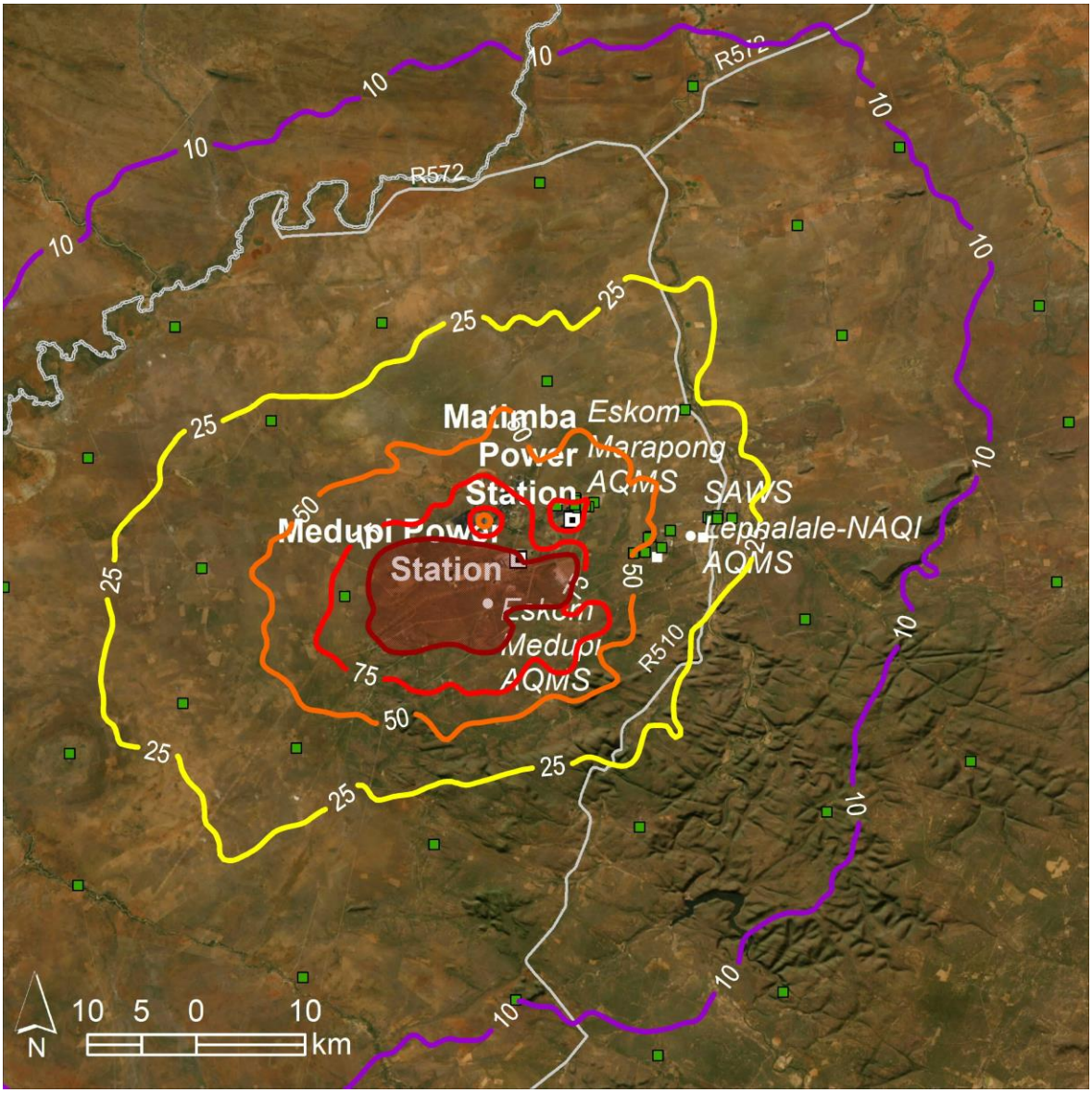


Figure 6-30: Predicted 99th percentile of the 24-hour PM_{10} concentrations in µg/m³ for Scenario A (2025) (NAAQS Limit is 75 µg/m³)

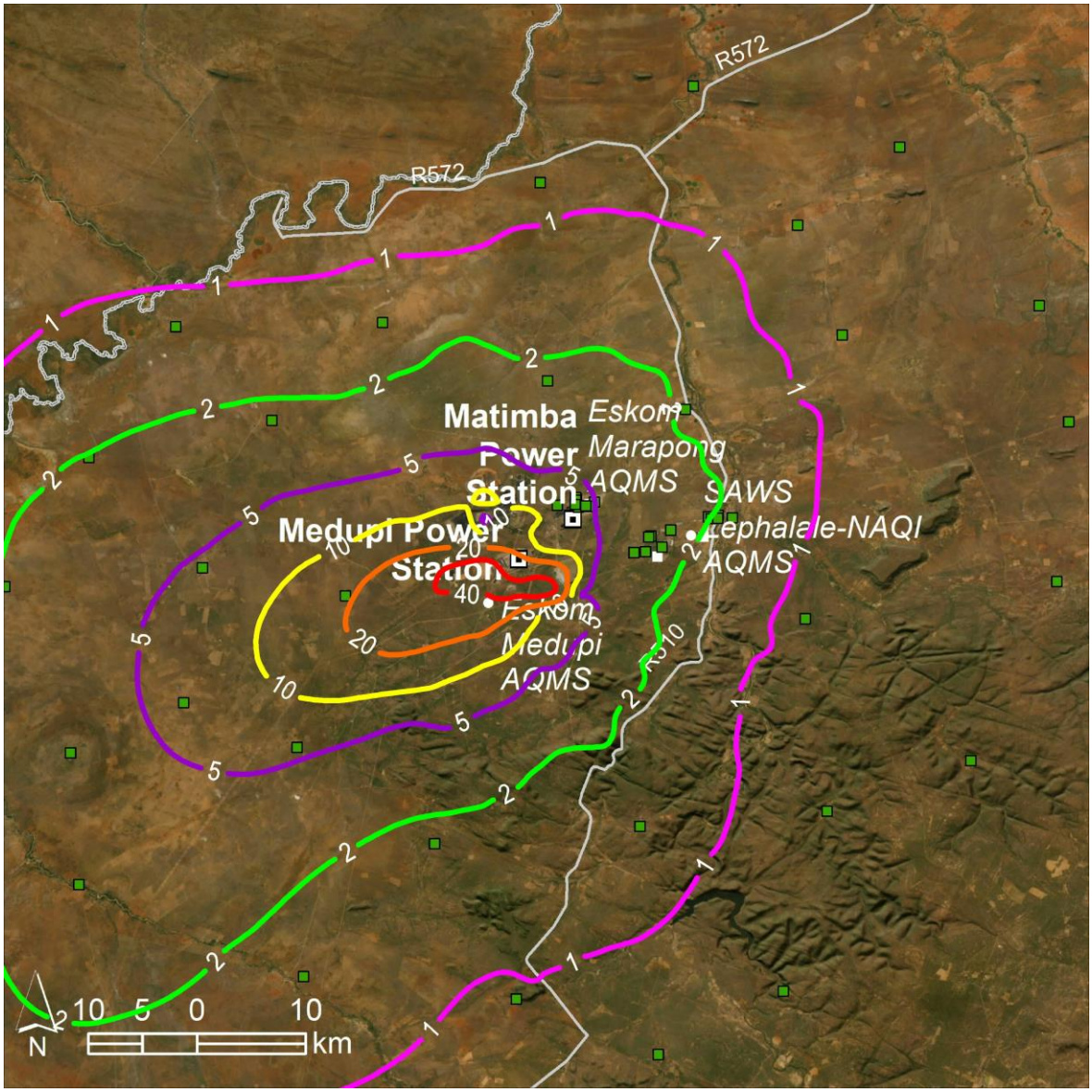


Figure 6-31: Predicted annual average PM_{10} concentrations in µg/m³ for Scenario B (2031) (NAAQS Limit is 40 µg/m³)

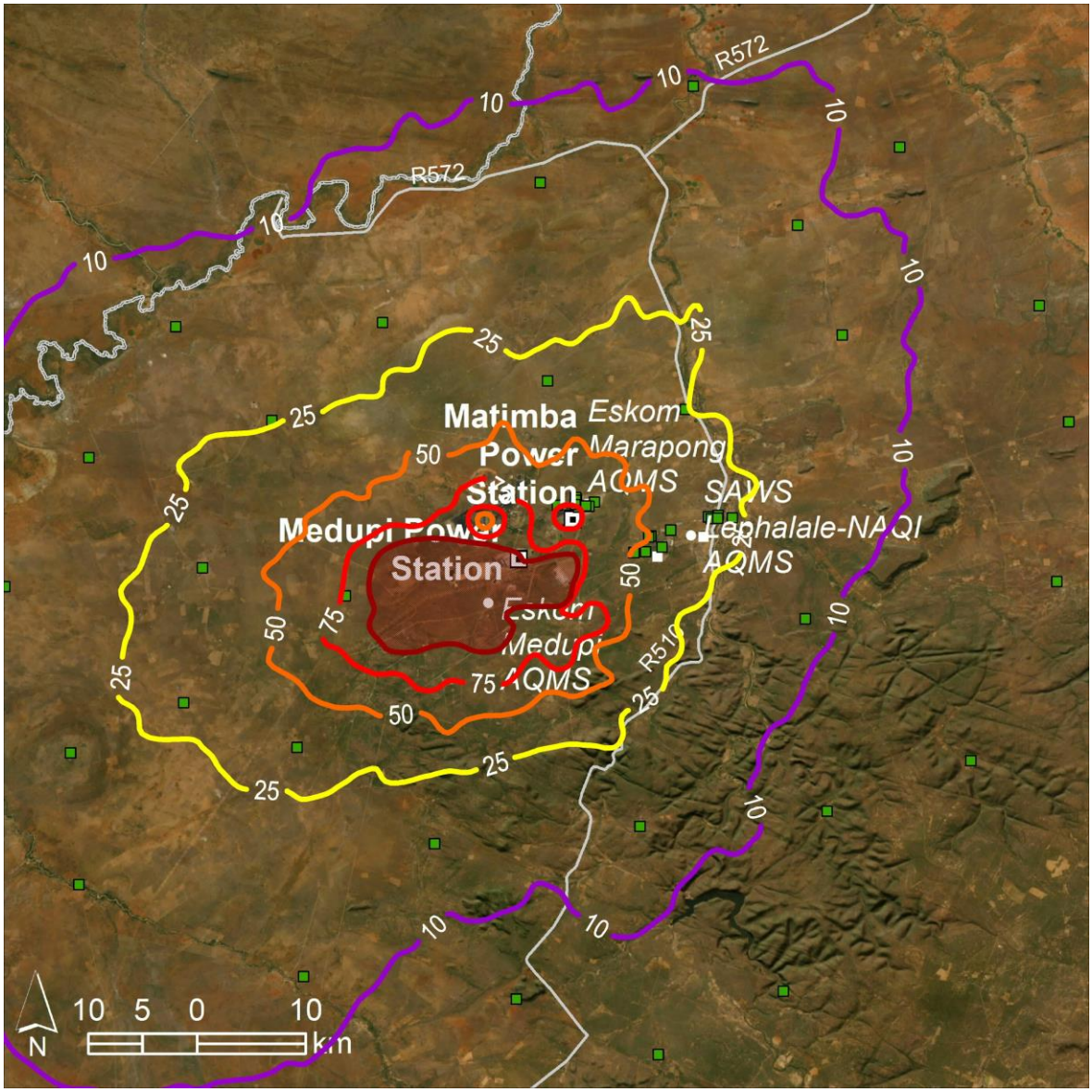


Figure 6-32: Predicted 99th percentile of the 24-hour PM_{10} concentrations in µg/m³ for Scenario B (2031) (NAAQS Limit is 75 µg/m³)

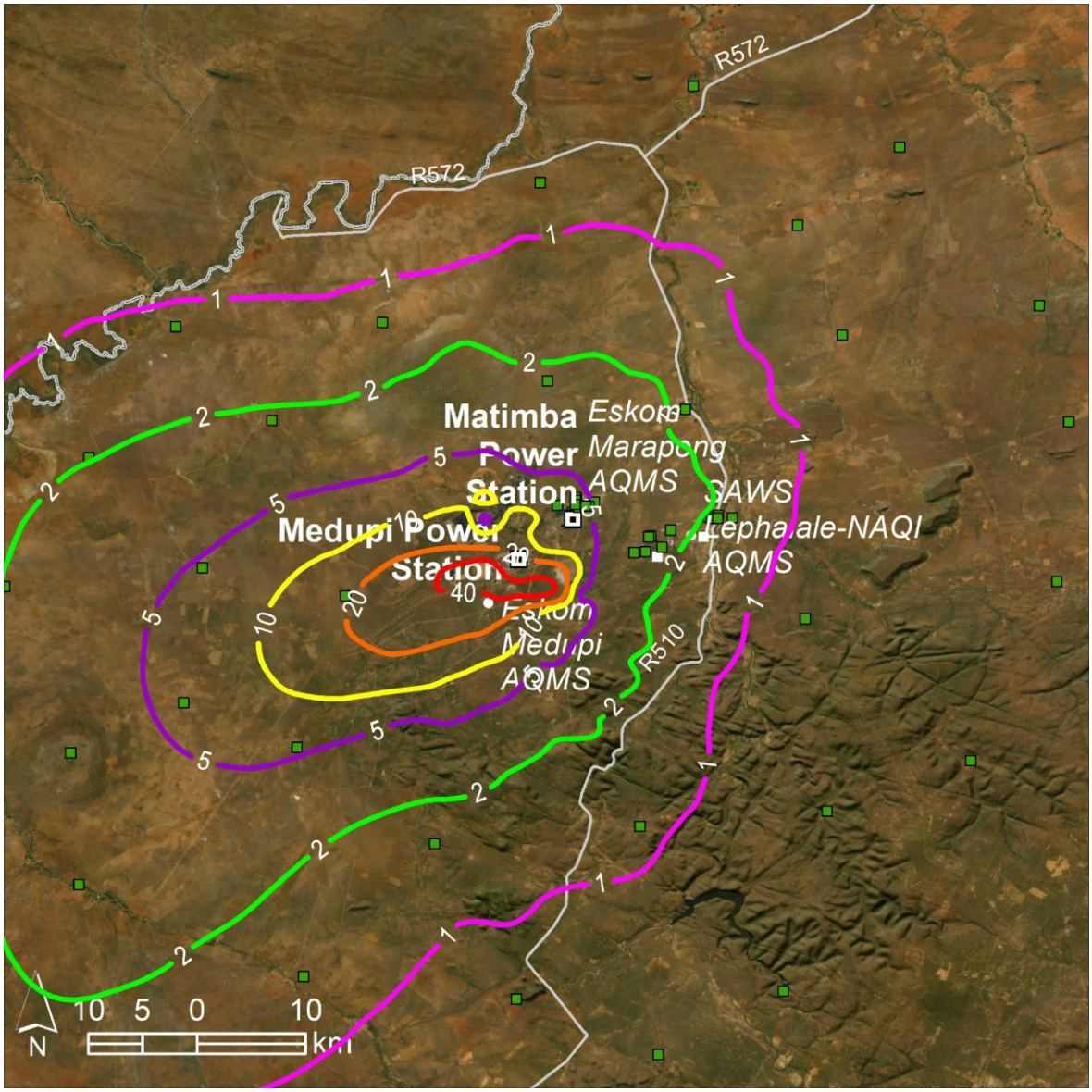


Figure 6-33: Predicted annual average PM_{10} concentrations in µg/m³ for Scenario C (2036) (NAAQS Limit is 40 µg/m³)

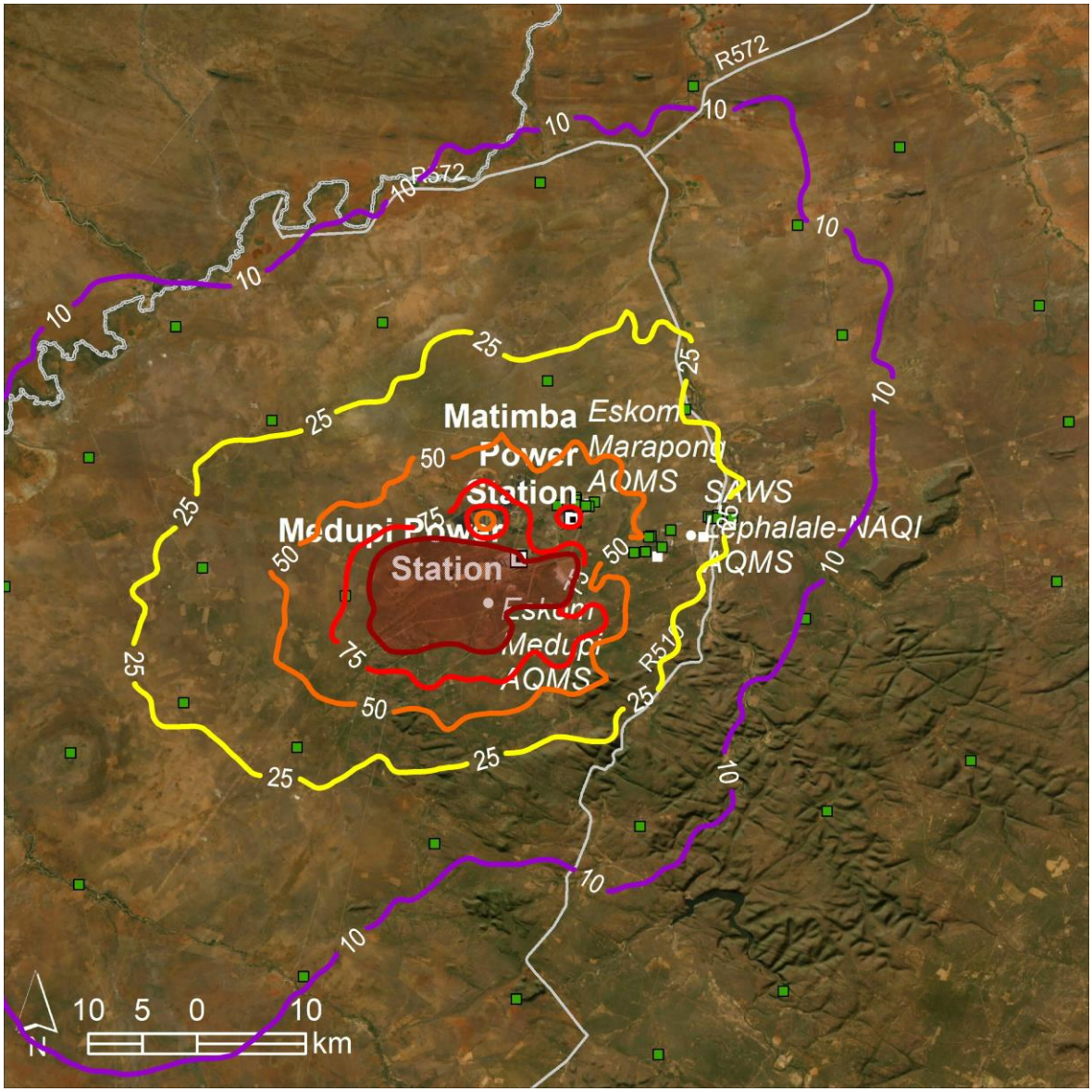


Figure 6-34: Predicted 99th percentile of the 24-hour PM_{10} concentrations in µg/m³ for Scenario C (2036) (NAAQS Limit is 75 µg/m³)

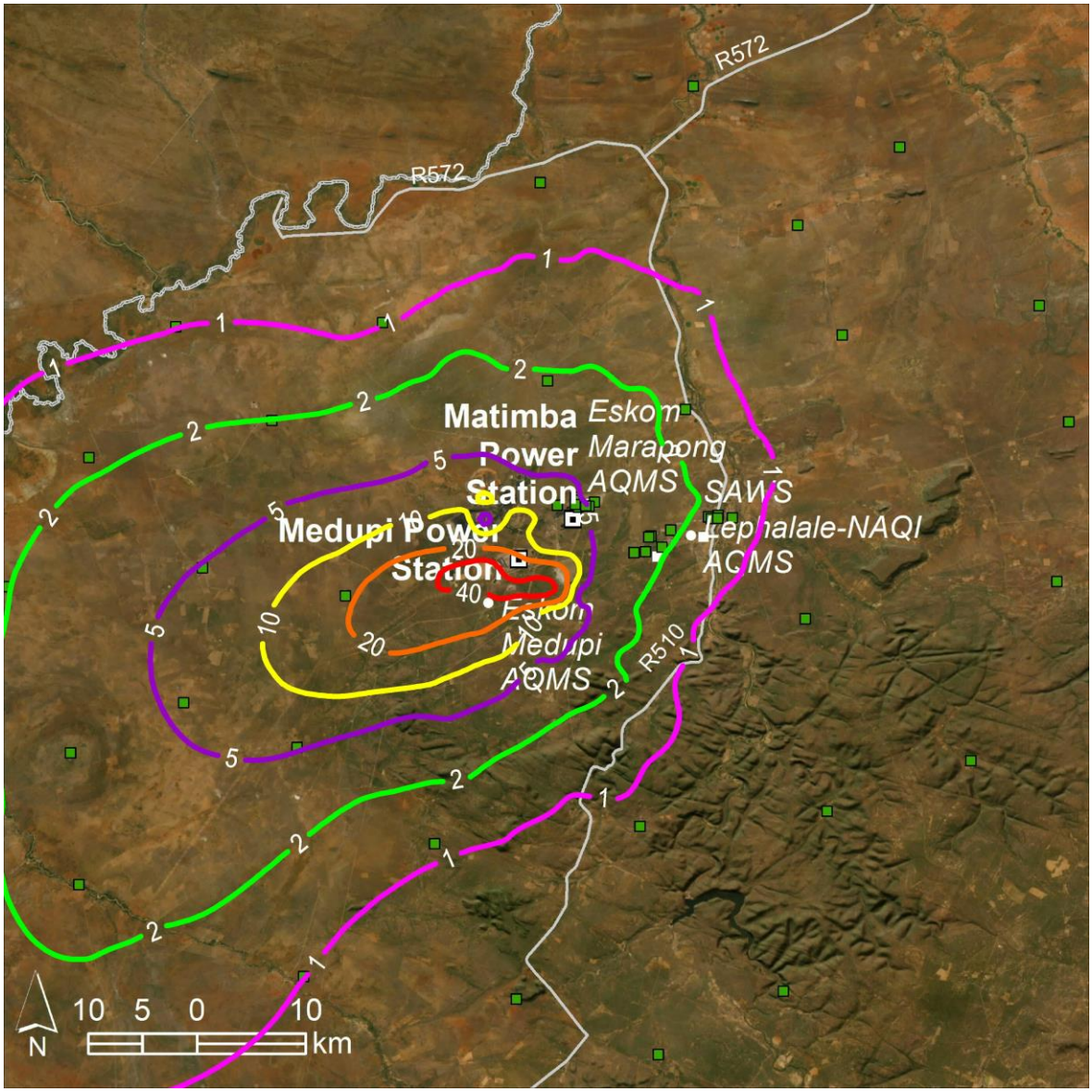


Figure 6-35: Predicted annual average PM_{10} concentrations in µg/m³ for Scenario D (MES) (NAAQS Limit is 40 µg/m³)

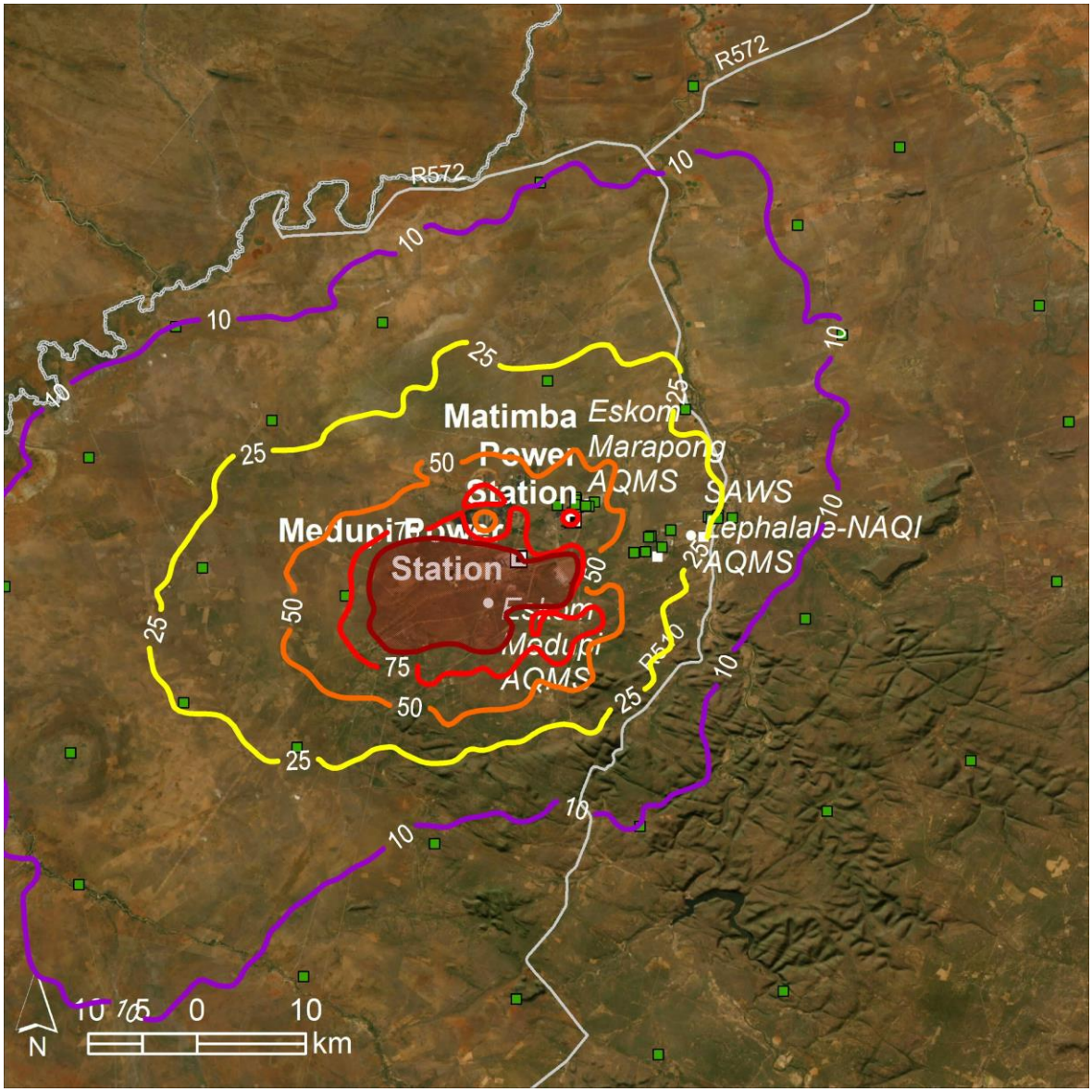


Figure 6-36: Predicted 99th percentile of the 24-hour PM_{10} concentrations in µg/m³ for Scenario D (MES) (NAAQS Limit is 75 µg/m³)

6.2.3.4 Particulates ($PM_{2.5}$)

The isopleth plots for $PM_{2.5}$ are similar for all scenarios due to the significant contribution of the low-level fugitive sources to the ambient concentrations close to the sources. The fugitive emission from the coal yards and the ash dumps at Medupi and Matimba are the same for all scenarios, hence the similarity in the model results for the five scenarios. The effect on ambient $PM_{2.5}$ concentrations of relatively small changes in the stack PM emissions is masked in the model output by the effect of the fugitive sources.

The area where the predicted annual average $PM_{2.5}$ concentrations exceed the NAAQS of 20 µg/m^3 extends approximately 10 km from the power station. The area is larger than for PM_{10} is due the more stringent NAAQS being applied for $PM_{2.5.}$ The reader is reminded that the PM has been simulated as $PM_{2.5}$ and compared against the most stringent NAAQS for $PM_{2.5}$.

For Scenario 1 (Current) and Scenario A (2025) the limit value of the 24-hour NAAQS of 40 µg/m^3 is exceeded at 17 sensitive receptors. At 9 of these the limit value is exceeded more than 12 times and are therefore non-compliant with NAAQS. In Scenario B (2031), Scenario C (2036) and Scenario D (MES) the limit value of the NAAQS of 25 µg/m^3 applies, resulting in an increase in the number of receptor points where the limit value is exceeded to 25. At 14 of these the limit value is exceeded more than 12 times and are therefore non-compliant with NAAQS. (See Appendix 1).

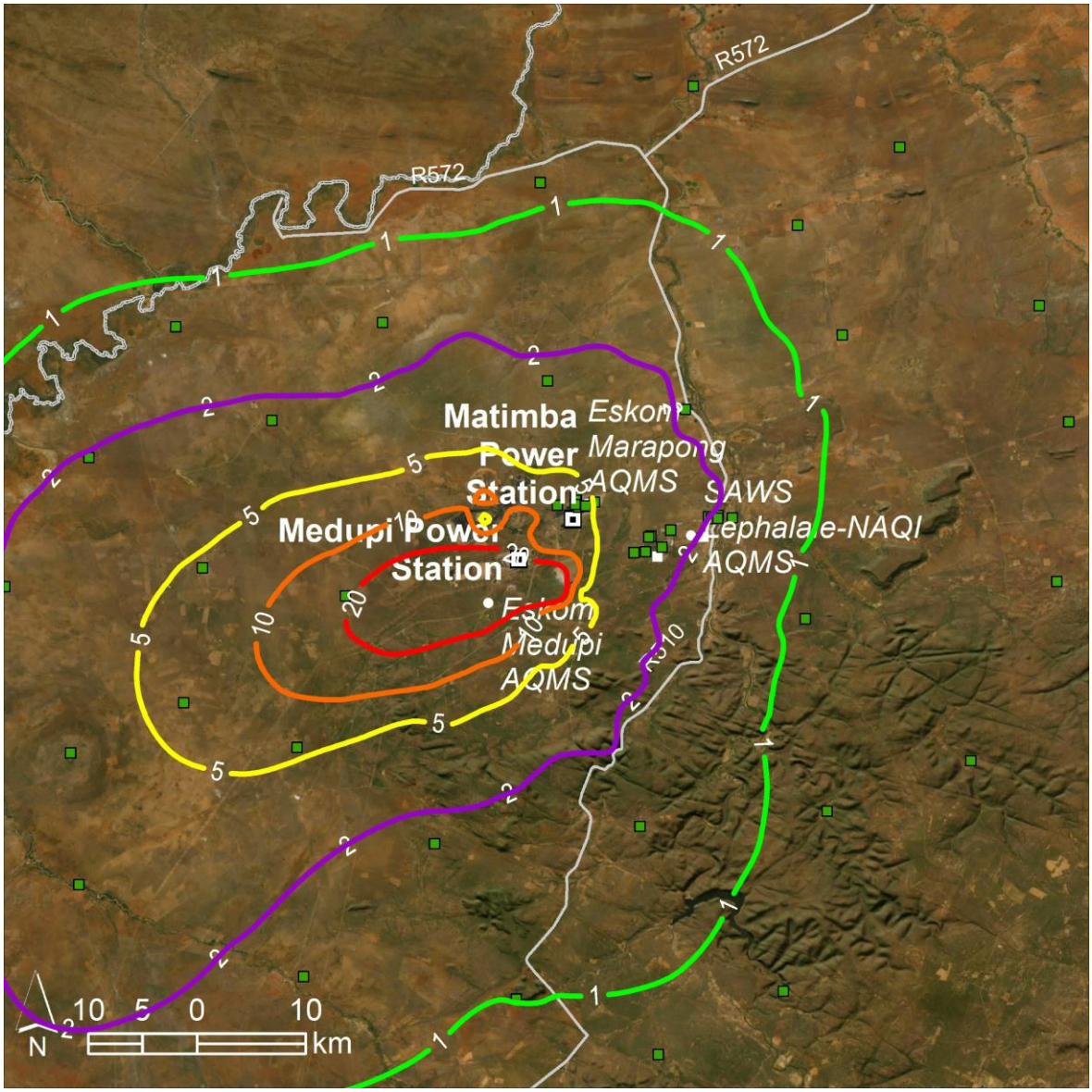


Figure 6-37: Predicted annual average $PM_{2.5}$ concentrations in µg/m³ for Scenario 1 (Current) (NAAQS Limit is 20 µg/m³)

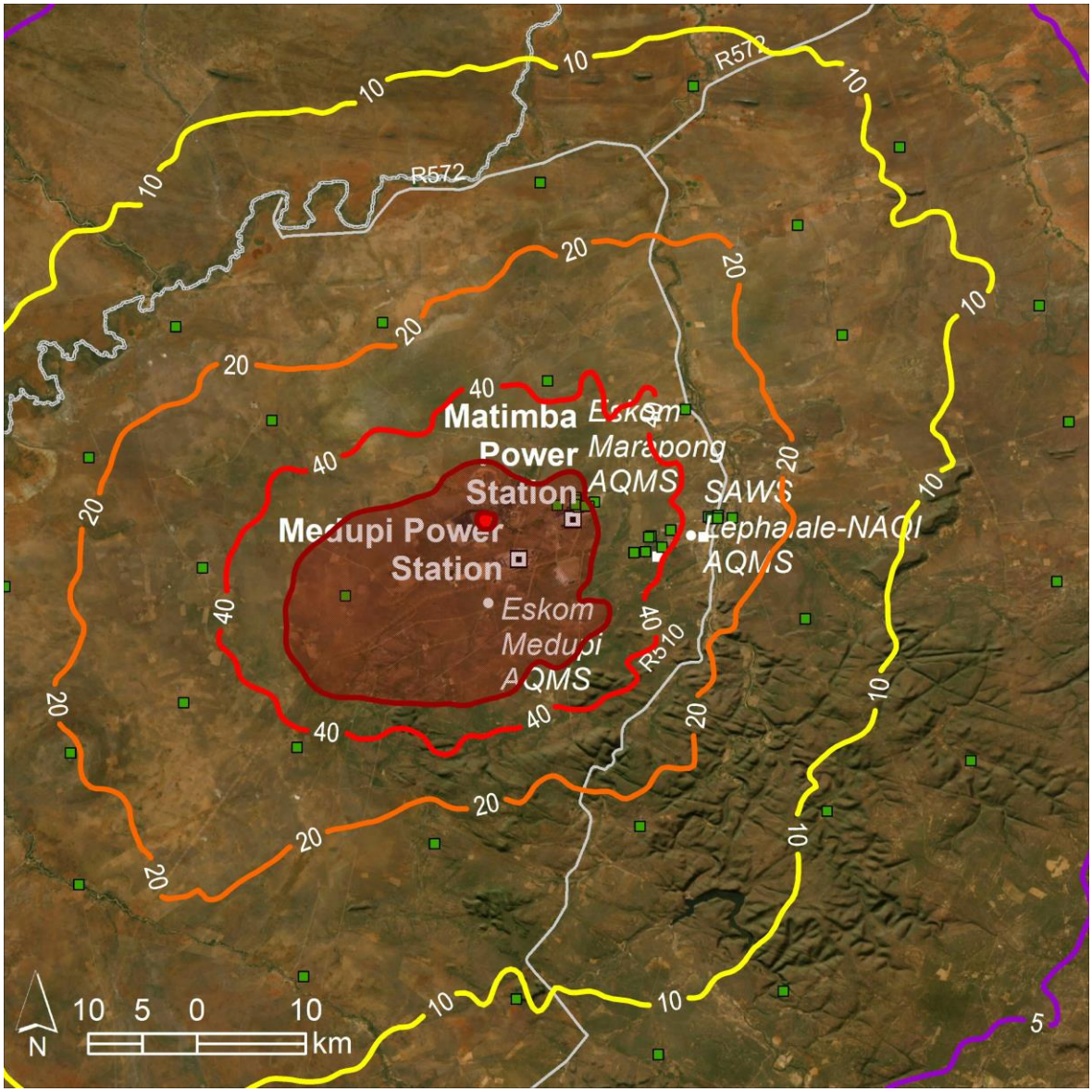


Figure 6-38: Predicted 99th percentile of the 24-hour $PM_{2.5}$ concentrations in µg/m³ for Scenario 1 (Current) (NAAQS Limit is 40 µg/m³)

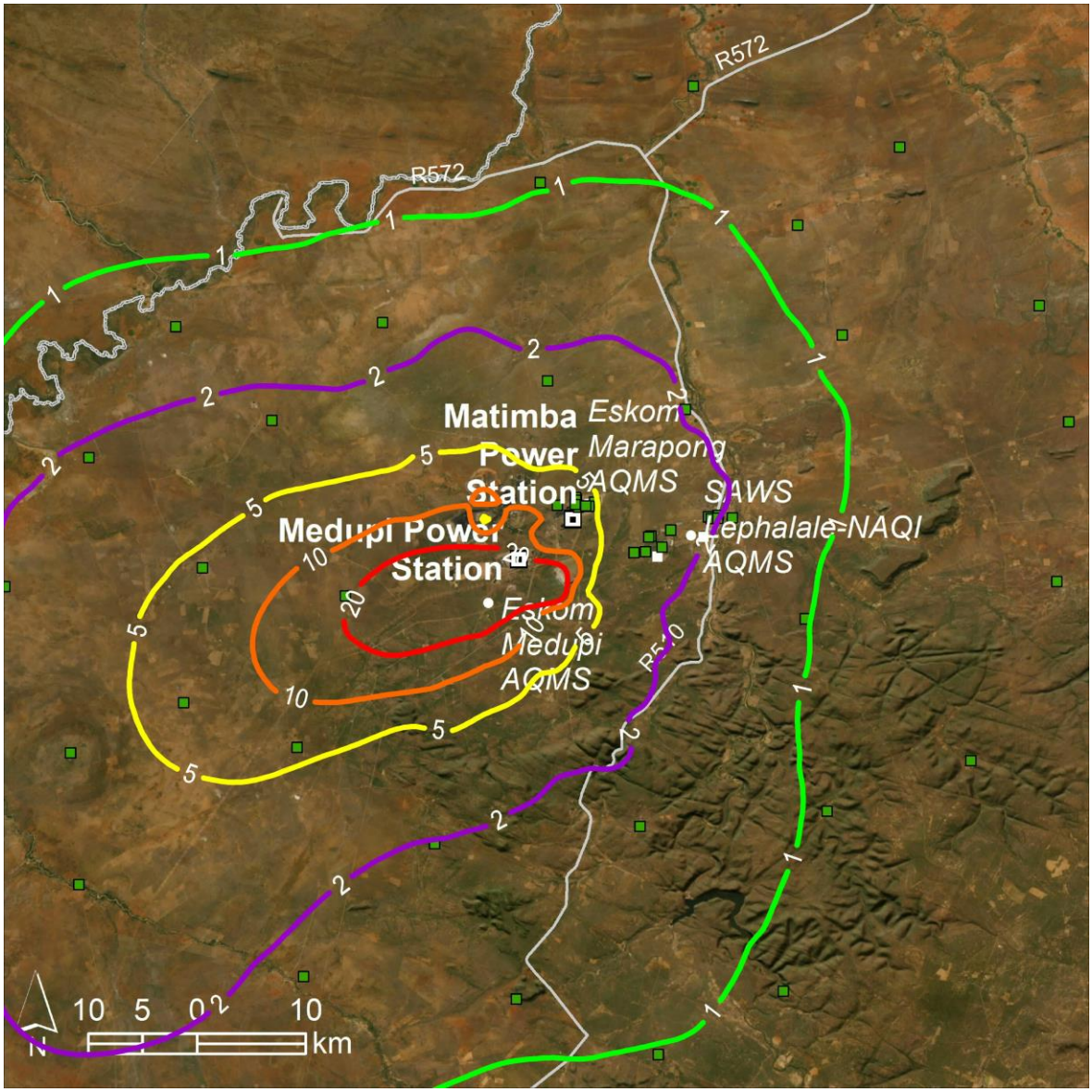


Figure 6-39: Predicted annual average $PM_{2.5}$ concentrations in µg/m³ for Scenario A (2025) (NAAQS Limit is 20 µg/m³)

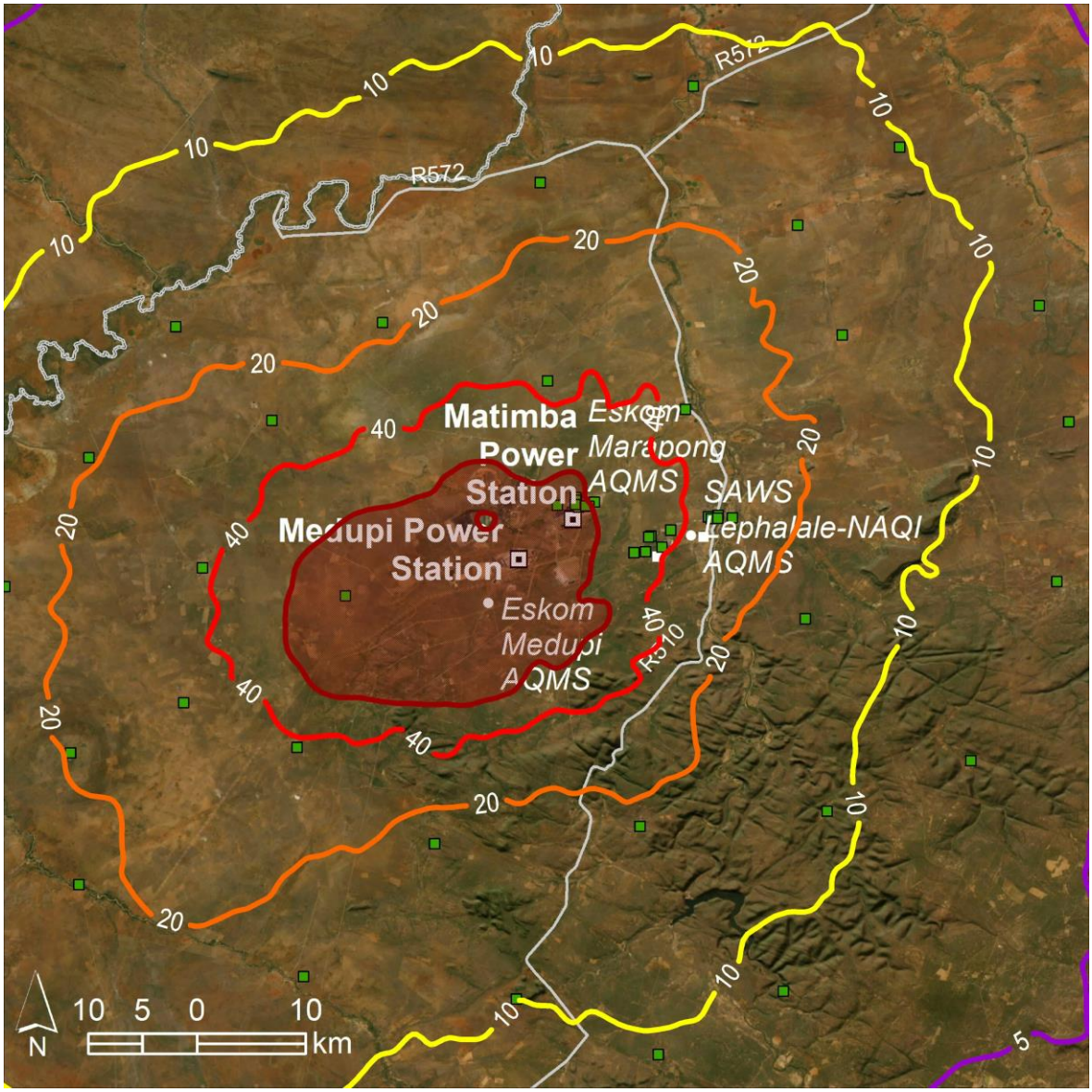


Figure 6-40: Predicted 99th percentile of the 24-hour $PM_{2.5}$ concentrations in µg/m³ for Scenario A (2025) (NAAQS Limit is 40 µg/m³)

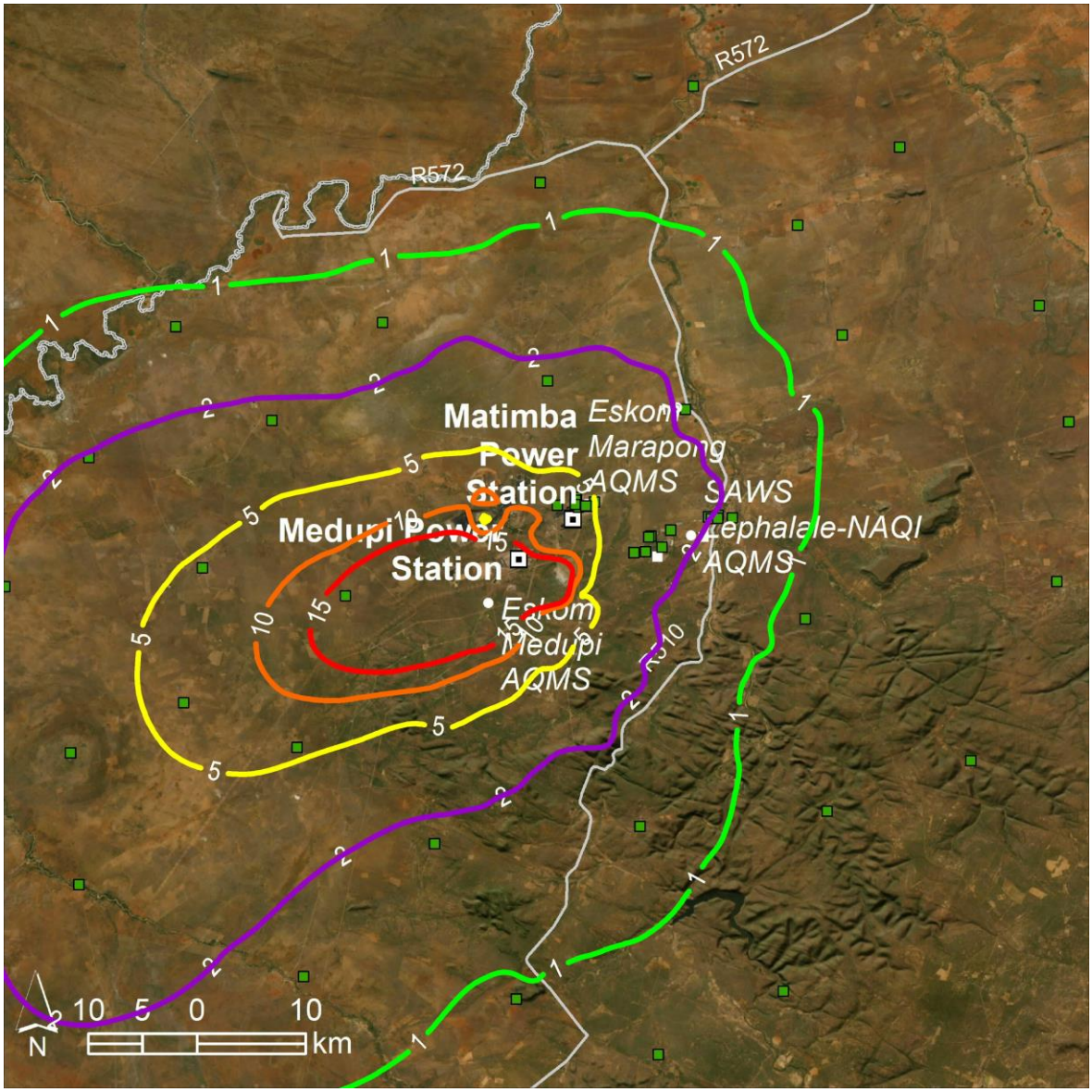


Figure 6-41: Predicted annual average $PM_{2.5}$ concentrations in µg/m³ for Scenario B (2031) (NAAQS Limit is 15 µg/m³)

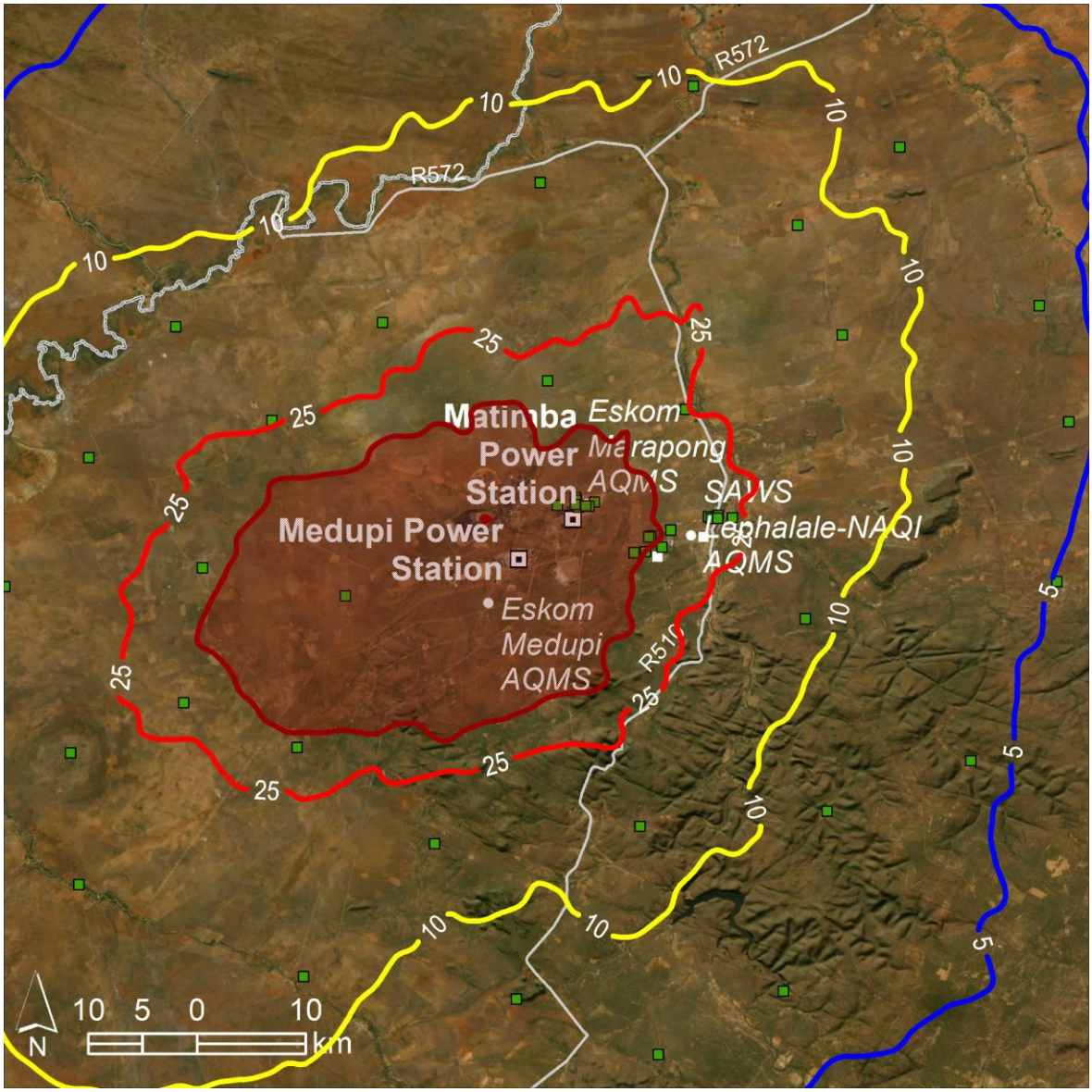


Figure 6-42: Predicted 99th percentile of the 24-hour $PM_{2.5}$ concentrations in µg/m³ for Scenario B (2031) (NAAQS Limit is 25 µg/m³)

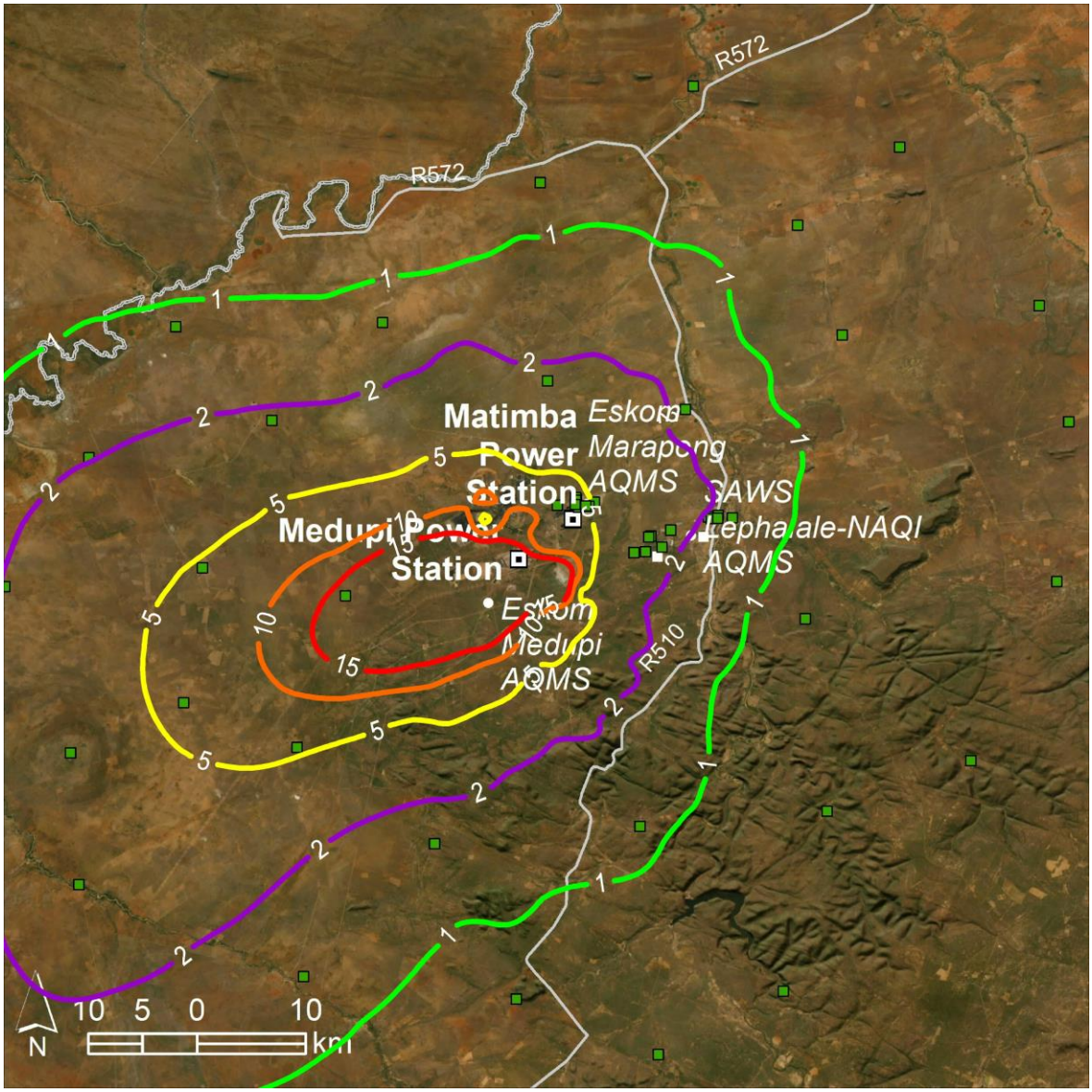


Figure 6-43: Predicted annual average $PM_{2.5}$ concentrations in µg/m³ for Scenario C (2036) (NAAQS Limit is 15 µg/m³)

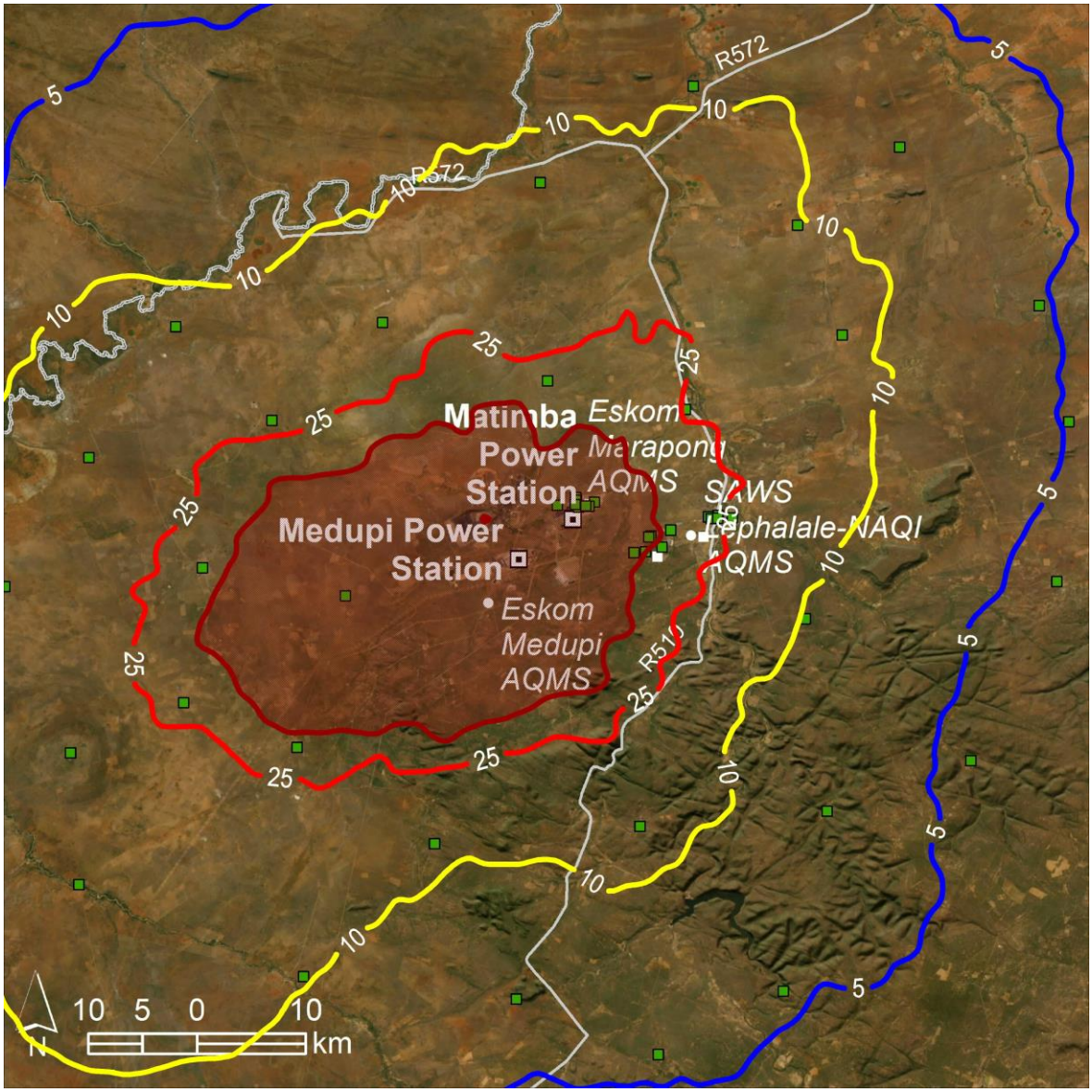


Figure 6-44: Predicted 99th percentile of the 24-hour $PM_{2.5}$ concentrations in µg/m³ for Scenario C (2036) (NAAQS Limit is 25 µg/m³)

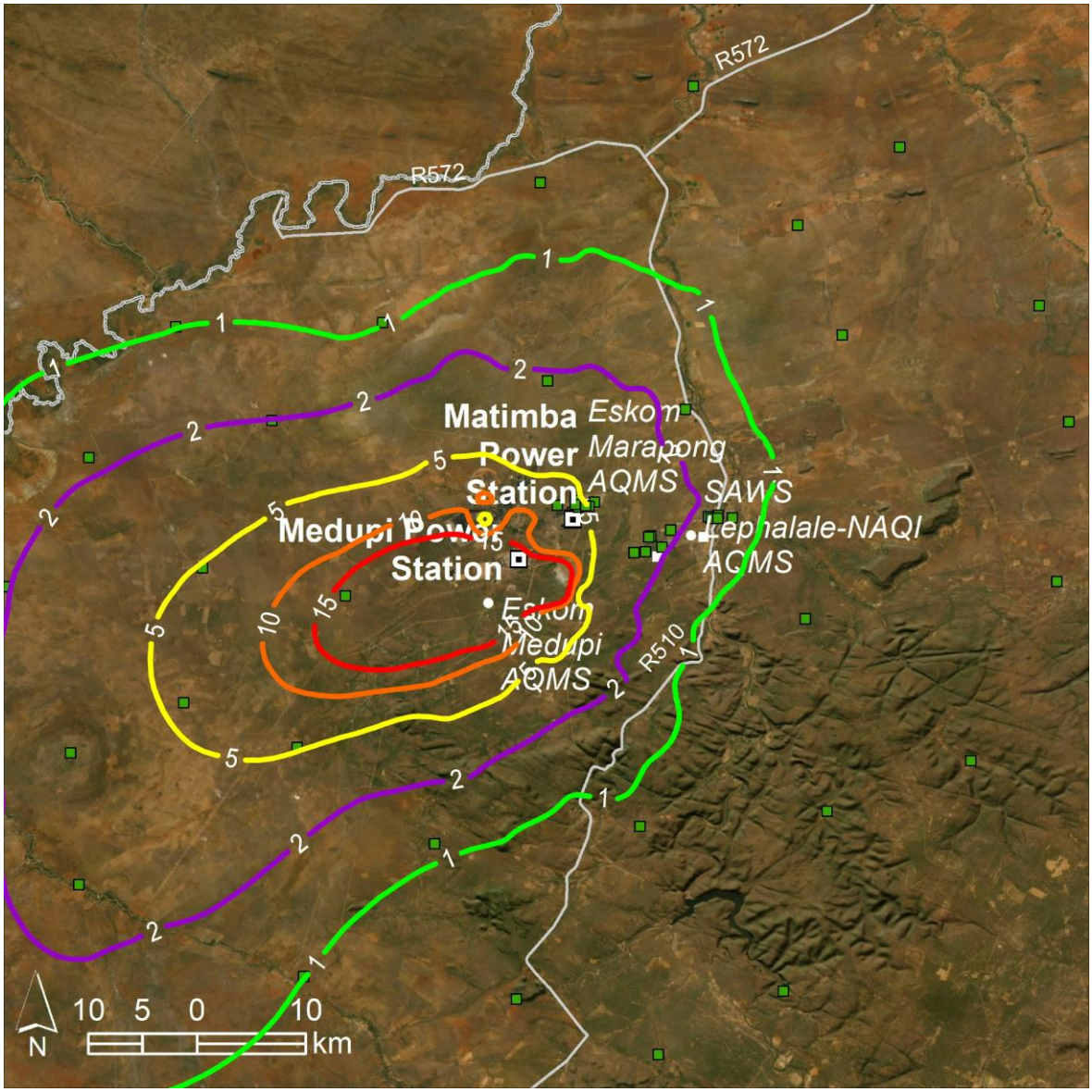


Figure 6-45: Predicted annual average $PM_{2.5}$ concentrations in µg/m³ for Scenario D (MES) (NAAQS Limit is 15 µg/m³)

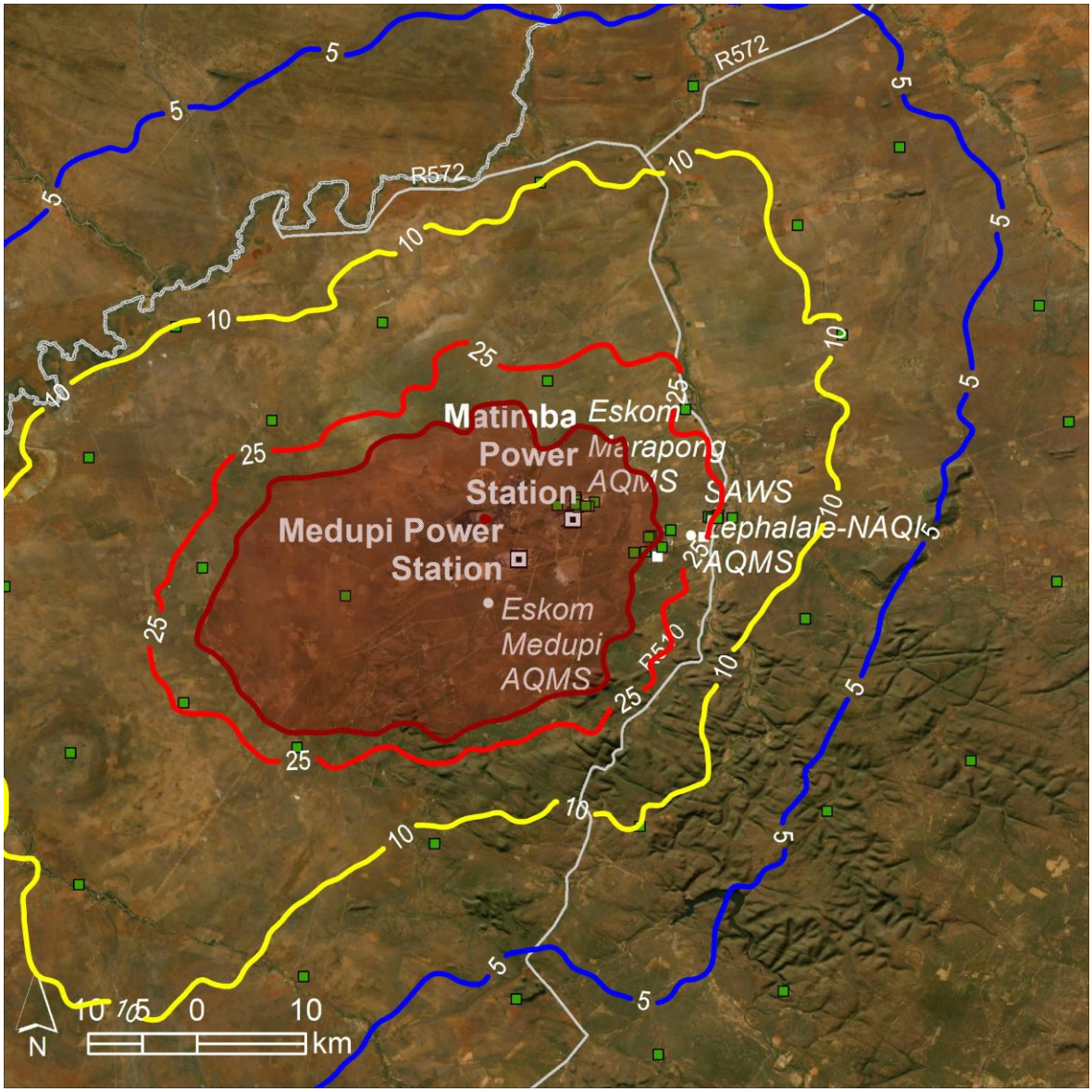


Figure 6-46: Predicted 99th percentile of the 24-hour $PM_{2.5}$ concentrations in µg/m³ for Scenario D (MES) (NAAQS Limit is 25 µg/m³)

7. SUMMARY AND CONCLUSION

In this AIR five emission scenarios are assessed collectively for the suite of 2 coal-fired power stations in the Waterberg to support Eskom's application for exemption from the MES for the 2 power stations. AIRs have been produced for the 2 power stations.

Dispersion modelling is used to demonstrate the effect of Eskom's emission reduction strategy by assessing 5 sequential emission scenarios. These are from Scenario 1 using actual emissions from 2021 to 2023, Scenario A using proposed 2025 emissions, Scenario B using proposed 2031 emissions and Scenario C using proposed 2036 emissions. Scenario D uses emissions that comply with the MES to demonstrate the relative effect of compliance.

Noteworthy findings from the modelling results may be summarised as:

i) Ambient SO_2 and NO_2 concentrations are attributed to the stack emissions only, while ambient PM_{10} and $PM_{2.5}$ concentrations are attributed to the stack emissions and the low-level fugitive sources. The stack emissions generally have an effect some distance from the source, while low-level emissions have an effect close to the source.

ii) The predicted ambient concentrations are lower than the monitored concentrations for all pollutants at all AQMS, except at the Medupi AQMS where predicted and measured are higher in general. It is expected that measured concentrations will be higher than modelled since AQMS are exposed to all sources of the pollutants while the modelled concentrations result from power station emission only.

   Generally, the difference between the modelled concentrations and the measured concentrations are indicative of the contribution of other sources at the respective AQMS.

   The PM_{10} and $PM_{2.5}$ data recovery rate at the Medupi AQMS in 2022 and 2023 was poor so it is likely that the reported averages are unreliable.

iii) For Scenario 1 (Current):
   a. Predicted SO_2 and NO_2 concentrations comply with the NAAQS for all averaging periods throughout the modelling domain.
   b. Predicted PM_{10} and $PM_{2.5}$ concentrations comply with the NAAQS, except close to the power stations where the limit value of the 24-hour NAAQS are exceeded as a result of the fugitive sources. Exceedances of the limit value for PM_{10} are predicted once at 2 sensitive receptor points respectively and thereof compliant with the NAAQS. For $PM_{2.5}$ exceedances of the limit value were predicted at 17 sensitive receptor points, at 10 of which the limit value was exceeded more than 12 times, hence non-compliant with the NAAQS.

iv) For Scenario A (2025):
   a. Predicted annual and 1-hour SO_2 concentrations comply with the NAAQS throughout the modelling domain, but exceedances of the 24-hour limit value are predicted at 10 sensitive receptor points.
   b. Predicted NO_2 concentrations comply with the NAAQS for all averaging periods throughout the modelling domain.
   c. Predicted PM_{10} and $PM_{2.5}$ concentrations comply with the NAAQS, except close to the power stations where the limit value of the 24-hour NAAQS are exceeded as a result of the fugitive sources. Exceedances of the limit value

for PM_{10} are predicted once at 5 sensitive receptor points respectively and thereof compliant with the NAAQS. For $PM_{2.5}$ exceedances of the limit value were predicted at 17 sensitive receptor points, at 10 of which the limit value was exceeded more than 12 times, hence non-compliant with the NAAQS.

v) For Scenario B (2031):
   a. Predicted annual and 1-hour SO_2 concentrations comply with the NAAQS throughout the modelling domain, but exceedances of the 24-hour limit value are predicted at 10 sensitive receptor points.
   b. Predicted NO_2 concentrations comply with the NAAQS for all averaging periods throughout the modelling domain.
   c. Predicted PM_{10} and $PM_{2.5}$ concentrations comply with the NAAQS, except close to the power stations where the limit value of the 24-hour NAAQS are exceeded as a result of the fugitive sources. The number of predicted exceedances for PM_{10} decrease to 2, while the number of exceedances for $PM_{2.5}$ increase to 27 sensitive receptor points. The increase corresponds to the more stringent $PM_{2.5}$ limit value of 25 $\mu g/m^3$ which is implemented in 2030. At 14 of these points limit value was exceeded more than 12 times, hence non-compliant with the NAAQS.

vi) For Scenario C: (2036):
   a. Predicted annual and 1-hour SO_2 concentrations comply with the NAAQS throughout the modelling domain, but exceedances of the 24-hour limit value are predicted at 9 sensitive receptor points.
   b. Predicted NO_2 concentrations comply with the NAAQS for all averaging periods throughout the modelling domain.
   c. Predicted PM_{10} and $PM_{2.5}$ concentrations comply with the NAAQS, except close to the power stations where the 24-hour limit value of the NAAQS for $PM_{2.5}$ are exceeded as a result of fugitive sources. Exceedances of the limit value for $PM_{2.5}$ are predicted at 25 sensitive receptor points. At 14 of these points, the limit value was exceeded more than 12 times, hence non-compliant with the NAAQS.

vii) For Scenario D:
   a. Predicted SO_2 and NO_2 concentrations comply with the NAAQS for all averaging periods throughout the modelling domain.
   b. Predicted PM_{10} and $PM_{2.5}$ concentrations comply with the NAAQS, except close to the power stations where the 24-hour limit value of the NAAQS for $PM_{2.5}$ are exceeded as a result of fugitive sources. Exceedances of the limit value for $PM_{2.5}$ are predicted at 25 sensitive receptor points. At 14 of these points, the limit value was exceeded more than 12 times, hence non-compliant with the NAAQS.

Given the conservative approach to the fugitive emission source simulations, and that this has provided an absolute worst-case emission scenario, and based on recommendations received from uMoya-Nilu, Eskom will be undertaking an additional modelling scenario, assessing only PM, SO_2, and NO_X stack emissions. NO_X and SO_2 emissions will be included in this scenario to ensure secondary particulate formation is accounted for. This will provide improved insight to impacts directly related to stack emissions, which are the focus of this exemption application.

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9. FORMAL DECLARATIONS

A declaration of the accuracy of the information contained in this Atmospheric Impact Report is included here. A declaration of the independence of the practitioners in the uMoya-NILU consultancy team that compiled this AIR is also included.

DECLARATION OF ACCURACY OF INFORMATION – APPLICANT

Name of Enterprise: uMoya-NILU Consulting (Pty) Ltd

Declaration of accuracy of information provided:

Atmospheric Impact Report in terms of Section 30 of the Act

I, Mark Zunckel [duly authorised], declare that the information provided in this atmospheric impact report is, to the best of my knowledge, in all respects factually true and correct. I am aware that the supply of false or misleading information to an air quality office is a criminal office in terms of section 51(1)(g) of this Act.

Signed at Durban on this 4th day of November 2024.



SIGNATURE

Managing Director – uMoya-NILU Consulting
CAPACITY OF SIGNATORY

DECLARATION OF INDEPENDENCE – PRACTITIONER

Name of Practitioner: Mark Zunckel

Name of Registered Body: South African Council for Natural Scientific Professionals

Professional Registration Number: 400449/04

Declaration of independence and accuracy of information provided:

Atmospheric Impact Report in terms of Section 30 of the Act

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

Signed at Durban on this 4th day of November 2024.



SIGNATURE

Managing Director – uMoya-NILU Consulting
CAPACITY OF SIGNATORY

ANNEXURE 1: PREDICTED CONCENTRATIONS AT SENSIIVE RECEPTORS

Predicted concentrations in µg/m³ at the sensitive receptors for Scenario 1 (Current), together with the limit value of the NAAQS and number of exceedances (NoE)

	SO_2				NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	NoE	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**12**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Phegelelo Senior Secondary	137.1	118.9		5.7	15.4	0.7	69.9		5.5	**69.9**	**13**	5.5
Contractors Village	127.8	80.7		5.3	14.8	0.6	**76.5**	1	7.8	**76.5**	**24**	7.8
Ditheku Primary School	136.4	112.7		5.6	15.5	0.6	70.7		5.5	**70.7**	**13**	5.5
Ditheko Primary School	149.7	111.5		6.2	17.8	0.7	69.4		5.0	**69.4**	10	5.0
Marapong Training Centre	135.2	104.5		5.9	15.2	0.7	71.3		5.9	**71.3**	**13**	5.9
Marapong Clinic	149.7	120.3		6.4	17.0	0.7	73.6		5.4	**73.6**	**15**	5.4
Tielelo Secondary School	136.1	119.0		5.8	15.2	0.7	71.3		5.6	**71.3**	**13**	5.6
Grootegeluk Medical Centre - Community Center	141.0	99.5		6.0	15.5	0.7	71.6		5.8	**71.6**	**14**	5.8
Lephalale College	161.5	80.8		6.1	20.7	0.7	51.7		3.2	**51.7**	1	3.2
Nelsonskop Primary School	152.0	116.8		6.4	16.7	0.7	73.2		5.5	**73.2**	**13**	5.5
Hansie en Grietjie Pre-Primary School	159.3	82.2		6.2	20.8	0.7	52.6		3.3	**52.6**	2	3.3
Sedibeng Special School for the Deaf and Disabilities	152.1	73.7		6.0	19.3	0.6	44.2		2.6	**44.2**	1	2.6
Kings College	162.7	79.4		6.6	20.6	0.7	51.6		3.4	**51.6**	1	3.4
Bosveld Primary School	157.9	76.2		6.3	20.4	0.7	46.6		3.0	**46.6**	1	3.0
Lephalale Medical Hospital	134.8	108.8		5.8	15.9	0.7	73.8		5.9	**73.8**	**15**	5.9
Ellisras Hospital	158.1	71.9		5.7	19.6	0.6	43.6		2.7	**43.6**	1	2.7
Laerskool Ellisras Primary School	141.0	60.4		4.9	15.9	0.5	31.1		1.9	31.1		1.9
Hoerskool Ellisras Secondary School	148.0	60.6		5.0	16.8	0.5	31.9		2.0	31.9		2.0
Marlothii Learning Academy	145.7	59.5		5.0	16.3	0.5	32.7		2.0	32.7		2.0
Hardekool Akademie vir C.V.O	135.9	63.6		4.8	14.7	0.5	27.0		1.6	27.0		1.6
Lephalale Clinic	141.7	58.5		4.9	15.7	0.5	30.7		1.9	30.7		1.9
Ons Hoop	116.0	66.9		4.3	10.3	0.4	26.8		1.8	26.8		1.8
Woudend	50.0	38.5		1.8	3.5	0.2	12.0		0.6	12.0		0.6
Ramabara's	114.4	53.7		4.5	11.3	0.4	12.9		0.9	12.9		0.9

	SO_2				NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	NoE	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**12**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Ga-Shongoane	54.9	31.1		2.0	3.8	0.2	6.8		0.4	6.8		0.4
Bulge River	112.7	35.5		5.0	12.8	0.5	8.6		0.8	8.6		0.8
Kaingo Mountain Lodge	95.8	34.6		4.3	9.7	0.4	8.6		0.8	8.6		0.8
Community	131.5	43.1		6.3	15.4	0.7	9.6		1.0	9.6		1.0
Kiesel	146.9	57.1		6.3	18.7	0.7	16.1		2.8	16.1		2.8
Kremetartpan	226.2	80.4		9.4	31.3	1.1	34.6		5.9	34.6		5.9
Mbala Private Camp	182.9	67.0		8.8	24.0	1.0	15.7		1.7	15.7		1.7
Steenbokpan	193.2	70.7		7.1	25.9	0.8	**78.3**	1	17.4	**78.3**	**92**	17.4
Receptor	96.9	52.6		3.7	9.9	0.3	26.7		2.3	26.7		2.3
Sandbult	128.6	59.4		4.7	14.5	0.5	36.5		5.5	36.5		5.5
Hardekraaltjie	68.4	30.2		2.5	5.4	0.2	15.0		1.3	15.0		1.3
Receptor	102.6	71.8		3.9	9.9	0.4	34.9		2.5	34.9		2.5
Receptor	76.2	42.9		2.6	5.6	0.2	18.2		1.3	18.2		1.3
Receptor	65.2	42.5		2.3	4.2	0.2	14.6		0.9	14.6		0.9
Receptor	59.2	39.1		2.2	4.0	0.2	13.6		0.7	13.6		0.7
Receptor	72.3	41.4		2.7	5.4	0.2	14.0		0.8	14.0		0.8
Ditaung	50.0	27.9		1.8	3.1	0.1	7.5		0.4	7.5		0.4
Letlora	48.7	32.1		1.7	3.2	0.1	9.4		0.5	9.4		0.5
Receptor	165.0	60.0		6.5	20.5	0.7	31.7		6.1	31.7		6.1
Glenover	130.5	48.2		5.3	15.9	0.6	19.3		3.5	19.3		3.5
Oxford Safaris	82.2	36.4		3.0	8.0	0.3	14.6		2.2	14.6		2.2
Receptor	83.8	37.5		2.9	7.4	0.2	18.5		2.1	18.5		2.1
Tholo Bush Estate	103.6	39.0		4.2	9.7	0.4	9.2		0.8	9.2		0.8
Receptor	165.0	55.1		7.1	20.3	0.7	17.1		1.4	17.1		1.4
Receptor	66.4	29.3		2.7	5.2	0.2	7.4		0.5	7.4		0.5
Cheetah Safaris	146.7	55.3		7.1	18.4	0.8	13.3		1.5	13.3		1.5
Rhinoland Safaris	57.0	30.3		2.2	4.5	0.2	5.9		0.4	5.9		0.4

Predicted concentrations in µg/m³ at the sensitive receptors for Scenario A (2025), together with the limit value of the NAAQS and number of exceedances (NoE)

	SO_2				NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	NoE	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**12**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Phegelelo Senior Secondary	272.5	**171.2**	**13**	10.8	43.2	1.5	70.5		5.7	**70.5**	**13**	5.7
Contractors Village	259.1	**145.9**	2	10.3	40.2	1.4	**77.7**	1	8.0	**77.7**	**24**	8.0
Ditheku Primary School	274.2	**163.6**	12	10.6	43.8	1.5	71.8		5.7	**71.8**	**13**	5.7
Ditheko Primary School	332.4	**166.2**	**16**	11.9	50.9	1.7	74.2		5.2	**74.2**	10	5.2
Marapong Training Centre	287.9	**195.5**	**14**	11.6	44.2	1.6	74.7		6.1	**74.7**	**13**	6.1
Marapong Clinic	324.4	**184.4**	**22**	12.5	48.9	1.8	**78.5**	1	5.7	**78.5**	**15**	5.7
Tielelo Secondary School	273.9	**178.2**	**18**	11.0	43.9	1.5	72.4		5.8	**72.4**	**13**	5.8
Grootegeluk Medical Centre - Community Center	298.1	**190.2**	**13**	11.9	46.9	1.7	74.9		6.1	**74.9**	**14**	6.1
Lephalale College	264.1	89.9		9.9	40.0	1.3	53.2		3.4	**53.2**	1	3.4
Nelsonskop Primary School	318.0	**172.2**	**24**	12.5	49.8	1.7	**77.5**	1	5.8	**77.5**	**14**	5.8
Hansie en Grietjie Pre-Primary School	263.3	90.5		10.0	40.3	1.3	54.2		3.5	**54.2**	2	3.5
Sedibeng Special School for the Deaf and Disabilities	248.8	78.4		9.3	36.6	1.2	43.3		2.8	**43.3**	1	2.8
Kings College	278.1	93.1		10.8	42.9	1.5	53.2		3.7	**53.2**	1	3.7
Bosveld Primary School	265.7	89.4		10.1	40.4	1.3	46.6		3.2	**46.6**	1	3.2
Lephalale Medical Hospital	273.6	**170.2**	**17**	11.4	43.5	1.6	**75.6**	1	6.1	**75.6**	**15**	6.1
Ellisras Hospital	242.3	93.2		9.0	36.1	1.2	44.7		2.8	**44.7**	1	2.8
Laerskool Ellisras Primary School	218.4	89.8		7.4	28.9	0.9	32.7		2.1	32.7		2.1
Hoerskool Ellisras Secondary School	228.0	81.9		7.7	30.3	0.9	33.8		2.2	33.8		2.2
Marlothii Learning Academy	223.4	83.2		7.6	30.0	0.9	33.8		2.1	33.8		2.1
Hardekool Akademie vir C.V.O	201.1	83.2		7.0	26.8	0.8	27.4		1.8	27.4		1.8
Lephalale Clinic	217.7	84.0		7.4	29.1	0.9	31.7		2.0	31.7		2.0
Ons Hoop	190.2	94.6		6.2	21.1	0.7	27.8		1.9	27.8		1.9
Woudend	67.8	48.0		2.3	6.2	0.2	12.2		0.7	12.2		0.7
Ramabara's	143.7	64.2		5.8	18.1	0.6	14.1		1.0	14.1		1.0
Ga-Shongoane	68.3	38.0		2.4	5.8	0.2	7.7		0.5	7.7		0.5
Bulge River	130.7	43.8		6.2	16.6	0.7	9.0		1.0	9.0		1.0

	SO_2				NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	NoE	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**12**	**50**	**200**	**40**	**75**	**12**	**40**	**40**	**12**	**20**
Kaingo Mountain Lodge	104.6	35.0		4.9	11.8	0.5	8.5		0.9	8.5		0.9
Community	155.3	52.4		8.4	21.7	1.0	10.2		1.2	10.2		1.2
Kiesel	179.2	73.1		8.6	26.8	1.1	17.2		3.0	17.2		3.0
Kremetartpan	296.2	106.7		14.0	47.9	2.0	36.9		6.2	36.9		6.2
Mbala Private Camp	241.9	81.9		12.9	37.7	1.7	16.9		2.0	16.9		2.0
Steenbokpan	293.2	99.7		11.7	46.7	1.6	**79.7**	1	17.7	**79.7**	**92**	17.7
Receptor	142.8	57.7		5.0	17.3	0.5	26.4		2.5	26.4		2.5
Sandbult	173.3	75.5		6.8	23.4	0.8	38.2		5.7	38.2		5.7
Hardekraaltjie	96.4	42.8		3.2	8.7	0.3	15.6		1.4	15.6		1.4
Receptor	163.3	92.3		5.5	21.5	0.7	35.5		2.7	35.5		2.7
Receptor	100.3	56.2		3.5	9.3	0.3	18.4		1.4	18.4		1.4
Receptor	89.3	50.7		2.8	7.5	0.3	15.1		1.0	15.1		1.0
Receptor	78.0	48.9		2.9	6.4	0.3	14.6		0.8	14.6		0.8
Receptor	100.7	49.8		3.4	8.7	0.3	15.5		0.9	15.5		0.9
Ditaung	66.4	36.2		2.2	5.1	0.2	7.6		0.5	7.6		0.5
Letlora	64.2	36.4		2.1	4.8	0.2	10.3		0.5	10.3		0.5
Receptor	202.2	73.8		9.3	29.7	1.2	33.2		6.3	33.2		6.3
Glenover	159.9	62.9		7.2	23.3	0.9	20.7		3.6	20.7		3.6
Oxford Safaris	103.7	41.9		4.0	12.3	0.4	15.6		2.3	15.6		2.3
Receptor	110.9	40.5		3.9	11.8	0.4	19.4		2.2	19.4		2.2
Tholo Bush Estate	122.4	48.3		5.1	13.8	0.5	10.8		0.9	10.8		0.9
Receptor	196.9	69.3		9.1	25.9	1.1	17.9		1.6	17.9		1.6
Receptor	79.7	32.1		3.2	7.9	0.3	7.5		0.6	7.5		0.6
Cheetah Safaris	186.8	68.1		10.0	27.7	1.3	14.5		1.7	14.5		1.7
Rhinoland Safaris	68.2	32.2		2.5	6.2	0.2	6.3		0.5	6.3		0.5

Predicted concentrations in µg/m^3 at the sensitive receptors for Scenario B (2031), together with the limit value of the NAAQS and number of exceedances (NoE)

	SO_2				NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	NoE	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**12**	**50**	**200**	**40**	**75**	**12**	**40**	**25**	**12**	**15**
Phegelelo Senior Secondary	255.1	**159.4**	**15**	10.4	40.3	1.4	67.8		5.5	**67.8**	**49**	5.5
Contractors Village	268.4	**139.1**	4	10.5	42.3	1.4	**75.8**	1	7.9	**75.8**	**76**	7.9
Ditheku Primary School	256.7	**149.2**	11	10.2	40.1	1.4	68.7		5.5	**68.7**	**50**	5.5
Ditheko Primary School	307.0	**154.5**	12	11.1	45.4	1.5	68.3		5.1	**68.3**	**50**	5.1
Marapong Training Centre	261.8	**186.1**	**14**	11.2	42.6	1.5	70.5		6.0	**70.5**	**57**	6.0
Marapong Clinic	315.1	**165.9**	12	11.7	47.7	1.6	72.7		5.5	**72.7**	**51**	5.5
Tielelo Secondary School	254.4	**169.5**	**15**	10.6	40.4	1.4	69.7		5.6	**69.7**	**51**	5.6
Grootegeluk Medical Centre - Community Center	271.9	**186.1**	**17**	11.4	42.8	1.6	71.1		5.9	**71.1**	**57**	5.9
Lephalale College	232.9	81.9		9.0	33.1	1.1	51.0		3.3	**51.0**	**18**	3.3
Nelsonskop Primary School	297.1	**163.7**	**18**	11.6	43.9	1.6	72.2		5.6	**72.2**	**55**	5.6
Hansie en Grietjie Pre-Primary School	233.8	82.2		9.2	33.5	1.2	51.8		3.4	**51.8**	**18**	3.4
Sedibeng Special School for the Deaf and Disabilities	217.5	71.1		8.5	30.6	1.0	41.5		2.7	**41.5**	8	2.7
Kings College	250.9	86.1		10.0	35.6	1.3	52.1		3.5	**52.1**	**20**	3.5
Bosveld Primary School	241.7	75.0		9.4	33.4	1.2	45.7		3.1	**45.7**	12	3.1
Lephalale Medical Hospital	262.4	**186.9**	**15**	11.1	41.2	1.5	72.7		5.9	**72.7**	**57**	5.9
Ellisras Hospital	220.0	76.1		7.9	30.2	1.0	43.5		2.7	**43.5**	7	2.7
Laerskool Ellisras Primary School	175.7	65.8		6.3	22.3	0.7	30.9		1.9	**30.9**	1	1.9
Hoerskool Ellisras Secondary School	184.7	68.1		6.6	23.6	0.7	31.8		2.1	**31.8**	1	2.1
Marlothii Learning Academy	182.4	67.2		6.5	23.3	0.7	32.1		2.0	**32.1**	1	2.0
Hardekool Akademie vir C.V.O	165.8	62.8		5.9	20.3	0.6	26.6		1.7	**26.6**	1	1.7
Lephalale Clinic	177.5	65.9		6.3	22.4	0.7	30.1		1.9	**30.1**	1	1.9
Ons Hoop	153.4	71.3		5.1	16.4	0.6	25.8		1.8	**25.8**	1	1.8
Woudend	53.4	30.7		1.7	4.5	0.1	10.2		0.6	10.2		0.6
Ramabara's	111.6	51.0		4.6	12.9	0.5	11.5		0.9	11.5		0.9
Ga-Shongoane	49.7	27.6		1.7	3.9	0.1	5.7		0.4	5.7		0.4
Bulge River	90.1	32.1		4.5	10.9	0.4	7.3		0.8	7.3		0.8
Kaingo Mountain Lodge	70.4	26.4		3.5	7.3	0.3	6.5		0.7	6.5		0.7

	SO_2				NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	NoE	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**12**	**50**	**200**	**40**	**75**	**12**	**40**	**25**	**12**	**15**
Community	109.3	39.7		6.4	14.8	0.7	7.7		1.0	7.7		1.0
Kiesel	130.0	50.7		6.7	19.1	0.8	14.7		2.7	14.7		2.7
Kremetartpan	211.6	78.8		11.3	33.0	1.5	33.6		5.9	**33.6**	1	5.9
Mbala Private Camp	172.9	60.2		10.2	26.1	1.3	14.0		1.7	14.0		1.7
Steenbokpan	231.4	83.2		10.2	35.6	1.4	**75.5**	1	17.6	**75.5**	**270**	**17.6**
Receptor	112.4	45.8		4.0	12.9	0.4	23.4		2.3	23.4		2.3
Sandbult	135.6	56.6		5.6	17.2	0.6	34.0		5.5	**34.0**	1	5.5
Hardekraaltjie	76.8	32.3		2.5	6.4	0.2	13.7		1.2	13.7		1.2
Receptor	144.8	72.2		4.5	17.8	0.5	32.1		2.5	**32.1**	1	2.5
Receptor	86.5	38.3		2.7	7.4	0.2	15.7		1.2	15.7		1.2
Receptor	65.8	35.8		2.0	5.5	0.2	13.2		0.8	13.2		0.8
Receptor	62.9	35.9		2.1	5.0	0.2	11.4		0.7	11.4		0.7
Receptor	79.3	37.5		2.6	6.6	0.2	12.6		0.8	12.6		0.8
Ditaung	49.7	26.3		1.6	3.3	0.1	6.0		0.4	6.0		0.4
Letlora	50.3	28.1		1.6	3.3	0.1	8.4		0.5	8.4		0.5
Receptor	150.5	62.4		7.4	21.7	0.9	31.4		6.1	**31.4**	1	6.1
Glenover	118.7	49.9		5.6	16.3	0.7	19.1		3.4	19.1		3.4
Oxford Safaris	77.3	30.8		3.2	8.7	0.3	13.7		2.2	13.7		2.2
Receptor	85.7	31.5		3.1	8.3	0.3	16.8		2.1	16.8		2.1
Tholo Bush Estate	83.2	32.0		3.6	8.2	0.3	7.7		0.7	7.7		0.7
Receptor	133.5	44.6		6.7	16.5	0.7	14.0		1.3	14.0		1.3
Receptor	57.5	24.1		2.3	4.9	0.2	5.5		0.4	5.5		0.4
Cheetah Safaris	131.8	53.5		8.1	19.4	1.0	12.4		1.5	12.4		1.5
Rhinoland Safaris	49.7	22.4		1.9	4.1	0.1	4.9		0.4	4.9		0.4

Predicted concentrations in µg/m³ at the sensitive receptors for Scenario C (2036), together with the limit value of the NAAQS and number of exceedances (NoE)

	SO_2				NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	NoE	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**12**	**50**	**200**	**40**	**75**	**12**	**40**	**25**	**12**	**15**
Phegelelo Senior Secondary	135.3	**146.2**	2	7.3	32.3	1.2	66.1		5.4	**66.1**	**49**	5.4
Contractors Village	128.7	**129.7**	1	7.3	32.9	1.2	74.0		7.7	**74.0**	**76**	7.7
Ditheku Primary School	129.7	**130.6**	2	7.2	32.4	1.2	66.8		5.4	**66.8**	**50**	5.4
Ditheko Primary School	202.4	115.8		8.0	40.7	1.3	65.8		4.9	**65.8**	**50**	4.9
Marapong Training Centre	134.3	**152.4**	4	8.0	34.9	1.4	68.7		5.8	**68.7**	**57**	5.8
Marapong Clinic	179.5	**131.9**	2	8.5	40.9	1.4	71.1		5.3	**71.1**	**51**	5.3
Tielelo Secondary School	123.3	**148.8**	6	7.5	32.4	1.3	67.9		5.5	**67.9**	**51**	5.5
Grootegeluk Medical Centre - Community Center	141.6	**148.1**	5	8.2	36.0	1.4	68.7		5.7	**68.7**	**57**	5.7
Lephalale College	188.7	66.1		6.4	32.1	1.1	49.0		3.1	**49.0**	**18**	3.1
Nelsonskop Primary School	175.4	**141.7**	5	8.5	39.6	1.4	70.3		5.5	**70.3**	**55**	5.5
Hansie en Grietjie Pre-Primary School	187.2	66.1		6.5	32.5	1.1	49.9		3.2	**49.9**	**18**	3.2
Sedibeng Special School for the Deaf and Disabilities	173.1	57.9		6.0	29.9	1.0	39.8		2.5	**39.8**	8	2.5
Kings College	194.9	65.2		7.2	35.0	1.2	48.6		3.3	**48.6**	**20**	3.3
Bosveld Primary School	189.7	60.4		6.7	33.3	1.1	42.9		2.9	**42.9**	**13**	2.9
Lephalale Medical Hospital	129.8	**146.8**	7	7.8	33.2	1.3	71.3		5.8	**71.3**	**57**	5.8
Ellisras Hospital	164.3	56.4		5.7	28.8	0.9	40.3		2.5	**40.3**	7	2.5
Laerskool Ellisras Primary School	137.4	48.9		4.6	22.2	0.7	28.6		1.7	**28.6**	1	1.7
Hoerskool Ellisras Secondary School	143.3	50.7		4.8	23.5	0.7	29.5		1.9	**29.5**	1	1.9
Marlothii Learning Academy	140.3	50.1		4.7	23.4	0.7	29.5		1.8	**29.5**	1	1.8
Hardekool Akademie vir C.V.O	127.0	47.8		4.3	20.2	0.6	24.3		1.5	24.3		1.5
Lephalale Clinic	137.3	49.1		4.6	22.4	0.7	27.7		1.7	**27.7**	1	1.7
Ons Hoop	117.6	59.3		3.8	16.2	0.5	23.5		1.6	23.5		1.6
Woudend	37.8	25.7		1.3	4.5	0.2	9.5		0.5	9.5		0.5
Ramabara's	87.1	35.5		3.5	13.1	0.5	9.8		0.7	9.8		0.7
Ga-Shongoane	38.9	19.6		1.4	4.1	0.1	4.9		0.3	4.9		0.3
Bulge River	68.9	24.3		3.3	11.8	0.5	6.1		0.6	6.1		0.6

	SO_2				NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	NoE	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**12**	**50**	**200**	**40**	**75**	**12**	**40**	**25**	**12**	**15**
Kaingo Mountain Lodge	53.7	19.8		2.6	7.8	0.3	5.5		0.6	5.5		0.6
Community	84.6	30.5		4.7	15.8	0.8	6.8		0.8	6.8		0.8
Kiesel	94.1	37.7		4.6	19.4	0.8	13.2		2.6	13.2		2.6
Kremetartpan	150.2	54.3		7.5	34.3	1.5	31.4		5.7	**31.4**	1	5.7
Mbala Private Camp	127.3	44.5		7.1	27.0	1.3	12.3		1.5	12.3		1.5
Steenbokpan	164.8	53.8		6.8	34.6	1.2	73.6		17.3	**73.6**	**269**	**17.3**
Receptor	85.0	35.4		2.9	12.6	0.4	22.1		2.2	22.1		2.2
Sandbult	96.6	37.6		3.9	17.1	0.6	32.6		5.4	**32.6**	1	5.4
Hardekraaltjie	55.7	25.0		1.9	6.2	0.2	12.5		1.1	12.5		1.1
Receptor	91.6	50.8		3.2	16.5	0.5	30.2		2.4	**30.2**	1	2.4
Receptor	60.8	31.8		2.1	7.3	0.2	13.9		1.1	13.9		1.1
Receptor	49.1	29.0		1.5	5.5	0.2	11.9		0.8	11.9		0.8
Receptor	45.5	27.6		1.6	4.6	0.2	10.8		0.6	10.8		0.6
Receptor	57.5	29.9		1.9	6.3	0.2	11.8		0.7	11.8		0.7
Ditaung	36.6	18.2		1.2	3.4	0.1	5.3		0.3	5.3		0.3
Letlora	36.9	20.7		1.2	3.2	0.1	7.5		0.4	7.5		0.4
Receptor	108.1	39.7		5.1	21.2	0.9	29.2		5.9	**29.2**	1	5.9
Glenover	84.5	32.9		3.9	16.7	0.6	17.4		3.3	17.4		3.3
Oxford Safaris	54.2	21.8		2.2	8.6	0.3	12.9		2.1	12.9		2.1
Receptor	62.2	22.3		2.2	8.5	0.3	15.6		1.9	15.6		1.9
Tholo Bush Estate	65.5	23.4		2.8	9.2	0.3	6.9		0.6	6.9		0.6
Receptor	109.1	35.9		5.0	18.6	0.8	12.6		1.1	12.6		1.1
Receptor	43.0	18.7		1.8	5.3	0.2	4.5		0.4	4.5		0.4
Cheetah Safaris	96.9	38.2		5.4	19.9	1.0	10.3		1.3	10.3		1.3
Rhinoland Safaris	36.8	17.7		1.4	4.3	0.2	4.1		0.3	4.1		0.3

Predicted concentrations in µg/m³ at the sensitive receptors for Scenario D (MES), together with the limit value of the NAAQS and number of exceedances (NoE)

	SO_2				NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	NoE	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**12**	**50**	**200**	**40**	**75**	**12**	**40**	**25**	**12**	**15**
Phegelelo Senior Secondary	68.6	48.2		2.9	32.3	1.2	61.7		5.1	**61.7**	**49**	5.1
Contractors Village	68.9	39.3		2.9	32.9	1.2	70.4		7.5	**70.4**	**76**	7.5
Ditheku Primary School	69.2	46.4		2.8	32.4	1.2	62.7		5.1	**62.7**	**50**	5.1
Ditheko Primary School	90.1	42.7		3.1	40.7	1.3	61.9		4.7	**61.9**	**50**	4.7
Marapong Training Centre	74.1	51.2		3.1	34.9	1.4	64.6		5.6	**64.6**	**57**	5.6
Marapong Clinic	89.8	48.2		3.3	40.9	1.4	67.0		5.1	**67.0**	**51**	5.1
Tielelo Secondary School	69.5	46.7		3.0	32.4	1.3	63.6		5.2	**63.6**	**51**	5.2
Grootegeluk Medical Centre - Community Center	76.5	51.6		3.2	36.0	1.4	65.0		5.5	**65.0**	**57**	5.5
Lephalale College	69.6	24.8		2.6	32.1	1.1	44.8		2.9	**44.8**	**18**	2.9
Nelsonskop Primary School	82.6	49.8		3.3	39.6	1.4	66.0		5.2	**66.0**	**55**	5.2
Hansie en Grietjie Pre-Primary School	70.1	25.3		2.7	32.5	1.1	45.7		2.9	**45.7**	**18**	2.9
Sedibeng Special School for the Deaf and Disabilities	65.6	21.6		2.5	29.9	1.0	35.7		2.2	**35.7**	8	2.2
Kings College	72.3	23.7		2.9	35.0	1.2	44.8		3.1	**44.8**	**20**	3.1
Bosveld Primary School	69.8	22.3		2.7	33.3	1.1	39.1		2.6	**39.1**	**13**	2.6
Lephalale Medical Hospital	70.4	52.4		3.1	33.2	1.3	66.8		5.5	**66.8**	**57**	5.5
Ellisras Hospital	64.3	22.9		2.3	28.8	0.9	36.7		2.3	**36.7**	7	2.3
Laerskool Ellisras Primary School	54.7	20.8		1.9	22.2	0.7	25.2		1.5	**25.2**	1	1.5
Hoerskool Ellisras Secondary School	57.1	21.6		2.0	23.5	0.7	26.0		1.7	**26.0**	1	1.7
Marlothii Learning Academy	55.8	21.2		1.9	23.4	0.7	26.2		1.6	**26.2**	1	1.6
Hardekool Akademie vir C.V.O	50.5	20.0		1.8	20.2	0.6	20.7		1.3	20.7		1.3
Lephalale Clinic	54.6	20.5		1.9	22.4	0.7	24.4		1.5	24.4		1.5
Ons Hoop	47.0	23.4		1.5	16.2	0.5	20.3		1.4	20.3		1.4
Woudend	17.0	10.8		0.6	4.5	0.2	7.6		0.4	7.6		0.4
Ramabara's	35.4	15.3		1.4	13.1	0.5	7.1		0.5	7.1		0.5
Ga-Shongoane	16.2	8.7		0.6	4.1	0.1	3.3		0.2	3.3		0.2
Bulge River	30.8	10.2		1.5	11.8	0.5	4.1		0.4	4.1		0.4

	SO_2				NO_2		PM_{10} Total			$PM_{2.5}$ Total		
	1-hr	24-hr	NoE	Ann	1-hr	Ann	24-hr	NoE	Ann	24-hr	NoE	Ann
Receptor	**350**	**125**	**12**	**50**	**200**	**40**	**75**	**12**	**40**	**25**	**12**	**15**
Kaingo Mountain Lodge	23.9	7.9		1.2	7.8	0.3	3.6		0.4	3.6		0.4
Community	37.0	13.5		2.0	15.8	0.8	4.3		0.6	4.3		0.6
Kiesel	42.9	17.1		2.1	19.4	0.8	11.3		2.3	11.3		2.3
Kremetartpan	69.8	25.8		3.5	34.3	1.5	28.0		5.3	**28.0**	1	5.3
Mbala Private Camp	57.6	19.5		3.2	27.0	1.3	9.1		1.1	9.1		1.1
Steenbokpan	73.1	24.1		3.0	34.6	1.2	70.3		17.1	**70.3**	**269**	**17.1**
Receptor	34.8	14.8		1.2	12.6	0.4	18.9		2.0	18.9		2.0
Sandbult	42.3	17.6		1.7	17.1	0.6	29.5		5.1	**29.5**	1	5.1
Hardekraaltjie	23.6	10.2		0.8	6.3	0.2	10.1		1.0	10.1		1.0
Receptor	42.6	21.8		1.4	16.5	0.5	26.6		2.2	**26.6**	1	2.2
Receptor	25.6	12.7		0.9	7.3	0.2	11.1		1.0	11.1		1.0
Receptor	21.3	12.0		0.7	5.5	0.2	9.8		0.6	9.8		0.6
Receptor	18.9	12.2		0.7	4.6	0.2	8.5		0.5	8.5		0.5
Receptor	23.7	12.9		0.8	6.3	0.2	9.5		0.5	9.5		0.5
Ditaung	15.6	8.4		0.5	3.4	0.1	3.7		0.2	3.7		0.2
Letlora	15.6	8.6		0.5	3.2	0.1	5.7		0.3	5.7		0.3
Receptor	47.7	17.7		2.3	21.2	0.9	26.9		5.6	**26.9**	1	5.6
Glenover	37.5	15.5		1.8	16.7	0.6	15.4		3.1	15.4		3.1
Oxford Safaris	24.5	10.0		1.0	8.6	0.3	11.4		1.9	11.4		1.9
Receptor	27.4	9.7		1.0	8.5	0.3	13.1		1.8	13.1		1.8
Tholo Bush Estate	28.9	11.3		1.2	9.2	0.3	4.6		0.4	4.6		0.4
Receptor	47.2	15.5		2.2	18.6	0.8	9.8		0.8	9.8		0.8
Receptor	18.9	7.3		0.8	5.3	0.2	3.0		0.2	3.0		0.2
Cheetah Safaris	44.0	17.3		2.5	19.9	1.0	7.6		1.0	7.6		1.0
Rhinoland Safaris	16.1	7.6		0.6	4.3	0.2	2.7		0.2	2.7		0.2

ANNEXURE 2: NEMA REGULATION – APPENDIX 6

Specialist Reports as per the NEMA EIA Regulations, 2014 (as amended), must contain the information outlined in According to Appendix 6 (1) of the Regulations. Table A1 indicates where this information is included in the AIR.

Table A1: Prescribed contents of the Specialist Reports (Appendix 6 of the EIA Regulations, 2014)

Relevant section in GNR. 982	Requirement description	Relevant section in this report
(a) details of—	(i) the specialist who prepared the report; and	Section 2.7
	(ii) the expertise of that specialist to compile a specialist report including a curriculum vitae;	Section 2.7 & Annexure 2
(b)	a declaration that the specialist is independent in a form as may be specified by the competent authority;	Section 12
(c)	an indication of the scope of, and the purpose for which, the report was prepared;	Section 1, 2.1 & 3.2
(cA)	an indication of the quality and age of base data used for the specialist report;	Section 5 & 6
(cB)	a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	Section 6.1
(d)	the duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment;	Site investigation not applicable
(e)	a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;	Section 5 & 6.2
(f)	details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives;	Section 6.3 & 6.4
(g)	an identification of any areas to be avoided, including buffers;	None identified
(h)	a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Section 6.3.2
(i)	a description of any assumptions made and any uncertainties or gaps in knowledge; Note: Uncertainties should be qualified within the report – there will always be uncertainties due to gaps in knowledge should also be qualified – a gap is to record that not all knowledge can be obtained for a study.	Section 2.9
(j)	a description of the findings and potential implications of such findings on the impact of the proposed activity or activities;	Section 6.4
(k)	any mitigation measures for inclusion in the EMPr;	Section 9

Relevant section in GNR. 982	Requirement description	Relevant section in this report
	Note: We need to include whether these mitigation measures (excluding ongoing monitoring) can be practically implemented prior to commencement or not.	
(l)	any conditions for inclusion in the environmental authorisation;	Section 9
(m)	any monitoring requirements for inclusion in the EMPr or environmental authorisation;	Section 9
(n) a reasoned opinion—	(i) whether the proposed activity, activities or portions thereof should be authorised;	Section 10
	(iA) regarding the acceptability of the proposed activity or activities; and	Section 10
	(ii) if the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan; Note: We need to include whether these mitigation measures (excluding ongoing monitoring) can be practically implemented prior to commencement or not.	Section 10
(o)	a description of any consultation process that was undertaken during the course of preparing the specialist report;	Section 1
(p)	a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	Addressed in April 2021 AIR
(q)	any other information requested by the competent authority.	Addressed in April 2021 AIR
(2)	Where a government notice gazetted by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply.	Section 1 & 6.2.1

ANNEXURE 3: CURRICULUM VITAE

MARK ZUNCKEL



Firm	:	uMoya-NILU (Pty) Ltd
Profession	:	Air quality consultant
Specialization	:	Air quality assessment, air quality management planning, air dispersion modelling, boundary layer meteorology, project management
Position in Firm	:	Managing director and senior consultant
Years with Firm	:	Since 1 August 2007
Nationality	:	South African
Year of Birth	:	1959
Language Proficiency	:	English and Afrikaans

EDUCATION AND PROFESSIONAL STATUS

Qualification	Institution	Year
National Diploma (Meteorology)	Technikon Pretoria	1980
BSc (Meteorology)	Univ. of Pretoria	1984
BSc Hons (Meteorology)	Univ. of Pretoria	1988
MSc	Univ. of Natal	1992
PhD	Univ. Witwatersrand	1999

Registered Natural Scientist: South African Society for Natural Scientific Professionals
Ex-Council Member: National Association for Clean Air
Member: National Association for Clean Air

EMPLOYMENT AND EXPERIENCE RECORD

Period	Organisation details and responsibilities/roles
1976 – May 1992	South African Weather Bureau : Observer, junior forecaster, senior forecast, researcher, assistant director
June 1992 – July 2007	CSIR: Consultant and researcher, Research group Leader: Atmospheric Impacts
August 2007 to present	uMoya-NILU Consulting: Managing Director and senior air quality consultant

Key and Recent Project Experience:

1996	Project leader & Principal researcher: Atmospheric impact assessment for the proposed Mozal aluminium smelter in Maputo, Mozambique.

1996 Project leader & Principal researcher: Dry sulphur deposition during the Ben MacDhui High Altitude Trace Gas and Transport Experiment (BATTEX) in the Eastern Cape.

1997 Project leader & Principal researcher: Atmospheric impact assessment of the proposed capacity expansion project for Alusaf in Richards Bay.

1997 Project leader & Principal researcher: The Uruguayan ambient air quality project with LATU.

1997 Principal researcher on the Air quality specialist study for the Strategic Environmental Assessment on the industrial and urban hinterland of Richards Bay.

1997 Project leader & Principal researcher: Feasibility study for the implementation of a fog detection system in the Cape Metropolitan area: Meteorological aspects.

2001 Project leader & Principal researcher: Air quality specialist study for the Environmental Impact Assessment for the proposed expansion of the Hillside Aluminium Smelter, Richards Bay.

2001-03 Researcher: The Cross Border air Pollution Impact (CAPIA) project. A 3-year modelling and impacts study in the SADC region.

2002 Project leader & Principal researcher: Air quality assessment specialist study for the proposed Pechiney Smelter at Coega.

2002 Project leader & Principal researcher: Air quality assessment specialist study for the proposed N2 Wild Coast Toll Road.

2002-05 Project leader on the NRF project – development of a dynamic air pollution prediction system

2004 Project leader on the specialist study for expansion at the Natal Portland Cement plant at Simuma, KwaZulu-Natal.

2004-05 Researcher: National Air Quality Management Plan implementation project for Department Environmental Affairs and Tourism.

2005 Researcher in the assessment of air quality impacts associated with the expansion of the Natal Portland Cement plant at Port Shepstone.

2006-07 Project team leader of a multi-national team to develop the National Framework for Air Quality Management for the Department of Environment Affairs and Tourism

2007 Air quality assessment for Mutla Early Production System in Uganda for ERM Southern Africa on behalf of Tullow Oil.

2007-10 Lead consultant on the development of a dust mitigation strategy fro the Bulk Terminal Saldanha and an ambient guideline for Fe_2O_3 dust for Transnet Projects and on-going monitoring.

2008 Lead consultant on the Air quality status quo assessment and scoping for the EIA for the Sonangol Refinery

2008-09 Lead consultant on the development of the air quality management plan for the Western Cape Provincial. Department of Environmental Affairs and Development Planning.

2008-10 Lead consultant on the development of the Highveld Priority Area air quality management plan for the Department of Environmental Affairs and Tourism.

2008 Lead consultant in the development of an odour management and implementation strategy for eThekwini, focussing on Wastewater Treatment Works and odourous industrial sources

2008&10 Lead consultant on the Air Quality Specialist Study for the EIA for the proposed Kalagadi Manganese Smelter at Coega

2008	Lead consultant on the Air Quality Assessment for the Proposed Construction and Operation of a Second Cement Mill at NPC-Cimpor, Simuma near Port Shepstone.
2008	Lead consultant on the Air Quality Specialist Study Report for the New Multi-Purpose Pipeline Project (NMPP) for Transnet Pipelines.
2008	Lead consultant on the Air quality assessment for the proposed UTE Power Plant and RMDZ coal mine at Moatize, Mozambique for Vale.
2008-09	Lead consultant on the Dust source apportionment study for the Coedmore region in Durban for NPC-Cimpor.
2009	Consultant on the Air quality specialist study for the upgrade of the Kwadukuza Landfill, KwaZulu-Natal
2009-10	Lead consultant on the Audit of ambient air quality monitoring programme and air quality training for air quality personnel at PetroSA
2010	Lead consultant on the Qualitative assessment of impact of dust on solar power station at Saldanha Bay
2010	Lead consultant on the Air quality specialist study for the EIA for the Kalagadi Manganese Smelter at Coega
2009-10	Lead consultant on the Air quality specialist study for the Environmental Management Framework for the Port of Richards Bay
2010	Lead consultant on the Air quality status quo assessment and abatement planning at Idwala Carbonates, Port Shepstone
2010	Lead consultant on the Air quality status quo assessment and abatement planning at Sappi Tugela, Mandeni
2010–11	Air quality status quo assessment and revision of the Air Quality Management Plan for City of Johannesburg
2010	Lead consultant on the Air quality status quo assessment and abatement planning at First Quantum Mining's Bwana Mkubwa and Kansanshi mines, Zambia
2010–11	Lead consultant on the Air quality specialist study for the EIA for the Alternative Fuel and Resources Project at Simuma, Port Shepstone
2010–11	Lead consultant on the Air quality specialist study for the EIA for the Coke Oven re-commissioning at ArcelorMittal Newcastle
2010	Qualitative air quality assessment for the EIA for the Mozpel sugar to ethanol project , Mozambique
2011	Development of the South African Air Quality Information System – Phase II The National Emission Inventory
2011	Ambient baseline monitoring for Riversdale's Zambezi Coal Project in Tete, Mozambique
2010-11	Ambient quality baseline assessment for the Ncondeze Coal Project, Tete Mozambique
2011-12	Air quality assessment for the mining and processing facilities at Longmin Platinum in Marikana
2012	Air quality assessment for the proposed LNG and OLNG power stations in Mozambique
2012	Modelling study in Abu Dhabi for the transport and deposition of radio nuclides
2012	Air quality assessment for the proposed manganese ore terminal at the Ngqura Port
2012-13	Air quality management plan development for Stellenbosch Municipality
2012-12	Air quality management plan development for the Eastern Cape Province

2013	Air quality specialist for Tullow Oil Waraga-D and Kinsinsi environmental audit in Uganda
2013	Air quality specialist study for the EIA for the Thabametsi IPP station
2013	Air quality management plan for the Ugu District Municipality
2013-14	Air quality specialist study for the application for postponement of the minimum emission standards for 9 Eskom power stations
2014	Air quality specialist study for the application for postponement applications of the minimum emission standards for the Engen Refinery in Merebank, Durban
2014-15	Baseline assessment and AQMP development for the uThungulu District Municipality
2013-15	Baseline assessment, AQMP and Threat Assessment for the Waterberg-Bojanala Priority Area
2014-15	Review of the 2007 AQMP for eThekwini Municipality, including metropolitan emission inventory development for all sectors, i.e. industrial, transport, waste management, biomass burning, residential fuel burning, dispersion modelling and strategy development
2014-14	Dispersion modelling study for Richards Bay Minerals
2015	Air quality assessment for Rainbow Chickens at Hammersdale
2015	Air quality status quo assessment and planning for TNPA ports in South Africa
2016- 7	Lead author of the National State of Air Report for 2005 to 2015, including national emission inventory development for all sectors, i.e. industrial, transport, waste management, biomass burning, residential fuel burning
2016	Air quality assessment for Kanshansi Mine, Solwesi, Zambia
2016	Assessment of air quality impacts associated with activities at the Venetia Mine, Limpopo Province
2016	Assessment of air quality impacts associated with activities at the Komati Anthracite Mine, Mpumalanga Province
2016	Air quality assessment for the proposed Powership Project at the Port of Nacala, Mozambique
2016	Air quality assessment for the proposed Richards Bay Gas to Power Project
2017	Baseline assessment and review of the 2009 AQMP for Gauteng Province, including emission inventory development for all sectors, i.e. industrial, transport, waste management, biomass burning, residential fuel burning, and dispersion modelling
2017	Baseline assessment and air quality management plan for Northern Cape Province
2017	Air quality assessment for the EIA for the Thabametsi Power Station in Limpopo Province
2017	Air quality assessment for the EIA for the proposed Tshivasho Power Station in Limpopo Province
2018	Air quality assessment for the EIA for the proposed Bellmall Thermal Plant in Ekurhuleni
2018	Air quality assessment for the EIA for the proposed Simba Oil mini Refinery in Tororo, Uganda
2018-19	Air dispersion modelling for input to the Atmospheric Reports for the postponement application for 14 Eskom power stations
2019	Air quality impact assessment for the proposed NamPower expansion project in Walvis Bay
2019	Air quality assessment for the mine expansion project at the Akanani Mine

2019	Air quality impact assessment for the proposed power plant at Nacala, Mozambique
2020	AIR for the KarpowershipSA proposal in the Ports of Ngqura, Richards Bay and Saldanha Bay
2020	AIR for the Coega Development Corporation gas-to-power project at 4 sites in the CDC
2020	AIRs for 10 Eskom coal-fired power power stations on the Highveld to support their postponement application
2020	AIR for the proposed Azure Power gas-to-power project in the Western Cape
2021	Air quality assessment for the proposed optimisation project at Beeshoek Iron Ore Mine, Postmasburg, Northern Cape
2021	AIR for the proposed Frontier Power Gas-to-Power project at Saldanha Bay, Western Cape
2021	AIR for the 2021 shutdown and start-up at Engen Refinery in Merebank
2021	AIR for the proposed expansion of the Swartkops Ore handling facility in Port Elizabeth, Eastern Cape
2016-21	AEL compliance monitoring for Joseph Grieveson, Durban, including dust fallout monitoring and reporting
2018-21	Dust fallout and HF monitoring and reporting for Hulamin, Richards Bay
2018-21	Dust fallout and H_2S monitoring and reporting for at KwaDukuza Landfill for Dolphin Coast Landfill Management (DCLM)
2019-21	AEL compliance monitoring for Umgeni Iron and Steel Foundry, including dust fallout monitoring and reporting

PUBLICATIONS

Author and co-author of 34 articles in scientific journals, chapters in books and conference proceedings. Author and co-author of more than 300 technical reports and presented 47 papers at local and international conferences.

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EDUCATION AND PROFESSIONAL STATUS

Qualification	**Institution**	**Year**
M.A. (Atmospheric Sciences)	University of Natal, Durban	2003
B.A. Hons. (Environmental Sciences)	University of Durban–Westville	2001
B.Paed. (Education)	University of Durban–Westville	2000

Memberships:

- National Association for Clean Air (NACA)
- South African Society for Atmospheric Sciences (SASAS)
- South African Council of Educators (SACE)

EMPLOYMENT AND EXPERIENCE RECORD

Period	Organisation details and responsibilities/roles
Jan 2003 – Oct 2008	CSIR: Consultant/Researcher in Air Quality Group, Research Group Leader – Air Quality Research Group
Nov 2008 – present	uMoya-NILU: Senior Air Quality Consultant

Key and Recent Project Experience:

2003	Baseline air dispersion modelling study for Natal Portland Cement (Pty) Ltd – Simuma Plant, Port Shepstone – Modelling and Reporting
2004	Air Quality Screening Study for MOZAL 3 – Modelling and Reporting
2005	Air Quality Specialist Study for the Proposed Kudu Combined Cycle Gas Turbine Power Station at Oranjemund, Namibia (Site D) – Modelling and Reporting
2005	Air Quality Specialist Study for the Proposed Kudu Combined Cycle Gas Turbine Power Plant at Uubvlei, Namibia – Modelling and Reporting
2005	Air Quality Specialist Study for a Proposed Cement Milling, Storage and Packaging Facility and a Second Clinker Kiln at Natal Portland Cement (Pty) Ltd – Simuma Plant, Port Shepstone – Modelling and Reporting
2005	Technology Review: Air quality specialist study for the Coega Aluminium Smelter at Coega, Port Elizabeth – Modelling and Reporting
2005	Assessment of Development Scenarios for Hillside Aluminium using Sulphur Dioxide (SO_2) as an Ambient Air Quality Indicator – Modelling and Reporting
2005	Air Quality Scoping Study for Eskom's Proposed Open Cycle Gas Turbine Power Station at Atlantis – Modelling and Reporting
2005	Air Quality Specialist Study for Eskom's Proposed Open Cycle Gas Turbine Power Station at Atlantis, Western Cape – Modelling and Reporting
2005	Air Quality Specialist Study for the Proposed Tata Steel Ferrochrome Project at Richards Bay – Alton North Site – Modelling and Reporting
2005	Air Quality Audit for the Amathole District Municipality - Compilation of detailed emissions inventory
2006	A Regional Scale Air Dispersion Modelling Study for Northeastern Uruguay – Modelling and Reporting

2006 Air Dispersion Modelling Study for Natal Portland Cement (Pty) Ltd for the Proposed AFR Programme at the Simuma Plant, Port Shepstone – Modelling and Reporting

2007 Development of an air quality management strategy for particulate matter at the Bulk Terminal Saldanha - Project Leader and Reporting

2007 Air Quality and Human Health Specialist Study for the Proposed Coega Integrated LNG to Power Project (CIP) within the Coega Industrial Zone, Port Elizabeth, South Africa - Project Leader, Modelling and Reporting

2008 Dispersion Modelling for the Proposed Coega Aluminium Smelter (CAL) at Port Elizabeth - Project Leader, Modelling and Reporting

2008 Modelled and Measured Vertical Ozone Profiles over Southern Africa (as part of the Young Researcher Establishment Fund (2005-2008)) - Project Leader

2008 Air Quality Specialist Study for the Proposed N2 Wild Coast Toll Highway - Project Leader, Modelling and Reporting

2008 Initial Air Quality Impact Assessment for the Proposed Illovo Ethanol Plant in Mali, West Africa - Project Leader, Modelling and Reporting

2008 Modelling Mercury Stack Emissions from South African Coal-fired Power Power stations – Modelling and Reporting

2009 Air Quality Management Plan for the Western Cape Province – Baseline Assessment – Modelling

2009 Proposed Exxaro AlloyStream™ Manganese Project in the Coega Industrial Development Zone: Air Quality Impact Assessment – Modelling and Reporting

2009 Air Quality Specialist Study for the Kalagadi Manganese Smelter at Coega, Eastern Cape – Modelling and Reporting

2009 Qualitative Air Quality Impact Assessment for the Wearne Platkop Quarry – Modelling and Reporting

2009 Specialist Air Quality Study for the Vopak Terminal Durban Efficiency Project – Modelling

2009 Qualitative Air Quality Impact Assessment for the Proposed ETA STAR Coal Mine at Moatize, Mozambique – Modelling and Reporting

2009 Specialist Air Quality Study for the Kwadukuza Landfill Upgrade Project – Modelling and Reporting

2010 Ambient dust assessment at Saldanha Bay for the period October 2006 to September 2009 for Transnet Bulk Terminal Saldanha – Reporting

2010 Dust Impact Assessment for the Proposed Saldanha Bay Pilot PV plant – Reporting

2010 Modelling Particulate Emission Concentration Scenarios for Eskom's Kriel Power Station – Modelling and Reporting

2010 Air Quality Dispersion Modelling for MOZAL, Mozambique – Modelling and Reporting

2010 Air Quality Management Plan for the Highveld Priority Area – Air Quality Baseline Assessment for the Highveld Priority Area – Modelling

2010 Ambient Air Quality Modelling and Monitoring at Sappi, Mandeni – Modelling and Reporting

2010 Dust Impact Study at Idwala Carbonates – Modelling and Reporting

2010 Air quality specialist study for the EIA for the proposed re-commissioning of an existing coke oven battery at ArcelorMittal South Africa, Newcastle Works – Modelling

2010 Air quality specialist study for the proposed storage and utilisation of alternative fuels and resources at NPC-Cimpor's Simuma facility, Port Shepstone, KwaZulu-Natal – Modelling and Reporting

2010 Air quality status quo assessment and abatement planning at First Quantum Mining's Bwana Mkubwa and Kansanshi mines, Zambia – Modelling

2010 Air quality specialist study for the proposed briquetting plant at the Mafube Colliery – Modelling and Reporting

2011 Air quality modelling study for the Copeland reactor at Sappi Stanger – Modelling and Reporting

2011 Air quality modelling study for the Copeland reactor at Sappi Tugela – Modelling and Reporting

2011 Air quality monitoring and modelling study for the Copeland reactor at Mpact Paper, Piet Retief – Modelling and Reporting

2011 Air Quality Study for the Basic Environmental Assessment for the Proposed Biomass Co-Firing Facility at the Arnot Power Station – Modelling and Reporting

2011 Assessment of Scenarios for Developing and Implementing a Sulphur Dioxide Emissions Licensing Strategy for Hillside Aluminum – Modelling and Reporting

2011-12 Air quality assessment for the mining and processing facilities at Lonmin Platinum in Marikana – Modelling and Reporting

2012 Development of an Air Quality Management Plan for Anglo's Mafube Colliery in Mpumalanga – Modelling and Reporting

2012 Air quality assessment for the proposed manganese ore terminal at the Ngqura Port – Modelling and Reporting

2012 Air Quality Impact Assessment for NPC Cimpor – Modelling and Reporting

2013 Air Quality Impact Assessment for Proposed AfriSam Plant in Coega – Modelling

2013 Air quality assessment for the Orion Engineered Carbons Co-Gen Plant – Modelling

2013 Air quality assessment for the Orion Engineered Carbons - Main Boiler – Modelling

2013 Air quality assessment for the EIA for the Sekoko Coal Mine – Modelling and Reporting

2013 Air quality specialist study for the EIA for the Thabametsi IPP station – Modelling and Reporting

2013 Air quality specialist study for the EIA for the Mamathwane Common User facility – Modelling and Reporting

2013-14 Air quality specialist study for the application for postponement of the minimum emission standards for 16 Eskom power stations: Acacia, Arnot, Camden, Duvha, Grootvlei, Hendrina, Kendal, Komati, Kriel, Lethabo, Majuba, Matimba, Matla, Madupi, Tutuka, Port Rex – Modelling and Reporting

2014 Air quality specialist study for the application for postponement of the minimum emission standards for the Engen Refinery in Merebank, Durban – Modelling and Reporting

2013-14 Baseline assessment and air quality management plan for the Waterberg-Bojanala Priority Area – Modelling

2013 Air Quality Specialist Study for the EIA for the Pandora Platinum Mine Joint Venture – Modelling and Reporting

2013 Air Quality Specialist Study for the EIA for the Proposed New Tailings Storage Facility (TD8) and Associated Infrastructure at Lonmin's Western Platinum Mine and Eastern Platinum Mine – Modelling and Reporting

2015 Waterberg-Bojanala Priority Area Air Quality Management Plan and Threat Assessment – Modelling

2015 Air Quality Management Plan for eThekwini Municipality – Modelling and Reporting

2015 Air Quality Management Plan for the uThungulu District Municipality – Modelling and Reporting

2015 Dispersion Modelling for Richards Bay Minerals – Modelling and Reporting

2015 Atmospheric Impact Report in support of Sancryl Chemicals's application for a verification to the existing AEL as a result of the introduction of Ethyl Acrylate and Vinyl Acetate, Prospecton – Modelling and Reporting

2016 Dispersion Modelling Study for the City of Johannesburg – Modelling and Reporting

2016 Air Quality Specialist Study for the Department of Energy's Emergency Power IPP Project at Richards Bay and Saldanha Bay – Modelling and Reporting

2016 Atmospheric Impact Report in support of the EIA for the Proposed Gas to Power Plant in Zone 1F of the Richards Bay IDZ – Modelling and Reporting

2016 Atmospheric Impact Report for the EIA for the proposed Tshivhaso Coal-fired Power Plant, Lephalale – Modelling and Reporting

2016 TNPA Air Quality Study – Dispersion Modelling for 8 Ports in South Africa: Port of Richards Bay, Durban, East London, Ngqura, Port Elizabeth, Mossel Bay, Cape Town and Saldanha Bay – Modelling and Reporting

2016 Atmospheric Impact Report for Durran's Calcination Plant – Modelling and Reporting

2016 Air Quality Assessment for the EIA for the Floating Power Plant in Nacala, Mozambique – Modelling and Reporting

2016 Ambient Air Quality Assessment for 2016 for Kansanshi Mining Plc – Modelling and Reporting

2016 Air Quality Impact Assessment for the EIA for the Proposed Hilli FLNG Project in Cameroon – Modelling and Reporting

2016 Kansanshi Smelter and TSF1 Modelling Scenarios for Kansanshi Mining Plc – Modelling and Reporting

2016 Air Quality Assessment the Proposed Accommodation Facility at the Venetia Mine in Limpopo – Modelling and Reporting

2016 Atmospheric Impact Report in support of the EIA for the Proposed Optimisation of the Process Plant at Nkomati Anthracite Mine – Modelling and Reporting

2017 Atmospheric Impact Report in support of the DRDAR Atmospheric Emission License (AEL) application for the proposed replacement and use of an incinerator at their State Veterinary Laboratories located in Grahamstown, Middelburg and Queesntown in the Eastern Cape – Modelling and Reporting

2017 Baseline Assessment and Review of the 2009 AQMP for Gauteng Province, including emission inventory development for all sectors, i.e. industrial,

transport, waste management, biomass burning, residential fuel burning, and dispersion modelling – Modelling and Reporting

2017 Baseline Assessment and Air Quality Management Plan for Northern Cape Province – Modelling and Reporting

2017 Atmospheric Impact Report in support of Maloka Machaba Surfacing's application for an Atmospheric Emission License (AEL) for a proposed asphalt plant located in Polokwane – Modelling and Reporting

2017 Assessment of modelling scenarios involving an increase in the open area of the cone on the Common Stack for the pretreater, reformer and CHD furnaces at Engen Refinery – Modelling and Reporting

2017 Atmospheric Impact Report in support of the Atmospheric Emission License (AEL) application and stack-height assessment for the proposed Thabametsi Power Plant near Lephalale, Limpopo – Modelling and Reporting

2017 Dispersion Modelling Study for the Beeshoek Mine, near Postmasburg, Northern Cape – Modelling and Reporting

2018 Air quality assessment for the EIA for the proposed Bellmall Thermal Plant in Ekurhuleni – Modelling and Reporting

2018 Air quality assessment for the EIA for the proposed Simba Oil mini Refinery in Tororo, Uganda – Modelling and Reporting

2018-19 Air dispersion modelling for input to the Atmospheric Reports for the postponement application for 14 Eskom power stations – Modelling and Reporting

2019 Air quality impact assessment for the proposed NamPower expansion project in Walvis Bay – Modelling and Reporting

2019 Air quality assessment for the mine expansion project at the Akanani Mine – Modelling and Reporting

2019 Air quality impact assessment for the proposed power plant at Nacala, Mozambique – Modelling and Reporting

2019 Atmospheric Impact Report in Support of the Atmospheric Emission License (AEL) Amendment Application and Basic Assessment for Dow Southern Africa - New Germany – Modelling and Reporting

2019 Atmospheric Impact Report in support of Tau-Pele Construction's application for an Atmospheric Emission License (AEL) for a proposed emulsion and asphalt plant located in Indwe, Eastern Cape – Modelling and Reporting

2019 Atmospheric Impact Report in Support of the EIA for the Proposed Material Source and Processing Sites Along the N3 Between Durban and Hilton, KwaZulu-Natal: RCL1, RCL9 and Harrison's Quarry – Modelling and Reporting

2019 Atmospheric Impact Report in Support of the Atmospheric Emission License (AEL) Amendment Application and Basic Assessment for the Vopak Efficiency (Growth 4) Expansion Project, Durban, South Africa – Modelling and Reporting

2020 AIR for the KarpowershipSA proposal in the Ports of Ngqura, Richards Bay and Saldanha Bay – Modelling and Reporting

2020 AIR for the Coega Development Corporation gas-to-power project at 4 sites in the CDC – Modelling and Reporting

2020 AIRs for 10 Eskom coal-fired power power stations on the Highveld to support their postponement application – Modelling and Reporting

2020 AIR for the proposed Azura Power gas-to-power project in the Western Cape – Modelling and Reporting

2020 Atmospheric Impact Report for the proposed 315 MW LPG Power Plant at Saldanha Bay – Modelling and Reporting
2021 Air quality assessment for the proposed optimisation project at Beeshoek Iron Ore Mine, Postmasburg, Northern Cape – Modelling and Reporting
2021 Air quality assessment for the proposed expansion at Akanani Mine in Limpopo – Modelling and Reporting
2021 AIR for the proposed Frontier Power Gas-to-Power project at Saldanha Bay, Western Cape
2021 AIR for the 2021 shutdown and start-up at Engen Refinery in Merebank – Modelling and Reporting
2021 AIR for the proposed expansion of the Swartkops Ore handling facility in Port Elizabeth, Eastern Cape – Modelling and Reporting
2021 Atmospheric Impact Report in support of the Proposed 200 MW Engie CB Hybrid Power Project in the Coega Special Economic Zone (SEZ) – Modelling and Reporting
2021 Air Quality Impact Assessment for the proposed Mining of TSF-1 at the Stibium Mopani Mine near Gravelotte, Limpopo Province – Modelling and Reporting
2021 Addendum to the Atmospheric Impact Report in support of the proposed Mulilo-Total 200 MW Gas-fired Power Station, Coega Special Development Zone, Eastern Cape – Reporting
2021 Air Quality Assessment for the EIA for the Tete 1 400 MW Coal-Fired Power Plant, Tete Province, Mozambique – Modelling and Reporting
2021 Atmospheric Impact Report in support of Tugela Asphalt's application for an Atmospheric Emission License (AEL) for a proposed asphalt plant located in Mandini, KwaZulu-Natal – Modelling
2021 Atmospheric Impact Report for Nkomati Mine – Modelling and Reporting
2022 Emission Inventory for Lanxess for 2021 – Reporting
2022 Annual Report for Puregas: Atmospheric Emission License - Submission to the City of Ekurhuleni in compliance with the Atmospheric Emission Licence of the facility for the Reporting Period Year 2021 – Reporting
2022 Emission Inventory for Puregas for 2021 – Reporting
2022 Emission Inventory for Dow Advanced Materials for 2020 – Reporting
2022 Atmospheric Impact Report for the Engen Cape Town Terminal – Modelling and Reporting

PUBLICATIONS

Author and co-author of 5 articles in scientific journals and conference proceedings. Author and co-author of more than 200 technical reports for external contract clients. Presented 4 papers at local conferences. A full list of publications, conference papers and contract reports is available on request.

NOPASIKA XULU



Firm	:	uMoya-NILU (Pty) Ltd
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Qualification	Institution	Year
BSc. Environmental Studies	Univ. of Witwatersrand	2011
BSc Hons (Env. Studies)	Univ. of Witwatersrand	2012
BSc MSc (Env Sciences)	NWU Potchefstroom	2017

EMPLOYMENT AND EXPERIENCE RECORD

Period	Organisation details and responsibilities/roles
Oct 2016 – Dec 2018	Gondwana Environmental Solutions (Pty) Ltd: Air Quality Management Plans; Report Writing; Business Development and Marketing, Researcher,
July 2019 – March 2023	Rayten Engineering Solutions (Pty) Ltd: Air Quality Consultant, Project Management; Report Writing and Review; Data Analysis; Dispersion Modelling and Air Quality Impact Assessment; Research; Compiling Atmospheric Emission License (AEL) Applications; Populating National Atmospheric Emissions Inventory System; AEL Compliance Auditing; Dust Emission Reduction Plans; Greenhouse Gas Emissions Inventory Reporting; Facilitating/ Attending meetings; Liaising with Clients and Suppliers.

March 2023 – Present: uMoya – Nilu Consulting (Pty) Ltd Senior Air Quality Consultant, Dispersion Modelling and Air Quality Impact Assessments; Project Management

Key Project Experience:

2019 – 2023: Project Leader: Air Quality Impact Assessment projects (Harmony Moab Khotsong; EzeeTile Bloemfontein, EzeeTile Mokopane; Transvaal Galvanizers; Duho Drying; Lingaro Drying; Nama Copper Pty Ltd) Project Leader: AEL Applications and Reporting (Harmony Kopanang Operations; Harmony Mponeng Operations; Sibanye Gold Mines; Sibanye Platinum

Mines; TotalEnergies Marketing; Matt Cast Supplies CC; Independent Crematorium SA; City of Tshwane Crematorium; Buffalo City Municipality Crematorium; Wahl Industries; Transvaal Galvanizers)

2014 – 2017: Researcher: Air Quality Assessment in low-income residential areas in the Highveld

Publications: Author: Xulu, N.A., Piketh, S.J. Feig,G.T., Lack, D.A and Garland,R.M., (2020).Characterizing Light Absorbing Aerosols in a Low –Income Settlement in South Africa. Aerosol Air Quality Aerosol Air Quality Research. https://doi.org/10.4209/aaqr.2019.09.004

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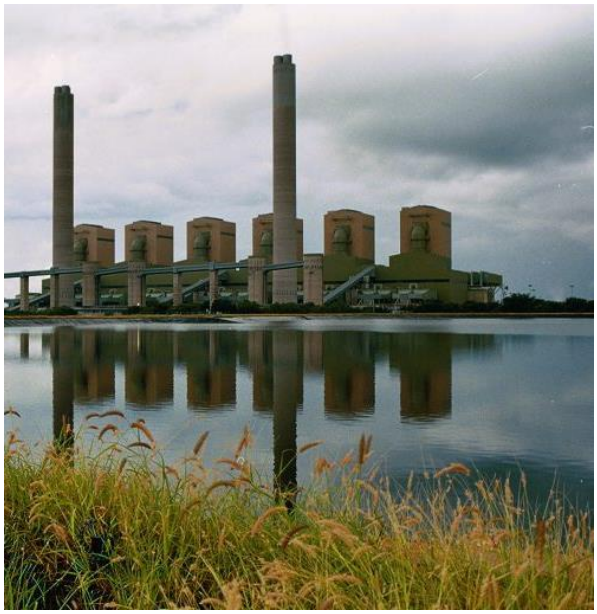
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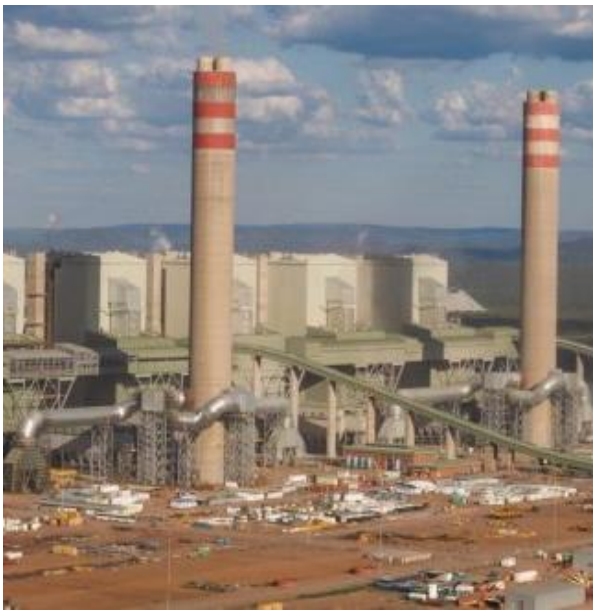
Appendix B

CUMULATIVE AIRSHED STACK PM EMISSIONS ONLY

Public

ADDENDUM TO:
ATMOSPHERIC IMPACT REPORT IN SUPPORT OF THE APPLICATION FOR EXEMPTION FROM THE MINIMUM EMISSION STANDARDS FOR ESKOM's COAL-FIRED POWER STATIONS IN THE WATERBERG (A CUMULATIVE ASSESSMENT)





9 December 2024

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Report Details

Client:	WSP Group Africa (Pty) Ltd
Report title:	Addendum to: Atmospheric Impact Report in Support of the Application for Exemption from the Minimum Emission Standards for Eskom's Coal-Fired Power Stations in the Waterberg (A Cumulative Assessment)
Project:	uMN920-24
Report number:	uMN296-24
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uMoya-NILU (2024): Addendum to: Atmospheric Impact Report in Support of the Application for Exemption from the Minimum Emission Standards for Eskom's Coal-Fired Power Stations in the Waterberg (A Cumulative Assessment), Report No.: uMN296-24, December 2024.

Front page picture credit: https://www.eskom.co.za/eskom-divisions/gx/coal-fired-power-stations/

GLOSSARY OF TERMS AND ACRONYMS

AEL	Atmospheric Emission Licence
AIR	Atmospheric Impact Report
DEA	Department of Environmental Affairs
DFFE	Department of Forestry, Fisheries and the Environment
DSI	Dry Sorbent Injection
EIA	Environmental Impact Assessment
FGD	Flue-gas desulfurisation
g/s	Grams per second
kPa	Kilo Pascal
LNB	Low NO_X burner
MES	Minimum Emission Standards
mg/Nm^3	Milligrams per normal cubic meter refers to emission concentration, i.e. mass per volume at normal temperature and pressure, defined as air at 20°C (293.15 K) and 1 atm (101.325 kPa)
NAAQS	National Ambient Air Quality Standards
NAQO	National Air Quality Officer
NECA	National Environmental Consultative and Advisory
NEM-AQA	National Environment Management: Air Quality Act, 2004 (Act No. 39 of 2004)
NEMA	National Environmental Management Act, 1998 (Act No. 107 of 1998)
USEPA	United States Environmental Protection Agency
µm	1 µm = Micro meter 1 µm = 10^{-6} m

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1. INTRODUCTION

On 22 May 2024, the Minister directed Eskom to submit an application in terms of Section 59 of the National Environmental Management: Air Quality Act for exemption of the MES for eight (8) power stations that will continue to operate post 2030. These are Duvha, Kendal, Majuba, Matla and Tutuka in the Highveld Priority Area; Lethabo in the Vaal Triangle Airshed Priority Area; and Medupi and Matimba in the Waterberg-Bojanala Priority Area.

In terms the Minister's ruling Eskom Holdings SOC Ltd appointed WSP Group Africa (Pty) Ltd to prepare the necessary applications. WSP Group Africa (Pty) Ltd sub-contracted uMoya-NILU Consulting (Pty) Ltd to prepare the associated Atmospheric Impact Reports (AIRs) to support the applications. AIRs were duly prepared to support the respective exemption applications for the individual power stations. Furthermore, two cumulative AIRs were prepared, for the suite of power stations on the Highveld and the Vaal Triangle, and for the two coal-fired power stations in the Waterberg-Bojanala Priority Area, i.e. Medupi and Matimba (uMoya-NILU, 2024). In so doing, 5 emission scenarios were assessed, which included SO_2, NO_X and PM emissions from the stacks as well as fugitive PM emissions from the coal stockyard and ash dumps. The intention was to provide an understanding of the power stations total contribution to ambient concentrations.

The stack emission data were provided by Eskom for the five scenarios based firstly on actual emissions, followed by emissions representing anticipated station performance in different years. Fugitive emissions were estimated based on a worst-case scenario, with little dust control implemented on the ash dumps. Specifically, 60-80% of the entire area of the ash dumps was assumed to be exposed and available for entrainment of particulates. It was assumed that the sides of the ash dumps are in fact partially vegetated, and the tops are partially wet.

To provide an absolute worst-case, it was assumed that the total PM emission from the stacks into the respective PM_{10} and $PM_{2.5}$ fractions. Therefore, the total PM emission was firstly assumed to be PM_{10}, then was assumed to be $PM_{2.5}$. For consistency in the modelling, the total PM emission from the fugitive sources was also assumed to be PM_{10}, then $PM_{2.5}$. The modelled outputs were then compared against the respective National Ambient Air Quality Standards (NAAQS).

The modelled PM_{10} and $PM_{2.5}$ concentrations were high close to the respective power stations and exceeded the NAAQS. Further away from the power stations, the predicted concentrations were relatively low and complied with the NAAQS. From the results it was however impossible to distinguish between the contribution of the fugitive sources and the stack emissions to ambient concentrations, although the results indicated that the high concentrations were due to the fugitive sources rather than the stack emissions themselves.

As Eskom's request to the Minister concerns stack emissions, it was decided to prepare an addendum to the cumulative assessment for the Waterberg power stations and to assess the contribution of stack PM emissions only to the ambient PM_{10} and $PM_{2.5}$ concentrations. The same dispersion model, stack parameterisation and model setup are used. In this

Addendum to the AIR (uMoya-NILU, 2024), the focus is specifically on stack emissions for PM and the modelled results for PM_{10} and $PM_{2.5}$.

2. STACK EMISSIONS

In this Addendum to the AIR (uMoya-NILU, 2024), the cumulative effect of stack emissions from 2 coal-fired power stations comprising the Waterberg fleet are assessed, i.e. Medupi and Matimba.

2.1 Operational Scenarios

The five operational scenarios anticipated by Eskom for the Waterberg power station fleet in the coming years are:

Scenario 1 (Current): The baseline scenario using actual monthly stack emissions for 2021-2023 (No FGD installed).

Scenario A (2025): Eskom's planned 2025 stack emissions, representing anticipated station performance between 2025 – 2030 (No FGD installed).

Scenario B (2031): Eskom's planned 2031 stack emissions, representing anticipated station performance between 2031 – 2035 (No FGD installed but load reduction).

Scenario C (2036): Eskom's planned 2036 stack emissions, representing anticipated station performance from 2036 onwards (FGD installed at Medupi).

Scenario D (MES): Full compliance with the MES (FGD installed at Medupi and Matimba).

The estimated emission rates for SO_2, NO_X and PM_{10} and equivalent emission concentrations that are used in the dispersion modelling for the power stations are shown in **Error! Reference source not found.**. A reminder that the total PM emission is assumed to be PM_{10}. The estimated emission rates and equivalent emission concentrations that are used in the dispersion modelling for the two power stations are shown in Table 2-1. The maximum anticipated emissions during each period are used for simulation in the model. The boiler units are assumed to operate continuously, i.e. 24 hours a day. Since each future scenario is a snapshot of the period of operation (e.g. Scenario A = 2025 to 2030), the maximum anticipated emissions during that period, in a single year was selected for simulation in the model.

Table 2-1: Annual emissions from the Medupi and Matimba Power Stations and the corresponding emission concentrations

Scenario	Stack	Emission rate (tonnes/annum)			Emission concentration @ 10% O_2 and average load (mg/Nm^3)		
		NO_X	SO_2	PM	NO_x	SO_2	PM
		Medupi Power Station					
1[a]	Stack 1	25 577	123 502	1 314	257	1 343	13
	Stack 2	25 577	123 502	1 314	257	1 343	13
A	Stack 1	34 716	134 340	1 663	522	2 020	25
	Stack 2	34 716	134 340	1 663	522	2 020	25
B	Stack 1	20 770	80 374	1 273	522	2 020	32
	Stack 2	20 770	80 374	1 273	522	2 020	32
C	Stack 1	23 447	31 263	1 438	375	500	23
	Stack 2	23 447	31 263	1 438	375	500	23
D	Stack 1	23 447	31 263	1 438	375	500	23
	Stack 2	23 447	31 263	1 438	375	500	23
		Matimba Power Station					
1[a]	Stack 1	28 921	150 457	2 648	291	1 514	27
	Stack 2	28 921	150 457	2 648	291	1 514	27
A	Stack 1	28 346	150 830	1 820	545	2 900	35
	Stack 2	28 346	150 830	1 820	545	2 900	35
B	Stack 1	18 118	103 026	1 243	510	2 900	35
	Stack 2	18 118	103 026	1 243	510	2 900	35
C	Stack 1	20 872	112 752	1 432	510	2 755	35
	Stack 2	20 872	112 752	1 432	510	2 755	35
D	Stack 1	20 872	33 825	1 432	510	827	35
	Stack 2	20 872	33 825	1 432	510	827	35
MES					**750**	**1000**	**50**

(a): Average from actual monthly emissions

2.2 Methodology for determining $PM_{2.5}$ emissions

In terms of the determination of fine particulate matter emissions ($PM_{2.5}$), it is noted that Eskom utilises the dry bottom boiler emission factors from the United States Environmental Protection Agency (US EPA AP42) (US EPA, 1995) to determine the fine particulate matter emissions ($PM_{2.5}$). The ratio of the $PM_{2.5}$ to PM_{10} is used to calculate $PM_{2.5}$ from the total PM measured from the Continuous Emission Monitoring System (CEMS) equipment at the respective stacks. The utilisation of CEMS equipment is a more accurate representation of site-specific PM and therefore constitutes a Tier 3 method of reporting.

The US EPA defines dry bottom boilers as those burning coals with high fusion temperatures resulting in dry ash. In wet bottom boilers, coal with low fusion temperatures is used, resulting in molten ash or slag. Eskom coal fired power stations are therefore considered to have dry bottom boilers. Eskom has either Electrostatic Precipitators (ESPs) or Fabric Filter Plants (FFPs) installed as air pollution control devices in all its coal fired units. The following ratios determined from dry bottom emission factors in the US EPA AP42 are used:

- ESP controlled - 0.024 lb/ton for $PM_{2.5}$ and 0.054 lb/ton for PM_{10} [ratio = 0.44]
- FFP controlled - 0.01 lb/ton for $PM_{2.5}$ and 0.02 lb/ton for PM_{10} [ratio = 0.5]

The above ratios for PM_{10}:$PM_{2.5}$ have been applied accordingly at the power stations as follows:

- Medupi has FFPs installed on both stacks, hence the PM_{10}:$PM_{2.5}$ ratio is 1:0.50
- Matimba has ESPs installed on both stacks, hence the PM_{10}:$PM_{2.5}$ ratio is 1:0.44

3. DISPERSION MODELLING RESULTS

The CALPUFF modelling suite provides for the chemical conversion of SO_2 and NO_X to secondary particulates, i.e. sulphates and nitrates in the modelling results. For PM_{10} and $PM_{2.5}$, the predicted concentrations presented are therefore attributed to stack emissions and the contribution from secondary particulate formation.

The DEA (2014) recommends the 99th percentile concentrations for short-term assessment with the NAAQS since the highest predicted ground-level concentrations can be considered outliers due to complex variability of meteorological processes. In addition, the limit value in the NAAQS is the 99th percentile. The impact assessment therefore compares the predicted 99th percentile concentrations with the respective NAAQS limit values and the permitted frequency of exceedance for the five scenarios.

3.1 Maximum predicted ambient concentrations

The maximum predicted annual PM_{10} and $PM_{2.5}$ concentrations and the 99th percentile of the 24-hour predicted concentrations are discussed here and are listed in Table 3-1 for the 5 scenarios.

Changes in the predicted annual average and 24-hour PM_{10} and $PM_{2.5}$ concentrations from one scenario to the next are strongly influenced by changes in PM_{10} and $PM_{2.5}$ emissions, the contribution from secondary particulate formation and stack exit velocity.

In all scenarios, the maximum predicted annual average PM_{10} and $PM_{2.5}$ concentrations are well below the limit values of the respective NAAQS. In all scenarios, the maximum predicted 99th percentile of the 24-hour PM_{10} and $PM_{2.5}$ concentrations are in general, relatively low compared to the limit value of the NAAQS. In other words, here are no predicted exceedances of the 24-hour limit value of the respective NAAQS for PM_{10} and for $PM_{2.5}$.

The increase in SO_2, NO_X, PM_{10} and $PM_{2.5}$ emissions at Medupi and a reduction in stack exit velocity from Scenario 1 (Current) to Scenario A (2025) is seen by an increase in the predicted PM_{10} and $PM_{2.5}$ ambient concentrations. Although there is a decrease in PM_{10} and $PM_{2.5}$ emissions at Matimba, the reduced exit velocity in the stacks reduces the dispersion potential.

The maximum predicted PM_{10} and $PM_{2.5}$ ambient concentrations decrease significantly from Scenario A (2025) to Scenario B (2031) due to the substantial decrease in SO_2, NO_X, PM_{10} and $PM_{2.5}$ emissions at Medupi and Matimba.

Although there is an increase in NO_X, PM_{10} and $PM_{2.5}$ emissions, and a reduction in exit velocity in the stacks at Medupi and Matimba from Scenario B (2031) to Scenario C (2036), the substantial decrease in SO_2 emissions at Medupi is responsible for a slight decrease in PM_{10} and $PM_{2.5}$ ambient concentrations, as this reduces the formation of secondary particulates.

Although NO_X, PM_{10} and $PM_{2.5}$ emissions remain the same for Scenario C (2036) and Scenario D (MES), it is noted that the maximum predicted PM_{10} and $PM_{2.5}$ ambient concentrations show a fairly large decrease between the two scenarios. This decrease is mainly attributed to the reduced formation of secondary particulates brought about by a substantial decrease in SO_2 emissions at Matimba.

Table 3-1: Maximum predicted ambient annual PM_{10}, and $PM_{2.5}$ concentrations in µg/m³ and the predicted 99th percentile concentrations for 24-hour averaging periods, with the South African NAAQS

Scenario and Pollutant	Averaging time	
Predicted maximum PM_{10}	**Annual**	**24-hour**
Scenario 1 (Current)	1.2	15.4
Scenario A (2025)	1.7	17.9
Scenario B (2031)	1.3	13.8
Scenario C (2035)	1.0	10.8
Scenario D (MES)	0.6	6.0
NAAQS	**40**	**75**
Predicted maximum $PM_{2.5}$	**Annual**	**24-hour**
Scenario 1 (Current)	1.1	14.3
Scenario A (2025)	1.5	16.8
Scenario B (2031)	1.2	12.8
Scenario C (2035)	0.9	10.0
Scenario D (MES)	0.5	4.9
NAAQS (up to 31 Dec 2029)	**20**	**40**
NAAQS (from 01 Jan 2030)	**15**	**25**

3.2 Predicted concentrations at the AQMSs

The predicted annual PM_{10} and $PM_{2.5}$ concentrations are compared with the measured annual averages in 2021, 2022 and 2023 at three Air Quality Monitoring Stations (AQMS) in the Waterberg modelling domain for Scenario 1 (Current) in Table 3-2 and Table 3-3, respectively.

For PM_{10} and $PM_{2.5}$ the predicted ambient concentrations result from the respective power station stack emissions. At all AQMSs, the modelled concentrations are considerably lower than the monitored concentrations. This is to be expected since the here are exposed to all sources of PM_{10} and $PM_{2.5}$. The difference between the predicted concentrations and the measured concentrations provides an indication of the contribution of the power station stack emissions at the respective AQMSs.

Table 3-2: Measured annual average PM_{10} concentration at the Waterberg AQMSs compared with predicted concentrations in µg/m³ for Scenario 1 (Current)

Receptor	2021	2022	2023	Modelled
Marapong AQMS	47.0	-	-	**0.7**
Medupi AQMS	28.8	28.4	37.5	**0.8**
Lephalale AQMS	37.3	-	17.4	**0.7**

Table 3-3: Measured annual average $PM_{2.5}$ concentration at the Waterberg AQMSs compared with predicted concentrations in µg/m³ for Scenario 1 (Current)

Receptor	2021	2022	2023	Modelled
Marapong AQMS	25.8	30.2	-	**0.6**
Medupi AQMS	15.2	-	-	**0.7**
Lephalale AQMS	-	-	12.2	**0.6**

3.3 Predicted concentrations at sensitive receptors

In the Waterberg study area, 51 sensitive receptors were identified. These are listed in Annexure 1. Predicted ambient concentrations for PM_{10} and $PM_{2.5}$ for the five scenarios are presented in Annexure 2.

At all identified sensitive receptors, the predicted PM_{10} and $PM_{2.5}$ concentrations are low and well below the limit value of the respective NAAQS for all five scenarios. The highest predicted concentrations occur for Scenario A (2025) and the lowest predicted concentrations occur for Scenario D (MES).

Noteworthy is the systematic decrease in predicted PM_{10} and $PM_{2.5}$ concentrations from 2025 to 2036 at all sensitive receptors.

3.4 Isopleth maps

Isopleth maps of predicted ambient PM_{10} and $PM_{2.5}$ concentrations are presented in the following sections. The predicted concentrations are shown as isopleths, lines of equal concentration, in µg/m³ for the respective NAAQS averaging periods. The isopleths are depicted as coloured lines on the various maps, corresponding to a particular predicted ambient concentration. Sensitive receptors are represented by green squares and AQMSs are represented by white dots.

The South African NAAQS permits 4 exceedances of the 24-hour or daily limit value per annum, implying 12 permitted exceedances in a three-year modelling period. In all scenarios, the maximum predicted annual average PM_{10} and $PM_{2.5}$ concentrations are well below the limit values of the respective NAAQS. In all scenarios, the maximum predicted 99th percentile of the 24-hour PM_{10} and $PM_{2.5}$ concentrations are in general, relatively low compared to the limit value of the NAAQS. The predicted 24-hour PM_{10} and $PM_{2.5}$ concentrations therefore comply with the NAAQS for all five scenarios. As discussed above, changes in the predicted concentrations are strongly influenced by changes in emissions, the contribution from secondary particulate formation and stack exit velocity.

3.4.1 Particulates (PM_{10})

In Scenario 1 (Current), the highest predicted annual concentrations occur approximately 20 km to the south-southwest of the Medupi Power Station. The highest predicted 24-hour concentrations occur up to 20 km around the Medupi and Matimba Power Stations.

The increase in SO_2, NO_X, PM_{10} and $PM_{2.5}$ emissions at Medupi and a reduction in stack exit velocity from Scenario 1 (Current) to Scenario A (2025) is seen by an increase in the predicted concentrations. In Scenario A (2025), the highest predicted annual concentrations occur approximately 20 km to the south-southwest of the Medupi Power Station. The highest predicted 24-hour concentrations occur approximately 20 km to the southwest of the Medupi Power Station, and approximately 10 km to the east of the Matimba Power Station.

Noticeable is the dramatic decrease in ambient concentrations on the isopleths for Scenario B (2031), where the biggest reductions are seen, due to the substantial decrease in SO_2, NO_X, PM_{10} and $PM_{2.5}$ emissions at Medupi and Matimba. In Scenario B (2031), the highest predicted annual concentrations occur approximately 20 km to the south-southwest of the Medupi Power Station. The highest predicted 24-hour concentrations occur up to 20 km around the Medupi and Matimba Power Stations.

The effect of the reduced formation of secondary particulates brought about by the substantial decrease in SO_2 emissions at Medupi are also noticeable on the isopleths for Scenario C (2036). In Scenario C (2036), the highest predicted annual concentrations occur approximately 20 km to the south-southwest of the Medupi Power Station. The highest predicted 24-hour concentrations occur approximately 10 km to the west of the Medupi Power Station, and approximately 5 km to the east of the Matimba Power Station.

Although PM_{10} emissions remain the same for Scenario C (2036) and Scenario D (MES), the predicted PM_{10} concentrations show a fairly large decrease on the isopleths for Scenario D (MES) (as discussed previously, this decrease is mainly attributed to the reduced formation of secondary particulates brought about by a substantial decrease in SO_2 emissions between these scenarios at Matimba). In Scenario D (MES), the highest predicted annual concentrations occur approximately 20 km to the south-southwest of the Medupi Power Station. The highest predicted 24-hour concentrations occur approximately 20 km to the southwest of the Medupi Power Station, and approximately 10 km to the west of the Matimba Power Station.

Isopleth maps of the predicted annual average and 99th percentile of the 24-hour PM_{10} concentrations are presented in Figure 3-1 to Figure 3-10.

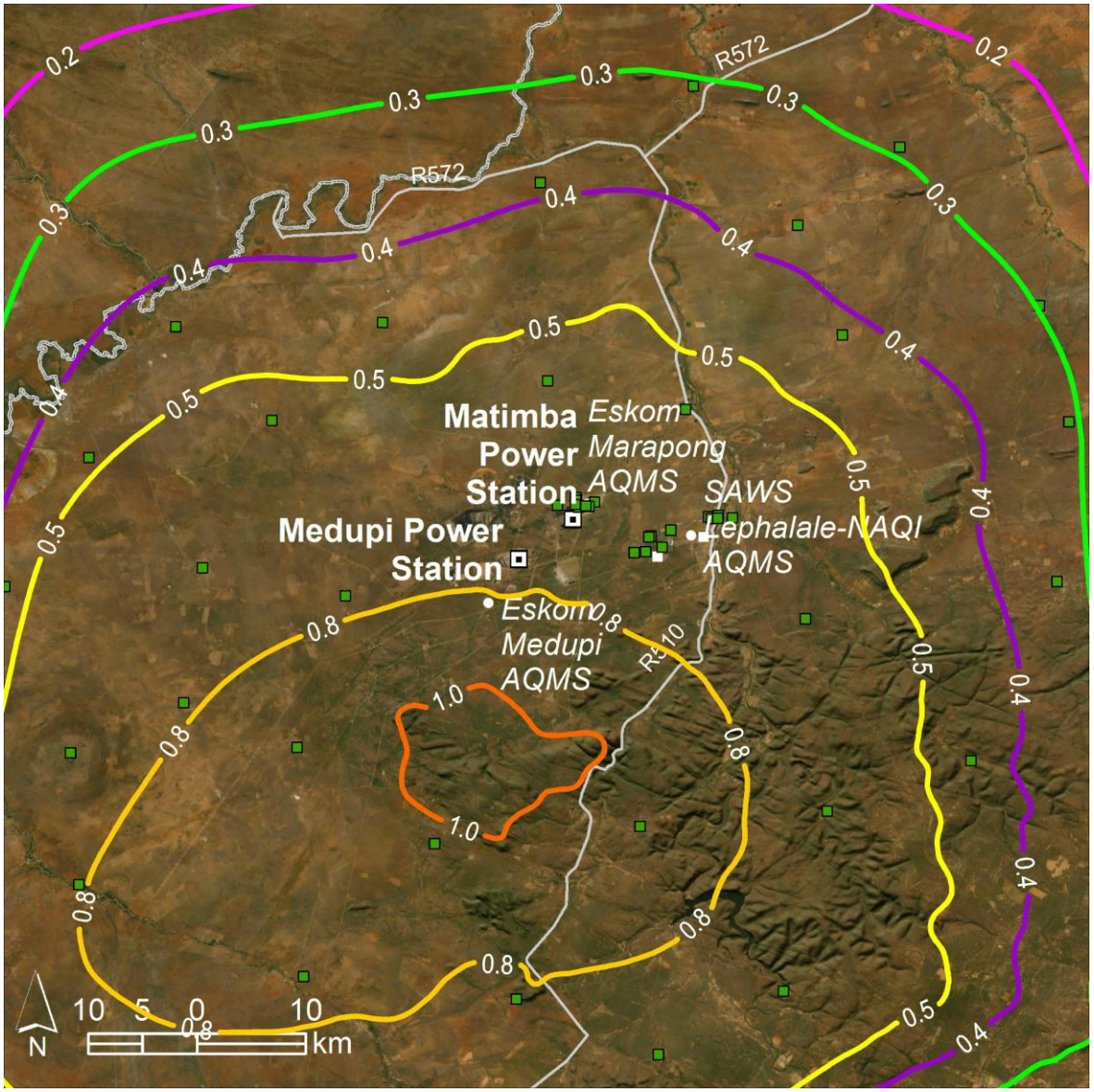


Figure 3-1: Predicted annual average PM_{10} concentrations in µg/m³ for Scenario 1 (Current) (NAAQS Limit is 40 µg/m³)

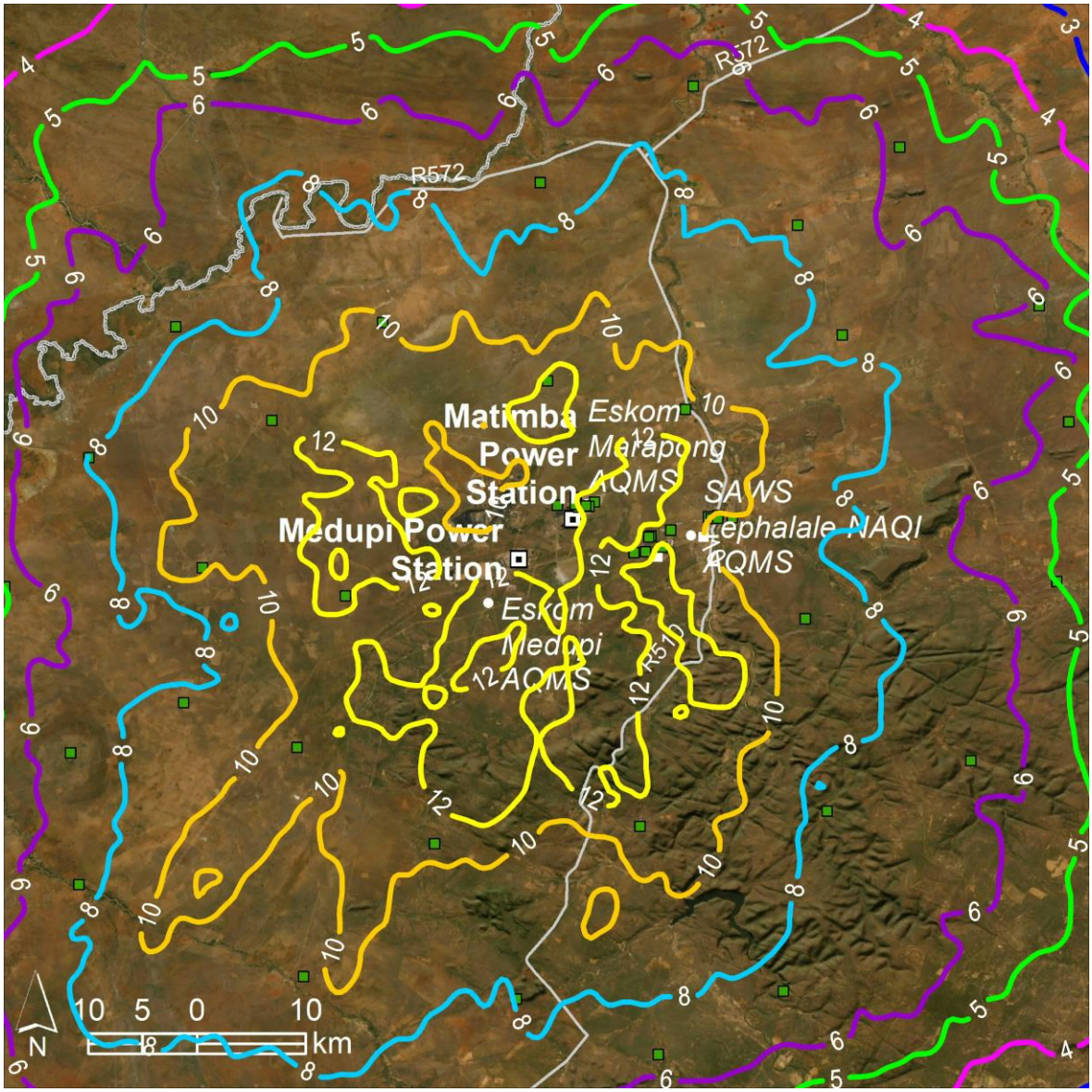


Figure 3-2: Predicted 99th percentile of the 24-hour PM_{10} concentrations in µg/m³ for Scenario 1 (Current) (NAAQS Limit is 75 µg/m³)

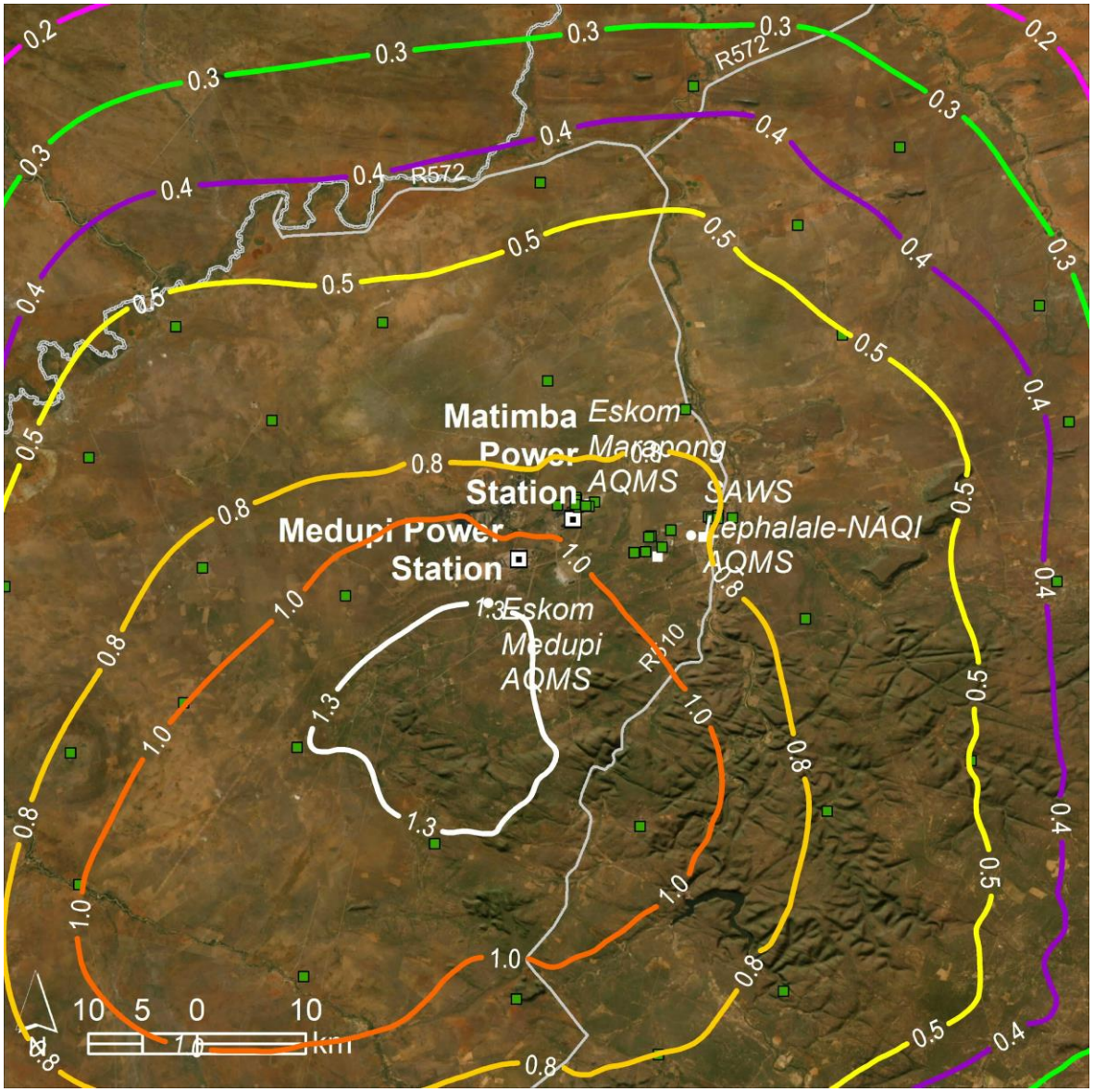


Figure 3-3: Predicted annual average PM_{10} concentrations in µg/m³ for Scenario A (2025) (NAAQS Limit is 40 µg/m³)

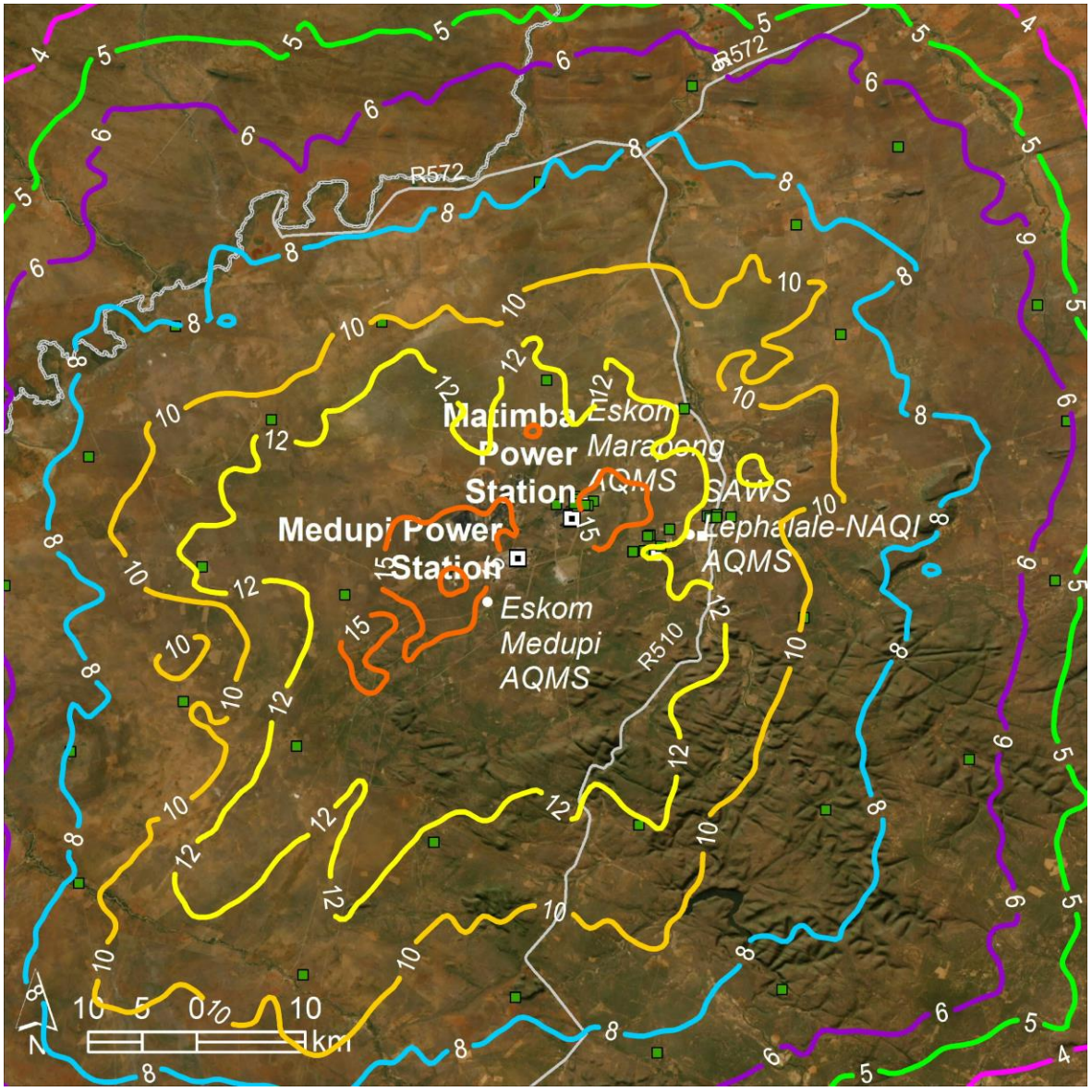


Figure 3-4: Predicted 99th percentile of the 24-hour PM_{10} concentrations in µg/m³ for Scenario A (2025) (NAAQS Limit is 75 µg/m³)

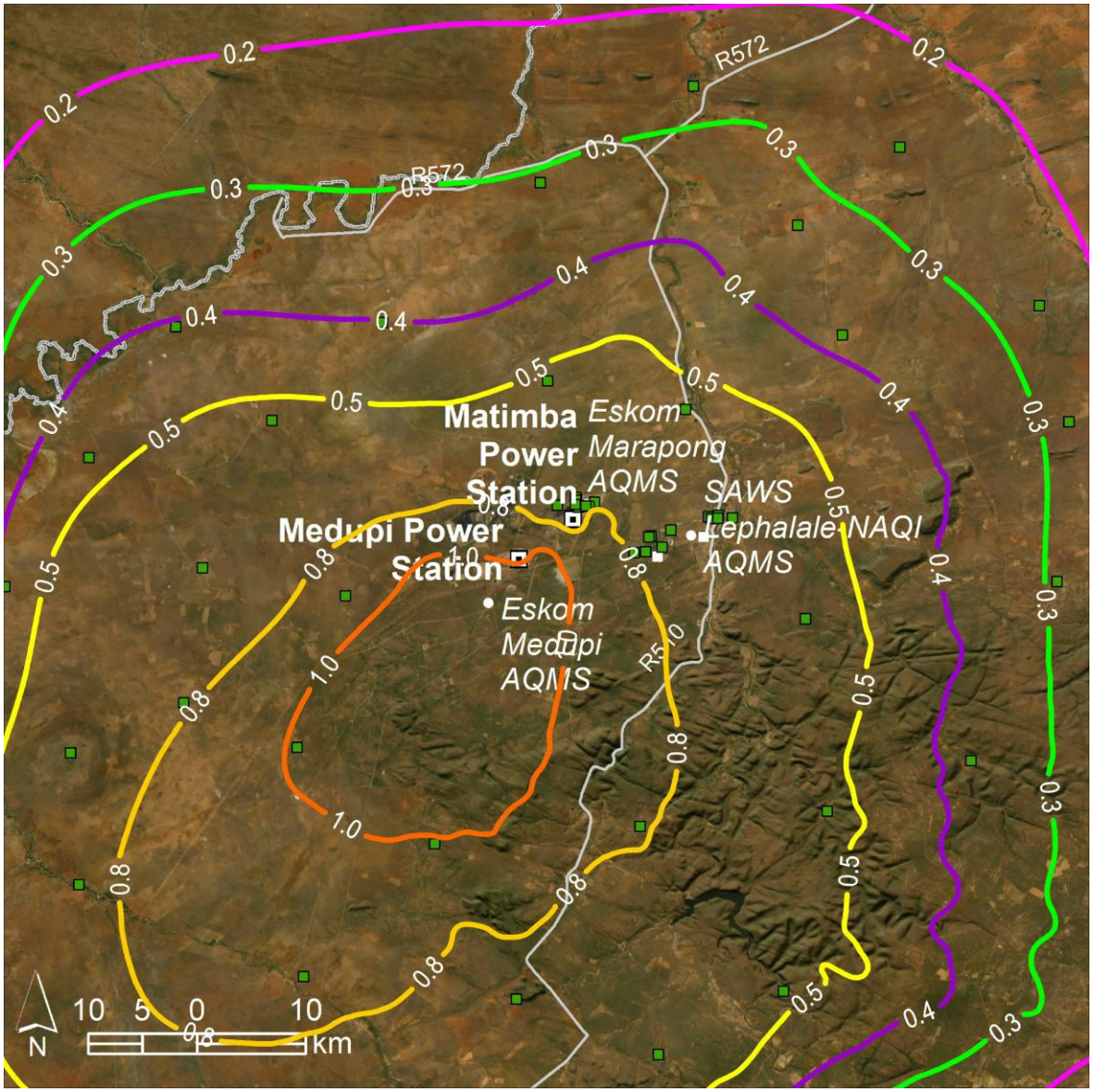


Figure 3-5: Predicted annual average PM_{10} concentrations in µg/m³ for Scenario B (2031) (NAAQS Limit is 40 µg/m³)

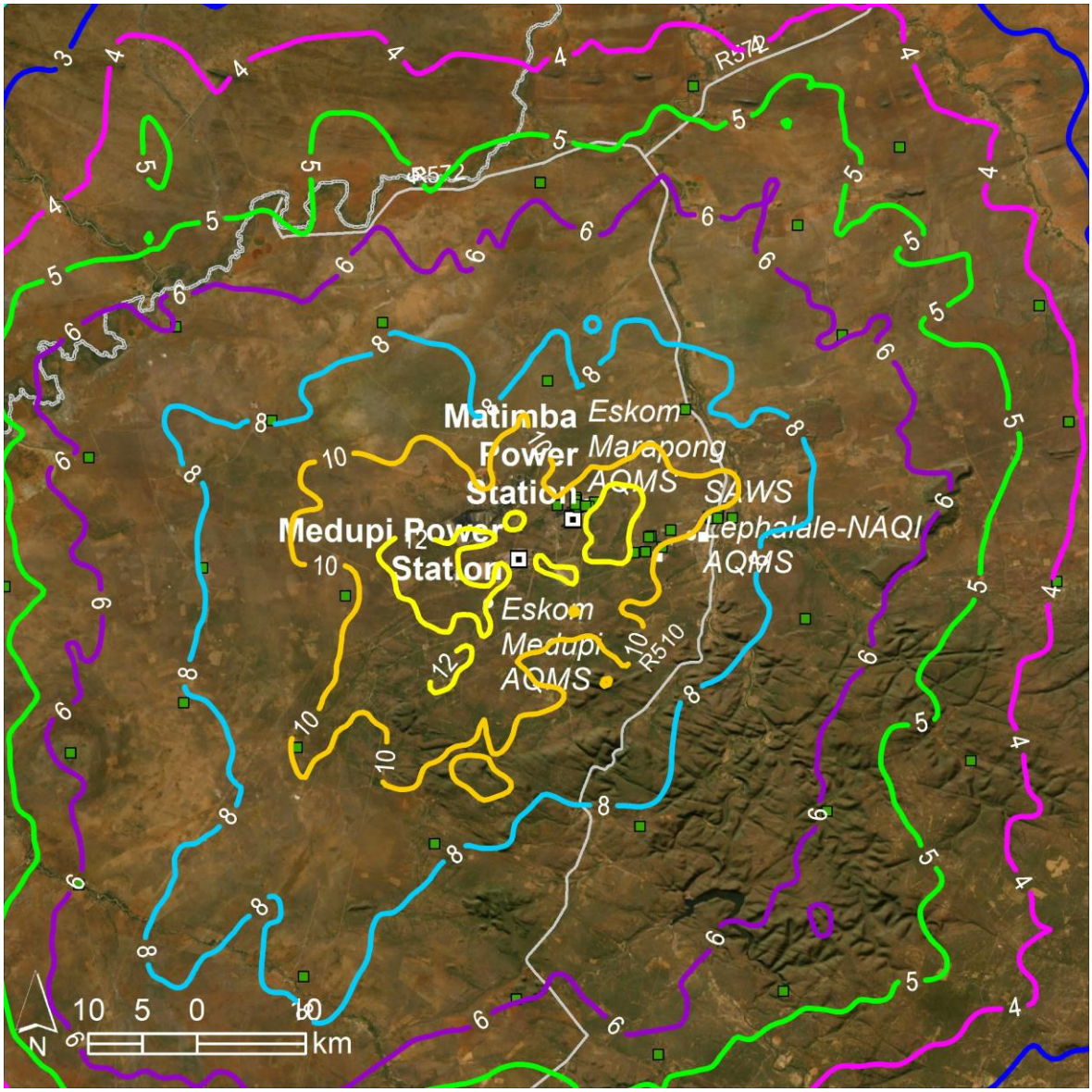


Figure 3-6: Predicted 99th percentile of the 24-hour PM_{10} concentrations in µg/m³ for Scenario B (2031) (NAAQS Limit is 75 µg/m³)

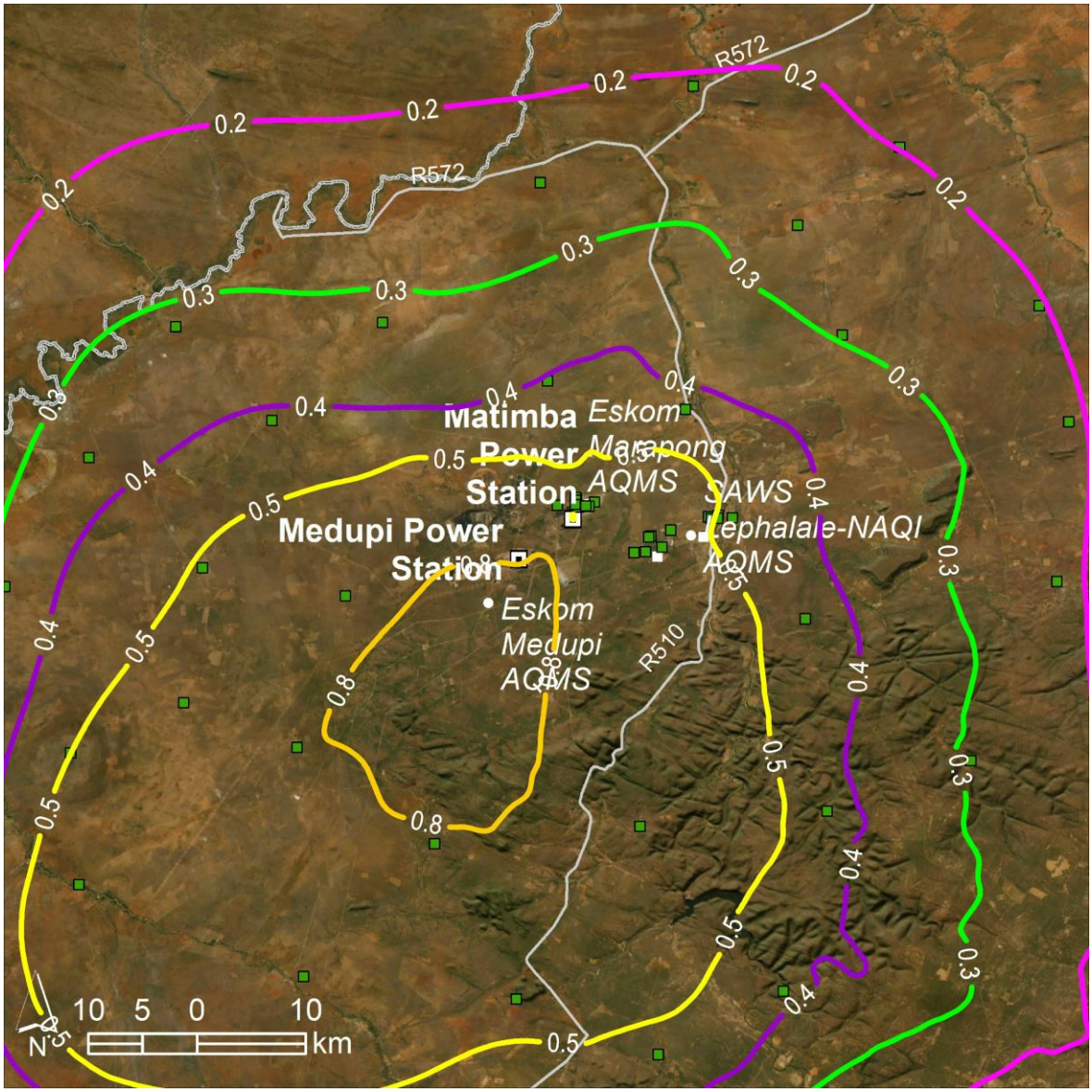


Figure 3-7: Predicted annual average PM_{10} concentrations in µg/m³ for Scenario C (2036) (NAAQS Limit is 40 µg/m³)

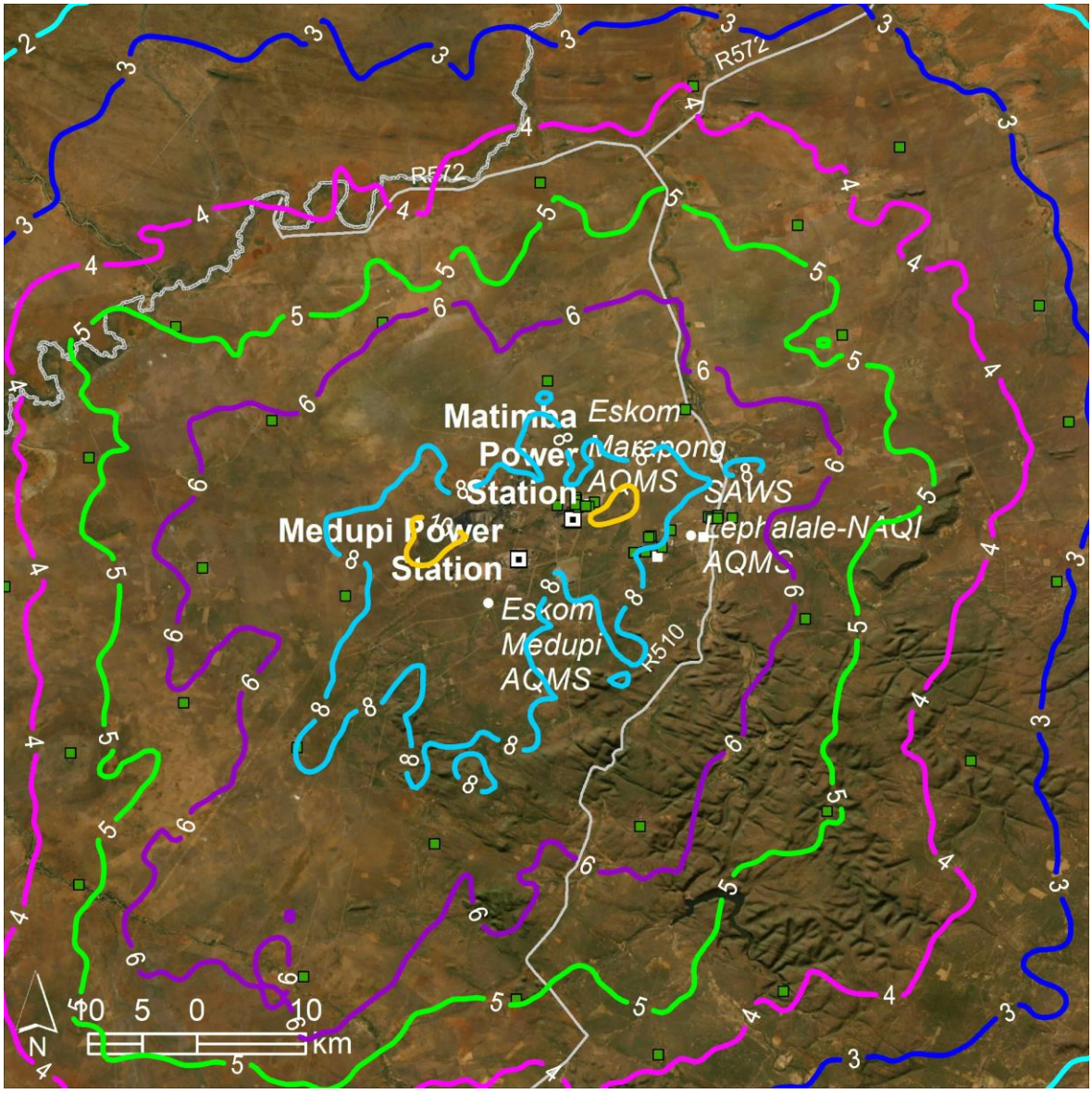


Figure 3-8: Predicted 99th percentile of the 24-hour PM_{10} concentrations in µg/m³ for Scenario C (2036) (NAAQS Limit is 75 µg/m³)

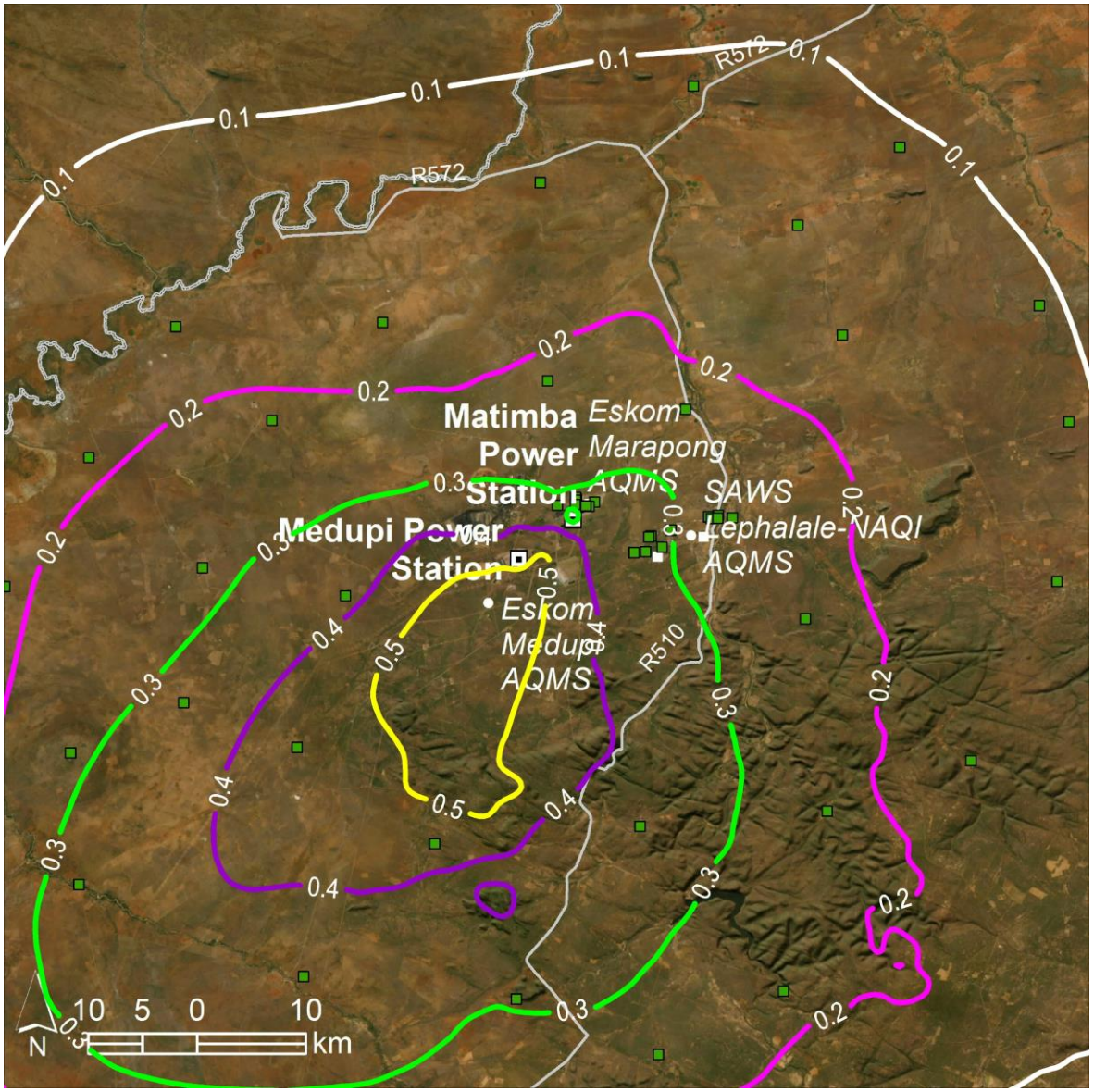


Figure 3-9: Predicted annual average PM_{10} concentrations in µg/m³ for Scenario D (MES) (NAAQS Limit is 40 µg/m³)

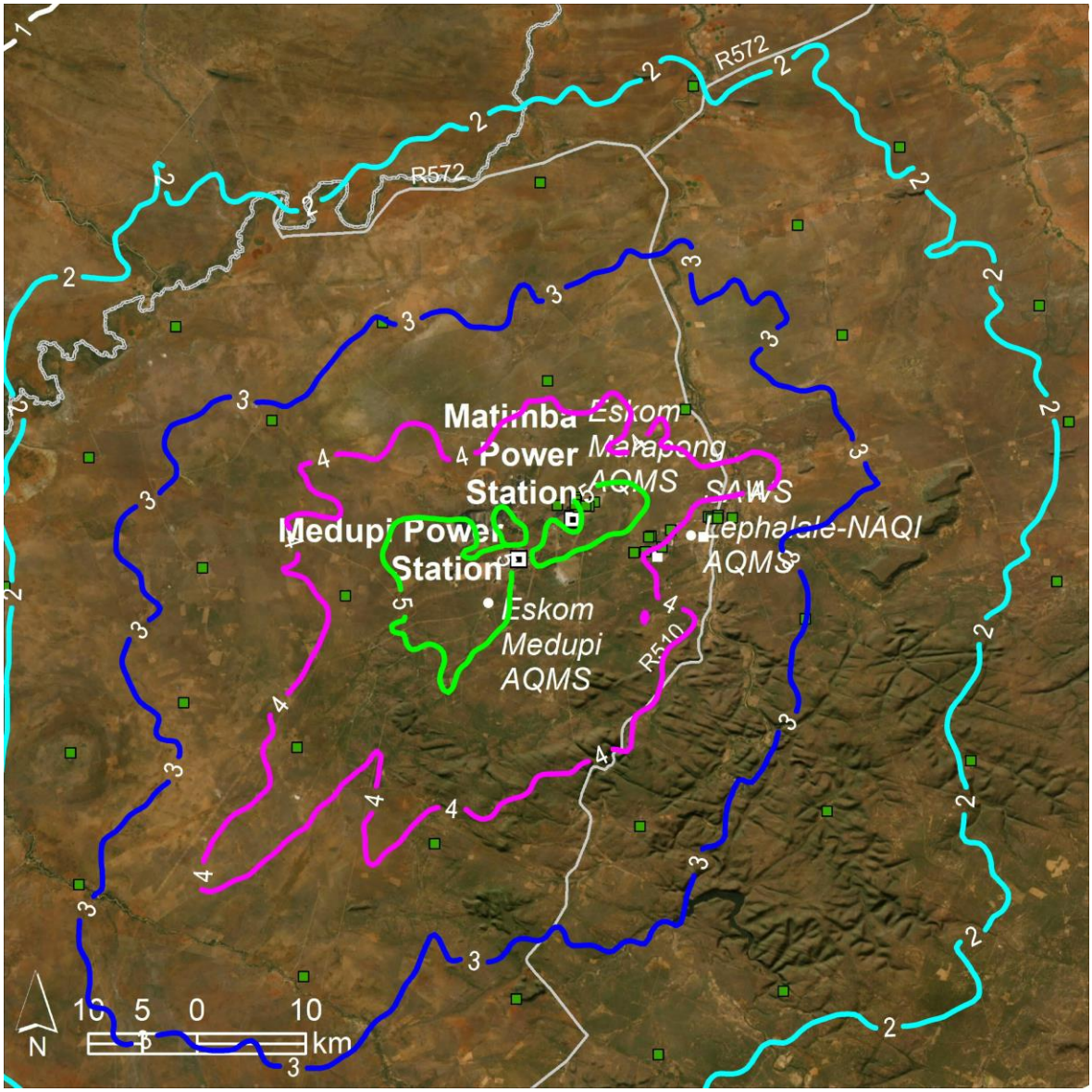


Figure 3-10: Predicted 99th percentile of the 24-hour PM_{10} concentrations in µg/m³ for Scenario D (MES) (NAAQS Limit is 75 µg/m³)

3.4.2 Particulates ($PM_{2.5}$)

In Scenario 1 (Current), the highest predicted annual concentrations occur approximately 20 km to the south-southwest of the Medupi Power Station. The highest predicted 24-hour concentrations occur up to 20 km around the Medupi and Matimba Power Stations.

The increase in SO_2, NO_X, PM_{10} and $PM_{2.5}$ emissions at Medupi and a reduction in stack exit velocity from Scenario 1 (Current) to Scenario A (2025) is seen by an increase in the predicted concentrations. In Scenario A (2025), the highest predicted annual concentrations occur approximately 20 km to the south-southwest of the Medupi Power Station. The highest predicted 24-hour concentrations occur approximately 20 km to the southwest of the Medupi Power Station, and approximately 10 km to the east of the Matimba Power Station.

Noticeable is the dramatic decrease in ambient concentrations on the isopleths for Scenario B (2031), where the biggest reductions are seen, due to the substantial decrease in SO_2, NO_X, PM_{10} and $PM_{2.5}$ emissions at Medupi and Matimba. In Scenario B (2031), the highest predicted annual concentrations occur approximately 20 km to the south-southwest of the Medupi Power Station. The highest predicted 24-hour concentrations occur up to 20 km around the Medupi and Matimba Power Stations.

The effect of the reduced formation of secondary particulates brought about by the substantial decrease in SO_2 emissions at Medupi are also noticeable on the isopleths for Scenario C (2036). In Scenario C (2036), the highest predicted annual concentrations occur approximately 20 km to the south-southwest of the Medupi Power Station. The highest predicted 24-hour concentrations occur approximately 10 km to the west of the Medupi Power Station, and approximately 5 km to the east of the Matimba Power Station.

Although $PM_{2.5}$ emissions remain the same for Scenario C (2036) and Scenario D (MES), the predicted $PM_{2.5}$ concentrations show a fairly large decrease on the isopleths for Scenario D (MES) (as discussed previously, this decrease is mainly attributed to the reduced formation of secondary particulates brought about by a substantial decrease in SO_2 emissions between these scenarios at Matimba). In Scenario D (MES), the highest predicted annual concentrations occur approximately 20 km to the south-southwest of the Medupi Power Station. The highest predicted 24-hour concentrations occur approximately 20 km to the southwest of the Medupi Power Station, and approximately 10 km to the west of the Matimba Power Station.

Isopleth maps of the predicted annual average and 99th percentile of the 24-hour $PM_{2.5}$ concentrations are presented in Figure 3-11 to Figure 3-20.

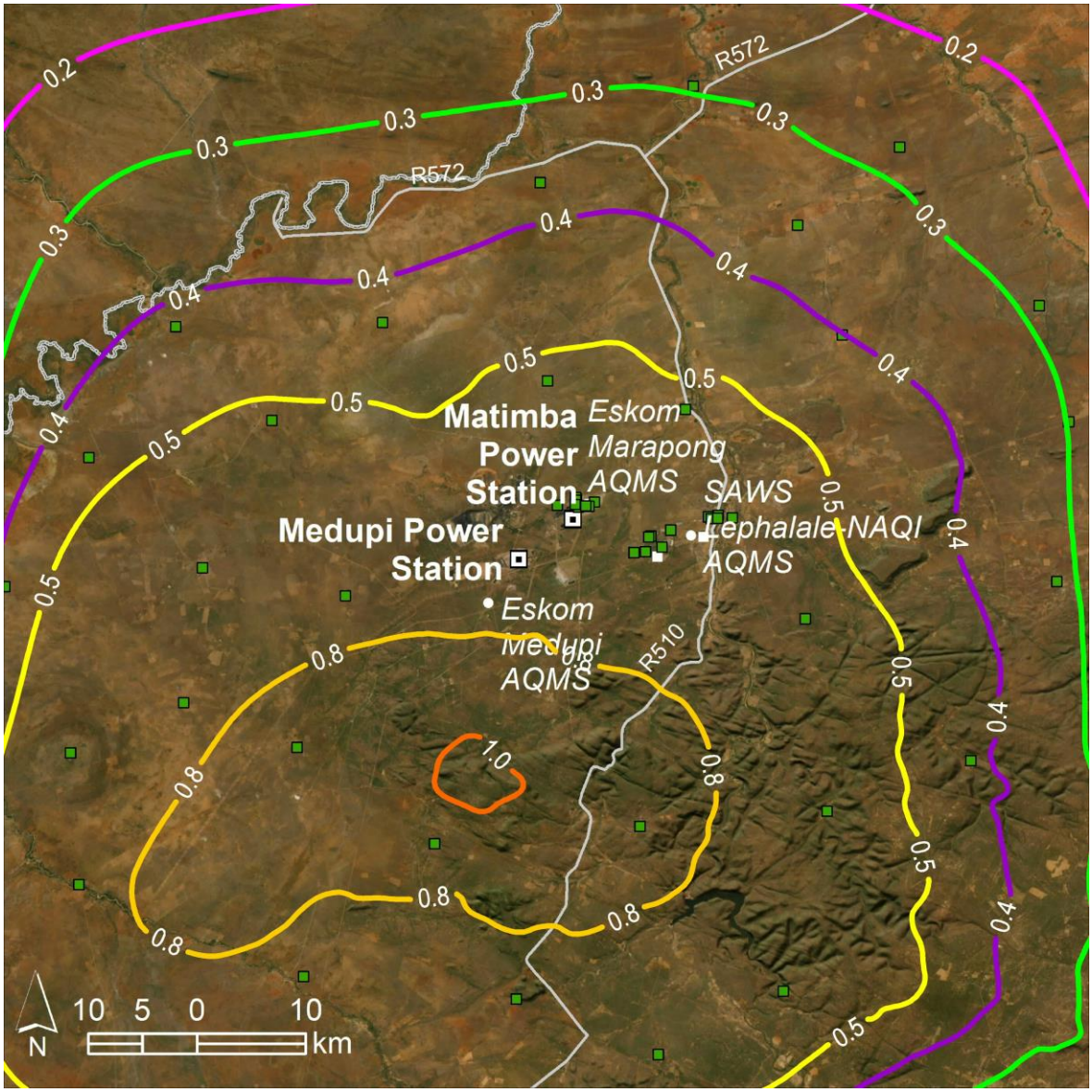


Figure 3-11: Predicted annual average $PM_{2.5}$ concentrations in µg/m³ for Scenario 1 (Current) (NAAQS Limit is 20 µg/m³)

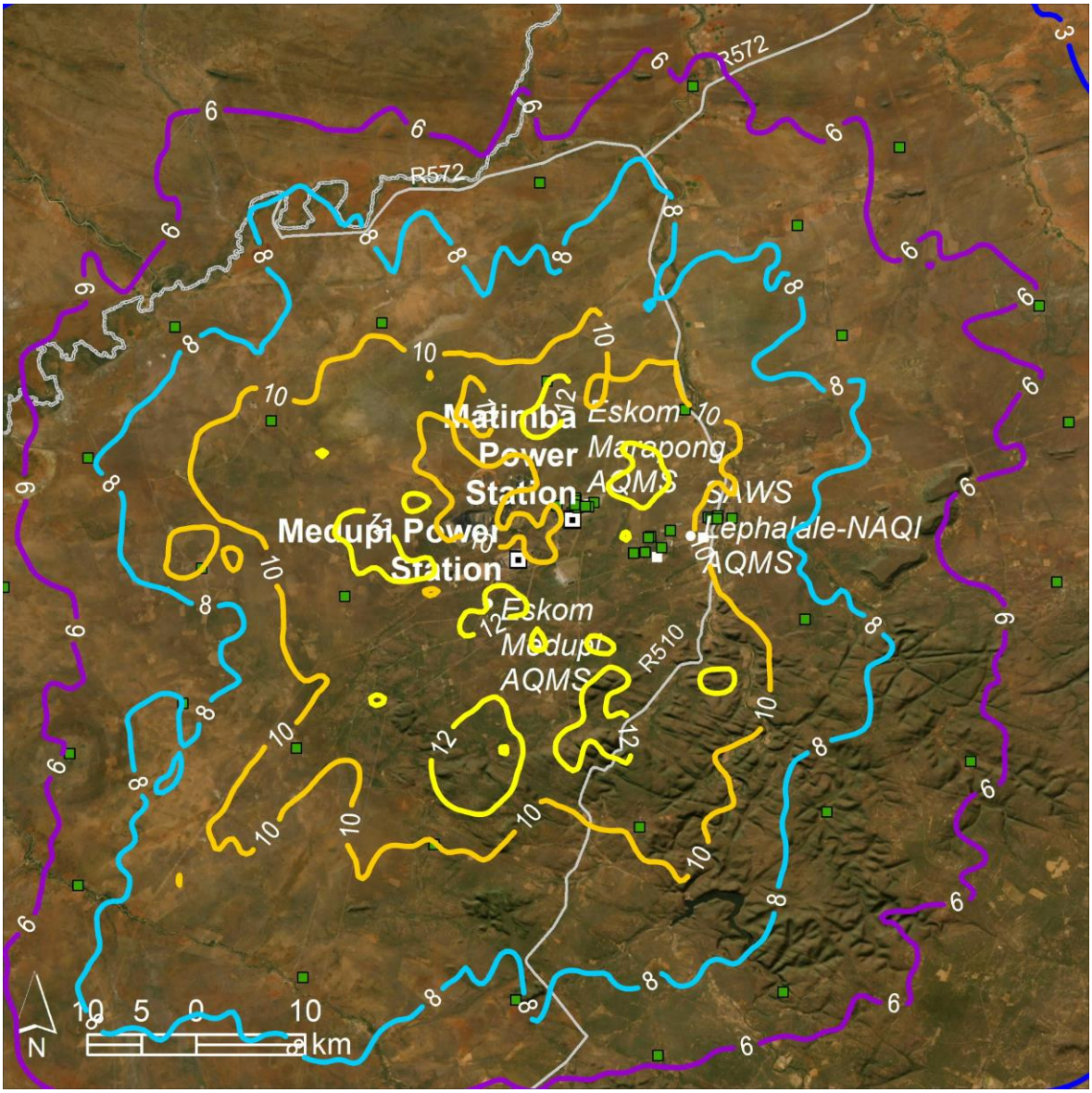


Figure 3-12: Predicted 99th percentile of the 24-hour $PM_{2.5}$ concentrations in µg/m³ for Scenario 1 (Current) (NAAQS Limit is 40 µg/m³)

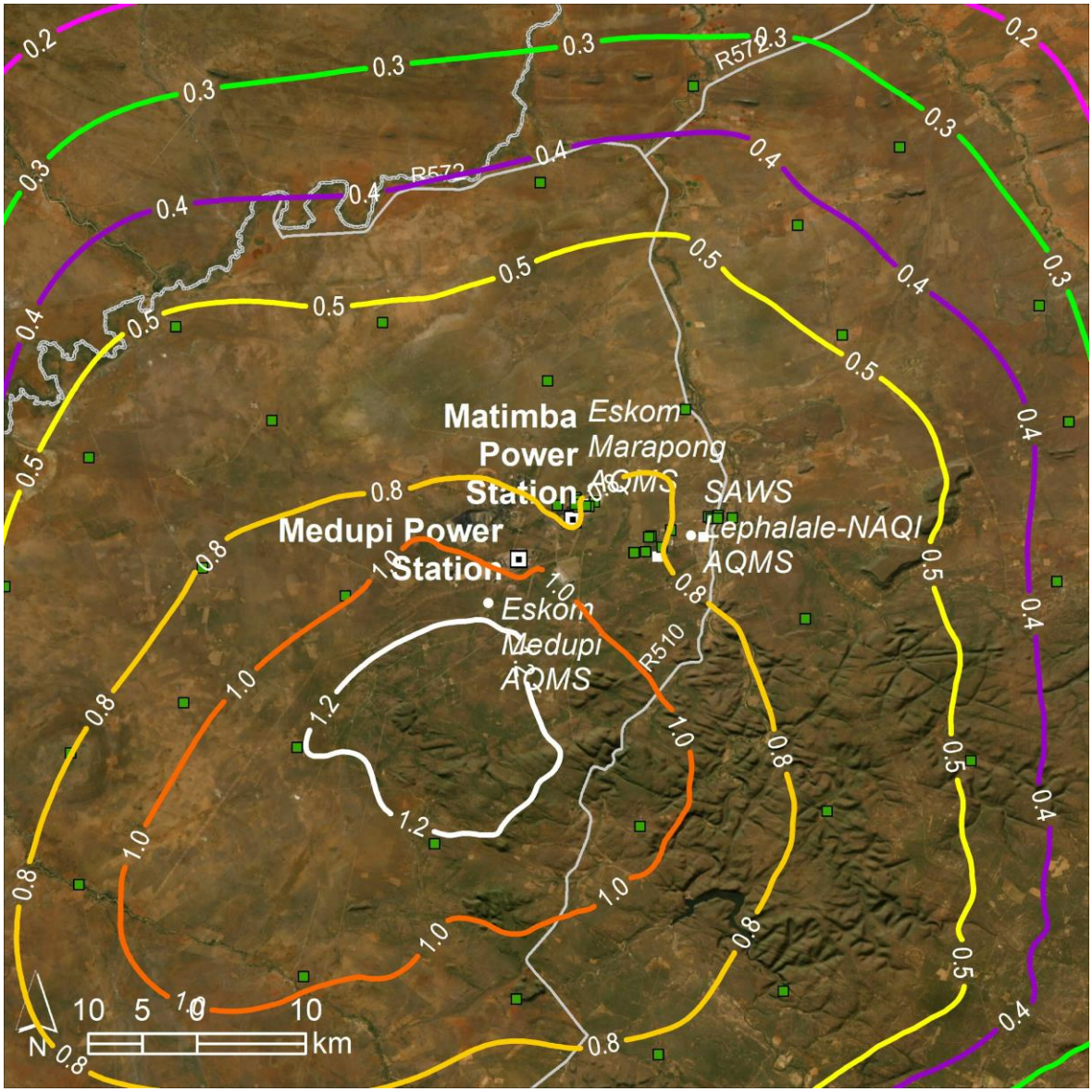


Figure 3-13: Predicted annual average $PM_{2.5}$ concentrations in µg/m³ for Scenario A (2025) (NAAQS Limit is 20 µg/m³)

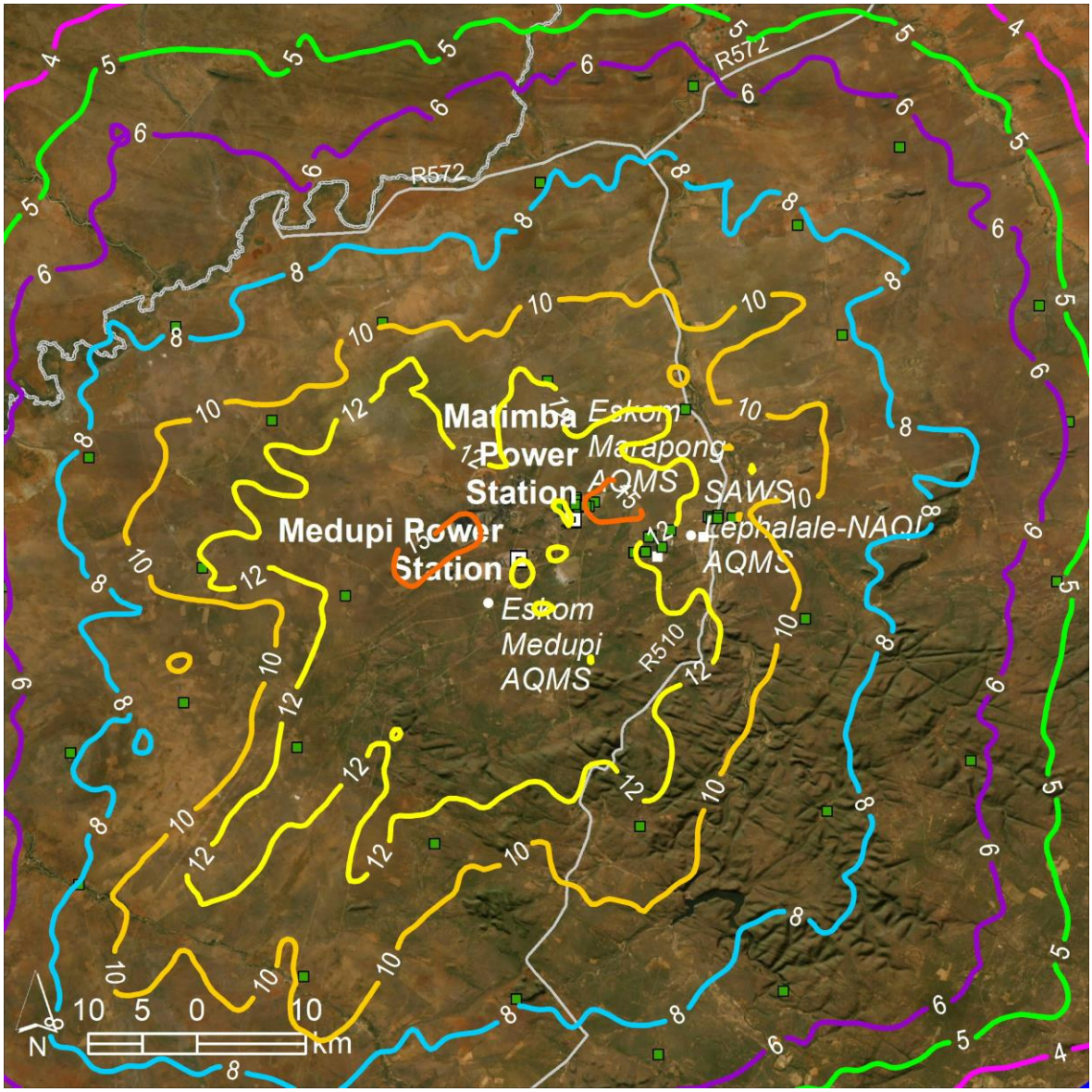


Figure 3-14: Predicted 99th percentile of the 24-hour $PM_{2.5}$ concentrations in µg/m³ for Scenario A (2025) (NAAQS Limit is 40 µg/m³)

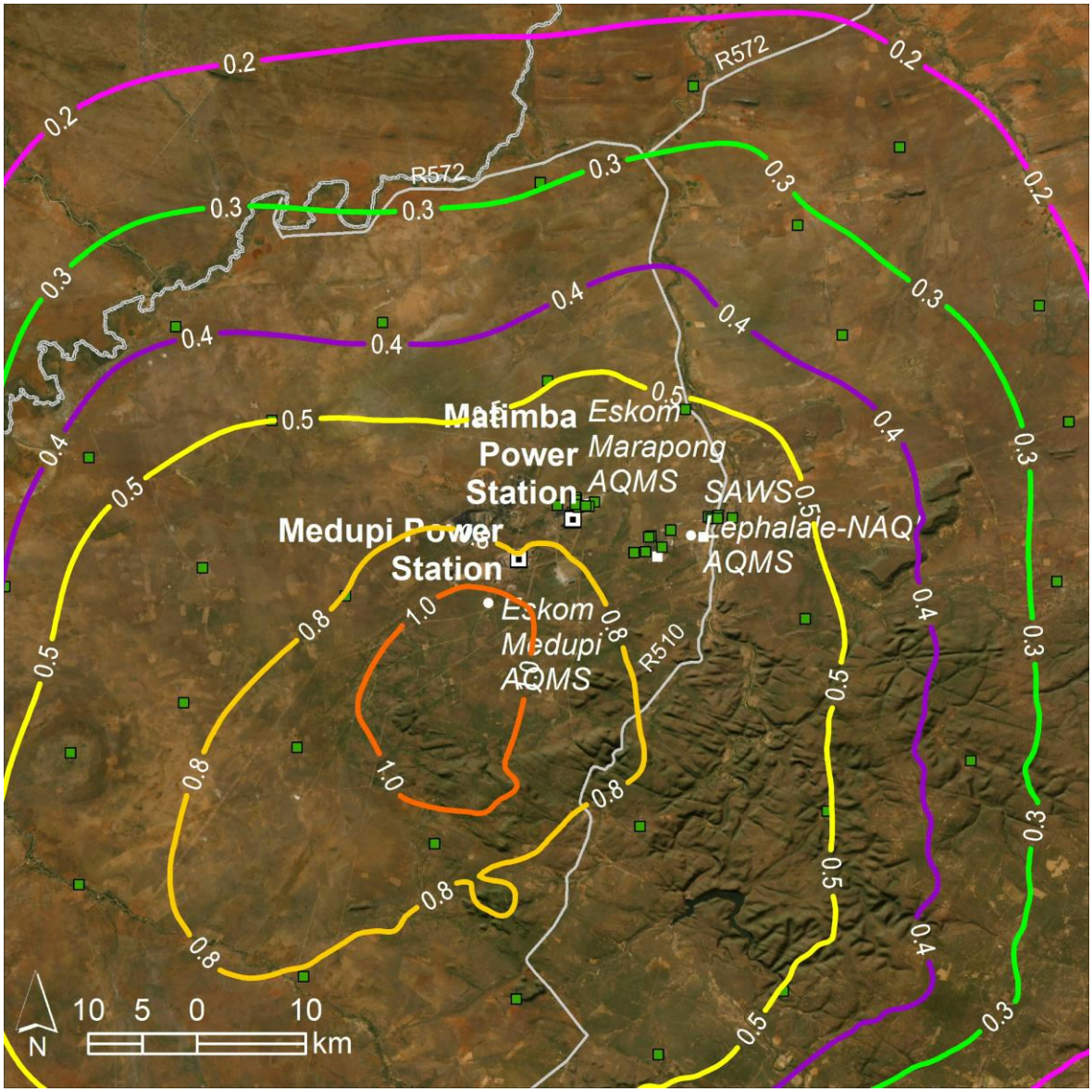


Figure 3-15: Predicted annual average $PM_{2.5}$ concentrations in µg/m³ for Scenario B (2031) (NAAQS Limit is 15 µg/m³)

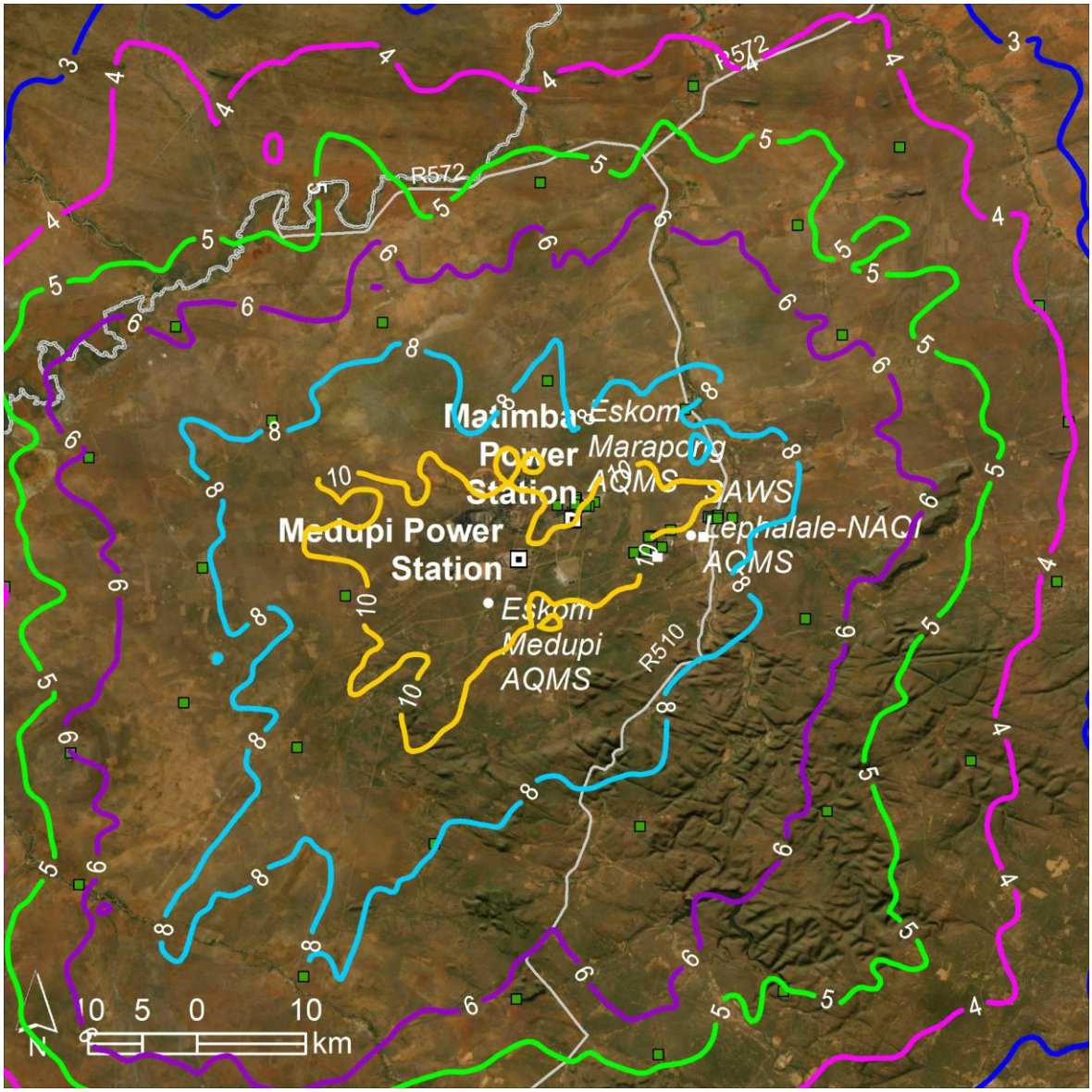


Figure 3-16: Predicted 99th percentile of the 24-hour $PM_{2.5}$ concentrations in µg/m³ for Scenario B (2031) (NAAQS Limit is 25 µg/m³)

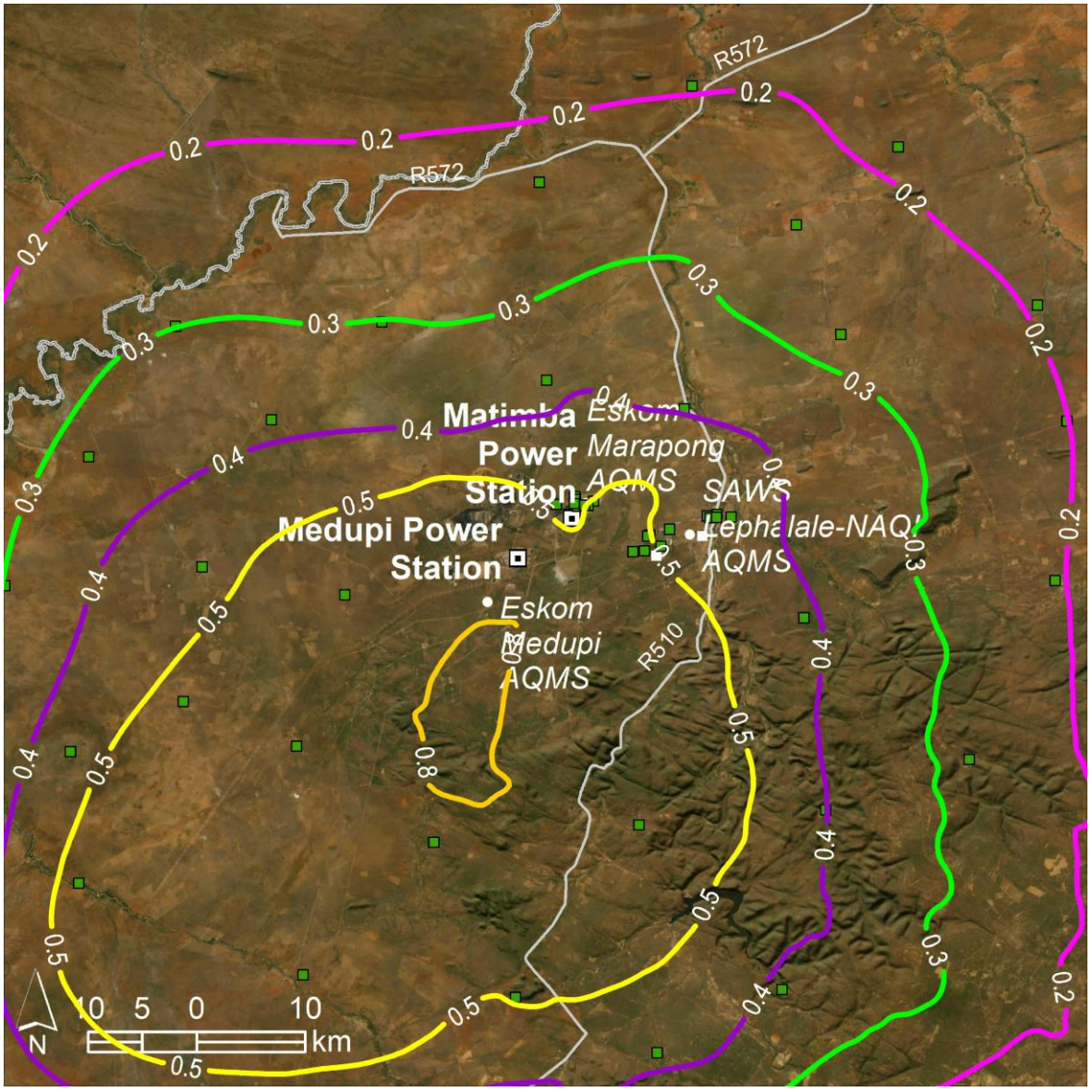


Figure 3-17: Predicted annual average $PM_{2.5}$ concentrations in µg/m³ for Scenario C (2036) (NAAQS Limit is 15 µg/m³)

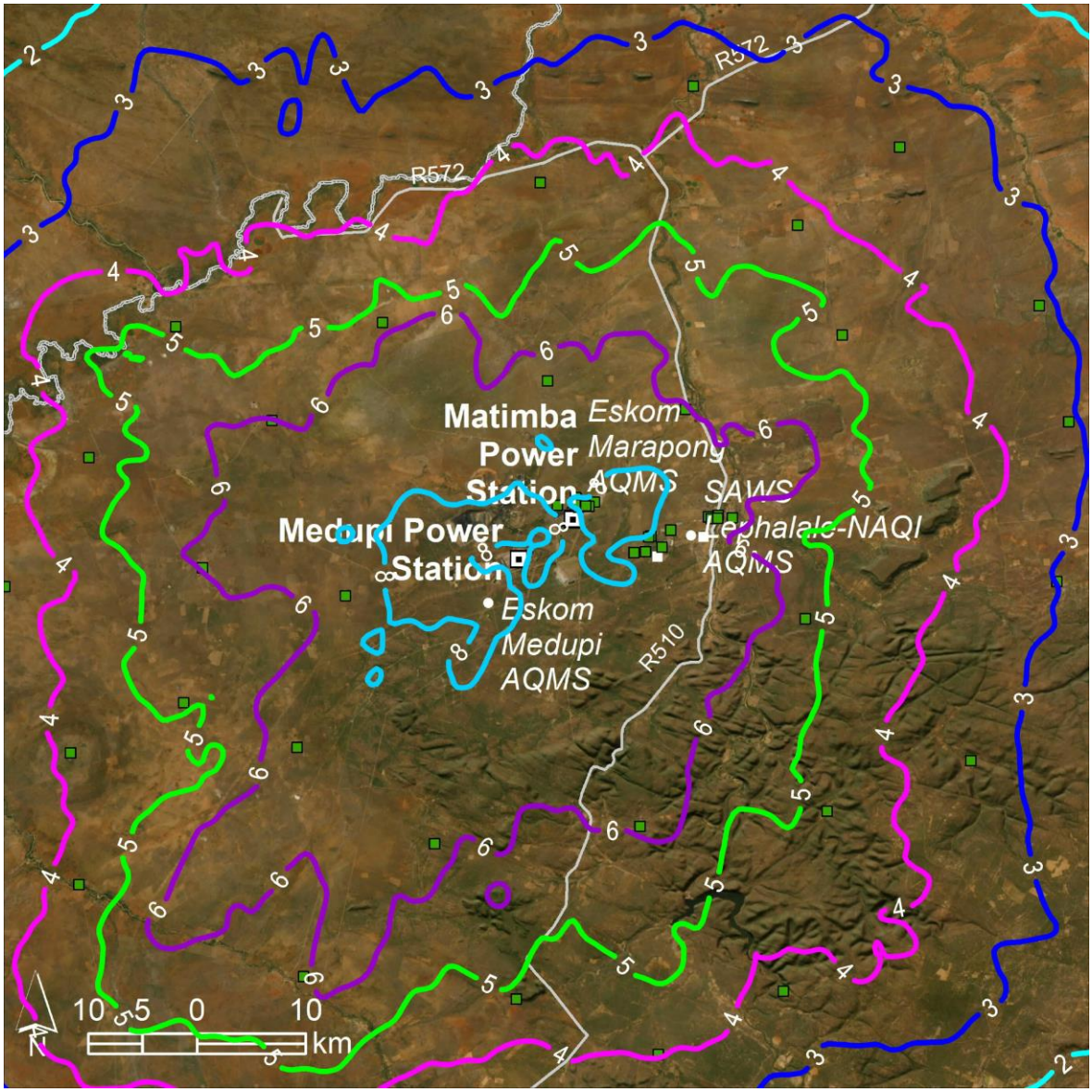


Figure 3-18: Predicted 99th percentile of the 24-hour $PM_{2.5}$ concentrations in µg/m³ for Scenario C (2036) (NAAQS Limit is 25 µg/m³)

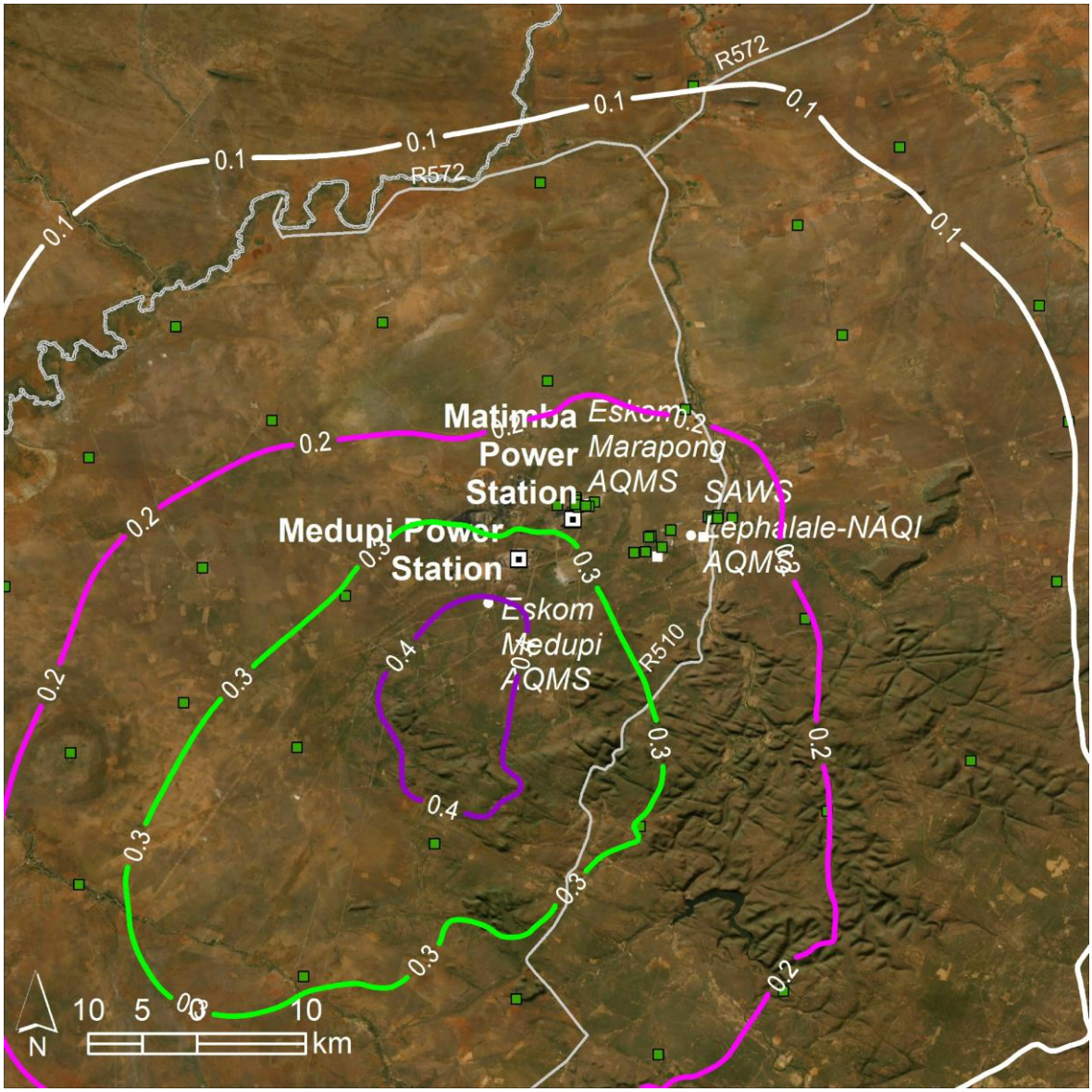


Figure 3-19: Predicted annual average $PM_{2.5}$ concentrations in µg/m³ for Scenario D (MES) (NAAQS Limit is 15 µg/m³)

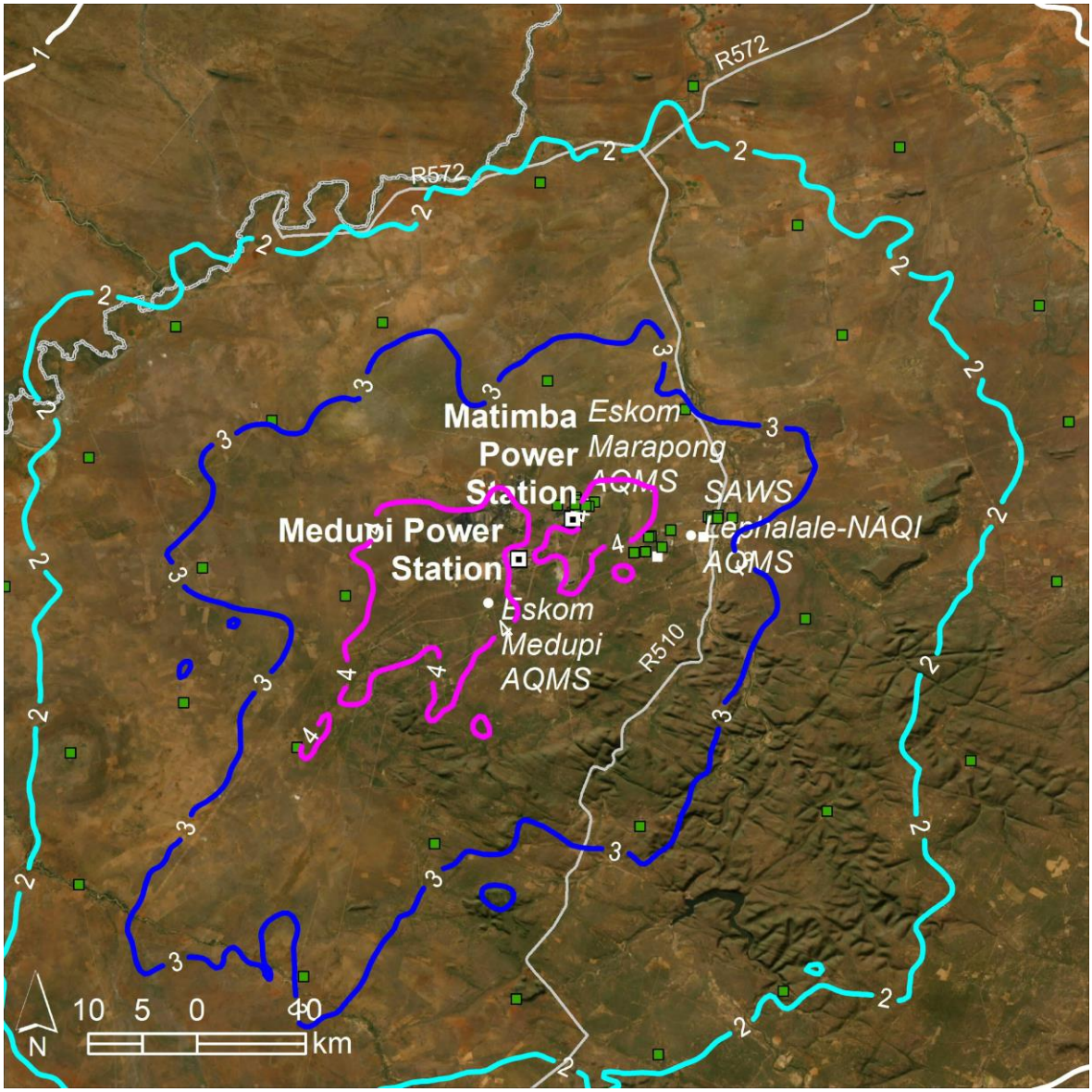


Figure 3-20: Predicted 99th percentile of the 24-hour $PM_{2.5}$ concentrations in µg/m³ for Scenario D (MES) (NAAQS Limit is 25 µg/m³)

4. SUMMARY AND CONCLUSION

In this Addendum to the AIR (uMoya-NILU, 2024), the focus is specifically on stack emissions for PM and the modelled results for PM_{10} and $PM_{2.5}$. In this Addendum, the cumulative effect of stack emissions from the 2 coal-fired power stations comprising the Waterberg power station fleet are assessed, i.e. Medupi and Matimba in the Waterberg-Bojanala Priority Area.

Dispersion modelling is used to demonstrate the effect of Eskom's emission reduction strategy by assessing 5 sequential emission scenarios. These are from Scenario 1 using actual emissions from 2021 to 2023, Scenario A using proposed 2025 emissions, Scenario B using proposed 2031 emissions and Scenario C using proposed 2036 emissions. Scenario D uses emissions that comply with the MES to demonstrate the relative effect of compliance.

Noteworthy findings from the modelling results may be summarised as follows:

i) Changes in the predicted annual average and 24-hour PM_{10} and $PM_{2.5}$ concentrations from one scenario to the next are strongly influenced by changes in PM_{10} and $PM_{2.5}$ emissions, the contribution from secondary particulate formation and stack exit velocity.

ii) In all scenarios, the maximum predicted annual average PM_{10} and $PM_{2.5}$ concentrations are well below the limit values of the respective NAAQS. In all scenarios, the maximum predicted 99th percentile of the 24-hour PM_{10} and $PM_{2.5}$ concentrations are in general, relatively low compared to the limit value of the NAAQS.

iii) The increase in SO_2, NO_X, PM_{10} and $PM_{2.5}$ emissions at Medupi and a reduction in stack exit velocity from Scenario 1 (Current) to Scenario A (2025) is seen by an increase in the predicted PM_{10} and $PM_{2.5}$ ambient concentrations. Although there is a decrease in PM_{10} and $PM_{2.5}$ emissions at Matimba, the reduced exit velocity in the stacks reduces the dispersion potential.

iv) The maximum predicted PM_{10} and $PM_{2.5}$ ambient concentrations decrease significantly from Scenario A (2025) to Scenario B (2031) due to the substantial decrease in SO_2, NO_X, PM_{10} and $PM_{2.5}$ emissions at Medupi and Matimba.

v) Although there is an increase in NO_X, PM_{10} and $PM_{2.5}$ emissions, and a reduction in exit velocity in the stacks at Medupi and Matimba from Scenario B (2031) to Scenario C (2036), the substantial decrease in SO_2 emissions at Medupi is responsible for a slight decrease in PM_{10} and $PM_{2.5}$ ambient concentrations, as this reduces the formation of secondary particulates.

vi) Although NO_X, PM_{10} and $PM_{2.5}$ emissions remain the same for Scenario C (2036) and Scenario D (MES), it is noted that the maximum predicted PM_{10} and $PM_{2.5}$ ambient concentrations show a fairly large decrease between the two scenarios. This decrease is mainly attributed to the reduced formation of secondary particulates brought about by a substantial decrease in SO_2 emissions at Matimba.

vii) At all AQMSs, the modelled PM_{10} and $PM_{2.5}$ concentrations are considerably lower than the monitored concentrations. This is to be expected since the AQMSs are exposed to all sources of PM_{10} and $PM_{2.5}$. The difference between the predicted concentrations and the measured concentrations provides an indication of the contribution of the power station stack emissions at the respective AQMSs.

viii) At all identified sensitive receptors, the predicted PM_{10} and $PM_{2.5}$ concentrations are low and well below the limit value of the respective NAAQS for all five scenarios. Noteworthy is the systematic decrease in predicted PM_{10} and $PM_{2.5}$ concentrations from 2025 to 2036 at all sensitive receptors.

5. REFERENCES

DEA (2014): Code of Practice for Air Dispersion Modelling in Air Quality Management in South Africa, Government Notice R.533, Government Gazette, no. 37804, 11 July 2014.

uMoya-NILU (2024): Atmospheric Impact Report in Support of the Application for Exemption from the Minimum Emission Standards for Eskom's Coal-Fired Power Stations in the Waterberg (A Cumulative Assessment), Report No.: uMN219-24, November 2024.

USEPA (1995): Compilation of air pollutant emission factors. Volume 1: Stationary point and area sources. AP-42 fifth edition January 1995. US EPA

6. FORMAL DECLARATIONS

A declaration of the accuracy of the information contained in this Atmospheric Impact Report is included here. A declaration of the independence of the practitioners in the uMoya-NILU consultancy team that compiled this AIR is also included.

DECLARATION OF ACCURACY OF INFORMATION – APPLICANT

Name of Enterprise: uMoya-NILU Consulting (Pty) Ltd

Declaration of accuracy of information provided:

Atmospheric Impact Report in terms of Section 30 of the Act

I, Mark Zunckel [duly authorised], declare that the information provided in this atmospheric impact report is, to the best of my knowledge, in all respects factually true and correct. I am aware that the supply of false or misleading information to an air quality office is a criminal office in terms of section 51(1)(g) of this Act.

Signed at Durban on this 9th day of December 2024.



SIGNATURE

Managing Director – uMoya-NILU Consulting
CAPACITY OF SIGNATORY

DECLARATION OF INDEPENDENCE – PRACTITIONER

Name of Practitioner: Mark Zunckel

Name of Registered Body: South African Council for Natural Scientific Professionals

Professional Registration Number: 400449/04

Declaration of independence and accuracy of information provided:

Atmospheric Impact Report in terms of Section 30 of the Act

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

Signed at Durban on this 9th day of December 2024.



SIGNATURE

Managing Director – uMoya-NILU Consulting
CAPACITY OF SIGNATORY

ANNEXURE 1: WATERBERG SENSITIVE RECEPTORS

Area	Sensitive Receptors	Latitude	Longitude
Marapong	Phegelelo Senior Secondary	-23.651888°	27.618334°
	Contractors Village	-23.657320°	27.601031°
	Ditheku Primary School	-23.651003°	27.617502°
	Ditheko pramary School	-23.654704°	27.634336°
	Marapong Training Centre	-23.658318°	27.618626°
	Marapong Clinic	-23.658287°	27.629470°
	Tielelo Secondary School	-23.653177°	27.617447°
	Grootegeluk Medical Centre - Community center	-23.658717°	27.619834°
Lephalale	Lephalale College	-23.682740°	27.685668°
	Nelsonskop Primary School	-23.657586°	27.626724°
	Hansie En Grietjie Pre-Primary School	-23.683331°	27.683339°
	Sedibeng Special School for the Deaf and Disabilities	-23.691657°	27.695709°
	Kings College	-23.696561°	27.670262°
	Bosveld Primary School	-23.695608°	27.680724°
	Lephalale Medical Hospital	-23.656805°	27.617153°
	Ellisras Hospital	-23.677758°	27.703310°
	Laerskool Ellisras Primary School	-23.665398°	27.745938°
	Hoerskool Ellisras Secondary School	-23.666541°	27.737342°
	Marlothii Learning Academy	-23.667777°	27.739952°
	Hardekool Akademie vir C.V.O	-23.667215°	27.758752°
	Lephalale Clinic	-23.667615°	27.745728°
Ons Hoop	Ons Hoop	-23.577123°	27.716123°
Woudend	Woudend	-23.308433°	27.721479°
Ramabara's	Ramabara's	-23.750848°	27.825234°
Shongoane	Ga-Shongoane	-23.585319°	28.061576°
Bulge River	Bulge River	-24.113815°	27.694438°
	Kaingo Mountain Lodge	-24.060357°	27.807197°
	Community	-24.067953°	27.565793°
Kiesel	Kiesel	-23.974023°	27.169620°
	Kremetartpan	-23.859326°	27.366887°
	Mbala Private Camp	-23.939199°	27.491076°
Steenbokpan	Steenbokpan	-23.733401°	27.409802°
	Receptor	-23.587405°	27.343032°
Sandbult	Sandbult	-23.710158°	27.280718°
Hardekraaltjie	Hardekraaltjie	-23.509997°	27.256399°
	Receptor	-23.554188°	27.591804°
	Receptor	-23.506063°	27.442803°
	Receptor	-23.388962°	27.584125°
	Receptor	-23.423577°	27.816176°
	Receptor	-23.514728°	27.856760°
Ditaung	Ditaung	-23.489060°	28.034173°
Letlora	Letlora	-23.358262°	27.907715°
	Receptor	-23.822555°	27.264099°
	Glenover	-23.864360°	27.162054°

Area	Sensitive Receptors	Latitude	Longitude
	Oxford Safaris	-23.726164°	27.102742°
	Receptor	-23.618685°	27.178320°
Tholo Bush Estate	Tholo Bush Estate	-23.910668°	27.845646°
	Receptor	-23.924018°	27.676686°
	Receptor	-23.867661°	27.975574°
Thabazimbi	Cheetah Safaris	-24.049921°	27.373278°
	Rhinoland Safaris	-23.718286°	28.051922°

ANNEXURE 2: PREDICTED CONCENTRATIONS AT SENSIIVE RECEPTORS

Predicted concentrations in µg/m³ at the sensitive receptors for Scenario 1 (Current), together with the limit value of the NAAQS

Scenario 1 (Current)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**40**	**20**
Phegelelo Senior Secondary	12.6	0.6	11.9	0.6
Contractors Village	10.5	0.6	9.9	0.6
Ditheku Primary School	12.5	0.6	11.8	0.6
Ditheko Primary School	12.6	0.7	11.8	0.6
Marapong Training Centre	11.7	0.6	10.9	0.6
Marapong Clinic	12.4	0.7	11.6	0.6
Tielelo Secondary School	12.1	0.6	11.4	0.6
Grootegeluk Medical Centre - Community Center	11.7	0.7	10.9	0.6
Lephalale College	11.4	0.7	10.8	0.6
Nelsonskop Primary School	12.1	0.7	11.3	0.6
Hansie en Grietjie Pre-Primary School	11.5	0.7	10.9	0.6
Sedibeng Special School for the Deaf and Disabilities	12.4	0.7	11.9	0.6
Kings College	11.0	0.7	10.4	0.7
Bosveld Primary School	11.6	0.7	11.0	0.7
Lephalale Medical Hospital	11.6	0.6	10.8	0.6
Ellisras Hospital	10.9	0.7	10.4	0.6
Laerskool Ellisras Primary School	9.9	0.6	9.4	0.6
Hoerskool Ellisras Secondary School	10.2	0.6	9.8	0.6
Marlothii Learning Academy	10.1	0.6	9.6	0.6
Hardekool Akademie vir C.V.O	9.9	0.6	9.4	0.6
Lephalale Clinic	9.9	0.6	9.4	0.6
Ons Hoop	10.7	0.6	10.2	0.5
Woudend	6.6	0.3	6.3	0.3
Ramabara's	9.1	0.6	8.6	0.6
Ga-Shongoane	5.3	0.3	5.1	0.3
Bulge River	7.1	0.7	6.7	0.6
Kaingo Mountain Lodge	7.4	0.6	7.1	0.6
Community	8.1	0.8	7.7	0.7
Kiesel	7.6	0.8	7.2	0.7
Kremetartpan	11.2	1.0	10.5	0.9
Mbala Private Camp	10.6	0.9	10.0	0.9
Steenbokpan	12.2	0.8	11.6	0.7
Receptor	11.1	0.5	10.7	0.5
Sandbult	10.4	0.7	10.0	0.6
Hardekraaltjie	7.4	0.4	7.1	0.4
Receptor	12.0	0.6	11.5	0.5
Receptor	10.2	0.4	9.8	0.4
Receptor	7.2	0.4	6.9	0.4
Receptor	7.6	0.4	7.3	0.4
Receptor	7.2	0.4	6.9	0.4
Ditaung	5.7	0.3	5.5	0.3
Letlora	5.6	0.3	5.4	0.3
Receptor	8.3	0.8	7.9	0.7
Glenover	6.5	0.7	6.1	0.6
Oxford Safaris	5.1	0.5	4.8	0.4
Receptor	8.0	0.5	7.7	0.5
Tholo Bush Estate	7.7	0.6	7.3	0.6

Scenario 1 (Current)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**40**	**20**
Receptor	11.1	0.9	10.6	0.9
Receptor	6.5	0.4	6.2	0.4
Cheetah Safaris	9.3	0.8	8.9	0.8
Rhinoland Safaris	5.0	0.3	4.7	0.3

Predicted concentrations in µg/m³ at the sensitive receptors for Scenario A (2025), together with the limit value of the NAAQS

Scenario A (2025)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**40**	**20**
Phegelelo Senior Secondary	13.9	0.9	12.7	0.8
Contractors Village	12.3	0.8	11.3	0.8
Ditheku Primary School	14.1	0.9	13.0	0.8
Ditheko Primary School	17.9	0.9	16.8	0.8
Marapong Training Centre	15.6	0.9	14.3	0.8
Marapong Clinic	17.3	0.9	16.1	0.8
Tielelo Secondary School	14.0	0.9	12.8	0.8
Grootegeluk Medical Centre - Community Center	15.5	0.9	14.3	0.8
Lephalale College	12.9	0.9	12.3	0.8
Nelsonskop Primary School	17.1	0.9	15.9	0.8
Hansie en Grietjie Pre-Primary School	12.8	0.9	12.2	0.8
Sedibeng Special School for the Deaf and Disabilities	11.6	0.9	11.0	0.8
Kings College	12.6	0.9	12.0	0.8
Bosveld Primary School	11.7	0.9	11.1	0.8
Lephalale Medical Hospital	13.9	0.9	12.8	0.8
Ellisras Hospital	12.3	0.9	11.7	0.8
Laerskool Ellisras Primary School	11.1	0.8	10.5	0.8
Hoerskool Ellisras Secondary School	11.6	0.8	11.0	0.8
Marlothii Learning Academy	11.4	0.8	10.8	0.8
Hardekool Akademie vir C.V.O	10.5	0.8	9.9	0.7
Lephalale Clinic	11.0	0.8	10.5	0.8
Ons Hoop	11.4	0.7	10.8	0.7
Woudend	6.7	0.4	6.4	0.4
Ramabara's	10.0	0.7	9.5	0.7
Ga-Shongoane	6.2	0.4	6.0	0.4
Bulge River	7.4	0.8	7.1	0.8
Kaingo Mountain Lodge	7.0	0.7	6.8	0.7
Community	8.6	0.9	8.2	0.9
Kiesel	8.8	1.0	8.3	0.9
Kremetartpan	13.6	1.3	12.9	1.2
Mbala Private Camp	11.6	1.3	11.0	1.2
Steenbokpan	13.9	1.1	13.2	1.0
Receptor	10.8	0.7	10.4	0.6
Sandbult	12.5	0.9	11.9	0.8
Hardekraaltjie	8.0	0.5	7.7	0.5
Receptor	12.9	0.7	12.2	0.6
Receptor	10.5	0.5	10.1	0.5
Receptor	7.7	0.4	7.4	0.4
Receptor	8.7	0.4	8.4	0.4
Receptor	8.7	0.5	8.3	0.5
Ditaung	5.7	0.4	5.4	0.3
Letlora	6.6	0.3	6.4	0.3
Receptor	9.6	1.0	9.1	0.9
Glenover	8.0	0.8	7.6	0.8
Oxford Safaris	6.2	0.6	5.9	0.5
Receptor	8.8	0.6	8.5	0.6
Tholo Bush Estate	9.0	0.8	8.7	0.7

Scenario A (2025)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**40**	**20**
Receptor	11.9	1.1	11.4	1.0
Receptor	6.4	0.5	6.2	0.5
Cheetah Safaris	10.5	1.1	10.1	1.0
Rhinoland Safaris	5.4	0.4	5.2	0.4

Predicted concentrations in µg/m³ at the sensitive receptors for Scenario B (2031), together with the limit value of the NAAQS

Scenario B (2031)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**25**	**15**
Phegelelo Senior Secondary	10.8	0.7	9.7	0.6
Contractors Village	10.4	0.7	9.4	0.7
Ditheku Primary School	10.7	0.7	9.6	0.6
Ditheko Primary School	11.4	0.8	10.3	0.7
Marapong Training Centre	11.3	0.7	10.0	0.7
Marapong Clinic	11.5	0.8	10.3	0.7
Tielelo Secondary School	10.9	0.7	9.8	0.7
Grootegeluk Medical Centre - Community Center	11.6	0.8	10.3	0.7
Lephalale College	10.7	0.8	10.1	0.7
Nelsonskop Primary School	11.4	0.8	10.2	0.7
Hansie en Grietjie Pre-Primary School	10.7	0.8	10.0	0.7
Sedibeng Special School for the Deaf and Disabilities	9.7	0.7	9.1	0.7
Kings College	11.6	0.8	10.9	0.7
Bosveld Primary School	10.7	0.8	10.1	0.7
Lephalale Medical Hospital	11.1	0.7	9.8	0.7
Ellisras Hospital	10.9	0.7	10.4	0.7
Laerskool Ellisras Primary School	9.4	0.7	8.8	0.6
Hoerskool Ellisras Secondary School	9.7	0.7	9.2	0.6
Marlothii Learning Academy	9.6	0.7	9.1	0.6
Hardekool Akademie vir C.V.O	9.5	0.6	9.0	0.6
Lephalale Clinic	9.4	0.7	8.8	0.6
Ons Hoop	8.7	0.6	8.2	0.5
Woudend	4.7	0.3	4.4	0.3
Ramabara's	7.2	0.6	6.8	0.5
Ga-Shongoane	4.3	0.3	4.0	0.3
Bulge River	5.6	0.6	5.3	0.6
Kaingo Mountain Lodge	5.1	0.5	4.9	0.5
Community	6.1	0.7	5.8	0.7
Kiesel	6.1	0.8	5.7	0.7
Kremetartpan	10.1	1.0	9.5	0.9
Mbala Private Camp	8.5	1.0	8.1	0.9
Steenbokpan	9.5	0.9	8.9	0.8
Receptor	7.7	0.5	7.3	0.5
Sandbult	8.1	0.7	7.7	0.6
Hardekraaltjie	6.0	0.4	5.8	0.4
Receptor	9.4	0.5	8.8	0.5
Receptor	7.5	0.4	7.2	0.4
Receptor	5.8	0.3	5.5	0.3
Receptor	5.4	0.3	5.1	0.3
Receptor	5.8	0.4	5.5	0.4
Ditaung	4.2	0.3	4.0	0.2
Letlora	4.6	0.3	4.4	0.2
Receptor	7.9	0.8	7.4	0.7
Glenover	6.4	0.6	6.0	0.6
Oxford Safaris	4.3	0.4	4.0	0.4
Receptor	6.2	0.5	5.9	0.4
Tholo Bush Estate	5.9	0.5	5.6	0.5

Scenario B (2031)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**25**	**15**
Receptor	7.8	0.8	7.4	0.8
Receptor	4.5	0.4	4.3	0.3
Cheetah Safaris	8.3	0.9	7.9	0.8
Rhinoland Safaris	4.0	0.3	3.8	0.3

Predicted concentrations in µg/m³ at the sensitive receptors for Scenario C (2036), together with the limit value of the NAAQS

Scenario C (2036)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**25**	**15**
Phegelelo Senior Secondary	9.4	0.5	8.2	0.5
Contractors Village	8.6	0.5	7.6	0.5
Ditheku Primary School	9.1	0.5	8.0	0.5
Ditheko Primary School	9.1	0.6	8.1	0.5
Marapong Training Centre	9.5	0.6	8.3	0.5
Marapong Clinic	9.8	0.6	8.6	0.5
Tielelo Secondary School	9.4	0.5	8.2	0.5
Grootegeluk Medical Centre - Community Center	9.2	0.6	8.1	0.5
Lephalale College	8.6	0.6	8.0	0.5
Nelsonskop Primary School	9.8	0.6	8.6	0.5
Hansie en Grietjie Pre-Primary School	8.6	0.6	8.0	0.5
Sedibeng Special School for the Deaf and Disabilities	8.0	0.6	7.5	0.5
Kings College	8.0	0.6	7.4	0.5
Bosveld Primary School	7.9	0.6	7.4	0.5
Lephalale Medical Hospital	9.7	0.6	8.4	0.5
Ellisras Hospital	7.8	0.5	7.2	0.5
Laerskool Ellisras Primary School	7.0	0.5	6.5	0.5
Hoerskool Ellisras Secondary School	7.3	0.5	6.8	0.5
Marlothii Learning Academy	7.0	0.5	6.5	0.5
Hardekool Akademie vir C.V.O	7.2	0.5	6.7	0.4
Lephalale Clinic	6.9	0.5	6.4	0.5
Ons Hoop	6.7	0.4	6.2	0.4
Woudend	3.9	0.2	3.7	0.2
Ramabara's	5.6	0.4	5.2	0.4
Ga-Shongoane	3.4	0.2	3.2	0.2
Bulge River	4.4	0.5	4.1	0.4
Kaingo Mountain Lodge	4.1	0.4	3.8	0.4
Community	5.2	0.6	4.8	0.5
Kiesel	4.7	0.6	4.3	0.5
Kremetartpan	7.9	0.8	7.3	0.7
Mbala Private Camp	6.9	0.8	6.4	0.7
Steenbokpan	7.5	0.7	6.9	0.6
Receptor	6.4	0.4	6.0	0.4
Sandbult	6.7	0.5	6.3	0.5
Hardekraaltjie	4.7	0.3	4.5	0.3
Receptor	7.4	0.4	6.9	0.4
Receptor	5.9	0.3	5.5	0.3
Receptor	4.5	0.2	4.3	0.2
Receptor	4.8	0.3	4.5	0.2
Receptor	5.0	0.3	4.7	0.3
Ditaung	3.4	0.2	3.2	0.2
Letlora	3.7	0.2	3.5	0.2
Receptor	5.6	0.6	5.2	0.5
Glenover	4.6	0.5	4.2	0.5
Oxford Safaris	3.4	0.3	3.2	0.3
Receptor	4.9	0.4	4.7	0.3
Tholo Bush Estate	5.1	0.4	4.8	0.4

Scenario C (2036)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**25**	**15**
Receptor	6.5	0.6	6.1	0.6
Receptor	3.5	0.3	3.3	0.3
Cheetah Safaris	6.2	0.6	5.8	0.6
Rhinoland Safaris	3.2	0.2	3.0	0.2

Predicted concentrations in µg/m³ at the sensitive receptors for Scenario D (MES), together with the limit value of the NAAQS

Scenario D (MES)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**25**	**15**
Phegelelo Senior Secondary	4.9	0.3	3.8	0.2
Contractors Village	4.9	0.3	4.0	0.2
Ditheku Primary School	5.0	0.3	3.9	0.2
Ditheko Primary School	5.2	0.3	4.2	0.3
Marapong Training Centre	5.3	0.3	4.1	0.3
Marapong Clinic	5.6	0.3	4.5	0.3
Tielelo Secondary School	5.0	0.3	3.8	0.2
Grootegeluk Medical Centre - Community Center	5.5	0.3	4.3	0.3
Lephalale College	4.5	0.3	3.9	0.3
Nelsonskop Primary School	5.5	0.3	4.3	0.3
Hansie en Grietjie Pre-Primary School	4.4	0.3	3.8	0.3
Sedibeng Special School for the Deaf and Disabilities	3.9	0.3	3.4	0.2
Kings College	4.2	0.3	3.6	0.3
Bosveld Primary School	4.0	0.3	3.5	0.3
Lephalale Medical Hospital	5.2	0.3	4.0	0.3
Ellisras Hospital	4.1	0.3	3.6	0.2
Laerskool Ellisras Primary School	3.6	0.3	3.1	0.2
Hoerskool Ellisras Secondary School	3.8	0.3	3.3	0.2
Marlothii Learning Academy	3.7	0.3	3.2	0.2
Hardekool Akademie vir C.V.O	3.7	0.3	3.2	0.2
Lephalale Clinic	3.6	0.3	3.1	0.2
Ons Hoop	3.6	0.2	3.0	0.2
Woudend	2.1	0.1	1.8	0.1
Ramabara's	3.0	0.2	2.6	0.2
Ga-Shongoane	1.9	0.1	1.7	0.1
Bulge River	2.4	0.3	2.2	0.2
Kaingo Mountain Lodge	2.2	0.2	2.0	0.2
Community	2.7	0.3	2.4	0.3
Kiesel	2.8	0.3	2.4	0.3
Kremetartpan	4.5	0.5	3.9	0.4
Mbala Private Camp	3.7	0.4	3.2	0.4
Steenbokpan	4.2	0.4	3.7	0.3
Receptor	3.2	0.2	2.9	0.2
Sandbult	3.7	0.3	3.2	0.2
Hardekraaltjie	2.4	0.2	2.2	0.1
Receptor	3.8	0.2	3.3	0.2
Receptor	3.1	0.2	2.7	0.1
Receptor	2.4	0.1	2.1	0.1
Receptor	2.5	0.1	2.2	0.1
Receptor	2.7	0.2	2.4	0.1
Ditaung	1.8	0.1	1.6	0.1
Letlora	2.0	0.1	1.8	0.1
Receptor	3.3	0.3	2.9	0.3
Glenover	2.7	0.3	2.3	0.2
Oxford Safaris	1.9	0.2	1.7	0.2
Receptor	2.5	0.2	2.2	0.2
Tholo Bush Estate	2.7	0.2	2.5	0.2

Scenario D (MES)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**25**	**15**
Receptor	3.6	0.4	3.2	0.3
Receptor	1.9	0.2	1.7	0.1
Cheetah Safaris	3.5	0.4	3.1	0.3
Rhinoland Safaris	1.7	0.1	1.5	0.1

ADDENDUM TO:
ATMOSPHERIC IMPACT REPORT IN SUPPORT OF THE APPLICATION FOR EXEMPTION FROM THE MINIMUM EMISSION STANDARDS FOR ESKOM's COAL-FIRED POWER STATIONS ON THE HIGHVELD AND IN THE VAAL TRIANGLE (A CUMULATIVE ASSESSMENT)



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GLOSSARY OF TERMS AND ACRONYMS

AEL	Atmospheric Emission Licence
AIR	Atmospheric Impact Report
DEA	Department of Environmental Affairs
DFFE	Department of Forestry, Fisheries and the Environment
DSI	Dry Sorbent Injection
EIA	Environmental Impact Assessment
FGD	Flue-gas desulfurisation
g/s	Grams per second
kPa	Kilo Pascal
LNB	Low NO_X burner
MES	Minimum Emission Standards
mg/Nm^3	Milligrams per normal cubic meter refers to emission concentration, i.e. mass per volume at normal temperature and pressure, defined as air at 20°C (293.15 K) and 1 atm (101.325 kPa)
NAAQS	National Ambient Air Quality Standards
NAQO	National Air Quality Officer
NECA	National Environmental Consultative and Advisory
NEM-AQA	National Environment Management: Air Quality Act, 2004 (Act No. 39 of 2004)
NEMA	National Environmental Management Act, 1998 (Act No. 107 of 1998)
USEPA	United States Environmental Protection Agency
µm	1 µm = Micro meter 1 µm = 10^{-6} m

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1. INTRODUCTION

On 22 May 2024, the Minister directed Eskom to submit an application in terms of Section 59 of the National Environmental Management: Air Quality Act for exemption of the MES for eight (8) power stations that will continue to operate post 2030. These are Duvha, Kendal, Majuba, Matla and Tutuka in the Highveld Priority Area; Lethabo in the Vaal Triangle Airshed Priority Area; and Medupi and Matimba in the Waterberg-Bojanala Priority Area.

In terms of the Minister's ruling, Eskom Holdings SOC Ltd appointed WSP Group Africa (Pty) Ltd to prepare the necessary applications. WSP Group Africa (Pty) Ltd sub-contracted uMoya-NILU Consulting (Pty) Ltd to prepare the associated Atmospheric Impact Reports (AIRs) to support these applications. AIRs were duly prepared to support the respective exemption applications for the individual power stations. Furthermore, two cumulative AIRs were prepared, for the suite of power stations on the Highveld and the Vaal Triangle, and for the two coal-fired power stations in the Waterberg-Bojanala Priority Area, i.e. Medupi and Matimba (uMoya-NILU, 2024). In so doing, 5 emission scenarios were assessed, which included SO_2, NO_X and PM emissions from the stacks as well as fugitive PM emissions from the coal stockyard and ash dumps. The intention was to provide an understanding of the power stations total contribution to ambient concentrations.

The stack emission data were provided by Eskom for the five scenarios based firstly on actual emissions, followed by emissions representing anticipated station performance in different years. Fugitive emissions were estimated based on a worst-case scenario, with little dust control implemented on the ash dumps. Specifically, 60-80% of the entire area of the ash dumps was assumed to be exposed and available for entrainment of particulates. It was assumed that the sides of the ash dumps are in fact partially vegetated, and the tops are partially wet.

To provide an absolute worst-case, it was assumed that the total PM emission from the stacks into the respective PM_{10} and $PM_{2.5}$ fractions. Therefore, the total PM emission was firstly assumed to be PM_{10}, then was assumed to be $PM_{2.5}$. For consistency in the modelling, the total PM emission from the fugitive sources was also assumed to be PM_{10}, then $PM_{2.5}$. The modelled outputs were then compared against the respective National Ambient Air Quality Standards (NAAQS).

The modelled PM_{10} and $PM_{2.5}$ concentrations were high close to the respective power stations and exceeded the NAAQS. Further away from the power stations, the predicted concentrations were relatively low and complied with the NAAQS. From the results it was however impossible to distinguish between the contribution of the fugitive sources and the stack emissions to ambient concentrations, although the results indicated that the high concentrations were due to the fugitive sources rather than the stack emissions themselves.

As Eskom's request to the Minister concerns stack emissions, it was decided to prepare an addendum to the cumulative assessment for the Highveld and Vaal Triangle power stations and to assess the contribution of stack PM emissions only to the ambient PM_{10} and $PM_{2.5}$ concentrations. The same dispersion model, stack parameterisation and model setup are

used. In this Addendum to the AIR (uMoya-NILU, 2024), the focus is specifically on stack emissions for PM and the modelled results for PM_{10} and $PM_{2.5}$.

2. STACK EMISSIONS

In this Addendum to the AIR (uMoya-NILU, 2024), the cumulative effect of stack emissions from 13 coal-fired power stations comprising the Highveld and Vaal power station fleet are assessed, i.e. Arnot, Camden, Duvha, Grootvlei, Hendrina, Kendal, Komati, Kriel, Kusile, Majuba, Matla and Tutuka in the Highveld Priority area and Lethabo in the Vaal Triangle Airshed Priority Area.

2.1 Operational Scenarios

The five operational scenarios anticipated by Eskom for the Highveld and Vaal power station fleet in the coming years are:

Scenario 1 (Current): The baseline scenario using actual monthly stack emissions for 2021-2023.

Scenario A (2025): Eskom's planned 2025 stack emissions, representing anticipated station performance between 2025 – 2030. This includes the shutdown of Komati; the completion of some of the PM abatement projects. The approach to selecting emissions was that the highest year of emissions was selected in a 5-year period, so in some cases if the PM projects were not yet complete, the benefit of these would not be modelled.

Scenario B (2031): Eskom's planned 2031 stack emissions, representing anticipated station performance between 2031 – 2035. This includes completion of shutdowns at Arnot, Kriel, Hendrina, Camden, and Grootvlei, including their fugitive sources, with Matla and Duvha also entering shutdown phase; the completion of all PM abatement projects; FGD at Kusile and completion of the DSI at Majuba (SO_2 emissions); reduced SO_2 emissions achieved though load curtailment and efficiency improvement projects; and NO_X abatement (LNB) at Majuba, Lethabo, and Tutuka.

Scenario C (2036): Eskom's planned 2036 stack emissions, representing anticipated station performance from 2036 onwards. This includes the complete shutdown of Matla and Duvha; shutdowns of Tutuka, Lethabo, and Kendal, including their fugitive sources, with Majuba entering shutdown phase in FY2047; SO_2 abatement installed at Kusile (FGD), Majuba (DSI), Kendal (FGD); as well as reduced SO_2 emissions achieved though load curtailment and efficiency improvement projects.

Scenario D (MES): Full compliance with the MES, where relevant (i.e. not for the stations shutdown), and in addition to the abatement included in above scenarios, FGD installations at Tutuka and Lethabo.

The estimated emission rates for SO_2, NO_X and PM_{10} and equivalent emission concentrations that are used in the dispersion modelling for the power stations are shown in Table 2-1 and Table 2-2, respectively. A reminder that the total PM emission is assumed to be PM_{10}. The maximum anticipated emissions during each period are used for simulation in the model. The boiler units are assumed to operate continuously, i.e. 24 hours a day.

Since each future scenario is a snapshot of the period of operation (e.g. Scenario A = 2025 to 2030), the maximum anticipated emissions during that period, in a single year was selected for simulation in the model.

Table 2-1: Stack emission rates (tonnes/annum) for the suite of coal-fired power stations and 5 emission scenarios

Power station	Stack	SCENARIO 1 (Current)			SCENARIO A (2025)			SCENARIO B (2031)			SCENARIO C (2036)			SCENARIO D (MES)		
		NO_X	SO_2	In	NO_X	SO_2	PM_{10}	NO_x	SO_2	PM_{10}	NO_x	SO_2	PM_{10}	NO_x	SO_2	PM_{10}
Arnot	Stack 1	21 487	24 465	890	21 619	29 833	1 031	0	0	0	0	0	0	0	0	0
	Stack 2	21 487	24 465	890	21 619	29 833	1 031	0	0	0	0	0	0	0	0	0
Camden	Stack 1	8 914	11 941	460	10 730	14 438	473	0	0	0	0	0	0	0	0	0
	Stack 2	8 914	11 941	460	10 730	14 438	473	0	0	0	0	0	0	0	0	0
	Stack 3	8 914	11 941	460	10 730	14 438	473	0	0	0	0	0	0	0	0	0
	Stack 4	8 914	11 941	460	10 730	14 438	473	0	0	0	0	0	0	0	0	0
Duvha	Stack 1	23 685	44 424	1 819	17 200	36 647	1 137	15 709	33 472	692	0	0	0	0	0	0
	Stack 2	23 685	44 424	1 819	25 800	54 971	2 652	23 564	50 208	1 384	0	0	0	0	0	0
Grootvlei	Stack 1	4 894	8 339	143	11 944	23 618	270	0	0	0	0	0	0	0	0	0
	Stack 2	4 894	8 339	143	0	0	0	0	0	0	0	0	0	0	0	0
Hendrina	Stack 1	7 695	15 589	266	10 585	23 572	356	0	0	0	0	0	0	0	0	0
	Stack 2	7 695	15 589	266	10 585	23 572	356	0	0	0	0	0	0	0	0	0
Kendal	Stack 1	22 623	58 298	13 321	26 033	88 749	1 799	22 770	77 970	1 639	27 213	26 557	1 959	27 213	26 557	1 959
	Stack 2	22 623	58 298	13 321	26 033	88 749	1 799	22 770	77 970	1 639	27 213	26 557	1 959	27 213	26 557	1 959
Komati	Stack 1	1 042	1 076	57	0	0	0	0	0	0	0	0	0	0	0	0
	Stack 2	1 042	1 076	57	0	0	0	0	0	0	0	0	0	0	0	0
Kriel	Stack 1	39 460	46 038	7 802	36 937	42 577	5 639	0	0	0	0	0	0	0	0	0
	Stack 2	39 460	46 038	7 802	36 937	42 577	5 639	0	0	0	0	0	0	0	0	0
Kusile	Stack 1	24 940	21 281	737	30 178	46 428	371	23 777	25 752	293	26 703	28 922	329	26 703	28 922	329
	Stack 2	24 940	21 281	737	30 178	46 428	371	23 777	25 752	293	26 703	28 922	329	26 703	28 922	329
Lethabo	Stack 1	51 234	100 147	5 740	46 808	99 197	3 720	28 583	56 370	1 393	22 246	59 258	1 542	22 246	17 777	1 542
	Stack 2	51 234	100 147	5 740	46 808	99 197	3 720	28 583	56 370	1 393	22 246	59 258	1 542	22 246	17 777	1 542
Majuba	Stack 1	58 301	67 177	952	33 034	105 666	837	25 262	80 804	640	33 250	75 779	842	33 250	22 734	842
	Stack 2	58 301	67 177	952	33 034	105 666	837	25 262	80 804	640	33 250	75 779	842	33 250	22 734	842
Matla	Stack 1	49 710	41 603	10 608	49 301	72 014	4 769	38 853	56 752	1 879	0	0	0	0	0	0
	Stack 2	49 710	41 603	10 608	37 490	54 761	3 627	29 545	43 156	1 429	0	0	0	0	0	0
Tutuka	Stack 1	24 217	45 512	7 692	28 989	59 187	7 006	4 945	15 654	597	17 621	55 242	1 982	17 621	16 573	1 982
	Stack 2	24 217	45 512	7 692	28 989	59 187	7 006	4 945	15 654	597	17 621	55 242	1 982	17 621	16 573	1 982

Table 2-2: Stack emission concentration in mg/Nm³ at 10% O_2 for the suite of coal-fired power stations and 5 emission scenarios

Power station	Stack	SCENARIO 1 (Current)			SCENARIO A (2025)			SCENARIO B (2031)			SCENARIO C (2036)			SCENARIO D (MES)		
		NO_X	SO_2	PM_{10}	NO_X	SO_2	PM_{10}	NO_x	SO_2	PM_{10}	NO_x	SO_2	PM_{10}	NO_x	SO_2	PM_{10}
Arnot	Stack 1	334	381	14	587	810	28	0	0	0	0	0	0	0	0	0
	Stack 2	334	381	14	587	810	28	0	0	0	0	0	0	0	0	0
Camden	Stack 1	461	617	24	680	915	30	0	0	0	0	0	0	0	0	0
	Stack 2	461	617	24	680	915	30	0	0	0	0	0	0	0	0	0
	Stack 3	461	617	24	680	915	30	0	0	0	0	0	0	0	0	0
	Stack 4	461	617	24	680	915	30	0	0	0	0	0	0	0	0	0
Duvha	Stack 1	297	557	23	681	1 451	45	681	1 451	30	0	0	0	0	0	0
	Stack 2	297	557	23	681	1 451	70	681	1 451	40	0	0	0	0	0	0
Grootvlei	Stack 1	145	247	4	885	1 750	20	0	0	0	0	0	0	0	0	0
	Stack 2	145	247	4	0	0	0	0	0	0	0	0	0	0	0	0
Hendrina	Stack 1	150	305	5	595	1 325	20	0	0	0	0	0	0	0	0	0
	Stack 2	150	305	5	595	1 325	20	0	0	0	0	0	0	0	0	0
Kendal	Stack 1	269	694	159	550	1 875	38	528	1 808	38	528	515	38	528	515	38
	Stack 2	269	694	159	550	1 875	38	528	1 808	38	528	515	38	528	515	38
Komati	Stack 1	33	35	2	0	0	0	0	0	0	0	0	0	0	0	0
	Stack 2	33	34	2	0	0	0	0	0	0	0	0	0	0	0	0
Kriel	Stack 1	535	624	106	655	755	100	0	0	0	0	0	0	0	0	0
	Stack 2	535	624	106	655	755	100	0	0	0	0	0	0	0	0	0
Kusile	Stack 1	247	210	7.28	325	500	4	325	352	4	325	352	4	325	352	4
	Stack 2	247	210	7.28	325	500	4	325	352	4	325	352	4	325	352	4
Lethabo	Stack 1	696	1 360	78	755	1 600	60	718	1 416	35	505	1 345	35	505	404	35
	Stack 2	696	1 360	78	755	1 600	60	718	1 416	35	505	1 345	35	505	404	35
Majuba	Stack 1	573	660	9	750	2 399	19	750	2 399	19	750	1 709	19	750	513	19
	Stack 2	573	660	9	750	2 399	19	750	2 399	19	750	1 709	19	750	513	19
Matla	Stack 1	551	461	117	827	1 208	80	827	1 208	40	0	0	0	0	0	0
	Stack 2	551	461	118	827	1 208	80	827	1 208	40	0	0	0	0	0	0
Tutuka	Stack 1	244	458	77	600	1 225	145	290	918	35	400	1 254	45	400	376	45
	Stack 2	244	458	77	600	1 225	145	290	918	35	400	1 254	45	400	376	45

2.2 Methodology for determining $PM_{2.5}$ emissions

In terms of the determination of fine particulate matter emissions ($PM_{2.5}$), it is noted that Eskom utilises the dry bottom boiler emission factors from the United States Environmental Protection Agency (US EPA AP42) (US EPA, 1995) to determine the fine particulate matter (PM) emissions ($PM_{2.5}$). The ratio of the $PM_{2.5}$ to PM_{10} is used to calculate $PM_{2.5}$ from the total PM measured from the Continuous Emission Monitoring System (CEMS) equipment at the respective stacks. The utilisation of CEMS equipment is a more accurate representation of site-specific PM and therefore constitutes a Tier 3 method of reporting.

The US EPA defines dry bottom boilers as those burning coal with high fusion temperatures resulting in dry ash. In wet bottom boilers, coal with low fusion temperatures is used, resulting in molten ash or slag. Eskom coal fired power stations are therefore considered to have dry bottom boilers. Eskom has either Electrostatic Precipitators (ESPs) or Fabric Filter Plants (FFPs) installed as air pollution control devices in all its coal fired units. The following ratios determined from dry bottom emission factors in the US EPA AP42 are used:

- ESP controlled - 0.024 lb/ton for $PM_{2.5}$ and 0.054 lb/ton for PM_{10} [ratio = 0.44]
- FFP controlled - 0.01 lb/ton for $PM_{2.5}$ and 0.02 lb/ton for PM_{10} [ratio = 0.5]

The above ratios for PM_{10}:$PM_{2.5}$ have been applied accordingly at the various power stations as follows:

- Arnot, Camden, Grootvlei, Hendrina, Kusile and Majuba have FFPs installed on both stacks, hence the PM_{10}:$PM_{2.5}$ ratio is 1:0.50
- Kendal, Kriel, Lethabo, Matla, Tutuka and Komati have ESPs installed on both stacks, hence the PM_{10}:$PM_{2.5}$ ratio is 1:0.44
- Duvha has an FFP on Unit 1 and Unit 2 (Stack 1) hence the PM_{10}:$PM_{2.5}$ ratio is 1:0.50; and ESP on Unit 4, Unit 5 and Unit 6 (Stack 2) hence the PM_{10}:$PM_{2.5}$ ratio is 1:0.44

3. DISPERSION MODELLING RESULTS

The CALPUFF modelling suite provides for the chemical conversion of SO_2 and NO_X to secondary particulates, i.e. sulphates and nitrates in the modelling results. For PM_{10} and $PM_{2.5}$, the predicted concentrations presented are therefore attributed to stack emissions and the contribution from secondary particulate formation.

The DEA (2014) recommends the 99th percentile concentrations for short-term assessment with the NAAQS since the highest predicted ground-level concentrations can be considered outliers due to complex variability of meteorological processes. In addition, the limit value in the NAAQS is the 99th percentile. The impact assessment therefore compares the predicted 99th percentile concentrations with the respective NAAQS limit values and the permitted frequency of exceedance for the five scenarios.

3.1 Maximum predicted ambient concentrations

The maximum predicted annual PM_{10} and $PM_{2.5}$ concentrations and the 99th percentile of the 24-hour predicted concentrations are discussed here and are listed in Table 3-1 for the 5 scenarios.

Changes in the predicted annual average and 24-hour PM_{10} and $PM_{2.5}$ concentrations from one scenario to the next are strongly influenced by changes in PM_{10} and $PM_{2.5}$ emissions, the contribution from secondary particulate formation and stack exit velocity.

In all scenarios, the maximum predicted annual average PM_{10} and $PM_{2.5}$ concentrations are well below the limit values of the respective NAAQS. In all scenarios, the maximum predicted 99th percentile of the 24-hour PM_{10} and $PM_{2.5}$ concentrations are in general, relatively low compared to the limit value of the NAAQS. In other words, here are no predicted exceedances of the 24-hour limit value of the respective NAAQS for PM_{10} and for $PM_{2.5}$.

The increase in SO_2, NO_X, PM_{10} and $PM_{2.5}$ emissions and a reduction in stack exit velocity from Scenario 1 (Current) to Scenario A (2025) is seen by an increase in the predicted PM_{10} and $PM_{2.5}$ ambient concentrations.

The maximum predicted PM_{10} and $PM_{2.5}$ ambient concentrations decrease significantly from Scenario A (2025) when 13 power stations are in operation to Scenario B (2031) due to the shutdown of 5 power stations (Arnot, Camden, Hendrina, Kriel, Grootvlei); and as a result of PM abatement projects at Duvha, Lethabo, Kendal, Matla and Tutuka being completed.

The slight decrease in PM_{10} and $PM_{2.5}$ ambient concentrations from Scenario B (2031) to Scenario C (2036) is mainly due to the shutdown of the Duvha and Matla generating units (which would have occurred by 2035).

Although PM_{10} and $PM_{2.5}$ emissions remain the same for Scenario C (2036) and Scenario D (MES), it is noted that the maximum predicted PM_{10} and $PM_{2.5}$ ambient concentrations show a fairly large decrease between the two scenarios. This decrease is mainly attributed

to the reduced formation of secondary particulates brought about by a substantial decrease in SO_2 emissions between these scenarios.

Table 3-1: Maximum predicted ambient annual PM_{10}, and $PM_{2.5}$ concentrations in µg/m³ and the predicted 99th percentile concentrations for 24-hour averaging periods, with the South African NAAQS

Scenario and Pollutant	Averaging time	
Predicted maximum PM_{10}	**Annual**	**24-hour**
Scenario 1 (Current)	4.1	34.7
Scenario A (2025)	4.7	36.5
Scenario B (2031)	2.2	16.9
Scenario C (2035)	1.8	14.0
Scenario D (MES)	1.2	8.8
NAAQS	**40**	**75**
Predicted maximum $PM_{2.5}$	**Annual**	**24-hour**
Scenario 1 (Current)	3.4	27.1
Scenario A (2025)	4.2	31.3
Scenario B (2031)	2.1	16.0
Scenario C (2035)	1.7	13.2
Scenario D (MES)	1.0	7.0
NAAQS (up to 31 Dec 2029)	**20**	**40**
NAAQS (from 01 Jan 2030)	**15**	**25**

3.2 Predicted concentrations at the AQMSs

The predicted annual PM_{10} and $PM_{2.5}$ concentrations are compared with the measured annual averages in 2021, 2022 and 2023 at several Air Quality Monitoring Stations (AQMSs) in the Highveld modelling domain for Scenario 1 (Current) in Table 3-2 and Table 3-3, respectively.

For PM_{10} and $PM_{2.5}$, the predicted ambient concentrations result from the respective power station stack emissions. At all the AQMSs, the modelled concentrations are considerably lower than the monitored concentrations. This is to be expected since the AQMSs are exposed to all sources of PM_{10} and $PM_{2.5}$. The difference between the predicted concentrations and the measured concentrations provides an indication of the contribution of the power station stack emissions at the respective AQMSs.

Table 3-2: Measured annual average PM_{10} concentration at the Highveld AQMSs compared with predicted concentrations in µg/m³ for Scenario 1 (Current)

Receptor	2021	2022	2023	Modelled
Grootdraai Dam AQMS	-	-	-	**2.6**
eMalahleni AQMS	36.7	40.1	47.5	**2.1**
Kendal AQMS	80.2	74.1	76.8	**2.4**
Kriel Village AQMS	42.7	51.2	50.8	**3.5**
Three Rivers AQMS	65.6	-	56.1	**1.5**
Majuba AQMS	-	54.3	-	**2.9**
Chicken Farm AQMS	21.9	15.8	34.4	**1.9**

Rand Water AQMS	-	-	-	**1.5**
Masakhane AQMS	-	63.8	55.8	**2.5**
Sivukile AQMS	38.7	47.7	42.4	**3.1**
Sharpeville AQMS	-	53.4	64.0	**1.3**

Table 3-3: Measured annual average $PM_{2.5}$ concentration at the Highveld AQMSs compared with predicted concentrations in µg/m³ for Scenario 1 (Current)

Receptor	2021	2022	2023	Modelled
Grootdraai Dam AQMS	-	-	-	**2.2**
eMalahleni AQMS	19.8	21.2	23.1	**1.8**
Kendal AQMS	6.1	9.1	-	**1.9**
Kriel Village AQMS	23.2	23.2	16.6	**2.6**
Three Rivers AQMS	28.1	-	34.9	**1.3**
Majuba AQMS	14.3	26.8	22.5	**2.5**
Chicken Farm AQMS	-	-	10.1	**1.6**
Rand Water AQMS	18.0	18.5	19.1	**1.3**
Masakhane AQMS	24.9	7.5	-	**2.0**
Sivukile AQMS	-	-	-	**2.6**
Sharpeville AQMS	-	22.1	33.0	**1.1**

3.3 Predicted concentrations at sensitive receptors

In the Highveld and Vaal Triangle study area, 405 sensitive receptors were identified. These are listed in Annexure 1. Predicted ambient concentrations for PM_{10} and $PM_{2.5}$ for the five scenarios are presented in Annexure 2.

At all identified sensitive receptors, the predicted PM_{10} and $PM_{2.5}$ concentrations are low and well below the limit value of the respective NAAQS for all five scenarios. The highest predicted concentrations occur for Scenario A (2025) and the lowest predicted concentrations occur for Scenario D (MES).

Noteworthy is the systematic decrease in predicted PM_{10} and $PM_{2.5}$ concentrations from 2025 to 2036 at all sensitive receptors due to station shutdowns (Arnot, Camden, Hendrina, Kriel, Grootvlei), with most generating units also shutdown at Duvha and Matla by 2035, and PM abatement projects being completed.

3.4 Isopleth maps

Isopleth maps of predicted ambient PM_{10} and $PM_{2.5}$ concentrations are presented in the following sections. The predicted concentrations are shown as isopleths, lines of equal concentration, in µg/m³ for the respective NAAQS averaging periods. The isopleths are depicted as coloured lines on the various maps, corresponding to a particular predicted ambient concentration. Sensitive receptors are represented by green squares and AQMSs are represented by white dots.

The South African NAAQS permits 4 exceedances of the 24-hour or daily limit value per annum, implying 12 permitted exceedances in a three-year modelling period. In all scenarios, the maximum predicted annual average PM_{10} and $PM_{2.5}$ concentrations are well below the limit values of the respective NAAQS. In all scenarios, the maximum predicted 99th percentile of the 24-hour PM_{10} and $PM_{2.5}$ concentrations are in general, relatively low

compared to the limit value of the NAAQS, with no predicted exceedances. The predicted 24-hour PM_{10} and $PM_{2.5}$ concentrations therefore comply with the NAAQS for all five scenarios. As discussed above, changes in the predicted concentrations are strongly influenced by changes in emissions, the contribution from secondary particulate formation and stack exit velocity.

3.4.1 Particulates (PM_{10})

In Scenario 1 (Current), the highest predicted annual concentrations occur close to the Kriel, Matla and Camden Power Stations. The highest predicted 24-hour concentrations occur close to the Kendal, Kriel and Matla Power Stations.

The increase in emissions and a reduction in stack exit velocity from Scenario 1 (Current) to Scenario A (2025) is seen by an increase in the predicted concentrations. In Scenario A (2025), the highest predicted annual concentrations occur close to the Kriel, Matla, Camden, Tutuka and Majuba Power Stations. The highest predicted 24-hour concentrations occur close to the Kriel, Matla and Tutuka Power Stations.

Noticeable is the dramatic effect of station shutdowns of Arnot, Camden, Hendrina, Grootvlei and Kriel by 2031 on the isopleths for Scenario B (2031), where the biggest reductions are seen. In Scenario B (2031), the highest predicted annual concentrations occur close to the Kriel, Matla, Camden, Tutuka, Majuba and Hendrina Power Stations. The highest predicted 24-hour concentrations occur close to the Kriel, Matla and Kendal Power Stations.

The effect of station shutdowns of Duvha and Matla by 2035 are also noticeable on the isopleths for Scenario C (2036). In Scenario C (2036), the highest predicted annual concentrations occur close to the Majuba Power Station. The highest predicted 24-hour concentrations occur close to the Tutuka and Majuba Power Stations.

Although PM_{10} emissions remain the same for Scenario C (2036) and Scenario D (MES), the predicted PM_{10} concentrations show a fairly large decrease on the isopleths for Scenario D (MES) (as discussed previously, this decrease is mainly attributed to the reduced formation of secondary particulates brought about by a substantial decrease in SO_2 emissions between these scenarios). In Scenario D (MES), the highest predicted annual concentrations occur close to the Camden, Tutuka and Majuba Power Stations. The highest predicted 24-hour concentrations occur close to the Kriel, Matla, Kendal, Tutuka and Majuba Power Stations.

Isopleth maps of the predicted annual average and 99th percentile of the 24-hour PM_{10} concentrations are presented in Figure 3-1 to Figure 3-10.

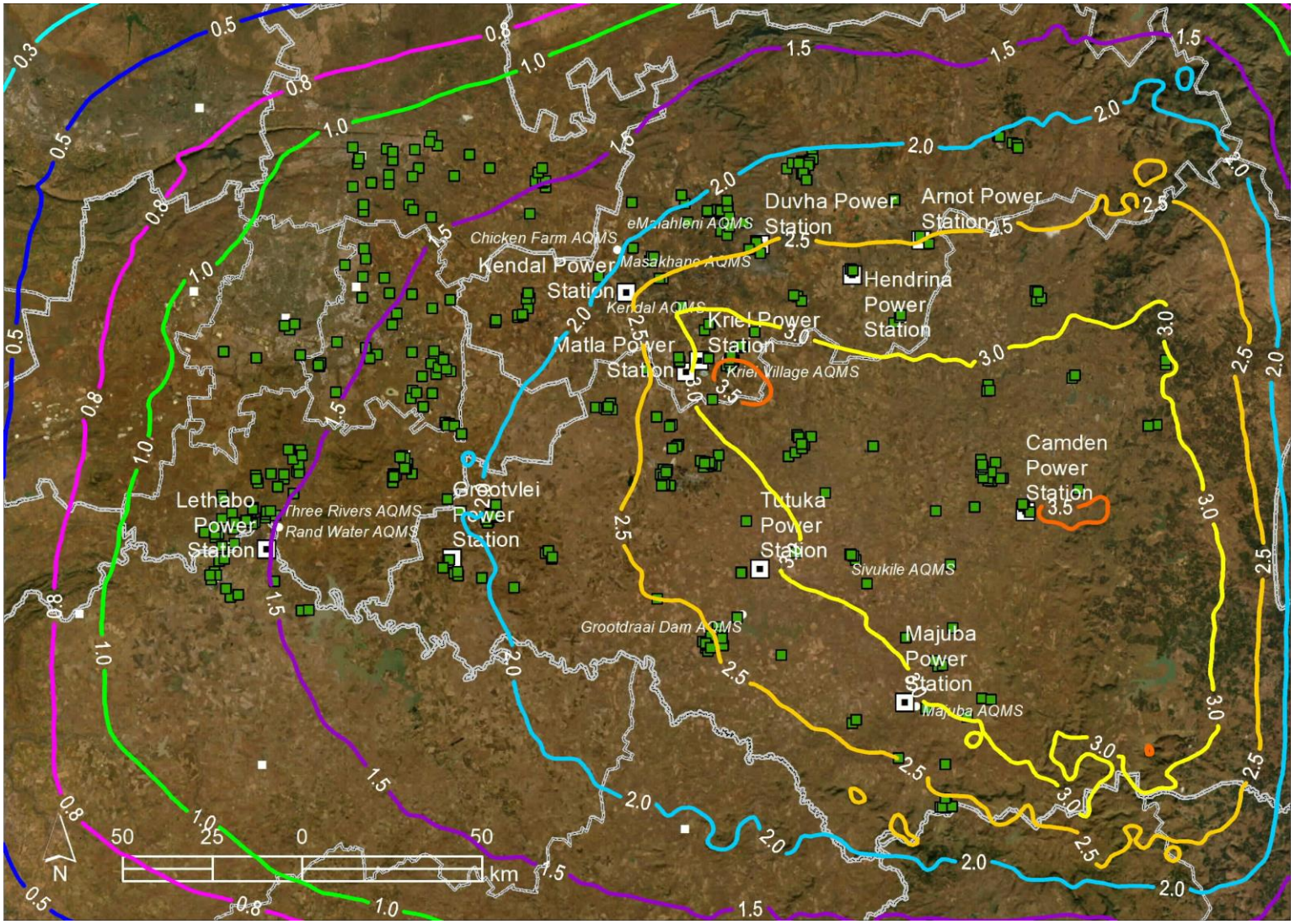


Figure 3-1: Predicted annual average PM_{10} concentrations in µg/m³ for Scenario 1 (Current) (NAAQS Limit is 40 µg/m³)

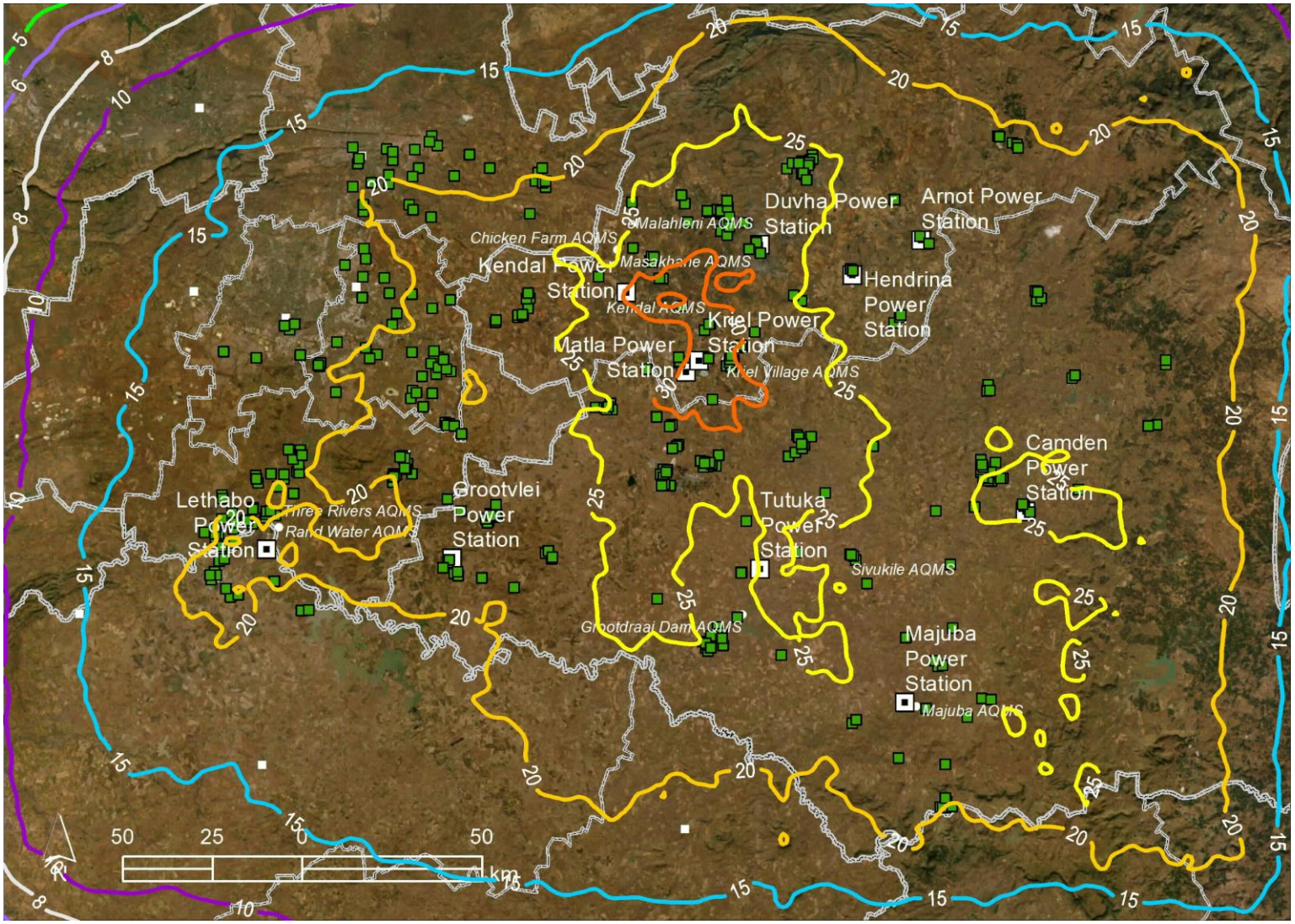


Figure 3-2: Predicted 99th percentile of the 24-hour PM_{10} concentrations in µg/m³ for Scenario 1 (Current) (NAAQS Limit is 75 µg/m³)

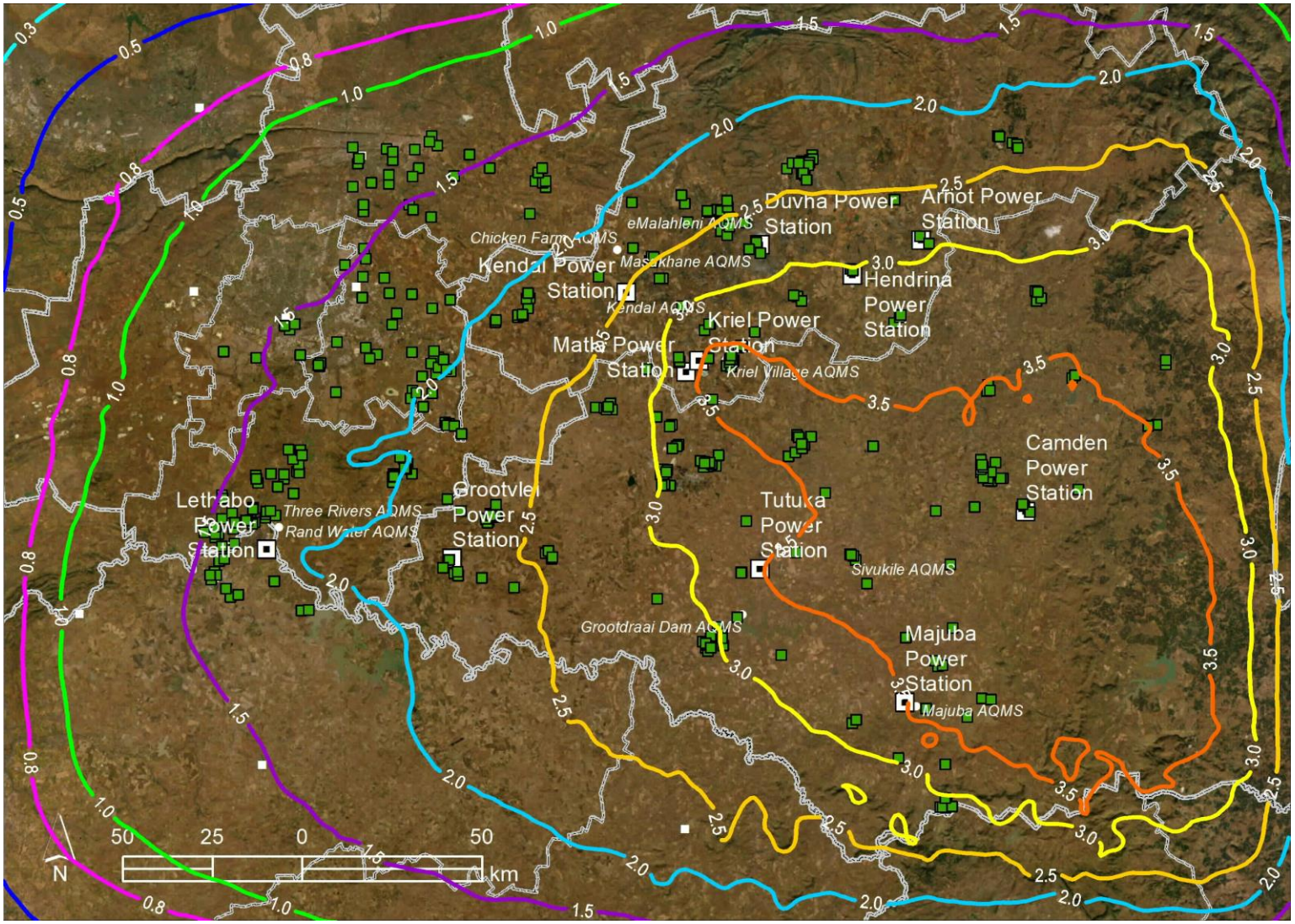


Figure 3-3: Predicted annual average PM_{10} concentrations in µg/m³ for Scenario A (2025) (NAAQS Limit is 40 µg/m³)

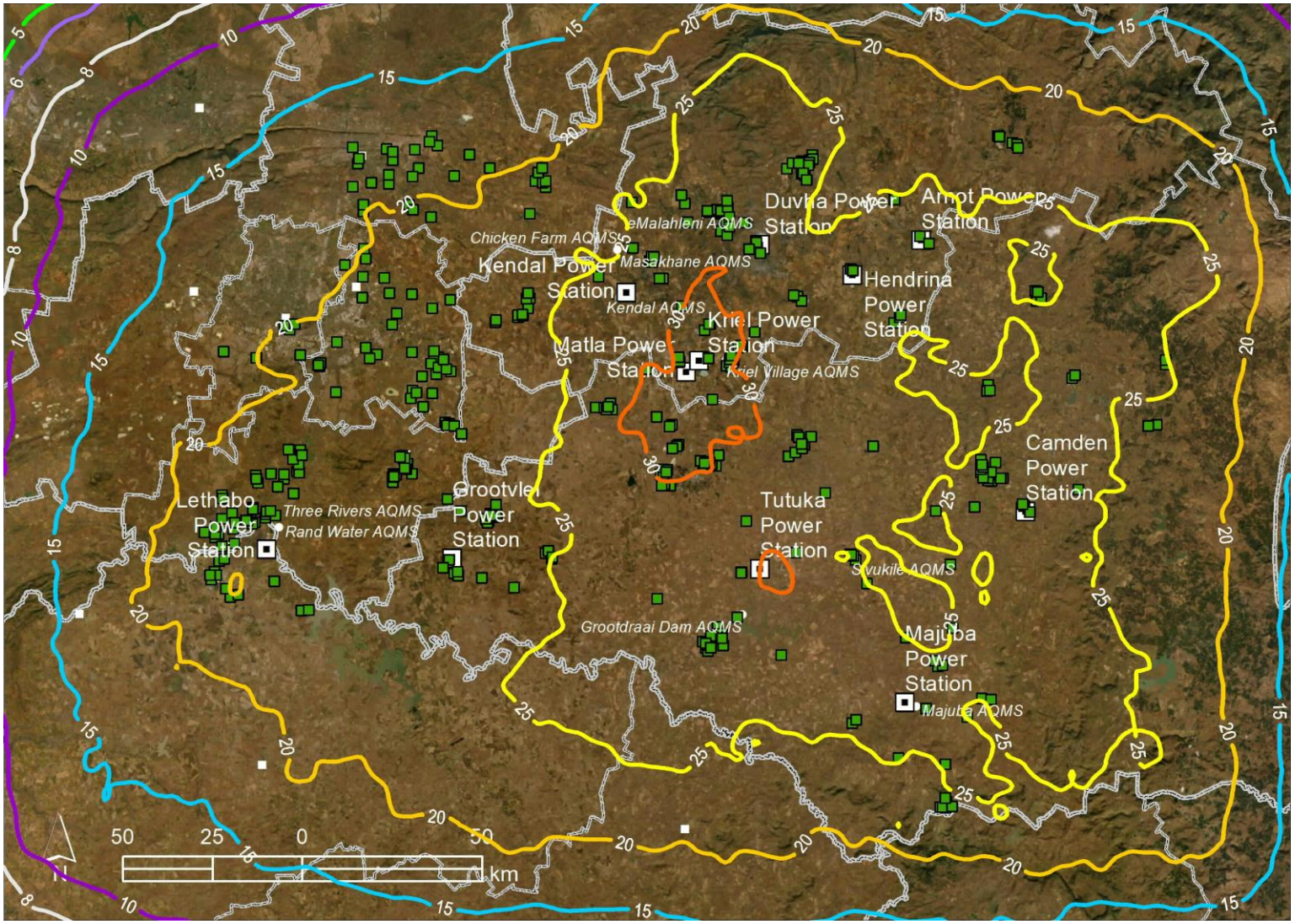


Figure 3-4: Predicted 99th percentile of the 24-hour PM_{10} concentrations in µg/m³ for Scenario A (2025) (NAAQS Limit is 75 µg/m³)

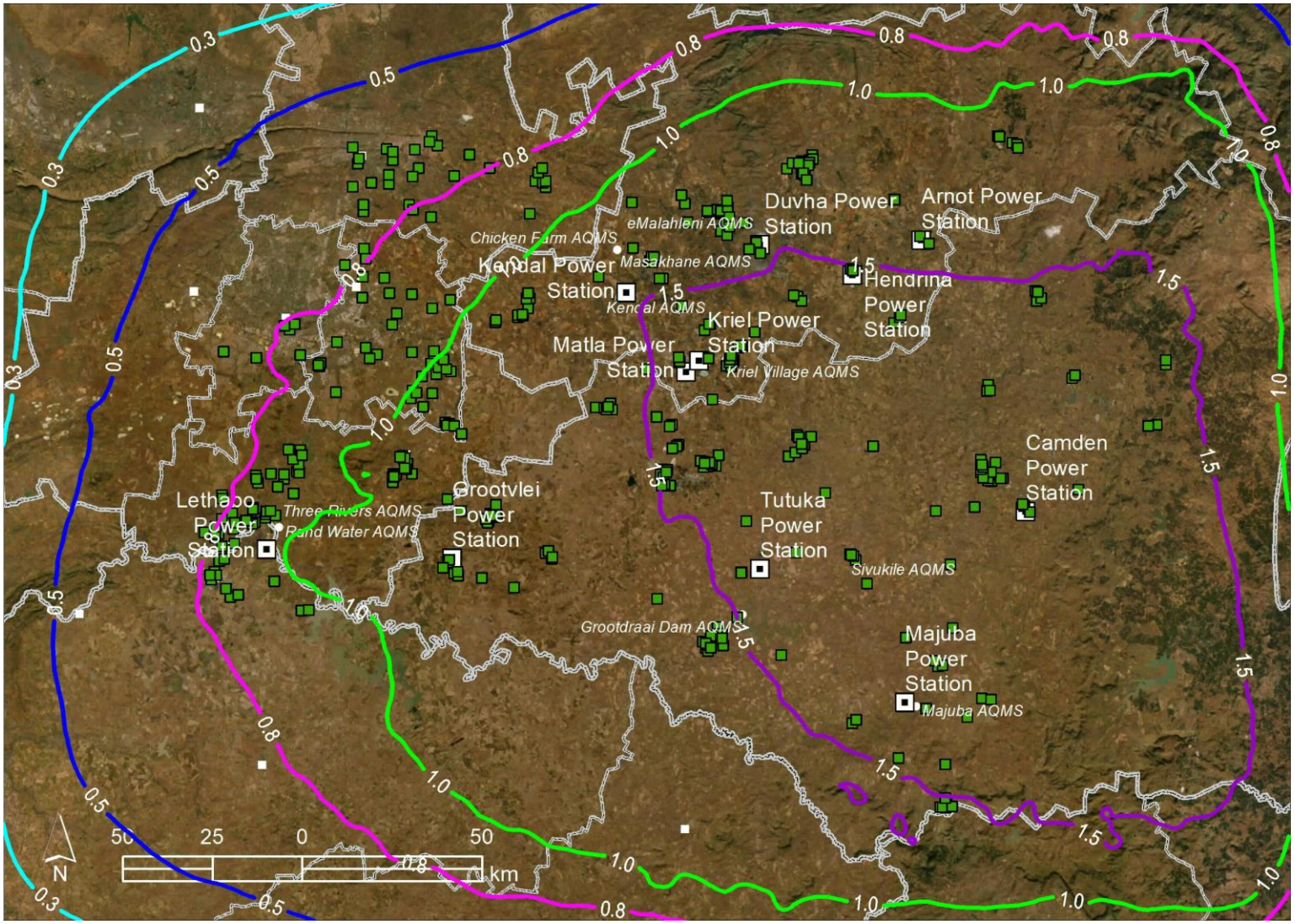


Figure 3-5: Predicted annual average PM_{10} concentrations in µg/m³ for Scenario B (2031) (NAAQS Limit is 40 µg/m³)

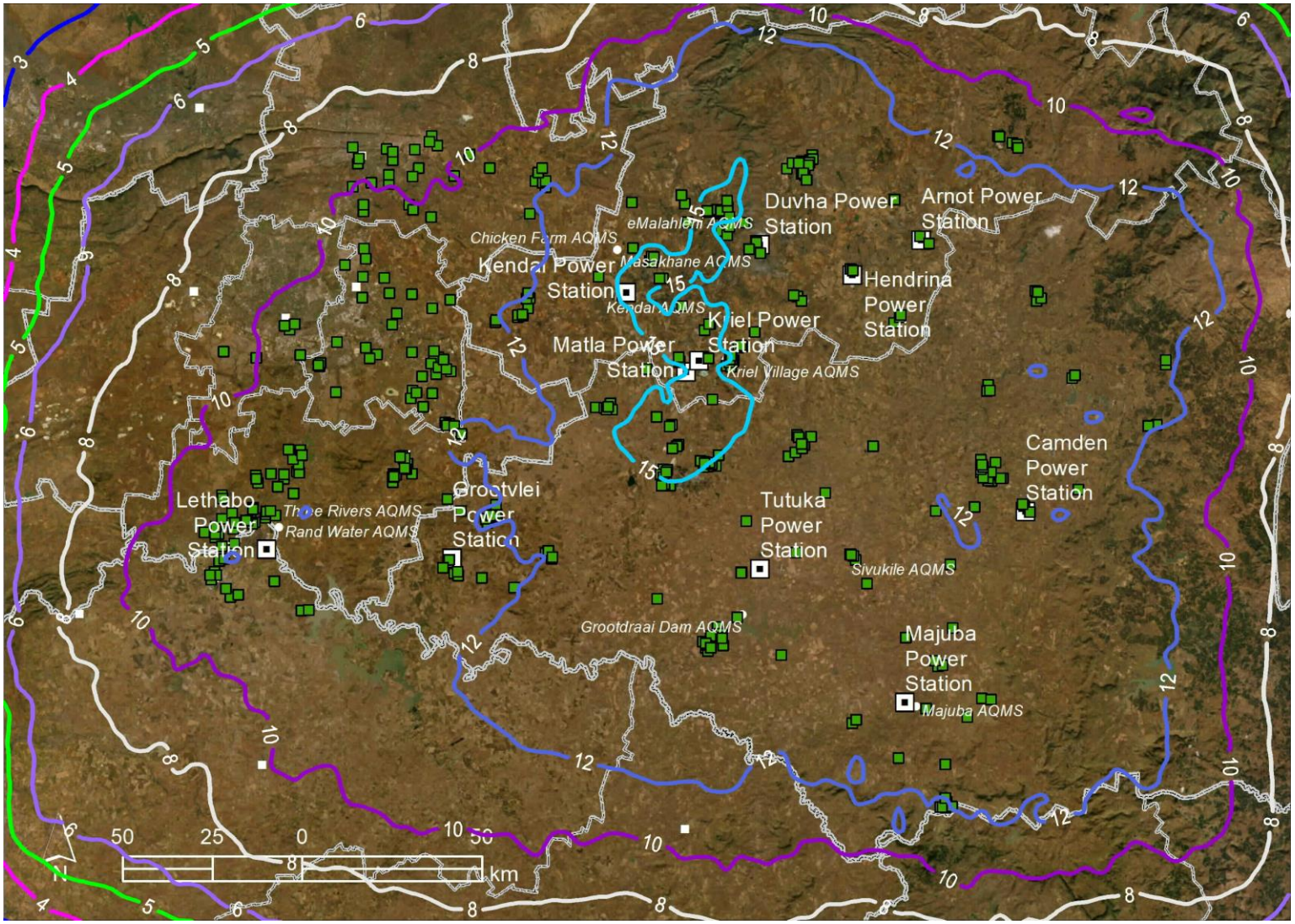


Figure 3-6: Predicted 99th percentile of the 24-hour PM_{10} concentrations in µg/m³ for Scenario B (2031) (NAAQS Limit is 75 µg/m³)

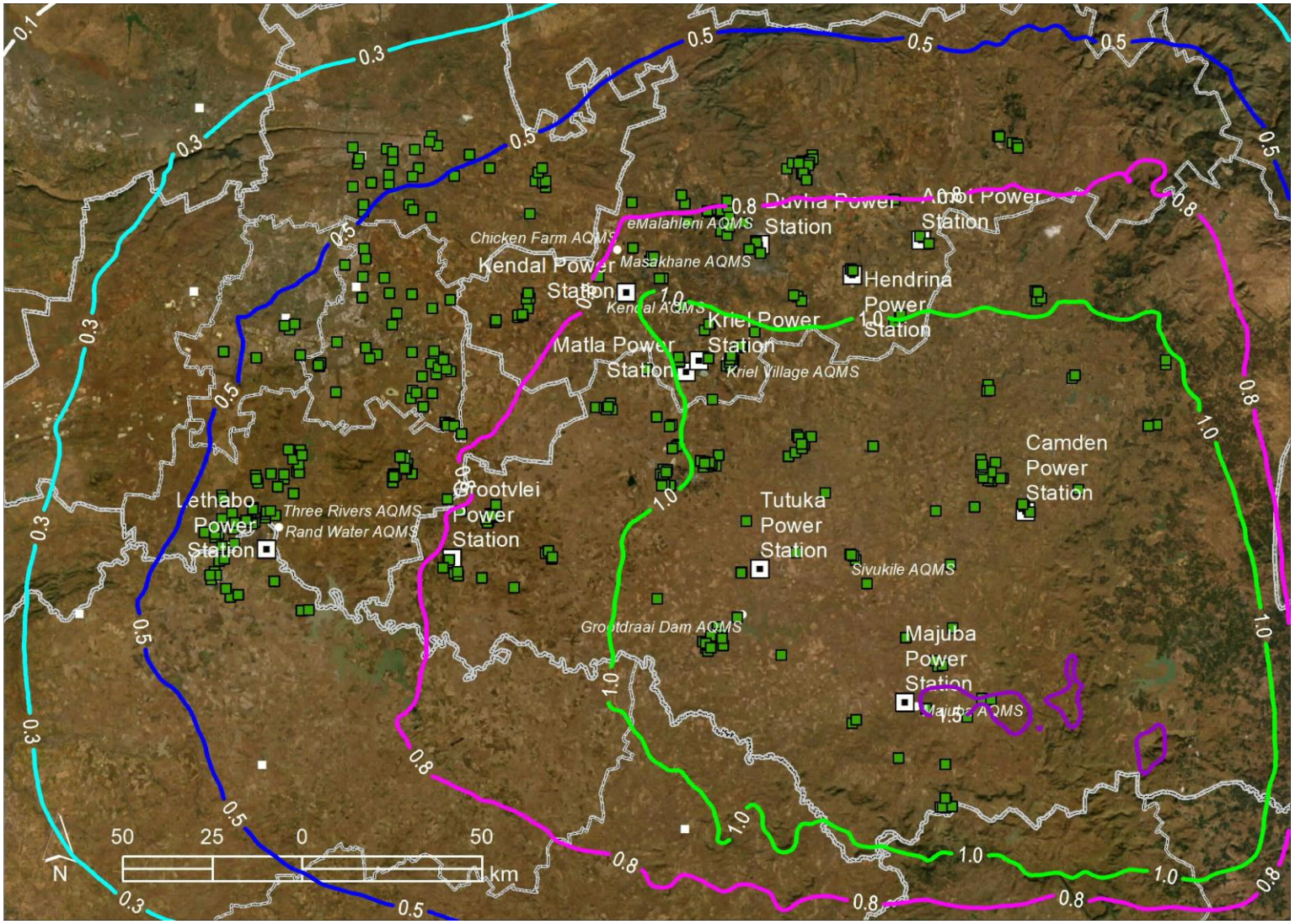


Figure 3-7: Predicted annual average PM_{10} concentrations in µg/m³ for Scenario C (2036) (NAAQS Limit is 40 µg/m³)

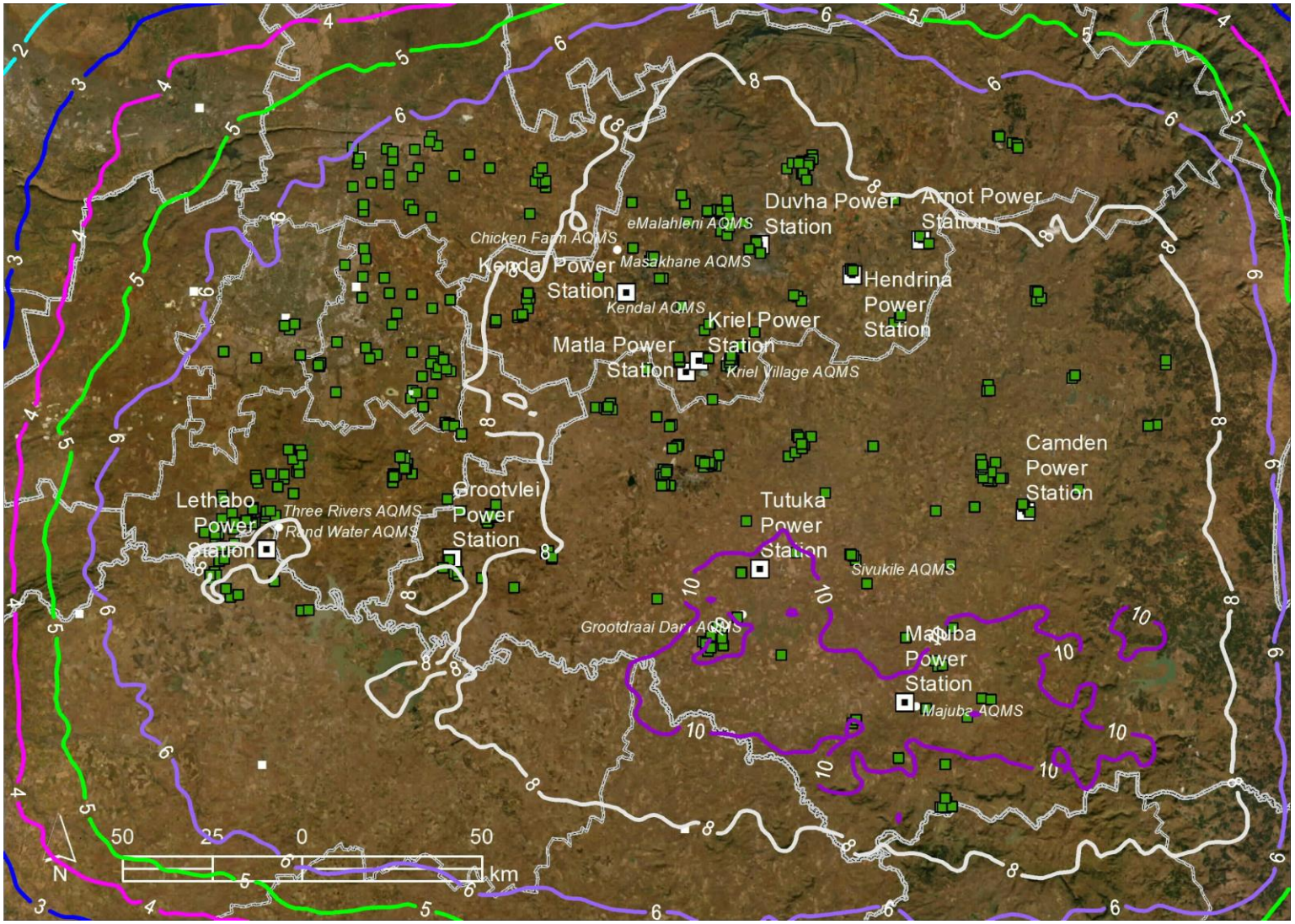


Figure 3-8: Predicted 99th percentile of the 24-hour PM_{10} concentrations in µg/m³ for Scenario C (2036) (NAAQS Limit is 75 µg/m³)

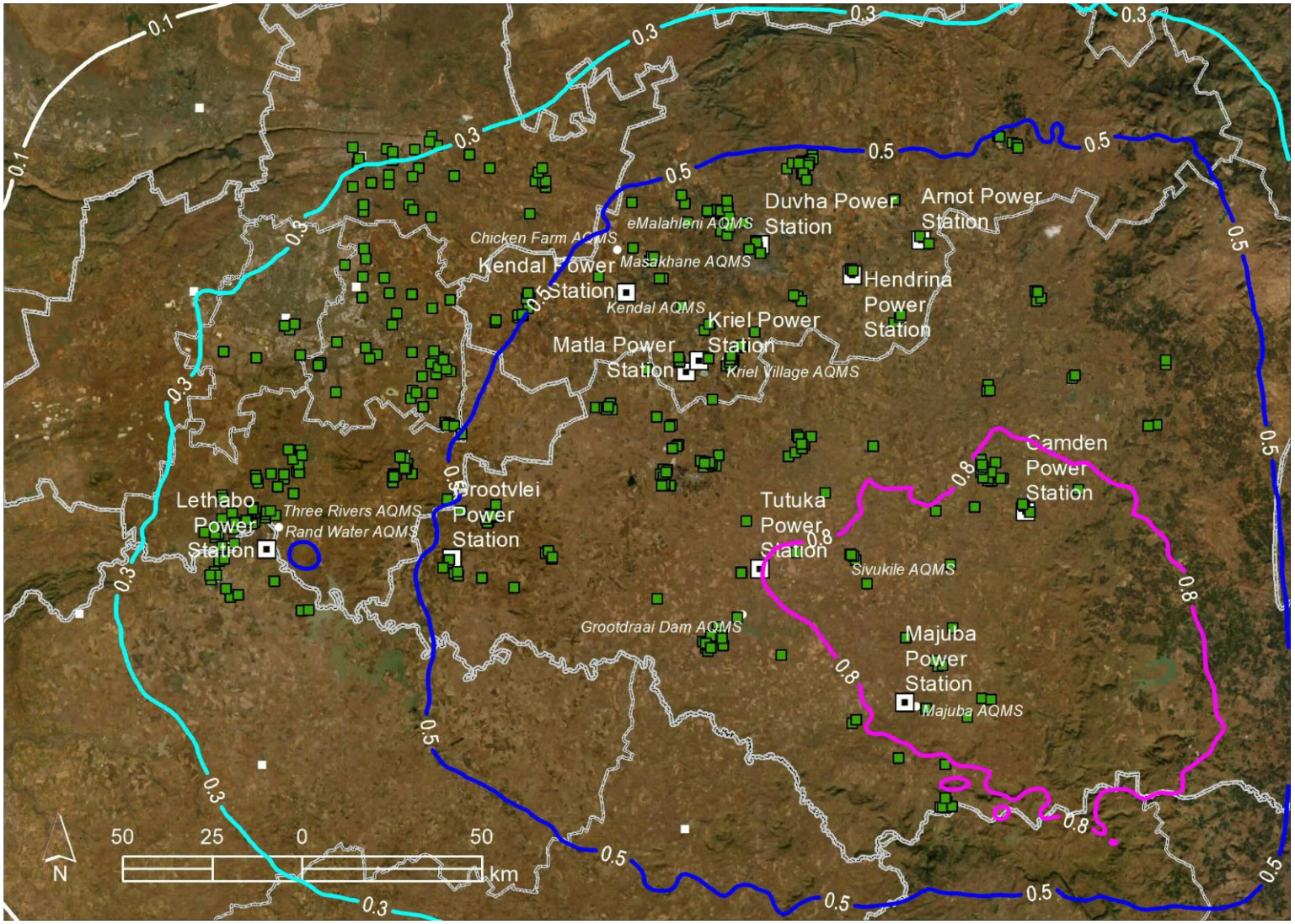


Figure 3-9: Predicted annual average PM_{10} concentrations in µg/m³ for Scenario D (MES) (NAAQS Limit is 40 µg/m³)

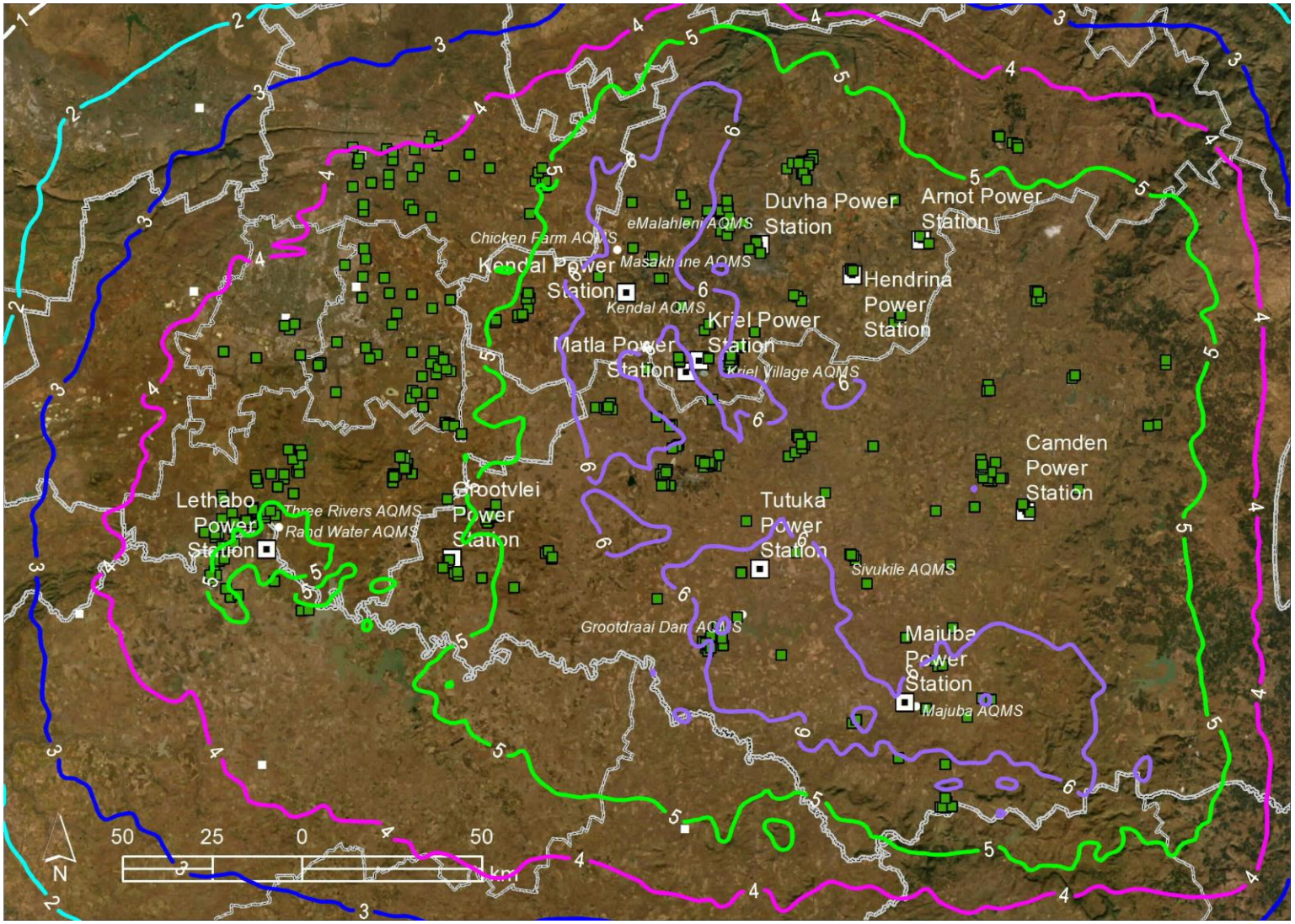


Figure 3-10: Predicted 99th percentile of the 24-hour PM_{10} concentrations in µg/m³ for Scenario D (MES) (NAAQS Limit is 75 µg/m³)

3.4.2 Particulates ($PM_{2.5}$)

In Scenario 1 (Current), the highest predicted annual concentrations occur close to the Majuba and Camden Power Stations. The highest predicted 24-hour concentrations occur close to the Kriel and Matla Power Stations.

The increase in emissions and a reduction in stack exit velocity from Scenario 1 (Current) to Scenario A (2025) is seen by an increase in the predicted concentrations. In Scenario A (2025), the highest predicted annual concentrations occur close to the Camden and Majuba Power Stations. The highest predicted 24-hour concentrations occur close to the Kriel, Matla, Kendal, Duvha, Hendrina, Tutuka, Majuba and Camden Power Stations.

Noticeable is the dramatic effect of station shutdowns of Arnot, Camden, Hendrina, Grootvlei and Kriel by 2031 on the isopleths for Scenario B (2031), where the biggest reductions are seen. In Scenario B (2031), the highest predicted annual concentrations occur close to the Camden and Majuba Power Stations. The highest predicted 24-hour concentrations occur close to the Kriel, Matla and Kendal Power Stations.

The effect of station shutdowns of Duvha and Matla by 2035 are also noticeable on the isopleths for Scenario C (2036). In Scenario C (2036), the highest predicted annual concentrations occur close to the Majuba, Tutuka and Camden Power Stations. The highest predicted 24-hour concentrations occur close to the Tutuka and Majuba Power Stations.

Although $PM_{2.5}$ emissions remain the same for Scenario C (2036) and Scenario D (MES), the predicted $PM_{2.5}$ concentrations show a fairly large decrease on the isopleths for Scenario D (MES) (as discussed previously, this decrease is mainly attributed to the reduced formation of secondary particulates brought about by a substantial decrease in SO_2 emissions between these scenarios). In Scenario D (MES), the highest predicted annual concentrations occur close to the Majuba Power Station. The highest predicted 24-hour concentrations occur close to the Kendal, Tutuka and Majuba Power Stations.

Isopleth maps of the predicted annual average and 99th percentile of the 24-hour $PM_{2.5}$ concentrations are presented in Figure 3-11 to Figure 3-20.

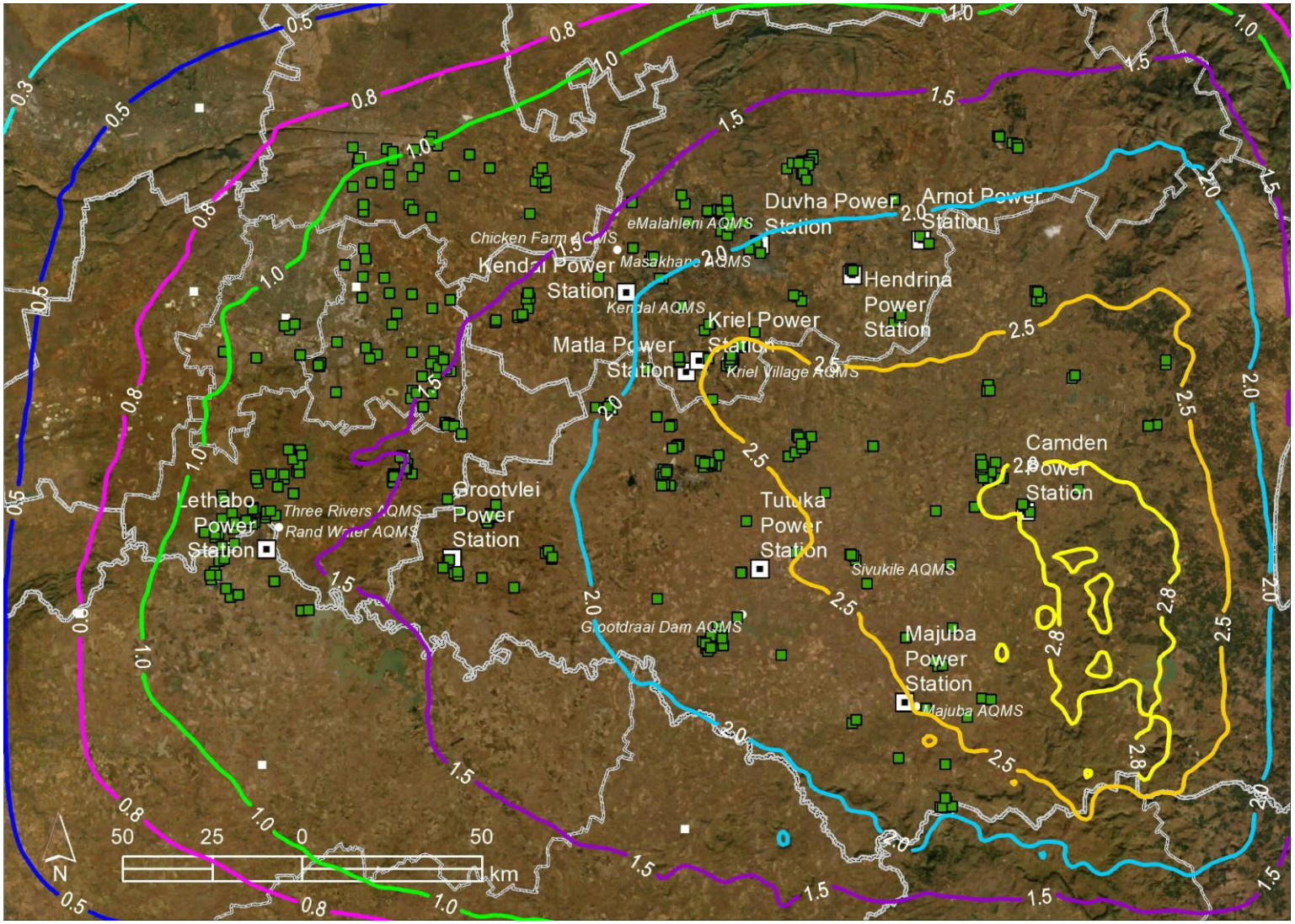


Figure 3-11: Predicted annual average $PM_{2.5}$ concentrations in µg/m³ for Scenario 1 (Current) (NAAQS Limit is 20 µg/m³)

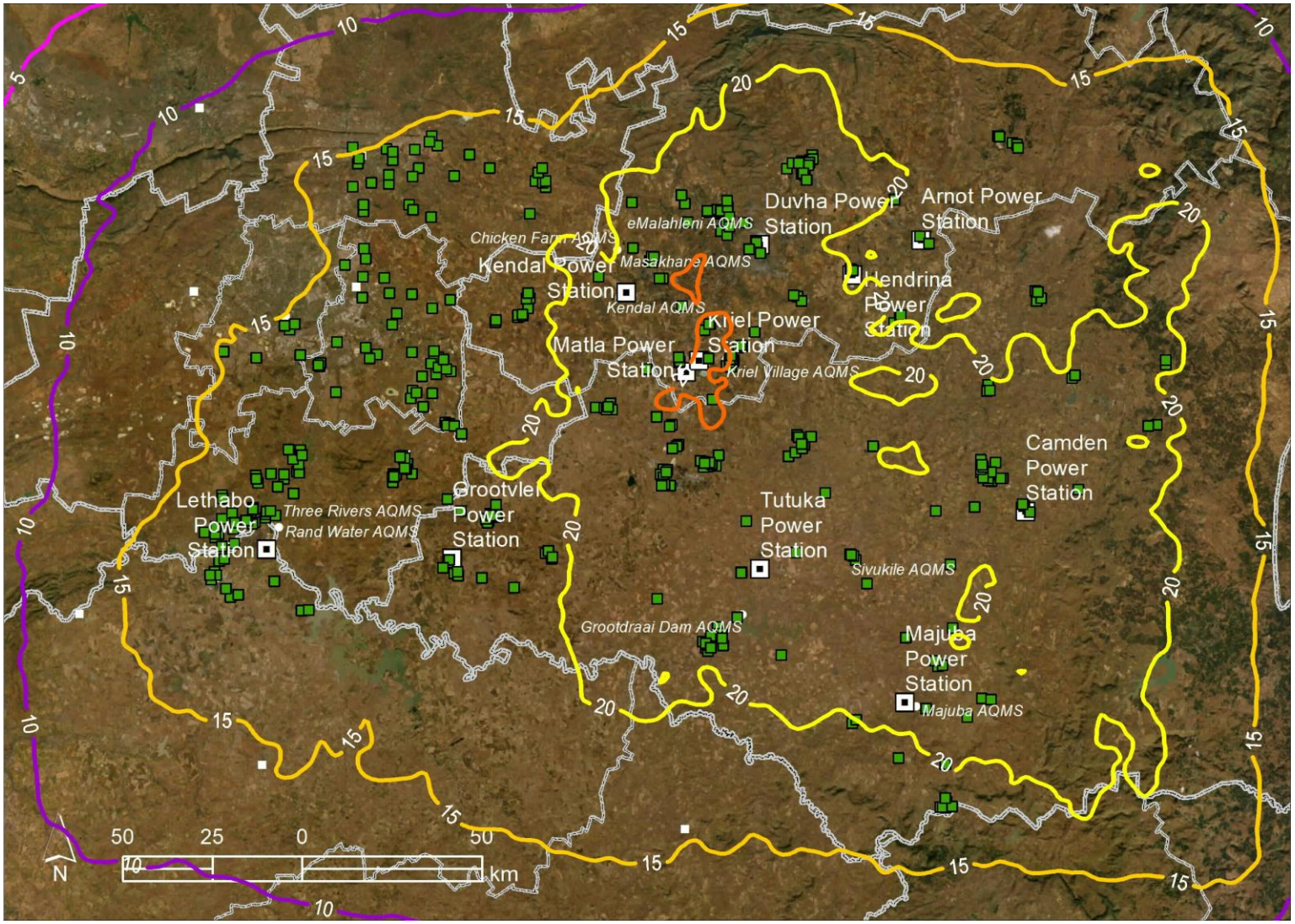


Figure 3-12: Predicted 99th percentile of the 24-hour $PM_{2.5}$ concentrations in µg/m³ for Scenario 1 (Current) (NAAQS Limit is 40 µg/m³)

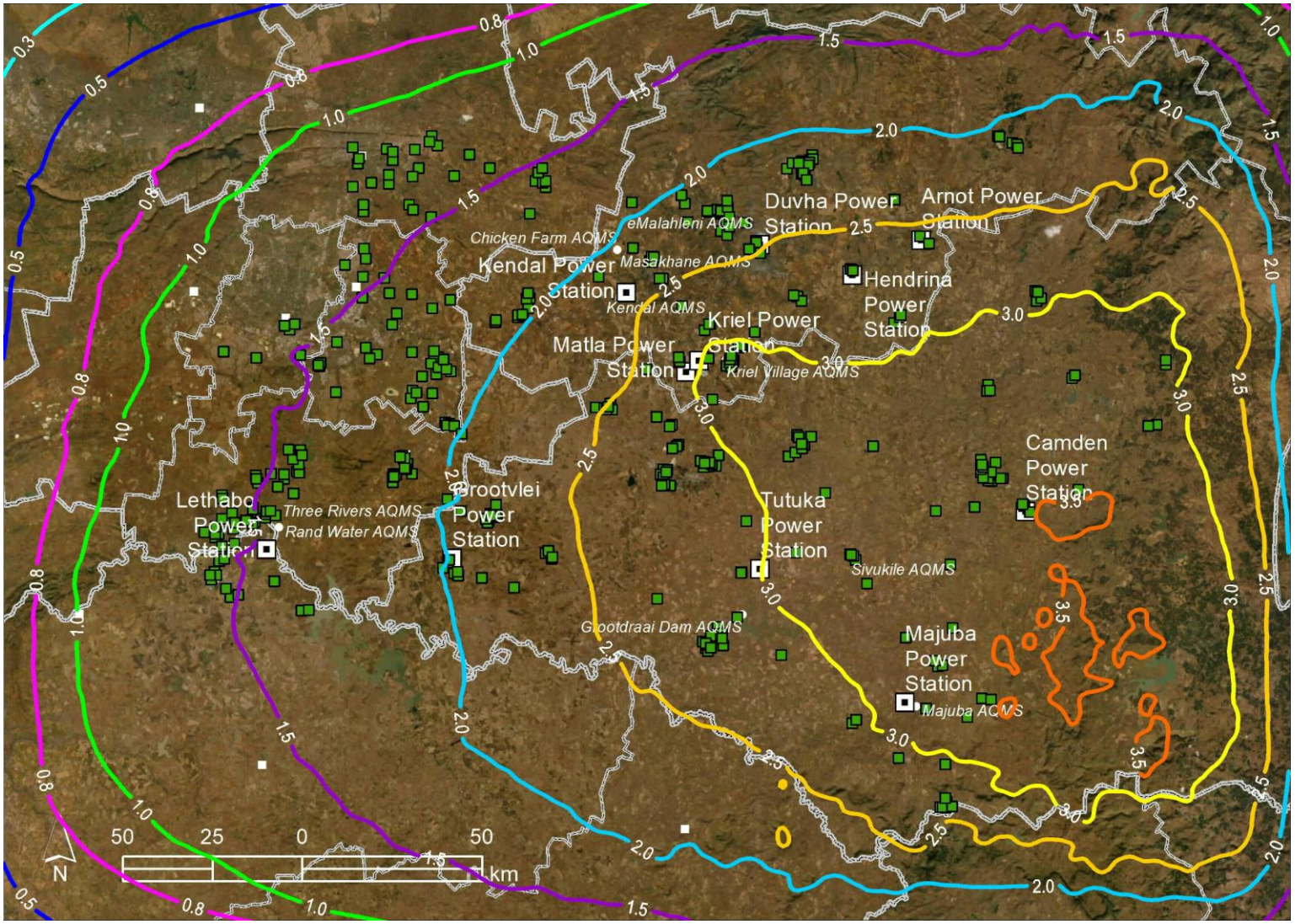


Figure 3-13: Predicted annual average $PM_{2.5}$ concentrations in µg/m³ for Scenario A (2025) (NAAQS Limit is 20 µg/m³)

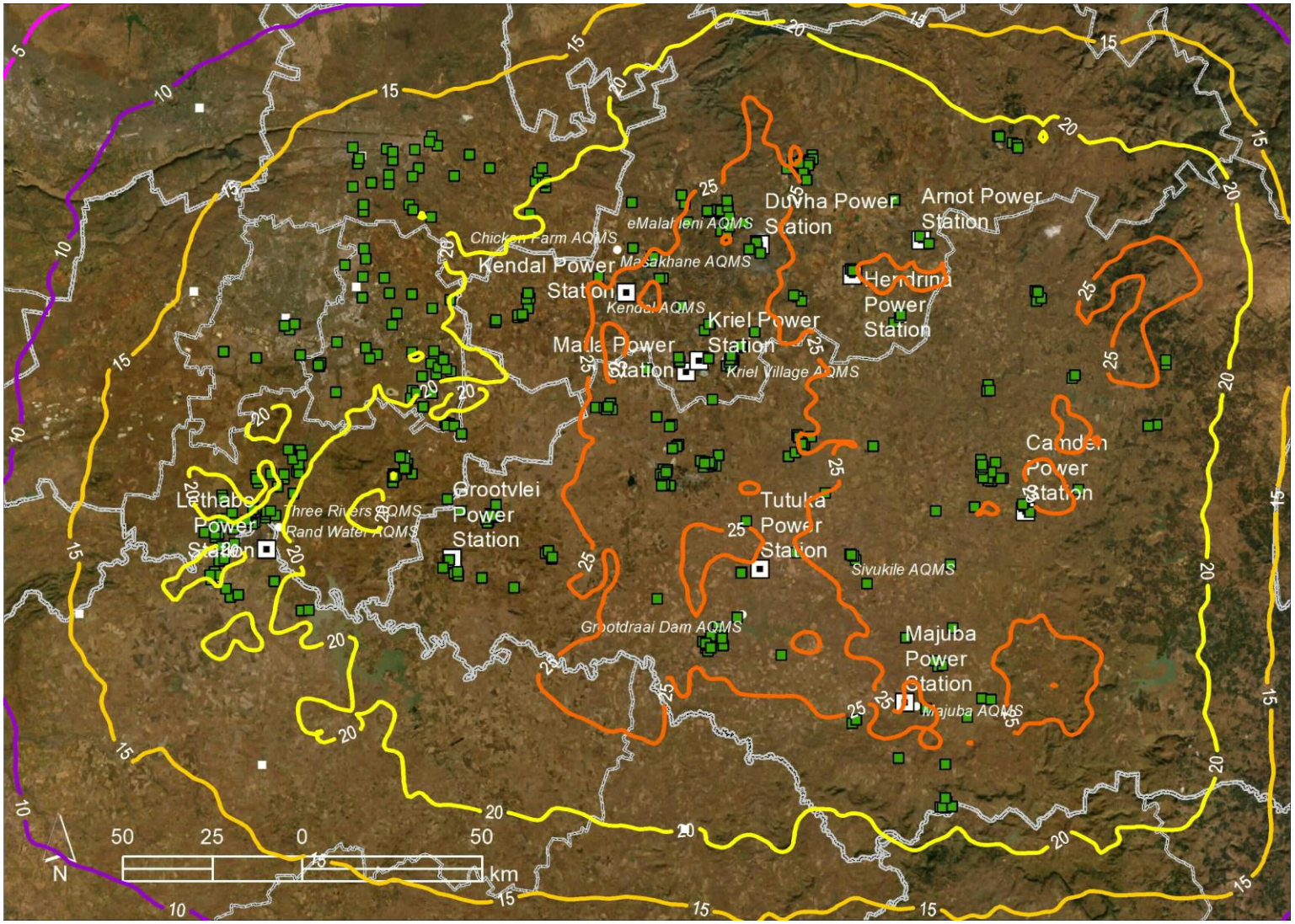


Figure 3-14: Predicted 99th percentile of the 24-hour $PM_{2.5}$ concentrations in µg/m³ for Scenario A (2025) (NAAQS Limit is 40 µg/m³)

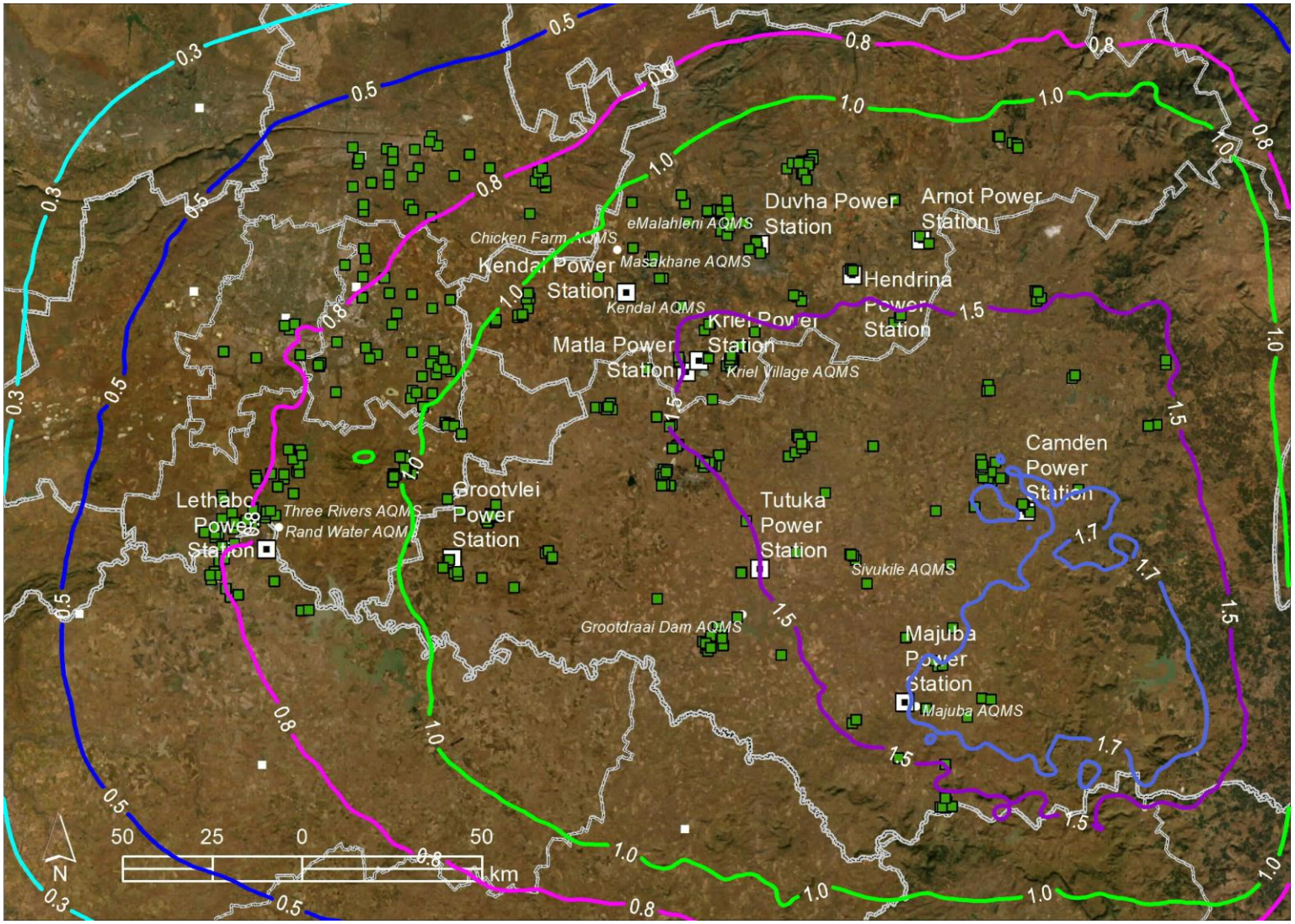


Figure 3-15: Predicted annual average $PM_{2.5}$ concentrations in µg/m³ for Scenario B (2031) (NAAQS Limit is 15 µg/m³)

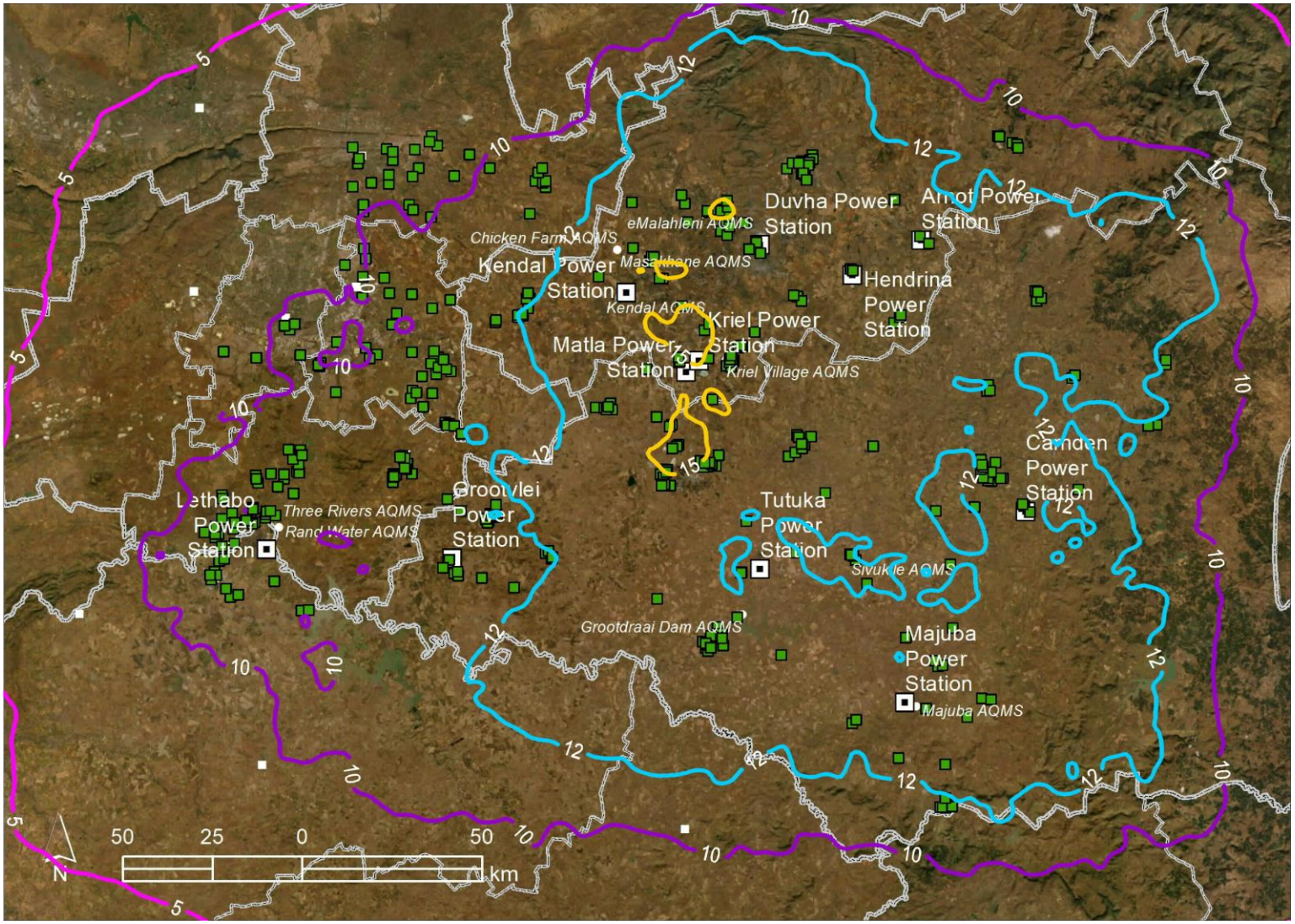


Figure 3-16: Predicted 99th percentile of the 24-hour $PM_{2.5}$ concentrations in µg/m³ for Scenario B (2031) (NAAQS Limit is 25 µg/m³)

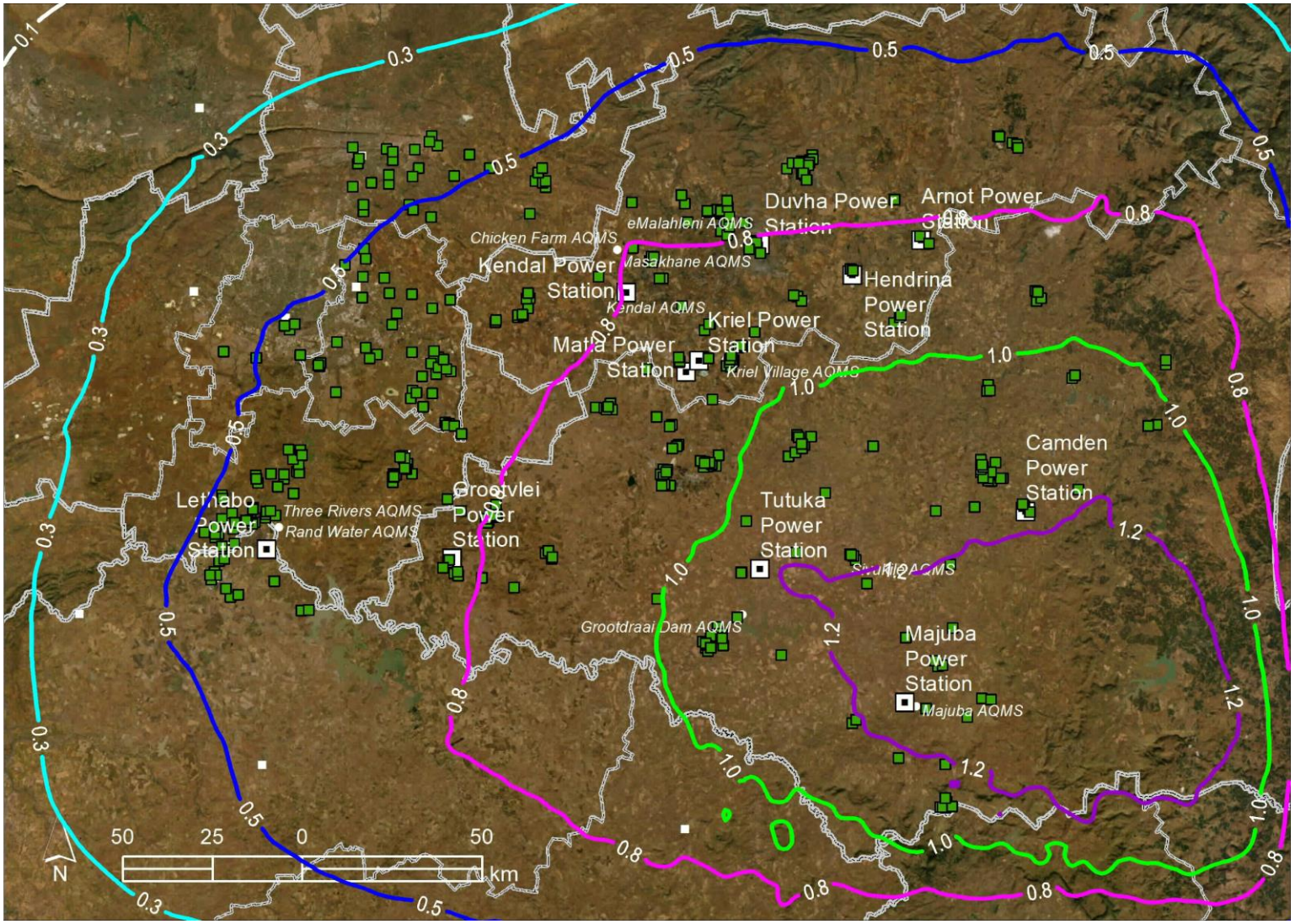


Figure 3-17: Predicted annual average $PM_{2.5}$ concentrations in µg/m³ for Scenario C (2036) (NAAQS Limit is 15 µg/m³)

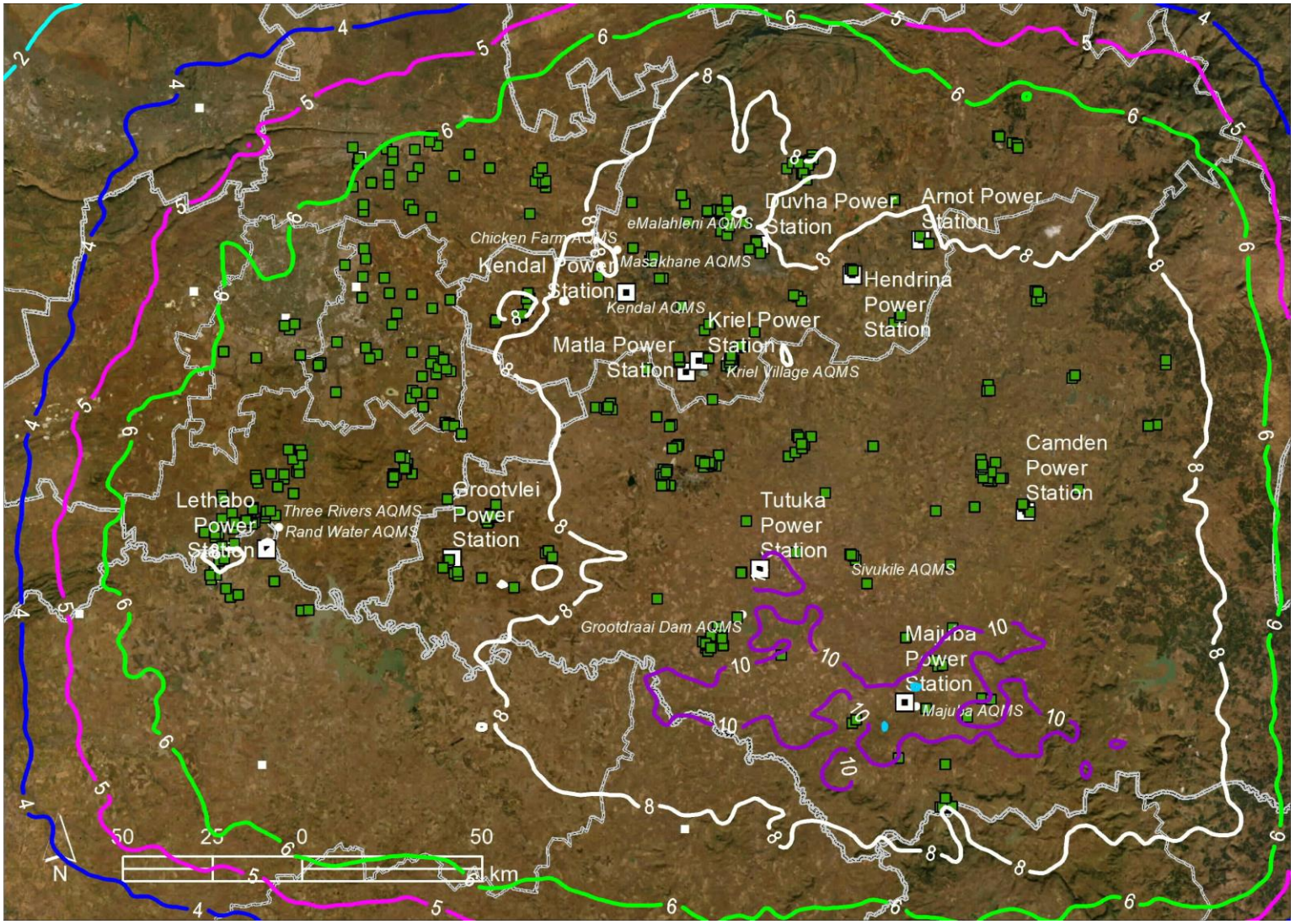


Figure 3-18: Predicted 99th percentile of the 24-hour $PM_{2.5}$ concentrations in µg/m³ for Scenario C (2036) (NAAQS Limit is 25 µg/m³)

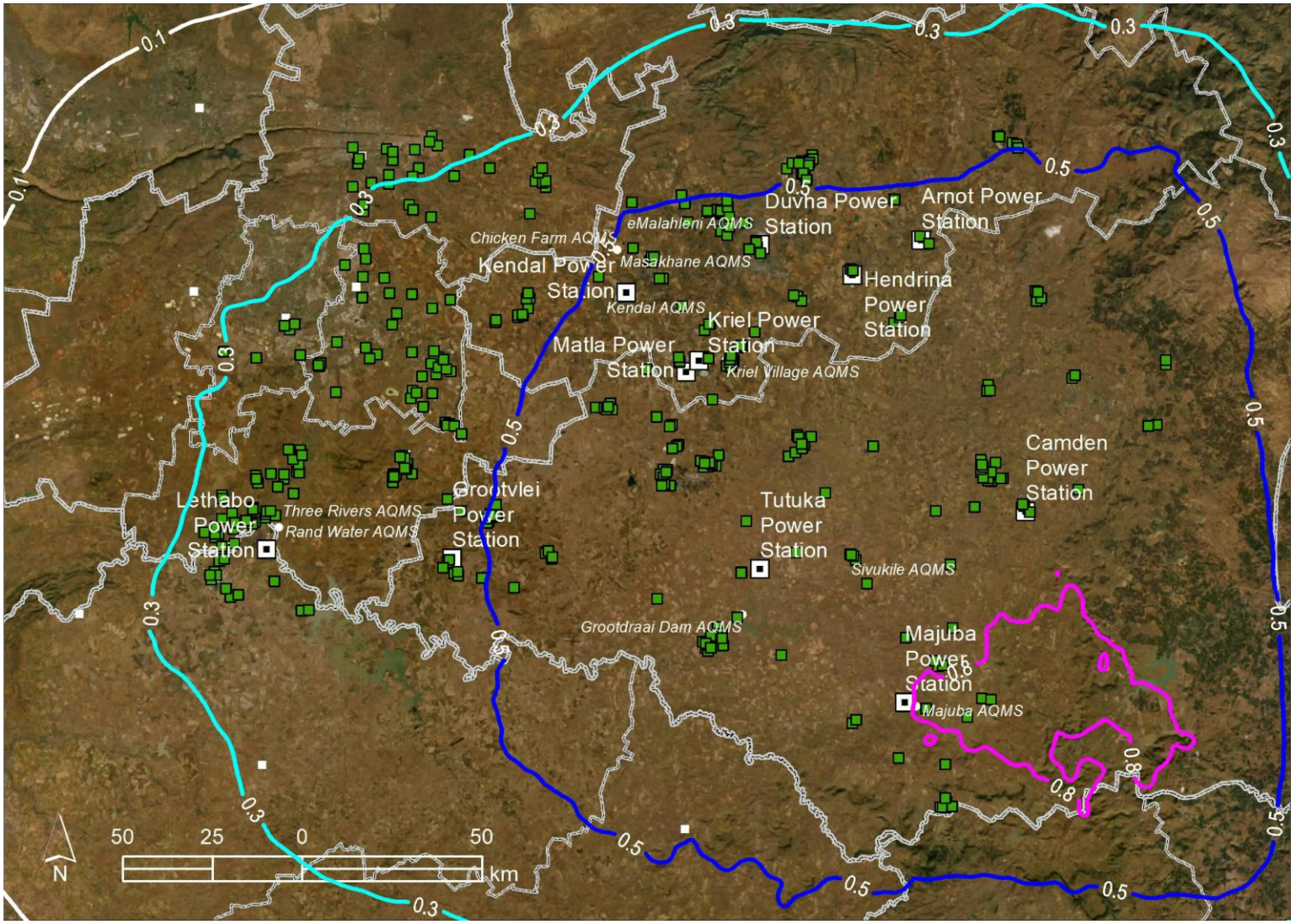


Figure 3-19: Predicted annual average $PM_{2.5}$ concentrations in µg/m³ for Scenario D (MES) (NAAQS Limit is 15 µg/m³)

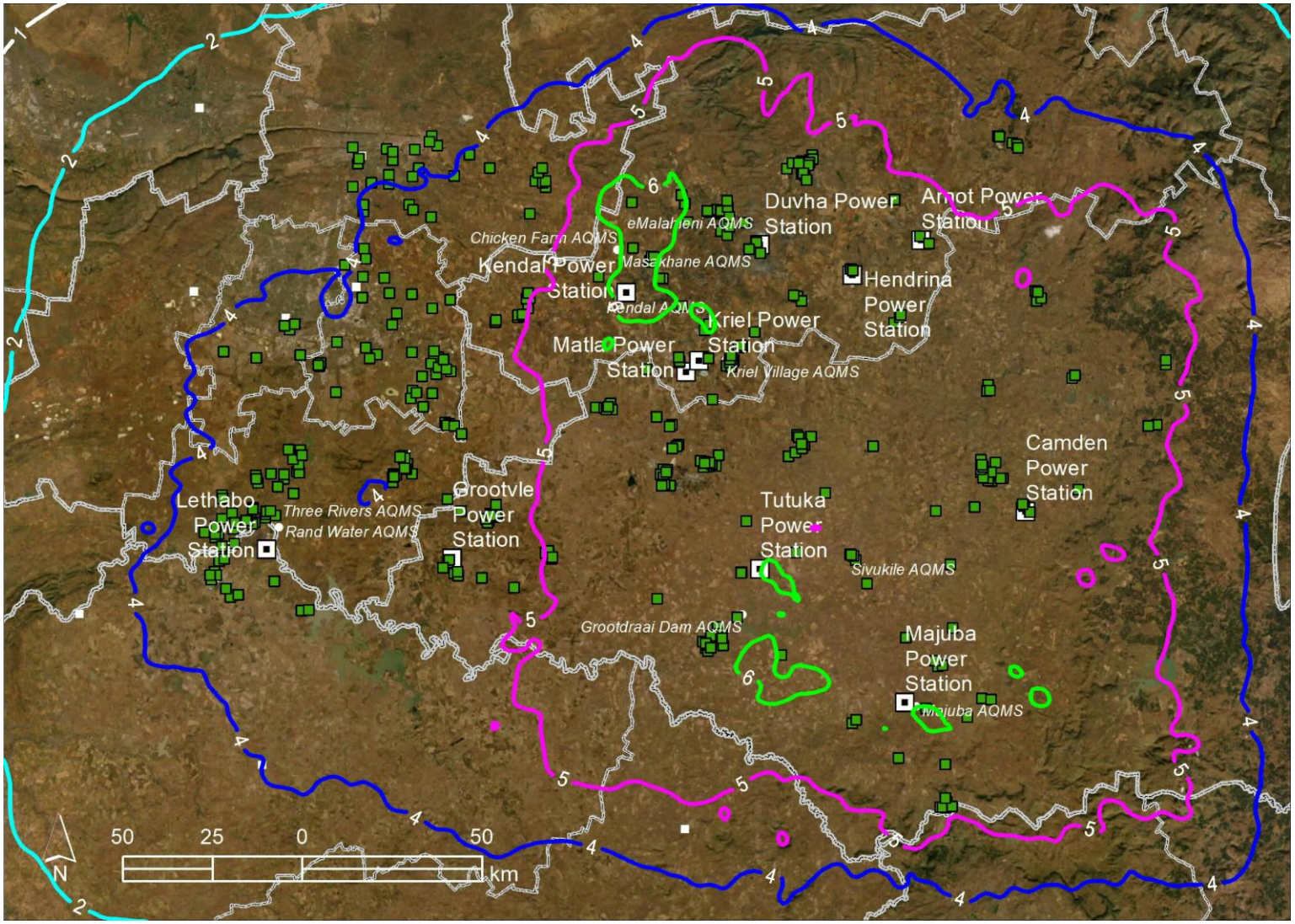


Figure 3-20: Predicted 99th percentile of the 24-hour $PM_{2.5}$ concentrations in µg/m³ for Scenario D (MES) (NAAQS Limit is 25 µg/m³)

4. SUMMARY AND CONCLUSION

In this Addendum to the AIR (uMoya-NILU, 2024), the focus is specifically on stack emissions for PM and the modelled results for PM_{10} and $PM_{2.5}$. In this Addendum, the cumulative effect of stack emissions from 13 coal-fired power stations comprising the Highveld and Vaal power station fleet are assessed, i.e. Arnot, Camden, Duvha, Grootvlei, Hendrina, Kendal, Komati, Kriel, Kusile, Majuba, Matla and Tutuka in the Highveld Priority area and Lethabo in the Vaal Triangle Airshed Priority Area.

Dispersion modelling is used to demonstrate the effect of Eskom's emission reduction strategy by assessing 5 sequential emission scenarios. These are from Scenario 1 using actual emissions from 2021 to 2023, Scenario A using proposed 2025 emissions, Scenario B using proposed 2031 emissions and Scenario C using proposed 2036 emissions. Scenario D uses emissions that comply with the MES to demonstrate the relative effect of compliance.

Noteworthy findings from the modelling results may be summarised as follows:

i) Changes in the predicted annual average and 24-hour PM_{10} and $PM_{2.5}$ concentrations from one scenario to the next are strongly influenced by changes in PM_{10} and $PM_{2.5}$ emissions, the contribution from secondary particulate formation and stack exit velocity.

ii) In all scenarios, the maximum predicted annual average PM_{10} and $PM_{2.5}$ concentrations are well below the limit values of the respective NAAQS. In all scenarios, the maximum predicted 99th percentile of the 24-hour PM_{10} and $PM_{2.5}$ concentrations are in general, relatively low compared to the limit value of the NAAQS. In other words, there are no predicted exceedances of the NAAQS for PM_{10} and $PM_{2.5}$.

iii) The increase in SO_2, NO_X, PM_{10} and $PM_{2.5}$ emissions and a reduction in stack exit velocity from Scenario 1 (Current) to Scenario A (2025) is seen by an increase in the predicted PM_{10} and $PM_{2.5}$ ambient concentrations.

iv) The maximum predicted PM_{10} and $PM_{2.5}$ ambient concentrations decrease significantly from Scenario A (2025) when 13 power stations are in operation to Scenario B (2031) due to the shutdown of 5 power stations (Arnot, Camden, Hendrina, Kriel, Grootvlei); and as a result of PM abatement projects being completed.

v) The slight decrease in PM_{10} and $PM_{2.5}$ ambient concentrations from Scenario B (2031) to Scenario C (2036) is mainly due to the shutdown of the Duvha and Matla generating units (which would have occurred by 2035).

vi) Although PM_{10} and $PM_{2.5}$ emissions remain the same for Scenario C (2036) and Scenario D (MES), it is noted that the maximum predicted PM_{10} and $PM_{2.5}$ ambient concentrations show a fairly large decrease between the two scenarios. This

decrease is mainly attributed to the reduced formation of secondary particulates brought about by a substantial decrease in SO_2 emissions between these scenarios.

vii) At all AQMSs, the modelled PM_{10} and $PM_{2.5}$ concentrations are considerably lower than the monitored concentrations. This is to be expected since the AQMSs are exposed to all sources of PM_{10} and $PM_{2.5}$. The difference between the predicted concentrations and the measured concentrations provides an indication of the contribution of the power station stack emissions at the respective AQMSs.

viii) At all identified sensitive receptors, the predicted PM_{10} and $PM_{2.5}$ concentrations are low and well below the limit value of the respective NAAQS for all five scenarios. Noteworthy is the systematic decrease in predicted PM_{10} and $PM_{2.5}$ concentrations from 2025 to 2036 at all sensitive receptors due to station shutdowns (Arnot, Camden, Hendrina, Kriel, Grootvlei), with most generating units also shutdown at Duvha and Matla by 2035, and PM abatement projects at Tutuka, Duvha and Matla being completed.

5. REFERENCES

DEA (2014): Code of Practice for Air Dispersion Modelling in Air Quality Management in South Africa, Government Notice R.533, Government Gazette, no. 37804, 11 July 2014.

uMoya-NILU (2024): Atmospheric Impact Report in Support of the Application for Exemption from the Minimum Emission Standards for Eskom's Coal-Fired Power Stations on the Highveld and in the Vaal Triangle (A Cumulative Assessment), Report No.: uMN220-24, November 2024.

USEPA (1995): Compilation of air pollutant emission factors. Volume 1: Stationary point and area sources. AP-42 fifth edition January 1995. US EPA

6. FORMAL DECLARATIONS

A declaration of the accuracy of the information contained in this Atmospheric Impact Report is included here. A declaration of the independence of the practitioners in the uMoya-NILU consultancy team that compiled this AIR is also included.

DECLARATION OF ACCURACY OF INFORMATION – APPLICANT

Name of Enterprise: uMoya-NILU Consulting (Pty) Ltd

Declaration of accuracy of information provided:

Atmospheric Impact Report in terms of Section 30 of the Act

I, Mark Zunckel [duly authorised], declare that the information provided in this atmospheric impact report is, to the best of my knowledge, in all respects factually true and correct. I am aware that the supply of false or misleading information to an air quality office is a criminal office in terms of section 51(1)(g) of this Act.

Signed at Durban on this 9th day of December 2024.



SIGNATURE

Managing Director – uMoya-NILU Consulting
CAPACITY OF SIGNATORY

DECLARATION OF INDEPENDENCE – PRACTITIONER

Name of Practitioner: Mark Zunckel

Name of Registered Body: South African Council for Natural Scientific Professionals

Professional Registration Number: 400449/04

Declaration of independence and accuracy of information provided:

Atmospheric Impact Report in terms of Section 30 of the Act

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

Signed at Durban on this 9th day of December 2024.



SIGNATURE

Managing Director – uMoya-NILU Consulting
CAPACITY OF SIGNATORY

ANNEXURE 1: HIGHVELD SENSITIVE RECEPTORS

Area	Sensitive Receptors	Latitude	Longitude
Amersfoort	Elsie Ballot Memorial Hospital	-27.011944	29.858333°
	Laerskool Amersfoort	-27.008678°	29.869944°
	Embuzane Primary School	-27.118291°	29.826786°
	Sangqotho Primary School	-26.941649°	29.765980°
Ezamokuhle	Amersfoort Combined School	-26.997325°	29.850319°
Mooifontein	Injubuko Primary School	-26.914817°	29.897307°
Daggaskraal	Daggakraal Primary School	-27.089170°	29.983250°
	Sizenzele Primary School	-27.137908°	29.943203°
	Seme Secondary School	-27.091589°	30.008177°
	Louwra Primary School	-27.257713°	29.884864°
Perdekop	Perdekop Agricultural School	-27.159970°	29.620400°
	Vukuzenzele Combined School	-27.150944°	29.632386°
	Bambelelani Primary School	-27.175659°	29.749177°
	Gunwana Primary School	-27.244071°	29.752985°
Volksrust	Amajuba Memorial Hospital	-27.351190°	29.890921°
	Volksrust High School	-27.365400°	29.87400°
	Volksrust Municipal Clinic	-27.366264°	29.889272°
	C V O Skool Amajuba	-27.365329°	29.879851°
	Qhubulwazi Combined School	-27.363173°	29.907290°
	Volksrust Primary School	-27.341897°	29.886710°
Ermelo	New Ermelo	-26.534977°	30.026896°
	Ermelo Christian School	-26.543889	29.996389
	Savf Home For Aged	-26.527681°	29.988536°
	Ermelo Hospital	-26.523077°	29.974891°
	Mediclinic Ermelo	-26.542500	29.986389
	Hoerskool Ermelo	-26.526100	29.977900
	Ermelo Indian Combined School	-26.521100	29.965400
	Lungelo Combined School (Outside Town)	-26.622000	29.841700
	New Ermelo Primary School	-26.535600	30.020700
	Kwashashe (Outside Town)	-26.495602°	30.006254°
	Hts Ligbron	-26.536691°	29.986828°
	Laerskool Ermelo	-26.520178°	29.992883°
	JJ Vd Merwe Pre-Primary School	-26.535660°	29.972140°
Wesselton (Ermelo)	Lindile Secondary School	-26.513500°	29.965500°
	Emthonjeni Clinic	-26.508028°	29.971060°
	Reggie Masuku Secondary School	-26.489756°	29.964026°
	Cebisa Secondary School	-26.503265°	29.968324°
Camden	Camden	-26.603573°	30.089437°
	Camden Combined School	-26.618056	30.104444
	Camden School	-26.599100	30.083900
	Umzimvelo Secondary School (Rural Area)	-26.558600	30.238500

Area	Sensitive Receptors	Latitude	Longitude
	BHEKIMFUNDO PRIMARY SCHOOL (Rural Area)	-26.609907°	29.950545°
	ESHWILENI PRIMARY SCHOOL (Rural Area)	-26.754375°	29.885636°
Davel	Davel Combined School	-26.462700°	29.663000°
Morgenzon	Morgenzon Landbou Akademie	-26.749100°	29.621200°
	Nqobangolwazi Secondary School	-26.738700°	29.615000°
	Siqondekhaya Pre Primary School	-26.734260°	29.604270°
	Sizakhele Primary School	-26.734486°	29.607360°
	Phezukwentaba Primary School (South of Morgenzon)	-26.807276°	29.653596°
	Kwaggalaagte Primary School (North of Morgenzon)	-26.581578°	29.531897°
	Sizakhele Clinic/Hospital	-26.735610°	29.608568°
Grootvlei	Grootvlei	-26.765600°	28.483800°
	Olive Grove Country Lodge	-26.785336°	28.467296°
Grootvlei Town	Grootvlei Town (South of Power Station)	-26.798562°	28.505729°
	Laerskool Grootvlei	-26.799705°	28.499296°
	Tokoloho Primary School	-26.805037°	28.509491°
	Tshepeha Combined School	-26.794589°	28.507561°
	Warembo Lodge	-26.809803°	28.575820°
Balfour	Balfour	-26.647368°	28.597344°
	Siyathemba	-26.651574°	28.611242°
	Bonukukhanya Primary (Siyathemba)	-26.656389°	28.610556°
	Qalabocha Primary School (Siyathemba)	-26.648510°	28.610239°
	Vusumuzi Primary School	-26.649302°	28.614483°
	Gekombineerde Skool Balfour	-26.666111°	28.593056°
	Im Manchu Secondary School	-26.662885°	28.585658°
	Isifisosethu Secondary School (Siyathemba)	-26.654091°	28.616910°
	Setsheng Secondary School (Siyathemba)	-26.646036°	28.613849°
	Dr Nieuwoudt And Dr Kok	-26.670556	28.589722
	Balfour Clinic	-26.660521°	28.584954°
	Siyathemba Clinic	-26.651428°	28.598763°
	Mondoro Lodge	-26.641806°	28.515683°
	Wegelegen Manor	-26.625555°	28.612550°
	The Stone Cellar	-26.611667	28.478056
Greylingstad	Greylingstad	-26.744551°	28.753659°
	Nthorwane	-26.759041°	28.771550°
	Laerskool Greylingstad	-26.740120°	28.761680°
	Nthoroane Secondary School	-26.755300	28.772500
	Badgarleur Bush Lodge	-26.832190°	28.666044°
Matla	Matla Village	-26.259808°	29.119138°
	Sifundise Primary School	-26.257623°	29.120118°
	Kwanala Primary School	-26.249384°	29.199724°
	Matla Coal Health Centre	-26.247649°	29.116928°
	Gweda Primary School	-26.352145°	29.212688°

Area	Sensitive Receptors	Latitude	Longitude
	Zithobe Primary School	-26.278423°	29.027500°
Kriel power station area	Kwanala Primary School	-26.249300°	29.200000°
Reedstream Park	Reedstream Park	-26.178723°	29.188144°
	Rietspruit Clinic	-26.162067°	29.202676°
	Lehlaka Combined School	-26.162533°	29.199891°
Blesboklaagte	Mbali Coal/Blesboklaagte Housing	-26.118280°	29.123520°
Kinross	Kinross	-26.417917°	29.100765°
	Kinross Settlement	-26.397865°	29.058050°
	Kinross Municipal Clinic	-26.421365°	29.094224°
Kriel	Kriel	-26.267078°	29.250870°
	Eagles Nest Guest House	-26.269553°	29.262920°
	Merlin Park Primary School	-26.251667°	29.270000°
	Kriel Medical Centre	-26.256300°	29.269300°
	Laerskool Krielpark	-26.258300°	29.258500°
	Laerskool Onverwacht	-26.250423°	29.265348°
	SILWER FLEUR AFTREE OORD (Old Age Home)	-26.251217°	29.260131°
Thubelihle	Thubelihle	-26.220737°	29.282778°
	Sibongamandla Secondary School	-26.215556	29.290000
	Ga-Nala Clinic	-26.241511°	29.263001°
	Impilo Primary School	-26.180232°	29.327259°
	Bonginhlanhla Primary School	-26.217923°	29.294090°
	Sibongamandla Secondary School	-26.215364°	29.290280°
Leandra	Leandra	-26.365552°	28.928450°
	Eendracht	-26.376131°	28.887873°
	Sidingulwazi Primary School	-26.377834°	28.910979°
	Ss Mshayisa Primary School	-26.381610°	28.933930°
	Chief Ampie Mayisa Secondary School	-26.381780°	28.918580°
	Lebogang Clinic	-26.375431°	28.921864°
Standerton	Kleuterskool Haas Das	-26.944550°	29.248400°
	Standerton Primary School	-26.941451°	29.250405°
	Laerskool Jeugkrag	-26.924090°	29.237685°
	Laerskool Standerton	-26.948786°	29.249351°
	Laerskool Kalie De Haas	-26.970223°	29.254828°
	Hoerskool Standerton	-26.941403°	29.250366°
	Standerton Provincial Government Hospital	-26.940531°	29.245199°
	Mar-Peh Medicare Private Hospital	-26.950190°	29.244825°
	Standerton Retirement Home	-26.952576°	29.244483°
	Standerton Ouetehuis/Old Age Home	-26.952129°	29.251705°
	Holmdene Secondary School	-26.854996°	29.068283°
	Cathuza Primary School (SE Of Town)	-26.991900°	29.417721°
Sakhile	Sizanani Pre Primary School	-26.965600°	29.219060°
	Hlobisa Primary School	-26.976914°	29.206318°

Area	Sensitive Receptors	Latitude	Longitude
	Shukuma Primary School	-26.985407°	29.213005°
	Retsebile Primary School	-26.961930°	29.197353°
	Thuto-Thebe Secondary School	-26.947030°	29.220020°
	Jandrell Secondary School	-26.969768°	29.207290°
	Thobelani Secondary School	-26.965240°	29.206523°
	Standerton Tb Hospital	-26.977124°	29.219607°
Thuthukani	Thuthukani Pre Primary School	-26.786030°	29.303590°
	Ulwazi Primary School	-26.785680°	29.301080°
	Zikhetheleni Secondary School	-26.787403°	29.301062°
	Joubertsvlei Primary School (North of Tutuka)	-26.657110°	29.312830°
	Amalumgelo Primary School (NE Of Tutuka)	-26.733160°	29.453775°
Grootdraai Dam	Grootdraaidam Primary School	-26.898947°	29.292610°
Secunda	Laerskool Secunda	-26.509385°	29.193941°
	Laerskool Kruinpark	-26.519159°	29.225740°
	Laerskool Oranjegloed Primary	-26.521260°	29.203110°
	Curro Castle Combined School	-26.523097°	29.191675°
	Hoërskool Oosterland	-26.515283°	29.214972°
	Mediclinic Secunda (Hospital)	-26.507573°	29.182451°
	Mediclinic Highveld (Hospital_Trichardt, Secunda)	-26.492055°	29.232606°
	Daviescourt/Davieshof Old Age Home	-26.511249°	29.198892°
	Highveld Park High School	-26.510499°	29.208618°
	Hoerskool Secunda	-26.512707°	29.194632°
EMBALENHLE	Basizeni Special School	-26.530052°	29.079094°
	Maphala-Gulube Primary School	-26.570566°	29.099115°
	Shapeve Primary School	-26.531614°	29.090534°
	Thomas Nhlabathi Secondary School	-26.543169°	29.071362°
	Embalenhle Hospital / Clinic	-26.550013°	29.080121°
	Vukuzithathe Primary School	-26.567722°	29.083243°
	K I Twala Secondary	-26.570501°	29.075089°
	Allan Makunga Primary School	-26.537324°	29.087230°
Evander	Evander Hospital Arv Clinic	-26.467000°	29.120000°
	Laerskool Hoeveld	-26.470539°	29.115757°
	Hoerskool Evander	-26.477655°	29.103231°
Delmas	Bernice Samuel Hospital	-26.152500°	28.667100°
	Hoerskool Delmas	-26.147355°	28.667599°
	Laerskool Delmas	-26.147749°	28.681442°
	Kangela Primary School (North of Delpark)	-26.130000°	28.695000°
	Savf Ons Eie Ouetehuis / Old Age Home	-26.146154°	28.680927°
Eloff	Laerskool Eloff	-26.165971°	28.605106°
	Rietkol Primary School	-26.159963°	28.606432°
Botleng	Bazani Primary School	-26.104500°	28.699400°
	Phaphamani Secondary School	-26.105839°	28.690500°
	Vezimfundo Primary School	-26.091625°	28.694387°

Area	Sensitive Receptors	Latitude	Longitude
Arbor	Arbor Primary School	-26.048219°	28.889804°
Ogies	Ogies Combined School	-26.049221°	29.068832°
	Umthombo Wolwazi Farm School	-26.156451°	28.930509°
	Kendal	-26.079592°	28.975296°
	Ogies Tb Clinic	-26.049669°	29.059596°
	Ogies Police Station	-26.049669°	29.059596°
Phola	Hlangu Phala Primary School	-26.006460°	29.032484°
	Sukumani Primary School	-26.005724°	29.036428°
	Thuthukani Primary School	-26.008877°	29.038899°
	Mehlwana Secondary School	-25.995286°	29.037621°
	Makause Combined School	-25.996758°	29.043456°
Wilge	Sibongindawo Primary School	-25.974651°	28.984930°
Balmoral	Laerskool Balmoral	-25.859262°	28.980030°
Emalahleni	Clewer Primary School	-25.906838°	29.136114°
	Witbank High School	-25.884914°	29.226438°
	Eden Park Retirement Village	-25.902283°	29.237194°
	Savf House Immergroen Old Age Home	-25.879707°	29.217916°
	MTHIMKULU Housing for the Aged	-25.881082°	29.189281°
	Emalahleni Private Hospital	-25.874996°	29.216316°
	Life Cosmos Hospital	-25.883956°	29.232671°
	Duvha Primary School	-25.928700°	29.228835°
	Laerskool Taalfees	-25.882069°	29.226736°
	Witbank Provincial Hospital	-25.876855°	29.226772°
	Nancy Shiba Primary School (Vosman)	-25.860442°	29.127636°
	Wh De Klerk Skool	-25.867762°	29.246453°
	Laerskool Panorama	-25.852265°	29.244652°
	Laerskool Duvhapark	-25.938354°	29.245539°
	Laerskool Klipfontein	-25.904014°	29.241984°
	Cambridge Academy	-25.893439°	29.251575°
	Besilindile Primary School	-25.839035°	29.116774°
	Reynopark High School	-25.916428°	29.252116°
	Bakenveld Golf Estate	-25.905932°	29.292706°
	Mms Primary School	-25.905558°	29.385417°
	Bongiduvha Primary School	-25.983853°	29.335681°
	Springvalley Primary School	-25.921086°	29.260948°
	Joy Crèche	-25.972528°	29.308427°
	Curro Bankenveld Preschool and Primary School	-25.905248°	29.277348°
	Little Eden Academy	-25.917056°	29.253835°
	Little Steps Pre School	-25.944674°	29.251428°
	Allendale Secondary School	-25.982387°	29.338986°
	Khayalethu Primary School	-25.877710°	29.189130°
	Illanga Secondary School	-25.955537°	29.327107°
	Joy Creche (Duvha)	-25.972408°	29.308161°
Middelburg	Linderus Old Age Home	-25.784009°	29.459212°

Area	Sensitive Receptors	Latitude	Longitude
	Vergeet My Nie Old Age Home	-25.780787°	29.449413°
	Middleburg Frail Care Unit and Home for Elderly	-25.746481°	29.471782°
	Life Midmed Hospital	-25.763147°	29.457650°
	Middelburg Hospital	-25.775692°	29.450413°
	Makhathini Primary School	-25.749305°	29.448461°
	Laerskool Dennesig	-25.733488°	29.478283°
	Hoerskool Kanonkop	-25.742627°	29.479874°
	Laerskool Kanonkop	-25.751354°	29.470764°
	Steelcrest High School	-25.759514°	29.468012°
	Middelburg Primary	-25.778514°	29.453271°
	Middleburg Ext 6 Clinic	-25.768193°	29.407838°
	Sofunda Secondary School	-25.754358°	29.423801°
	Mhluzi Primary School	-25.753279°	29.440498°
	Highlands Primary School	-25.795886°	29.463428°
Komati	Blinkpan Primary School	-26.089884°	29.444406°
	Laerskool Koornfontein	-26.099868°	29.456226°
	Blinkpan	-26.086337°	29.433989°
Pullens Hope	Laerskool Kragveld	-26.016735°	29.590369°
	Pullens Hope	-26.020916°	29.597472°
Rietkuil / Arnot	Arnot Colliery Primary School	-25.932110°	29.780624°
	Laerskool Rietkuil	-25.949477°	29.807062°
	Beestepan Agricultural School	-25.841453°	29.709393°
Hendrina	Gekombineerde Skool Hendrina	-26.151386°	29.713726°
Kwazamokhule	Hendrina Primary School	-26.136847°	29.729098°
	Kwazamokuhle Secondary School	-26.131117°	29.732418°
Lothair	Ubuhle Bolwai Secondary School	-26.391734°	30.452159°
	Lothair Primary School	-26.394524°	30.428535°
Warburton	Warburton Combined School	-26.239852°	30.472477°
	Warburton Town	-26.227585°	30.472905°
Chrissiesmeer	Kwachibikhulu Clinic	-26.280125°	30.213918°
	Kwachibikhulu Primary School	-26.272378°	30.221621°
Carolina	Carolina Hospital	-26.074581°	30.111313°
	Zinikeleni Secondary School (Silobela)	-26.087874°	30.109848°
	Volkskool Carolina	-26.062907°	30.106394°
	Sobuza Primary School	-26.080382°	30.122447°
	Ons Eie Ouetehuis (Old Age Home)	-26.065018°	30.112066°
Breyten	Laerskool Breyten	-26.301603°	29.979961°
	Siyazi Primary School (Kwazanele)	-26.316644°	29.977882°
	Masizakhe Secondary School (Kwazanele)	-26.315348°	29.984385°
Belfast	Belfast Rusoord (Old Age Home)	-25.691737°	30.031956°
	Belfast Hospital	-25.696074°	30.043783°
	Platorand School	-25.704015°	30.047859°
	Belfast Primary School (Siyathuthuka)	-25.675303°	29.991119°
	Siyathuthuka Clinic	-25.676301°	29.995601°

Area	Sensitive Receptors	Latitude	Longitude
Bethal	Life Bethal Hospital	-26.464532°	29.467456°
	Hoerskool Hoogenhout	-26.461930°	29.472023°
	Jim Van Tonderskool	-26.436887°	29.450970°
	Bethal Independent Primary School	-26.442824°	29.454517°
	Laerskool Marietjie Van Niekerk	-26.440565°	29.489773°
	Laerskool Hm Swart	-26.459925°	29.465474°
	Sakhisizwe Primary School (Emzinoni)	-26.492311°	29.427359°
	Alpheus D Nkosi Secondary School (Emzinoni)	-26.480923°	29.446290°
	Silwerjare Old Age Home	-26.470954°	29.465659°
	Residentia Palm Oord	-26.460488°	29.462766°
Bronkhorstspruit	Bronkhorspruit Hospital	-25.803183°	28.716819°
	Cultura High School	-25.824833°	28.739116°
	Bronkhorspruit Primary School	-25.809124°	28.710617°
	Bronkhorspruit Dam	-25.891281°	28.697112°
	Hoerskool Erasmus	-25.813056°	28.732392°
	Althea Independent School	-25.809393°	28.739630°
	Kgoro Primary School (Zithobeni)	-25.787526°	28.718686°
	Zithobeni Secondary School (Zithobeni)	-25.776080°	28.729297°
Sasolburg	Vaal Power Ah	-26.823034°	27.995199°
	Sasolburg Provincial Hospital	-26.801004°	27.827226°
	Moredou Old Age Home	-26.820627°	27.818609°
	Ons Gryse Jeug Old Age Home	-26.808971°	27.829287°
	Noord Primere Skool	-26.809079°	27.833205°
	Sasolburg High School	-26.809493°	27.815540°
Zamdela	Sakhubusa Secondary School	-26.864383°	27.872379°
	Bekezela Primary School	-26.858275°	27.895183°
	Isaac Mhlambi Primary	-26.843253°	27.860477°
Deneysville	Refenkgotso Primary School	-26.896796°	28.071849°
	Deneysville Primary School	-26.894767°	28.091936°
Vaalpark	Netcare Vaalpark Hospital	-26.772921°	27.840020°
	Vaalpark Articon Secondary School	-26.766998°	27.854563°
Vanderbijlpark	Mediclinic Emfuleni	-26.705051°	27.837480°
	Curro Vanderbijlpark	-26.721637°	27.881353°
	Jeugland Old Age Home	-26.714240°	27.829000°
	Herfsoord Huis Old Age Home	-26.705218°	27.828579°
	Vaal Christian Combined School	-26.760827°	27.945336°
	Pele-Ya-Pele Secondary School	-26.758447°	27.948168°
	Huis Prinscilla	-26.686758°	27.830074°
	Laerskool Emfulenipark	-26.736622°	27.848162°
	Nw University_Vaal Campus	-26.729104°	27.882396°
	Emfuleni Primary School	-26.701230°	27.798581°
Vereeniging	Mediclinic Vereeniging	-26.669380°	27.927271°
	Kopanong Provincial Hospital (Duncanville)	-26.638409°	27.933352°

Area	Sensitive Receptors	Latitude	Longitude
	Pride Junior High School	-26.673626°	27.930727°
	Milton Primary School	-26.664438°	27.967937°
	Avondrus Eventide Old Age Home	-26.642726°	27.934453°
	Riviera On Vaal Resort	-26.675535°	27.939516°
	Selborne Primary School	-26.670181°	27.918206°
	Sedibeng TVET College	-26.679262°	27.931965°
	General Smuts High School	-26.672889°	27.917628°
	Eureuka School & Selbourne Primary	-26.670308°	27.914584°
Three Rivers	Midvaal Private Hospital (Three Rivers)	-26.663943°	27.969386°
	Three Rivers Retirement Village	-26.654433°	27.970966°
	Drie Riviere Aftreeoord Old Age Home	-26.648419°	27.972201°
	Fundamental Faculty and Factory	-26.662652°	27.979278°
	Mannabos Retirement Centre	-26.659008°	28.007140°
	Riverside High School	-26.657354°	27.997307°
	Hoërskool Drie Riviere	-26.658617°	27.974794°
	Laerskool Drie Riviere	-26.656514°	27.967703°
	Panfontein Intermediate School	-26.718701°	28.017031°
	Risiville Primary School	-26.645815°	27.982017°
Sebokeng	Sebokeng Hospital	-26.607161°	27.847550°
	Clinix-Naledzi Private Hospital	-26.616004°	27.848311°
Sharpville	Mohloli Secondary School	-26.691794°	27.878703°
	Tshirela Primary School (Boipatong)	-26.667125°	27.846609°
	Tsoaranang Primary School (Thepiso)	-26.672748°	27.875504°
	Thepiso Primary School	-26.652388°	27.875650°
	Emmanuel Primary School	-26.676238°	27.883255°
Rust Ter Vaal	Rust Ter Vaal Combined School	-26.575722°	27.947132°
Dadaville	Roshnee Primary School	-26.557834°	27.940930°
	Roshnee High School	-26.566323°	27.942320°
Meyerton	Hoerskool Dr Malan	-26.564977°	28.019234°
	Laerskool Voorwaarts	-26.601766°	28.046543°
	Meyerton Secondary School	-26.585957°	28.003034°
	Ratasetjhaba Primary School	-26.553412°	27.983147°
	Meyerton Primary School	-26.553487°	28.020296°
Henley On Klip	Oprah Leadership Academy	-26.547041°	28.055309°
	Henley River Retirement Village	-26.548818°	28.062594°
	Henley High & Preparatory School	-26.528413°	28.060892°
	Randvaal Clinic	-26.515421°	28.044906°
Daleside / Valley Settlements	Laerskool Japie Greyling	-26.492618°	28.065508°
	Thomas Nhlapo Primary	-26.506179°	28.069969°
	Randvaal Old Age Home	-26.491357°	28.032070°
Heidelberg	Laerskool Ag Visser	-26.527385°	28.364387°
	Lethaba Siyangobe	-26.535127°	28.363146°

Area	Sensitive Receptors	Latitude	Longitude
	Shalimar Ridge Primary School	-26.512296°	28.352566°
	Jw Luckoff High School	-26.550141°	28.377976°
	Heidelberg Hospital	-26.505180°	28.350463°
	Thulatsatsi Operation (Rensburg)	-26.524848°	28.363676°
	Silwer Akker Tehuis	-26.510276°	28.356255°
	Riversands Retirement Village	-26.507195°	28.343400°
Ratanda	Qhaqholla Primary School	-26.550719°	28.325743°
	Ratanda Primary School	-26.571045°	28.323848°
	Boneha Primary School	-26.551890°	28.328050°
	Sithokomele Primary School	-26.552180°	28.332480°
	Ratanda Bertha Gxowa Primary School	-26.539078°	28.360724°
	Khanya Lesedi Secondary School	-26.558920°	28.323980°
	Ratanda Secondary School	-26.556930°	28.327600°
	New Ratanda Secondary School	-26.536066°	28.356365°
	Kgoro Ya Thuto Secondary School	-26.536087°	28.356288°
Katlehong	Ekurhuleni School For the Deaf	-26.345596°	28.163239°
Tsakane	Pholosong Hospital	-26.340323°	28.376981°
	Tsakane Home For Aged	-26.359892°	28.371919°
	Mmuso Primary School	-26.380790°	28.406465°
	Michael Zulu Primary School	-26.345305°	28.387950°
	Nkabinde Primary School (Thembilisha)	-26.303995°	28.403039°
Nigel	Nigel Clinic	-26.419586°	28.467950°
	Tehuis Vir Bejaardes	-26.422307°	28.479643°
	Hoerskool John Vorster	-26.427357°	28.472668°
	Laerskool Hannes Visagie	-26.427603°	28.494581°
	Nigel Secondary School	-26.447243°	28.514293°
	Laerskool Dunnottar	-26.346668°	28.431510°
Springs	Springs Retirement Village	-26.255461°	28.447029°
	Life Springs Parkland Hospital	-26.266018°	28.435500°
	Netcare N17 Hospital (Springs)	-26.271306°	28.427831°
	Springs Boys High School	-26.298323°	28.442511°
	Laerskool Selectionpark	-26.280731°	28.447617°
	Kwasa College Pre&Primary School	-26.290089°	28.483292°
	Edelweis Medical Centre	-26.285282°	28.469920°
	Laerskool Christiaan Beyers	-26.260785°	28.462528°
	Hoerskool Hugenote	-26.240027°	28.434373°
Brakpan	Brakpan Primary School	-26.243109°	28.373344°
Boksburg	Parkrand Primary School	-26.249653°	28.276180°
	Thabo Memorial Hospital	-26.232875°	28.244243°
	Sunward Park Hospital	-26.260136°	28.256683°
Alberton	Alberton High School	-26.281920°	28.117084°
	Netcare Clinton Hospital	-26.273268°	28.120227°
	Alberton Tuiste Vir Bejaardes	-26.278995°	28.113435°
Germiston	Bertha Gxowa Hospital	-26.220611°	28.165186°

Area	Sensitive Receptors	Latitude	Longitude
Benoni	Linmed Hospital	-26.145829°	28.330060°
	Hoerskool Brandwag (Airfield)	-26.174468°	28.317457°
	Thepiso Noto Intermediate School	-26.110681°	28.478384°
	Laerskool Bredell	-26.095549°	28.309374°
	Sibonelo Primary School (Daveyton)	-26.133366°	28.428877°
	Petit High School (Kempton Park Nu)	-26.097238°	28.371925°
Kempton Park	Arwyp Medical Centre	-26.106876°	28.233229°
	Hoerskool Birchleigh	-26.055418°	28.234975°
	Curro Serengeti Acadamy	-26.056936°	28.294549°
JHB South	South Rand Hospital	-26.252897°	28.062148°
Soweto	Chris Hani Baragwanath Hospital	-26.261492°	27.940355°
	Thulani Primary School	-26.245828°	27.848300°
Johannesburg	University Of Witwatersrand	-26.189947°	28.031656°
	Milpark Hospital	-26.180234°	28.017865°
	Charlotte Maxixe Academic Hospital	-26.175864°	28.045603°
	Thembisa West Secondary School (Thembisa)	-26.026012°	28.184597°
	Lenmed Zamokuhle Private Hospital (Thembisa)	-25.983681°	28.237972°
	Ikusasa Comprehensive School	-26.009079°	28.242320°
Centurion	Gem Village Old Age Home	-25.890517°	28.235196°
	Rustoord Old Age Home	-25.828157°	28.203777°
	Cornwell Hill College (Irene)	-25.873186°	28.234287°
Pretoria East	Kleinfontein Sorg Sentrum Old Age Home (Donkerhoek)	-25.799673°	28.486162°
	Valtaki AH (Rayton)	-25.777795°	28.584606°
	Laerskool Rayton (Rayton)	-25.744732°	28.527243°
	Tierkop AH	-25.902813°	28.422585°
	Redford House The Hills Private School (Mooikloof Glen)	-25.872295°	28.361134°
	Rietvlei View Country Estate	-25.884742°	28.372901°
	Hazeldean Curro School (Tyger Valley)	-25.780919°	28.387427°
	Tyger Valley College	-25.801750°	28.369799°
	Pretoria East Hospital (Moreletapark)	-25.820584°	28.304652°
	Groenkloof Old Age Home	-25.770356°	28.217846°
Pretoria	Steve Biko Academic Hospital	-25.729693°	28.203318°
	Willow Ridge High School (Wilgers)	-25.760751°	28.315444°
	Hoerskool Waterkloof	-25.818863°	28.255795°
	Hoerskool Garsfontein	-25.797751°	28.304342°
	Afrikaanse Hoer Seunskool	-25.758166°	28.220742°
	Huis Silversig Savf Old Age Home (Silverton)	-25.732724°	28.297254°
	Laersekool Meyerspark (Meyerspark)	-25.740127°	28.313935°
Mamelodi	Curro Academy Mamelodi	-25.698567°	28.422449°
	Impendulo Primary School	-25.723669°	28.437518°
	Nellmapius Ext 6 Primary School	-25.733098°	28.375745°
	Mamelodi Home For Aged	-25.714091°	28.415290°

ANNEXURE 2: PREDICTED CONCENTRATIONS AT SENSITIVE RECEPTORS

Predicted concentrations in µg/m³ at the sensitive receptors for Scenario 1 (Current), together with the limit value of the NAAQS

Scenario 1 (Current)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**40**	**20**
Elsie Ballot Memorial Hospital	23.7	3.1	20.6	2.6
Laerskool Amersfoort	23.7	3.1	20.6	2.6
Embuzane Primary School	24.7	3.0	21.8	2.5
Sangqotho Primary School	24.2	3.1	20.8	2.6
Amersfoort Combined School	23.6	3.1	20.5	2.6
Injubuko Primary School	23.2	3.1	20.1	2.6
Daggakraal Primary School	24.1	3.1	20.9	2.6
Sizenzele Primary School	23.6	3.0	20.5	2.6
Seme Secondary School	24.7	3.2	21.4	2.7
Louwra Primary School	22.8	2.6	20.1	2.3
Perdekop Agricultural School	22.5	2.6	19.5	2.3
Vukuzenzele Combined School	22.9	2.6	20.0	2.3
Gunwana Primary School	21.6	2.5	18.9	2.2
Amajuba Memorial Hospital	20.3	2.4	17.5	2.1
Volksrust High School	20.6	2.4	17.8	2.1
Volksrust Municipal Clinic	20.3	2.3	17.5	2.0
C V O Skool Amajuba	20.5	2.3	17.7	2.1
Qhubulwazi Combined School	20.0	2.4	17.3	2.1
Volksrust Primary School	20.6	2.4	17.8	2.1
New Ermelo	25.3	3.3	21.5	2.8
Ermelo Christian School	25.4	3.4	21.7	2.8
SAVF Home For Aged	25.2	3.3	21.5	2.8
Ermelo Hospital	25.0	3.3	21.2	2.7
Mediclinic Ermelo	25.3	3.3	21.6	2.8
Hoerskool Ermelo	25.1	3.3	21.3	2.8
Ermelo Indian Combined School	25.0	3.3	21.2	2.7
Lungelo Combined School (Outside Town)	24.1	3.2	20.7	2.6
New Ermelo Primary School	25.4	3.3	21.6	2.8
Kwashashe (Outside Town)	24.9	3.4	21.3	2.8
Hts Ligbron	25.3	3.3	21.5	2.8
Laerskool Ermelo	25.1	3.3	21.4	2.8
JJ Vd Merwe Pre-Primary School	25.1	3.3	21.3	2.8
Lindile Secondary School	24.6	3.3	21.0	2.7
Emthonjeni Clinic	24.5	3.3	21.0	2.7
Reggie Masuku Secondary School	24.6	3.3	21.2	2.7
Cebisa Secondary School	24.5	3.3	21.0	2.7
Camden	25.9	3.3	22.3	2.8
Camden Combined School	26.3	3.4	22.1	2.8
Camden School	26.2	3.3	22.6	2.8
Umzimvelo Secondary School (Rural Area)	24.4	3.4	21.1	2.9
Bhekimfundo Primary School (Rural Area)	24.6	3.3	20.9	2.8
Eshwileni Primary School (Rural Area)	24.3	3.2	21.0	2.7
Davel Combined School	24.7	3.3	20.5	2.7
Morgenzon Landbou Akademie	23.6	3.1	20.4	2.6
Nqobangolwazi Secondary School	23.7	3.1	20.4	2.6
Siqondekhaya Pre Primary School	24.1	3.1	20.6	2.6
Sizakhele Primary School	24.0	3.1	20.6	2.6

Scenario 1 (Current)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**40**	**20**
Phezukwentaba Primary School (South of Morgenzon)	24.2	3.1	20.9	2.6
Kwaggalaagte Primary School (North of Morgenzon)	26.7	3.1	22.4	2.5
Sizakhele Clinic/Hospital	24.0	3.1	20.6	2.6
Grootvlei	20.4	1.9	17.3	1.6
Olive Grove Country Lodge	20.4	1.9	17.3	1.6
Grootvlei Town (South of Power Station)	21.4	1.9	18.1	1.6
Laerskool Grootvlei	21.3	1.9	18.0	1.6
Tokoloho Primary School	21.2	1.9	18.0	1.6
Tshepeha Combined School	21.5	1.9	18.2	1.6
Warembo Lodge	21.4	2.0	18.2	1.7
Balfour	22.4	2.0	18.8	1.8
Siyathemba	22.2	2.1	18.7	1.8
Bonukukhanya Primary (Siyathemba)	21.9	2.1	18.5	1.8
Qalabocha Primary School (Siyathemba)	22.2	2.1	18.7	1.8
Vusumuzi Primary School	22.2	2.1	18.7	1.8
Gekombineerde Skool Balfour	21.8	2.0	18.3	1.7
Im Manchu Secondary School	21.9	2.0	18.4	1.7
Isifisosethu Secondary School (Siyathemba)	22.0	2.1	18.5	1.8
Setsheng Secondary School (Siyathemba)	22.3	2.1	18.8	1.8
Dr Nieuwoudt And Dr Kok	21.7	2.0	18.3	1.7
Balfour Clinic	22.1	2.0	18.5	1.7
Siyathemba Clinic	22.2	2.0	18.6	1.8
Mondoro Lodge	22.0	2.0	18.4	1.7
Wegelegen Manor	23.0	2.1	19.3	1.8
The Stone Cellar	20.7	1.9	17.8	1.6
Greylingstad	23.5	2.2	19.6	1.9
Nthorwane	23.7	2.2	19.8	1.9
Laerskool Greylingstad	23.8	2.2	19.9	1.9
Nthoroane Secondary School	23.8	2.2	19.8	1.9
Badgarleur Bush Lodge	20.4	2.1	17.4	1.8
Matla Village	29.4	2.8	23.8	2.2
Sifundise Primary School	29.3	2.8	23.7	2.2
Matla Coal Health Centre	29.0	2.8	23.6	2.2
Gweda Primary School	32.3	3.3	25.4	2.5
Zithobe Primary School	28.5	2.5	23.9	2.0
Kwanala Primary School	32.7	3.3	26.3	2.5
Reedstream Park	32.4	3.2	25.7	2.4
Rietspruit Clinic	32.0	3.2	25.4	2.4
Lehlaka Combined School	32.3	3.2	25.5	2.4
Mbali Coal/Blesboklaagte Housing	30.7	2.9	24.1	2.3
Kinross	29.9	2.7	24.9	2.3
Kinross Settlement	28.8	2.6	24.3	2.2
Kinross Municipal Clinic	29.7	2.7	24.7	2.3
Kriel	30.1	3.6	24.5	2.6
Eagles Nest Guest House	30.2	3.6	24.5	2.7
Merlin Park Primary School	30.3	3.5	24.5	2.6
Kriel Medical Centre	29.7	3.5	24.2	2.6
Laerskool Krielpark	29.3	3.5	24.1	2.6
Laerskool Onverwacht	30.5	3.5	24.7	2.6

Scenario 1 (Current)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**40**	**20**
Silwer Fleur Aftree Oord (Old Age Home)	30.2	3.5	24.7	2.6
Thubelihle	29.8	3.4	24.5	2.6
Sibongamandla Secondary School	29.6	3.4	24.2	2.6
Ga-Nala Clinic	31.2	3.4	25.5	2.6
Impilo Primary School	29.2	3.1	23.8	2.4
Bonginhlanhla Primary School	29.8	3.4	24.4	2.6
Sibongamandla Secondary School	29.6	3.4	24.2	2.6
Leandra	25.0	2.4	20.9	2.0
Eendracht	24.7	2.3	20.6	2.0
Sidingulwazi Primary School	25.6	2.4	21.2	2.0
Ss Mshayisa Primary School	25.3	2.4	21.0	2.0
Chief Ampie Mayisa Secondary School	25.6	2.4	21.1	2.0
Lebogang Clinic	25.3	2.4	20.9	2.0
Kleuterskool Haas Das	24.1	2.5	20.7	2.2
Standerton Primary School	24.1	2.5	20.7	2.2
Laerskool Jeugkrag	24.0	2.5	20.6	2.2
Laerskool Standerton	24.2	2.5	20.8	2.2
Laerskool Kalie De Haas	24.9	2.5	21.4	2.2
Hoerskool Standerton	24.1	2.5	20.7	2.2
Standerton Provincial Government Hospital	24.0	2.5	20.7	2.2
Mar-Peh Medicare Private Hospital	24.3	2.5	20.9	2.2
Standerton Retirement Home	24.3	2.5	20.9	2.2
Standerton Ouetehuis/Old Age Home	24.4	2.5	20.9	2.2
Holmdene Secondary School	26.6	2.5	22.6	2.1
Cathuza Primary School (SE of Town)	23.9	2.6	20.7	2.3
Sizanani Pre Primary School	24.7	2.5	21.3	2.1
Hlobisa Primary School	24.8	2.5	21.4	2.1
Shukuma Primary School	24.7	2.5	21.4	2.1
Retsebile Primary School	25.0	2.5	21.5	2.1
Thuto-Thebe Secondary School	24.3	2.5	21.0	2.1
Jandrell Secondary School	24.8	2.5	21.4	2.1
Thobelani Secondary School	24.7	2.5	21.3	2.1
Standerton Tb Hospital	24.5	2.5	21.3	2.1
Thuthukani Pre Primary School	24.1	2.6	20.8	2.2
Ulwazi Primary School	24.1	2.6	20.8	2.2
Zikhetheleni Secondary School	24.3	2.6	20.9	2.2
Joubertsvlei Primary School (North of Tutuka)	24.6	2.8	21.3	2.3
Amalumgelo Primary School (NE of Tutuka)	24.9	3.0	21.3	2.5
Grootdraaidam Primary School	24.5	2.6	21.2	2.2
Laerskool Secunda	27.0	2.7	22.8	2.3
Laerskool Kruinpark	26.8	2.8	22.8	2.3
Laerskool Oranjegloed Primary	27.1	2.7	22.8	2.3
Curro Castle Combined School	26.4	2.7	22.5	2.3
Hoërskool Oosterland	27.3	2.8	23.0	2.3
Mediclinic Secunda (Hospital)	26.7	2.7	22.7	2.3
Mediclinic Highveld (Hospital_Trichardt, Secunda)	26.8	2.8	22.7	2.4
Daviescourt/Davieshof Old Age Home	27.2	2.7	22.9	2.3
Highveld Park High School	27.5	2.7	23.1	2.3
Hoerskool Secunda	26.9	2.7	22.8	2.3

Scenario 1 (Current)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**40**	**20**
Basizeni Special School	26.6	2.6	22.2	2.2
Maphala-Gulube Primary School	26.4	2.6	22.3	2.2
Shapeve Primary School	26.7	2.6	22.3	2.2
Thomas Nhlabathi Secondary School	26.9	2.6	22.4	2.2
Embalenhle Hospital / Clinic	27.0	2.6	22.5	2.2
Vukuzithathe Primary School	26.7	2.6	22.5	2.2
K I Twala Secondary	26.9	2.6	22.6	2.2
Allan Makunga Primary School	26.8	2.6	22.4	2.2
Evander Hospital Arv Clinic	29.3	2.7	24.5	2.3
Laerskool Hoeveld	29.2	2.7	24.2	2.3
Hoerskool Evander	28.0	2.7	23.6	2.2
Bernice Samuel Hospital	22.3	1.9	18.4	1.6
Hoerskool Delmas	22.0	1.8	18.3	1.6
Laerskool Delmas	22.3	1.9	18.4	1.6
Kangela Primary School (North of Delpark)	22.4	1.8	18.6	1.6
Savf Ons Eie Ouetehuis / Old Age Home	22.3	1.9	18.4	1.6
Laerskool Eloff	22.2	1.8	18.4	1.6
Rietkol Primary School	21.9	1.8	18.3	1.6
Bazani Primary School	22.2	1.8	18.7	1.5
Phaphamani Secondary School	22.2	1.8	18.7	1.5
Vezimfundo Primary School	22.0	1.8	18.6	1.5
Arbor Primary School	25.8	2.0	21.1	1.6
Ogies Combined School	30.6	2.5	24.0	2.0
Ogies Tb Clinic	30.6	2.5	23.8	2.0
Ogies Police Station	30.6	2.5	23.8	2.0
Hlangu Phala Primary School	28.1	2.2	22.1	1.8
Sukumani Primary School	28.0	2.2	22.1	1.8
Thuthukani Primary School	27.5	2.2	21.9	1.8
Mehlwana Secondary School	28.0	2.2	22.1	1.8
Makause Combined School	27.3	2.2	21.8	1.8
Sibongindawo Primary School	26.0	2.0	21.0	1.7
Laerskool Balmoral	24.6	1.8	20.7	1.5
Clewer Primary School	26.3	2.1	22.3	1.7
Witbank High School	26.6	2.1	22.5	1.8
Eden Park Retirement Village	26.1	2.2	22.1	1.8
Savf House Immergroen Old Age Home	26.6	2.1	22.7	1.8
Mthimkulu Housing for the Aged	27.2	2.1	23.2	1.8
Emalahleni Private Hospital	26.6	2.1	22.8	1.8
Life Cosmos Hospital	26.3	2.2	22.3	1.8
Duvha Primary School	27.0	2.2	22.6	1.9
Laerskool Taalfees	26.5	2.1	22.5	1.8
Witbank Provincial Hospital	26.4	2.1	22.5	1.8
Nancy Shiba Primary School (Vosman)	26.2	2.0	22.2	1.7
Wh De Klerk Skool	25.9	2.1	22.1	1.8
Laerskool Panorama	26.3	2.1	22.4	1.8
Laerskool Duvhapark	27.5	2.3	22.9	1.9
Laerskool Klipfontein	26.3	2.2	22.2	1.9
Cambridge Academy	26.2	2.2	22.3	1.9
Besilindile Primary School	26.8	1.9	22.5	1.6

Scenario 1 (Current)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**40**	**20**
Reynopark High School	27.1	2.3	22.7	1.9
Bakenveld Golf Estate	28.2	2.3	23.7	1.9
Allendale Secondary School	28.4	2.5	23.9	2.1
Khayalethu Primary School	27.2	2.1	23.2	1.8
Illanga Secondary School	28.8	2.5	23.9	2.0
Joy Creche (Duvha)	28.7	2.5	23.9	2.0
Linderus Old Age Home	25.1	2.1	21.0	1.8
Vergeet My Nie Old Age Home	25.0	2.1	21.0	1.8
Middleburg Frail Care Unit and Home For Elderly	25.6	2.1	21.6	1.8
Life Midmed Hospital	25.2	2.1	21.2	1.8
Middelburg Hospital	25.0	2.1	21.0	1.8
Makhathini Primary School	25.4	2.1	21.5	1.8
Laerskool Dennesig	25.7	2.0	21.7	1.7
Hoerskool Kanonkop	25.6	2.1	21.6	1.7
Laerskool Kanonkop	25.4	2.1	21.4	1.8
Steelcrest High School	25.3	2.1	21.3	1.8
Middelburg Primary	25.0	2.1	21.0	1.8
Middleburg Ext 6 Clinic	25.7	2.1	21.9	1.8
Sofunda Secondary School	25.6	2.1	21.8	1.8
Mhluzi Primary School	25.5	2.1	21.6	1.8
Highlands Primary School	25.1	2.2	21.1	1.8
Blinkpan Primary School	25.1	2.8	21.2	2.3
Laerskool Koornfontein	24.7	2.8	20.9	2.3
Blinkpan	25.4	2.8	21.3	2.3
Laerskool Kragveld	23.7	2.7	20.0	2.2
Pullens Hope	23.4	2.7	19.8	2.2
Arnot Colliery Primary School	22.5	2.5	19.3	2.1
Laerskool Rietkuil	22.2	2.5	19.1	2.1
Beestepan Agricultural School	23.3	2.3	19.8	1.9
Gekombineerde Skool Hendrina	23.4	2.9	19.8	2.4
Hendrina Primary School	23.4	2.9	19.8	2.4
Kwazamokuhle Secondary School	23.2	2.9	19.8	2.4
Ubuhle Bolwai Secondary School	23.5	3.1	20.5	2.7
Lothair Primary School	23.4	3.1	20.4	2.7
Warburton Combined School	23.5	3.0	20.5	2.6
Warburton Town	23.4	3.0	20.5	2.6
Kwachibikhulu Clinic	22.8	3.1	20.2	2.6
Kwachibikhulu Primary School	22.8	3.1	20.2	2.6
Carolina Hospital	22.1	2.8	19.1	2.4
Zinikeleni Secondary School (Silobela)	21.9	2.9	19.0	2.4
Volkskool Carolina	22.2	2.8	19.2	2.4
Sobuza Primary School	22.0	2.9	19.1	2.4
Ons Eie Ouetehuis (Old Age Home)	22.2	2.8	19.1	2.4
Laerskool Breyten	23.2	3.1	20.4	2.6
Siyazi Primary School (Kwazanele)	23.2	3.1	20.3	2.6
Masizakhe Secondary School (Kwazanele)	23.2	3.1	20.3	2.6
Belfast Rusoord (Old Age Home)	21.0	2.1	18.1	1.8
Belfast Hospital	21.1	2.1	18.2	1.8
Platorand School	21.0	2.1	18.1	1.8

Scenario 1 (Current)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**40**	**20**
Belfast Primary School (Siyathuthuka)	20.5	2.0	17.7	1.8
Siyathuthuka Clinic	20.5	2.0	17.7	1.8
Life Bethal Hospital	27.7	3.3	22.5	2.6
Hoerskool Hoogenhout	27.0	3.3	22.1	2.6
Jim Van Tonderskool	26.6	3.3	21.8	2.6
Bethal Independent Primary School	27.0	3.3	22.1	2.6
Laerskool Marietjie Van Niekerk	27.0	3.3	21.8	2.7
Laerskool Hm Swart	27.1	3.3	22.2	2.6
Sakhisizwe Primary School (Emzinoni)	27.4	3.2	22.3	2.6
Alpheus D Nkosi Secondary School (Emzinoni)	27.2	3.2	22.1	2.6
Silwerjare Old Age Home	27.3	3.3	22.3	2.6
Residentia Palm Oord	27.3	3.3	22.3	2.6
Bronkhorspruit Hospital	20.3	1.5	17.1	1.3
Cultura High School	20.6	1.5	17.3	1.3
Bronkhorspruit Primary School	20.4	1.5	17.2	1.3
Bronkhorspruit Dam	22.1	1.6	18.3	1.4
Hoerskool Erasmus	20.5	1.5	17.2	1.3
Althea Independent School	20.2	1.5	17.0	1.3
Kgoro Primary School (Zithobeni)	19.8	1.5	16.7	1.3
Zithobeni Secondary School (Zithobeni)	19.6	1.4	16.6	1.2
Vaal Power AH	20.0	1.5	17.0	1.3
Sasolburg Provincial Hospital	21.1	1.3	18.1	1.2
Moredou Old Age Home	21.5	1.3	18.4	1.2
Ons Gryse Jeug Old Age Home	21.5	1.3	18.3	1.2
Noord Primere Skool	21.6	1.3	18.4	1.2
Sasolburg High School	21.3	1.3	18.2	1.1
Sakhubusa Secondary School	20.2	1.4	17.2	1.2
Bekezela Primary School	19.9	1.4	16.8	1.2
Isaac Mhlambi Primary	20.1	1.4	17.2	1.2
Refenkgotso Primary School	19.9	1.6	17.1	1.4
Deneysville Primary School	19.3	1.7	16.6	1.4
Netcare Vaalpark Hospital	20.8	1.3	17.9	1.2
Vaalpark Articon Secondary School	21.0	1.4	18.0	1.2
Mediclinic Emfuleni	20.1	1.3	17.6	1.1
Jeugland Old Age Home	20.0	1.3	17.5	1.1
Herfsoord Huis Old Age Home	20.2	1.3	17.6	1.1
Huis Prinscilla	20.2	1.3	17.8	1.1
Laerskool Emfulenipark	20.1	1.3	17.4	1.2
Nw University_Vaal Campus	19.9	1.3	17.4	1.2
Emfuleni Primary School	19.3	1.3	16.9	1.1
Mediclinic Vereeniging	20.2	1.4	17.7	1.2
Kopanong Provincial Hospital (Duncanville)	19.5	1.4	17.0	1.2
Avondrus Eventide Old Age Home	19.7	1.4	17.1	1.2
Riviera On Vaal Resort	20.3	1.4	17.8	1.2
Sedibeng Tvet College	20.6	1.4	18.0	1.2
General Smuts High School	20.4	1.3	17.9	1.2
Eureuka School & Selbourne Primary	20.3	1.3	17.8	1.2
Midvaal Private Hospital (Three Rivers)	19.8	1.4	17.3	1.2
Three Rivers Retirement Village	19.8	1.4	17.2	1.2

Scenario 1 (Current)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**40**	**20**
Drie Riviere Aftreeoord Old Age Home	19.9	1.4	17.3	1.2
Riverside High School	19.9	1.5	17.2	1.3
Risiville Primary School	19.5	1.4	17.0	1.2
Sebokeng Hospital	19.2	1.3	16.8	1.1
Clinix-Naledzi Private Hospital	19.4	1.3	17.0	1.1
Mohloli Secondary School	20.4	1.3	17.9	1.1
Tshirela Primary School (Boipatong)	19.9	1.3	17.5	1.1
Tsoaranang Primary School (Thepiso)	20.2	1.3	17.8	1.1
Thepiso Primary School	19.9	1.3	17.4	1.1
Emmanuel Primary School	20.1	1.3	17.6	1.1
Rust Ter Vaal Combined School	19.4	1.4	16.8	1.2
Roshnee Primary School	19.5	1.3	16.9	1.2
Roshnee High School	19.5	1.3	16.9	1.2
Hoerskool Dr Malan	20.5	1.4	17.9	1.2
Laerskool Voorwaarts	19.9	1.5	17.2	1.3
Meyerton Secondary School	20.3	1.4	17.6	1.2
Ratasetjhaba Primary School	19.4	1.4	16.8	1.2
Meyerton Primary School	20.2	1.4	17.6	1.2
Oprah Leadership Academy	19.9	1.4	17.1	1.3
Henley River Retirement Village	19.9	1.5	17.2	1.3
Henley High & Preparatory School	19.7	1.4	16.9	1.2
Randvaal Clinic	19.8	1.4	17.1	1.2
Laerskool Japie Greyling	19.6	1.4	16.9	1.2
Thomas Nhlapo Primary	19.9	1.4	17.2	1.2
Randvaal Old Age Home	19.4	1.4	16.7	1.2
Laerskool Ag Visser	20.5	1.7	17.7	1.5
Lethaba Siyangobe	20.6	1.7	17.8	1.5
Shalimar Ridge Primary School	20.5	1.7	17.6	1.5
Jw Luckoff High School	20.4	1.8	17.8	1.5
Heidelberg Hospital	20.4	1.7	17.5	1.5
Thulatsatsi Operation (Rensburg)	20.5	1.7	17.7	1.5
Silwer Akker Tehuis	20.6	1.7	17.7	1.5
Riversands Retirement Village	20.2	1.7	17.3	1.5
Qhaqholla Primary School	20.2	1.7	17.3	1.5
Ratanda Primary School	19.8	1.7	17.1	1.5
Boneha Primary School	20.3	1.7	17.5	1.5
Sithokomele Primary School	20.5	1.7	17.6	1.5
Ratanda Bertha Gxowa Primary School	20.6	1.8	17.8	1.5
Khanya Lesedi Secondary School	20.0	1.7	17.2	1.5
Ratanda Secondary School	20.2	1.7	17.4	1.5
New Ratanda Secondary School	20.6	1.7	17.8	1.5
Kgoro Ya Thuto Secondary School	20.6	1.7	17.8	1.5
Ekurhuleni School for the Deaf	19.2	1.5	16.4	1.3
Pholosong Hospital	21.5	1.7	18.3	1.5
Tsakane Home For Aged	21.0	1.7	18.0	1.5
Mmuso Primary School	21.1	1.8	18.1	1.5
Michael Zulu Primary School	21.5	1.7	18.4	1.5
Nkabinde Primary School (Thembilisha)	22.0	1.7	18.4	1.5
Nigel Clinic	20.5	1.8	17.6	1.6

Scenario 1 (Current)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**40**	**20**
Tehuis Vir Bejaardes	20.7	1.8	17.8	1.6
Hoerskool John Vorster	20.5	1.8	17.7	1.6
Laerskool Hannes Visagie	21.1	1.8	18.3	1.6
Nigel Secondary School	21.2	1.9	18.3	1.6
Laerskool Dunnottar	21.1	1.8	18.1	1.5
Springs Retirement Village	21.8	1.7	18.0	1.5
Life Springs Parkland Hospital	21.9	1.7	18.1	1.5
Netcare N17 Hospital (Springs)	21.9	1.7	18.1	1.5
Springs Boys High School	21.4	1.7	18.1	1.5
Laerskool Selectionpark	21.5	1.7	17.9	1.5
Kwasa College Pre&Primary School	21.0	1.7	17.9	1.5
Edelweis Medical Centre	21.6	1.7	18.1	1.5
Laerskool Christiaan Beyers	22.0	1.7	18.1	1.5
Hoerskool Hugenote	21.1	1.7	17.6	1.5
Brakpan Primary School	21.7	1.6	17.8	1.4
Parkrand Primary School	20.9	1.5	17.2	1.3
Thabo Memorial Hospital	20.0	1.5	16.8	1.3
Sunward Park Hospital	21.0	1.5	17.3	1.3
Alberton High School	19.6	1.4	16.3	1.2
Netcare Clinton Hospital	19.4	1.4	16.2	1.2
Alberton Tuiste Vir Bejaardes	19.6	1.4	16.3	1.2
Bertha Gxowa Hospital	19.5	1.4	16.1	1.2
Linmed Hospital	19.4	1.5	16.5	1.3
Hoerskool Brandwag (Airfield)	19.9	1.5	16.8	1.3
Thepiso Noto Intermediate School	21.8	1.6	18.5	1.4
Laerskool Bredell	19.2	1.5	16.6	1.3
Sibonelo Primary School (Daveyton)	21.0	1.6	17.9	1.4
Petit High School (Kempton Park Nu)	20.6	1.5	17.6	1.3
Arwyp Medical Centre	19.1	1.4	16.2	1.2
Hoerskool Birchleigh	19.1	1.4	16.1	1.2
Curro Serengeti Acadamy	19.3	1.4	16.5	1.2
South Rand Hospital	19.3	1.4	16.1	1.2
Chris Hani Baragwanath Hospital	18.7	1.2	15.8	1.1
Thulani Primary School	17.4	1.1	14.9	1.0
University of Witwatersrand	18.7	1.4	15.7	1.2
Milpark Hospital	18.2	1.3	15.3	1.1
Charlotte Maxixe Academic Hospital	18.5	1.4	15.5	1.2
Thembisa West Secondary School (Thembisa)	18.0	1.3	15.4	1.1
Lenmed Zamokuhle Private Hospital (Thembisa)	18.3	1.3	15.6	1.1
Ikusasa Comprehensive School	18.2	1.3	15.4	1.1
Gem Village Old Age Home	19.6	1.2	16.5	1.1
Rustoord Old Age Home	20.0	1.2	16.7	1.0
Cornwell Hill College (Irene)	19.6	1.2	16.5	1.1
Kleinfontein Sorg Sentrum Old Age Home (Donkerhoek)	19.4	1.3	16.2	1.1
Valtaki AH (Rayton)	19.7	1.4	16.7	1.2
Laerskool Rayton (Rayton)	19.1	1.3	16.3	1.1
Tierkop AH	21.3	1.4	17.2	1.2
Redford House The Hills Private School (Mooikloof Glen)	21.8	1.4	17.6	1.2
Rietvlei View Country Estate	21.8	1.4	17.7	1.2

Scenario 1 (Current)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**40**	**20**
Hazeldean Curro School (Tyger Valley)	19.0	1.2	15.9	1.1
Tyger Valley College	19.5	1.3	16.2	1.1
Pretoria East Hospital (Moreletapark)	20.2	1.3	16.8	1.1
Groenkloof Old Age Home	18.6	1.1	15.7	1.0
Steve Biko Academic Hospital	17.4	1.1	14.8	0.9
Willow Ridge High School (Wilgers)	18.4	1.2	15.5	1.0
Hoerskool Waterkloof	20.0	1.2	16.6	1.1
Hoerskool Garsfontein	19.7	1.2	16.5	1.0
Afrikaanse Hoer Seunskool	18.2	1.1	15.4	1.0
Huis Silversig SAVF Old Age Home (Silverton)	17.9	1.1	15.2	1.0
Laersekool Meyerspark (Meyerspark)	18.2	1.1	15.4	1.0
Curro Academy Mamelodi	18.1	1.1	15.5	1.0
Impendulo Primary School	18.8	1.2	15.9	1.0
Nellmapius Ext 6 Primary School	18.4	1.2	15.6	1.0
Mamelodi Home For Aged	18.2	1.1	15.5	1.0

Predicted concentrations in µg/m³ at the sensitive receptors for Scenario A (2025), together with the limit value of the NAAQS

Scenario A (2025)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**40**	**20**
Elsie Ballot Memorial Hospital	25.5	3.6	23.9	3.3
Laerskool Amersfoort	25.2	3.6	23.6	3.3
Embuzane Primary School	28.5	3.7	26.7	3.3
Sangqotho Primary School	25.1	3.7	23.4	3.3
Amersfoort Combined School	25.3	3.7	23.6	3.3
Injubuko Primary School	25.0	3.7	23.6	3.3
Daggakraal Primary School	24.8	3.7	23.4	3.4
Sizenzele Primary School	25.0	3.6	23.4	3.3
Seme Secondary School	25.5	3.8	24.0	3.4
Louwra Primary School	26.3	3.1	24.8	2.9
Perdekop Agricultural School	25.4	3.2	23.8	2.9
Vukuzenzele Combined School	25.7	3.2	24.0	2.9
Gunwana Primary School	25.5	3.0	24.0	2.8
Amajuba Memorial Hospital	22.8	2.9	21.3	2.6
Volksrust High School	22.6	2.8	21.1	2.6
Volksrust Municipal Clinic	22.2	2.8	20.8	2.6
C V O Skool Amajuba	22.2	2.8	20.8	2.6
Qhubulwazi Combined School	22.8	2.8	21.2	2.6
Volksrust Primary School	23.1	2.9	21.5	2.7
New Ermelo	25.7	3.7	24.1	3.4
Ermelo Christian School	25.9	3.8	24.4	3.4
SAVF Home For Aged	25.3	3.7	23.8	3.4
Ermelo Hospital	25.3	3.7	23.8	3.3
Mediclinic Ermelo	25.8	3.7	24.2	3.4
Hoerskool Ermelo	25.4	3.7	23.8	3.3
Ermelo Indian Combined School	25.5	3.7	23.9	3.3
Lungelo Combined School (Outside Town)	25.0	3.6	23.3	3.3
New Ermelo Primary School	25.7	3.7	24.2	3.4
Kwashashe (Outside Town)	25.4	3.7	23.9	3.4
Hts Ligbron	25.6	3.7	24.0	3.4
Laerskool Ermelo	25.2	3.7	23.7	3.4
JJ Vd Merwe Pre-Primary School	25.7	3.7	24.1	3.4
Lindile Secondary School	25.3	3.7	23.8	3.3
Emthonjeni Clinic	25.1	3.7	23.6	3.3
Reggie Masuku Secondary School	25.1	3.7	23.6	3.3
Cebisa Secondary School	25.1	3.7	23.5	3.3
Camden	26.1	3.8	24.5	3.4
Camden Combined School	27.4	3.8	25.2	3.4
Camden School	26.3	3.8	24.7	3.4
Umzimvelo Secondary School (Rural Area)	25.5	3.8	24.0	3.4
Bhekimfundo Primary School (Rural Area)	26.6	3.8	25.0	3.4
Eshwileni Primary School (Rural Area)	25.7	3.7	24.1	3.3
Davel Combined School	26.4	3.6	24.7	3.3
Morgenzon Landbou Akademie	25.4	3.7	23.7	3.2
Nqobangolwazi Secondary School	25.4	3.6	23.6	3.2
Siqondekhaya Pre Primary School	25.6	3.6	23.8	3.2
Sizakhele Primary School	25.5	3.6	23.7	3.2

Scenario A (2025)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**40**	**20**
Phezukwentaba Primary School (South of Morgenzon)	24.9	3.7	23.3	3.2
Kwaggalaagte Primary School (North of Morgenzon)	27.0	3.5	25.1	3.2
Sizakhele Clinic/Hospital	25.5	3.6	23.7	3.2
Grootvlei	23.8	2.2	22.5	2.0
Olive Grove Country Lodge	23.8	2.2	22.3	2.0
Grootvlei Town (South of Power Station)	22.8	2.2	21.5	2.0
Laerskool Grootvlei	23.0	2.2	21.7	2.0
Tokoloho Primary School	22.5	2.2	21.3	2.0
Tshepeha Combined School	22.8	2.2	21.5	2.0
Warembo Lodge	22.1	2.3	20.8	2.1
Balfour	23.1	2.3	21.8	2.2
Siyathemba	23.4	2.4	22.0	2.2
Bonukukhanya Primary (Siyathemba)	23.5	2.4	22.1	2.2
Qalabocha Primary School (Siyathemba)	23.3	2.4	21.9	2.2
Vusumuzi Primary School	23.5	2.4	22.1	2.2
Gekombineerde Skool Balfour	23.4	2.3	22.1	2.1
Im Manchu Secondary School	23.2	2.3	21.9	2.1
Isifisosethu Secondary School (Siyathemba)	23.6	2.4	22.2	2.2
Setsheng Secondary School (Siyathemba)	23.4	2.4	21.9	2.2
Dr Nieuwoudt And Dr Kok	23.5	2.3	22.2	2.1
Balfour Clinic	23.1	2.3	21.9	2.1
Siyathemba Clinic	23.1	2.3	21.8	2.2
Mondoro Lodge	22.6	2.2	21.2	2.1
Wegelegen Manor	23.3	2.4	21.8	2.2
The Stone Cellar	22.5	2.1	21.1	2.0
Greylingstad	24.5	2.6	23.0	2.4
Nthorwane	25.0	2.6	23.5	2.4
Laerskool Greylingstad	24.7	2.6	23.2	2.4
Nthoroane Secondary School	25.0	2.6	23.5	2.4
Badgarleur Bush Lodge	23.2	2.4	21.8	2.2
Matla Village	30.7	3.1	27.4	2.8
Sifundise Primary School	30.7	3.1	27.5	2.8
Matla Coal Health Centre	31.3	3.1	27.9	2.8
Gweda Primary School	33.5	3.6	30.4	3.1
Zithobe Primary School	30.3	2.9	27.4	2.6
Kwanala Primary School	34.3	3.6	29.4	3.1
Reedstream Park	32.4	3.3	28.5	2.9
Rietspruit Clinic	32.7	3.3	29.2	2.9
Lehlaka Combined School	32.5	3.3	29.0	2.9
Mbali Coal/Blesboklaagte Housing	29.4	3.0	27.2	2.7
Kinross	32.6	3.2	29.6	2.9
Kinross Settlement	31.4	3.0	28.7	2.7
Kinross Municipal Clinic	32.2	3.1	29.3	2.8
Kriel	30.4	3.8	27.4	3.2
Eagles Nest Guest House	30.3	3.8	27.5	3.2
Merlin Park Primary School	30.5	3.7	27.4	3.1
Kriel Medical Centre	30.3	3.7	27.3	3.1
Laerskool Krielpark	30.6	3.7	27.4	3.1
Laerskool Onverwacht	30.6	3.7	27.5	3.1

Scenario A (2025)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**40**	**20**
Silwer Fleur Aftree Oord (Old Age Home)	30.6	3.7	27.4	3.1
Thubelihle	30.2	3.5	27.0	3.1
Sibongamandla Secondary School	30.4	3.5	27.3	3.0
Ga-Nala Clinic	31.0	3.6	27.8	3.1
Impilo Primary School	28.7	3.3	26.2	2.9
Bonginhlanhla Primary School	30.1	3.5	27.2	3.0
Sibongamandla Secondary School	30.4	3.5	27.3	3.0
Leandra	27.8	2.7	25.6	2.5
Eendracht	27.8	2.7	25.7	2.5
Sidingulwazi Primary School	27.9	2.7	25.8	2.5
Ss Mshayisa Primary School	28.3	2.8	26.2	2.5
Chief Ampie Mayisa Secondary School	28.0	2.7	25.9	2.5
Lebogang Clinic	27.9	2.7	25.8	2.5
Kleuterskool Haas Das	27.3	3.0	25.4	2.7
Standerton Primary School	27.4	3.0	25.4	2.7
Laerskool Jeugkrag	27.6	3.0	25.6	2.7
Laerskool Standerton	27.3	3.0	25.4	2.7
Laerskool Kalie De Haas	27.5	3.0	25.5	2.7
Hoerskool Standerton	27.4	3.0	25.4	2.7
Standerton Provincial Government Hospital	27.4	3.0	25.5	2.7
Mar-Peh Medicare Private Hospital	27.3	3.0	25.4	2.7
Standerton Retirement Home	27.3	3.0	25.4	2.7
Standerton Ouetehuis/Old Age Home	27.3	3.0	25.4	2.7
Holmdene Secondary School	28.5	2.9	26.7	2.7
Cathuza Primary School (SE of Town)	27.9	3.2	25.8	2.9
Sizanani Pre Primary School	27.4	3.0	25.6	2.7
Hlobisa Primary School	27.1	2.9	25.3	2.7
Shukuma Primary School	27.1	2.9	25.3	2.7
Retsebile Primary School	27.4	3.0	25.4	2.7
Thuto-Thebe Secondary School	27.5	3.0	25.6	2.7
Jandrell Secondary School	27.3	3.0	25.4	2.7
Thobelani Secondary School	27.3	3.0	25.4	2.7
Standerton Tb Hospital	27.3	3.0	25.5	2.7
Thuthukani Pre Primary School	29.3	3.1	26.1	2.8
Ulwazi Primary School	29.2	3.1	26.1	2.8
Zikhetheleni Secondary School	29.2	3.1	26.1	2.8
Joubertsvlei Primary School (North of Tutuka)	27.4	3.2	25.6	2.9
Amalumgelo Primary School (NE of Tutuka)	28.0	3.6	25.2	3.2
Grootdraaidam Primary School	27.3	3.1	25.2	2.8
Laerskool Secunda	30.4	3.1	28.4	2.8
Laerskool Kruinpark	29.9	3.2	27.9	2.9
Laerskool Oranjegloed Primary	30.0	3.1	27.9	2.8
Curro Castle Combined School	30.1	3.1	28.1	2.8
Hoërskool Oosterland	30.0	3.2	27.9	2.9
Mediclinic Secunda (Hospital)	31.0	3.1	28.8	2.8
Mediclinic Highveld (Hospital_Trichardt, Secunda)	29.5	3.2	27.3	2.9
Daviescourt/Davieshof Old Age Home	30.1	3.1	28.0	2.9
Highveld Park High School	29.9	3.2	27.8	2.9
Hoerskool Secunda	30.1	3.1	28.2	2.8

Scenario A (2025)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**40**	**20**
Basizeni Special School	30.6	3.0	28.3	2.8
Maphala-Gulube Primary School	29.7	3.0	27.6	2.8
Shapeve Primary School	30.9	3.0	28.5	2.8
Thomas Nhlabathi Secondary School	29.9	3.0	27.7	2.7
Embalenhle Hospital / Clinic	29.9	3.0	27.7	2.7
Vukuzithathe Primary School	29.8	3.0	27.7	2.7
K I Twala Secondary	29.8	3.0	27.6	2.7
Allan Makunga Primary School	30.5	3.0	28.2	2.8
Evander Hospital Arv Clinic	32.0	3.1	29.4	2.8
Laerskool Hoeveld	32.2	3.1	29.6	2.8
Hoerskool Evander	32.4	3.1	29.7	2.8
Bernice Samuel Hospital	22.8	2.1	21.1	2.0
Hoerskool Delmas	22.8	2.1	21.2	1.9
Laerskool Delmas	22.9	2.1	21.2	2.0
Kangela Primary School (North of Delpark)	22.7	2.1	21.1	2.0
Savf Ons Eie Ouetehuis / Old Age Home	22.8	2.1	21.2	2.0
Laerskool Eloff	22.5	2.1	20.8	1.9
Rietkol Primary School	22.6	2.1	20.9	1.9
Bazani Primary School	23.0	2.1	21.4	1.9
Phaphamani Secondary School	22.9	2.1	21.3	1.9
Vezimfundo Primary School	23.0	2.1	21.3	1.9
Arbor Primary School	26.4	2.3	24.7	2.1
Ogies Combined School	27.8	2.7	26.1	2.4
Ogies Tb Clinic	27.5	2.7	25.8	2.4
Ogies Police Station	27.5	2.7	25.8	2.4
Hlangu Phala Primary School	27.4	2.5	25.6	2.3
Sukumani Primary School	27.5	2.5	25.8	2.3
Thuthukani Primary School	27.7	2.5	26.0	2.3
Mehlwana Secondary School	27.1	2.5	25.4	2.2
Makause Combined School	27.5	2.5	25.8	2.3
Sibongindawo Primary School	25.4	2.4	23.6	2.2
Laerskool Balmoral	24.9	2.1	23.3	1.9
Clewer Primary School	27.5	2.4	25.6	2.2
Witbank High School	28.3	2.5	26.3	2.3
Eden Park Retirement Village	27.6	2.5	25.6	2.3
Savf House Immergroen Old Age Home	28.2	2.5	26.3	2.2
Mthimkulu Housing for the Aged	27.3	2.4	25.4	2.2
Emalahleni Private Hospital	28.2	2.4	26.3	2.2
Life Cosmos Hospital	28.2	2.5	26.2	2.3
Duvha Primary School	27.4	2.5	25.4	2.3
Laerskool Taalfees	28.3	2.5	26.3	2.3
Witbank Provincial Hospital	28.2	2.5	26.3	2.3
Nancy Shiba Primary School (Vosman)	26.8	2.3	25.0	2.1
Wh De Klerk Skool	28.0	2.4	26.0	2.2
Laerskool Panorama	27.9	2.4	26.0	2.2
Laerskool Duvhapark	27.2	2.6	25.1	2.4
Laerskool Klipfontein	27.6	2.5	25.5	2.3
Cambridge Academy	27.8	2.5	25.7	2.3
Besilindile Primary School	26.3	2.2	24.5	2.0

Scenario A (2025)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**40**	**20**
Reynopark High School	27.5	2.6	25.5	2.3
Bakenveld Golf Estate	27.1	2.6	25.0	2.3
Allendale Secondary School	27.9	2.8	25.7	2.5
Khayalethu Primary School	27.2	2.4	25.3	2.2
Illanga Secondary School	28.5	2.7	26.1	2.5
Joy Creche (Duvha)	28.7	2.7	26.3	2.5
Linderus Old Age Home	26.6	2.4	24.7	2.2
Vergeet My Nie Old Age Home	26.7	2.4	24.7	2.2
Middleburg Frail Care Unit and Home For Elderly	26.2	2.3	24.3	2.1
Life Midmed Hospital	26.5	2.4	24.6	2.2
Middelburg Hospital	26.7	2.4	24.7	2.2
Makhathini Primary School	26.7	2.3	24.8	2.2
Laerskool Dennesig	26.2	2.3	24.4	2.1
Hoerskool Kanonkop	26.0	2.3	24.2	2.1
Laerskool Kanonkop	26.1	2.3	24.3	2.2
Steelcrest High School	26.3	2.4	24.4	2.2
Middelburg Primary	26.7	2.4	24.7	2.2
Middleburg Ext 6 Clinic	27.4	2.4	25.3	2.2
Sofunda Secondary School	27.3	2.3	25.3	2.2
Mhluzi Primary School	26.9	2.3	25.1	2.2
Highlands Primary School	26.9	2.4	24.9	2.2
Blinkpan Primary School	26.5	3.1	24.8	2.8
Laerskool Koornfontein	26.9	3.1	24.9	2.8
Blinkpan	26.5	3.1	24.8	2.8
Laerskool Kragveld	26.3	3.0	24.6	2.7
Pullens Hope	26.5	3.0	24.8	2.7
Arnot Colliery Primary School	25.7	2.8	23.9	2.6
Laerskool Rietkuil	26.3	2.9	24.5	2.6
Beestepan Agricultural School	25.4	2.6	23.8	2.4
Gekombineerde Skool Hendrina	25.6	3.2	23.9	2.9
Hendrina Primary School	25.5	3.2	23.9	2.9
Kwazamokuhle Secondary School	25.6	3.2	24.0	2.9
Ubuhle Bolwai Secondary School	23.5	3.5	22.2	3.2
Lothair Primary School	23.5	3.5	22.2	3.2
Warburton Combined School	25.6	3.4	24.3	3.1
Warburton Town	25.4	3.4	24.1	3.1
Kwachibikhulu Clinic	25.4	3.5	24.0	3.2
Kwachibikhulu Primary School	25.1	3.5	23.7	3.2
Carolina Hospital	24.7	3.2	23.2	2.9
Zinikeleni Secondary School (Silobela)	25.0	3.2	23.5	3.0
Volkskool Carolina	24.6	3.2	23.0	2.9
Sobuza Primary School	24.7	3.2	23.2	3.0
Ons Eie Ouetehuis (Old Age Home)	24.6	3.2	23.0	2.9
Laerskool Breyten	24.3	3.5	22.9	3.2
Siyazi Primary School (Kwazanele)	24.2	3.5	22.7	3.2
Masizakhe Secondary School (Kwazanele)	24.2	3.5	22.7	3.2
Belfast Rusoord (Old Age Home)	22.2	2.3	20.8	2.2
Belfast Hospital	22.2	2.4	20.9	2.2
Platorand School	22.5	2.4	21.1	2.2

Scenario A (2025)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**40**	**20**
Belfast Primary School (Siyathuthuka)	22.1	2.3	20.8	2.1
Siyathuthuka Clinic	22.1	2.3	20.8	2.1
Life Bethal Hospital	26.9	3.6	24.8	3.2
Hoerskool Hoogenhout	26.7	3.6	24.6	3.2
Jim Van Tonderskool	27.3	3.6	25.1	3.2
Bethal Independent Primary School	27.2	3.6	25.0	3.2
Laerskool Marietjie Van Niekerk	26.8	3.6	24.7	3.2
Laerskool Hm Swart	26.9	3.6	24.8	3.2
Sakhisizwe Primary School (Emzinoni)	28.3	3.5	26.1	3.2
Alpheus D Nkosi Secondary School (Emzinoni)	27.6	3.6	25.5	3.2
Silwerjare Old Age Home	26.9	3.6	24.8	3.2
Residentia Palm Oord	27.0	3.6	24.8	3.2
Bronkhorspruit Hospital	21.1	1.7	19.7	1.6
Cultura High School	22.0	1.7	20.5	1.6
Bronkhorspruit Primary School	21.1	1.7	19.7	1.6
Bronkhorspruit Dam	21.8	1.8	20.3	1.7
Hoerskool Erasmus	21.5	1.7	20.1	1.6
Althea Independent School	21.4	1.7	20.1	1.6
Kgoro Primary School (Zithobeni)	20.8	1.7	19.5	1.5
Zithobeni Secondary School (Zithobeni)	20.4	1.7	19.0	1.5
Vaal Power AH	20.8	1.7	19.5	1.6
Sasolburg Provincial Hospital	21.9	1.6	20.3	1.5
Moredou Old Age Home	21.9	1.6	20.3	1.4
Ons Gryse Jeug Old Age Home	21.9	1.6	20.3	1.5
Noord Primere Skool	21.9	1.6	20.3	1.5
Sasolburg High School	21.8	1.6	20.3	1.4
Sakhubusa Secondary School	19.7	1.6	18.2	1.5
Bekezela Primary School	20.5	1.6	19.1	1.5
Isaac Mhlambi Primary	19.6	1.6	18.1	1.5
Refenkgotso Primary School	22.4	1.9	21.0	1.7
Deneysville Primary School	22.2	1.9	20.8	1.7
Netcare Vaalpark Hospital	22.9	1.6	21.3	1.5
Vaalpark Articon Secondary School	23.0	1.6	21.3	1.5
Mediclinic Emfuleni	20.8	1.5	19.5	1.4
Jeugland Old Age Home	21.1	1.5	19.7	1.4
Herfsoord Huis Old Age Home	20.9	1.5	19.5	1.4
Huis Prinscilla	21.1	1.5	19.8	1.4
Laerskool Emfulenipark	21.5	1.6	19.9	1.5
Nw University_Vaal Campus	20.7	1.6	19.2	1.5
Emfuleni Primary School	21.2	1.5	19.9	1.4
Mediclinic Vereeniging	21.2	1.6	19.8	1.5
Kopanong Provincial Hospital (Duncanville)	21.4	1.6	20.1	1.5
Avondrus Eventide Old Age Home	21.5	1.6	20.1	1.5
Riviera On Vaal Resort	20.9	1.6	19.5	1.5
Sedibeng Tvet College	20.7	1.6	19.3	1.5
General Smuts High School	21.3	1.6	19.8	1.5
Eureuka School & Selbourne Primary	21.4	1.6	19.9	1.5
Midvaal Private Hospital (Three Rivers)	21.0	1.7	19.5	1.5
Three Rivers Retirement Village	21.1	1.7	19.6	1.5

Scenario A (2025)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**40**	**20**
Drie Riviere Aftreeoord Old Age Home	21.1	1.7	19.7	1.5
Riverside High School	20.7	1.7	19.3	1.6
Risiville Primary School	21.1	1.7	19.6	1.5
Sebokeng Hospital	22.5	1.5	21.0	1.4
Clinix-Naledzi Private Hospital	22.4	1.5	20.9	1.4
Mohloli Secondary School	21.4	1.6	19.9	1.5
Tshirela Primary School (Boipatong)	21.3	1.5	19.9	1.4
Tsoaranang Primary School (Thepiso)	21.5	1.6	20.1	1.4
Thepiso Primary School	21.6	1.6	20.1	1.4
Emmanuel Primary School	21.4	1.6	20.0	1.5
Rust Ter Vaal Combined School	21.1	1.6	19.7	1.5
Roshnee Primary School	21.3	1.6	19.8	1.5
Roshnee High School	21.2	1.6	19.7	1.5
Hoerskool Dr Malan	21.5	1.7	20.1	1.5
Laerskool Voorwaarts	21.2	1.7	19.8	1.6
Meyerton Secondary School	21.4	1.7	20.0	1.5
Ratasetjhaba Primary School	21.6	1.6	20.2	1.5
Meyerton Primary School	21.7	1.7	20.3	1.5
Oprah Leadership Academy	21.4	1.7	20.0	1.6
Henley River Retirement Village	21.2	1.7	19.9	1.6
Henley High & Preparatory School	21.2	1.7	19.8	1.6
Randvaal Clinic	21.2	1.7	19.8	1.5
Laerskool Japie Greyling	21.1	1.7	19.7	1.6
Thomas Nhlapo Primary	21.1	1.7	19.7	1.6
Randvaal Old Age Home	21.3	1.7	19.9	1.5
Laerskool Ag Visser	22.1	2.0	20.7	1.8
Lethaba Siyangobe	22.1	2.0	20.7	1.9
Shalimar Ridge Primary School	22.5	2.0	21.0	1.8
Jw Luckoff High School	22.2	2.0	20.8	1.9
Heidelberg Hospital	22.5	2.0	21.1	1.8
Thulatsatsi Operation (Rensburg)	22.2	2.0	20.8	1.8
Silwer Akker Tehuis	22.5	2.0	21.0	1.8
Riversands Retirement Village	22.5	2.0	21.0	1.8
Qhaqholla Primary School	21.4	2.0	20.0	1.8
Ratanda Primary School	21.5	2.0	20.1	1.8
Boneha Primary School	21.4	2.0	20.0	1.8
Sithokomele Primary School	21.3	2.0	20.0	1.8
Ratanda Bertha Gxowa Primary School	22.0	2.0	20.6	1.9
Khanya Lesedi Secondary School	21.4	2.0	20.0	1.8
Ratanda Secondary School	21.4	2.0	20.0	1.8
New Ratanda Secondary School	21.9	2.0	20.5	1.8
Kgoro Ya Thuto Secondary School	21.9	2.0	20.5	1.8
Ekurhuleni School for the Deaf	20.4	1.7	19.2	1.6
Pholosong Hospital	21.4	2.0	19.9	1.8
Tsakane Home For Aged	21.4	2.0	20.0	1.8
Mmuso Primary School	21.8	2.0	20.3	1.9
Michael Zulu Primary School	21.3	2.0	19.9	1.8
Nkabinde Primary School (Thembilisha)	21.1	2.0	19.7	1.8
Nigel Clinic	21.8	2.1	20.3	1.9

Scenario A (2025)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**40**	**20**
Tehuis Vir Bejaardes	21.8	2.1	20.3	1.9
Hoerskool John Vorster	22.0	2.1	20.4	1.9
Laerskool Hannes Visagie	21.7	2.1	20.2	2.0
Nigel Secondary School	21.8	2.2	20.2	2.0
Laerskool Dunnottar	21.7	2.0	20.2	1.9
Springs Retirement Village	20.6	1.9	19.2	1.8
Life Springs Parkland Hospital	20.8	1.9	19.3	1.8
Netcare N17 Hospital (Springs)	20.8	1.9	19.4	1.8
Springs Boys High School	20.9	2.0	19.5	1.8
Laerskool Selectionpark	21.0	2.0	19.5	1.8
Kwasa College Pre&Primary School	21.1	2.0	19.7	1.9
Edelweis Medical Centre	21.0	2.0	19.6	1.8
Laerskool Christiaan Beyers	20.8	2.0	19.3	1.8
Hoerskool Hugenote	21.0	1.9	19.6	1.8
Brakpan Primary School	21.3	1.9	19.9	1.7
Parkrand Primary School	20.9	1.8	19.5	1.6
Thabo Memorial Hospital	20.3	1.7	19.0	1.6
Sunward Park Hospital	20.8	1.8	19.5	1.6
Alberton High School	20.4	1.6	19.1	1.5
Netcare Clinton Hospital	20.4	1.6	19.1	1.5
Alberton Tuiste Vir Bejaardes	20.4	1.6	19.1	1.5
Bertha Gxowa Hospital	20.6	1.7	19.2	1.5
Linmed Hospital	20.7	1.8	19.2	1.6
Hoerskool Brandwag (Airfield)	20.7	1.8	19.3	1.6
Thepiso Noto Intermediate School	21.7	1.9	20.1	1.7
Laerskool Bredell	20.7	1.7	19.4	1.6
Sibonelo Primary School (Daveyton)	21.0	1.8	19.5	1.7
Petit High School (Kempton Park Nu)	21.0	1.8	19.6	1.6
Arwyp Medical Centre	21.0	1.6	19.6	1.5
Hoerskool Birchleigh	20.2	1.6	18.9	1.5
Curro Serengeti Acadamy	20.7	1.6	19.5	1.5
South Rand Hospital	20.7	1.6	19.4	1.5
Chris Hani Baragwanath Hospital	19.8	1.5	18.6	1.3
Thulani Primary School	18.2	1.3	17.0	1.2
University of Witwatersrand	20.2	1.6	18.7	1.5
Milpark Hospital	19.7	1.5	18.3	1.4
Charlotte Maxixe Academic Hospital	20.0	1.6	18.6	1.5
Thembisa West Secondary School (Thembisa)	19.7	1.5	18.4	1.4
Lenmed Zamokuhle Private Hospital (Thembisa)	19.9	1.5	18.7	1.4
Ikusasa Comprehensive School	20.4	1.5	19.2	1.4
Gem Village Old Age Home	20.0	1.4	18.7	1.3
Rustoord Old Age Home	18.7	1.3	17.6	1.2
Cornwell Hill College (Irene)	19.8	1.4	18.6	1.3
Kleinfontein Sorg Sentrum Old Age Home (Donkerhoek)	19.2	1.5	18.0	1.4
Valtaki AH (Rayton)	19.7	1.5	18.5	1.4
Laerskool Rayton (Rayton)	19.1	1.4	18.0	1.3
Tierkop AH	21.3	1.6	20.0	1.5
Redford House The Hills Private School (Mooikloof Glen)	20.3	1.5	19.0	1.4
Rietvlei View Country Estate	20.8	1.5	19.5	1.4

Scenario A (2025)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**40**	**20**
Hazeldean Curro School (Tyger Valley)	18.9	1.4	17.8	1.3
Tyger Valley College	19.0	1.4	17.9	1.3
Pretoria East Hospital (Moreletapark)	19.5	1.4	18.4	1.3
Groenkloof Old Age Home	18.4	1.3	17.3	1.2
Steve Biko Academic Hospital	17.9	1.2	16.9	1.1
Willow Ridge High School (Wilgers)	19.1	1.3	18.0	1.2
Hoerskool Waterkloof	19.8	1.4	18.6	1.3
Hoerskool Garsfontein	19.3	1.4	18.2	1.3
Afrikaanse Hoer Seunskool	18.4	1.3	17.3	1.2
Huis Silversig SAVF Old Age Home (Silverton)	19.0	1.3	17.9	1.2
Laersekool Meyerspark (Meyerspark)	19.1	1.3	18.0	1.2
Curro Academy Mamelodi	18.3	1.3	17.3	1.2
Impendulo Primary School	18.6	1.3	17.5	1.2
Nellmapius Ext 6 Primary School	18.6	1.3	17.4	1.2
Mamelodi Home For Aged	18.5	1.3	17.4	1.2

Predicted concentrations in µg/m³ at the sensitive receptors for Scenario B (2031), together with the limit value of the NAAQS

Scenario B (2031)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**25**	**15**
Elsie Ballot Memorial Hospital	13.7	1.8	13.3	1.7
Laerskool Amersfoort	13.8	1.8	13.4	1.7
Embuzane Primary School	15.4	1.9	14.8	1.8
Sangqotho Primary School	12.8	1.7	12.4	1.7
Amersfoort Combined School	13.2	1.8	12.9	1.7
Injubuko Primary School	12.6	1.8	12.2	1.7
Daggakraal Primary School	13.1	1.9	12.7	1.8
Sizenzele Primary School	13.0	1.9	12.5	1.8
Seme Secondary School	13.2	1.9	12.8	1.8
Louwra Primary School	12.9	1.6	12.5	1.5
Perdekop Agricultural School	13.7	1.6	13.4	1.5
Vukuzenzele Combined School	13.7	1.6	13.3	1.5
Gunwana Primary School	13.2	1.6	12.9	1.5
Amajuba Memorial Hospital	11.8	1.5	11.4	1.4
Volksrust High School	11.7	1.4	11.4	1.4
Volksrust Municipal Clinic	11.8	1.4	11.4	1.4
C V O Skool Amajuba	11.7	1.4	11.4	1.4
Qhubulwazi Combined School	11.9	1.4	11.5	1.4
Volksrust Primary School	12.0	1.5	11.6	1.4
New Ermelo	12.8	1.8	12.4	1.7
Ermelo Christian School	12.8	1.8	12.4	1.7
SAVF Home For Aged	12.7	1.8	12.3	1.7
Ermelo Hospital	12.6	1.8	12.2	1.7
Mediclinic Ermelo	12.7	1.8	12.4	1.7
Hoerskool Ermelo	12.6	1.8	12.2	1.7
Ermelo Indian Combined School	12.5	1.8	12.1	1.7
Lungelo Combined School (Outside Town)	12.2	1.7	11.8	1.6
New Ermelo Primary School	12.8	1.8	12.4	1.7
Kwashashe (Outside Town)	12.5	1.8	12.2	1.7
Hts Ligbron	12.7	1.8	12.3	1.7
Laerskool Ermelo	12.7	1.8	12.3	1.7
JJ Vd Merwe Pre-Primary School	12.6	1.8	12.2	1.7
Lindile Secondary School	12.5	1.8	12.1	1.7
Emthonjeni Clinic	12.5	1.8	12.2	1.7
Reggie Masuku Secondary School	12.5	1.8	12.1	1.7
Cebisa Secondary School	12.5	1.8	12.2	1.7
Camden	13.1	1.8	12.8	1.7
Camden Combined School	13.2	1.8	12.9	1.7
Camden School	13.0	1.8	12.6	1.7
Umzimvelo Secondary School (Rural Area)	12.5	1.8	12.2	1.7
Bhekimfundo Primary School (Rural Area)	12.5	1.8	12.2	1.7
Eshwileni Primary School (Rural Area)	12.5	1.7	12.2	1.7
Davel Combined School	13.6	1.8	13.1	1.7
Morgenzon Landbou Akademie	12.4	1.7	12.0	1.6
Nqobangolwazi Secondary School	12.3	1.7	12.0	1.6
Siqondekhaya Pre Primary School	12.3	1.7	11.9	1.6
Sizakhele Primary School	12.3	1.7	11.9	1.6

Scenario B (2031)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**25**	**15**
Phezukwentaba Primary School (South of Morgenzon)	12.4	1.7	12.0	1.6
Kwaggalaagte Primary School (North of Morgenzon)	13.2	1.7	12.7	1.6
Sizakhele Clinic/Hospital	12.3	1.7	11.9	1.6
Grootvlei	11.1	1.1	10.8	1.1
Olive Grove Country Lodge	11.2	1.1	10.9	1.0
Grootvlei Town (South of Power Station)	10.7	1.1	10.3	1.1
Laerskool Grootvlei	10.6	1.1	10.3	1.1
Tokoloho Primary School	10.7	1.1	10.4	1.1
Tshepeha Combined School	10.7	1.1	10.4	1.1
Warembo Lodge	11.1	1.1	10.7	1.1
Balfour	12.3	1.2	11.9	1.1
Siyathemba	12.4	1.2	12.1	1.2
Bonukukhanya Primary (Siyathemba)	12.4	1.2	12.1	1.1
Qalabocha Primary School (Siyathemba)	12.4	1.2	12.1	1.2
Vusumuzi Primary School	12.5	1.2	12.1	1.2
Gekombineerde Skool Balfour	12.3	1.2	11.9	1.1
Im Manchu Secondary School	12.3	1.2	11.9	1.1
Isifisosethu Secondary School (Siyathemba)	12.5	1.2	12.2	1.2
Setsheng Secondary School (Siyathemba)	12.4	1.2	12.1	1.2
Dr Nieuwoudt And Dr Kok	12.2	1.2	11.9	1.1
Balfour Clinic	12.3	1.2	12.0	1.1
Siyathemba Clinic	12.3	1.2	12.0	1.1
Mondoro Lodge	11.2	1.1	10.8	1.1
Wegelegen Manor	12.0	1.2	11.7	1.1
The Stone Cellar	10.6	1.1	10.3	1.0
Greylingstad	12.0	1.3	11.6	1.2
Nthorwane	12.2	1.3	11.8	1.2
Laerskool Greylingstad	12.1	1.3	11.8	1.3
Nthoroane Secondary School	12.2	1.3	11.8	1.2
Badgarleur Bush Lodge	11.9	1.2	11.5	1.2
Matla Village	15.2	1.6	14.2	1.5
Sifundise Primary School	15.7	1.6	14.7	1.5
Matla Coal Health Centre	15.9	1.6	15.1	1.5
Gweda Primary School	16.3	1.8	15.3	1.7
Zithobe Primary School	14.9	1.5	14.2	1.4
Kwanala Primary School	15.0	1.8	14.1	1.6
Reedstream Park	15.9	1.7	15.1	1.6
Rietspruit Clinic	15.8	1.7	15.1	1.5
Lehlaka Combined School	15.9	1.7	15.1	1.5
Mbali Coal/Blesboklaagte Housing	15.9	1.6	15.3	1.4
Kinross	15.6	1.6	14.9	1.5
Kinross Settlement	15.6	1.5	14.8	1.5
Kinross Municipal Clinic	15.6	1.6	14.9	1.5
Kriel	14.6	1.8	13.9	1.6
Eagles Nest Guest House	14.6	1.8	13.9	1.6
Merlin Park Primary School	14.7	1.7	14.1	1.6
Kriel Medical Centre	14.9	1.7	14.3	1.6
Laerskool Krielpark	14.9	1.7	14.3	1.6
Laerskool Onverwacht	14.9	1.7	14.2	1.6

Scenario B (2031)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**25**	**15**
Silwer Fleur Aftree Oord (Old Age Home)	15.2	1.7	14.5	1.6
Thubelihle	14.5	1.7	13.8	1.6
Sibongamandla Secondary School	14.5	1.7	13.8	1.6
Ga-Nala Clinic	14.7	1.7	14.0	1.6
Impilo Primary School	13.6	1.6	13.1	1.5
Bonginhlanhla Primary School	14.5	1.7	13.9	1.6
Sibongamandla Secondary School	14.5	1.7	13.8	1.6
Leandra	13.5	1.4	13.0	1.3
Eendracht	13.7	1.4	13.2	1.3
Sidingulwazi Primary School	13.7	1.4	13.2	1.3
Ss Mshayisa Primary School	13.6	1.4	13.1	1.3
Chief Ampie Mayisa Secondary School	13.7	1.4	13.2	1.3
Lebogang Clinic	13.5	1.4	13.0	1.3
Kleuterskool Haas Das	12.9	1.5	12.5	1.4
Standerton Primary School	12.8	1.5	12.4	1.4
Laerskool Jeugkrag	12.7	1.5	12.3	1.4
Laerskool Standerton	12.9	1.5	12.5	1.4
Laerskool Kalie De Haas	13.3	1.5	12.9	1.4
Hoerskool Standerton	12.8	1.5	12.4	1.4
Standerton Provincial Government Hospital	12.8	1.5	12.4	1.4
Mar-Peh Medicare Private Hospital	12.9	1.5	12.5	1.4
Standerton Retirement Home	12.9	1.5	12.5	1.4
Standerton Ouetehuis/Old Age Home	13.0	1.5	12.5	1.4
Holmdene Secondary School	13.6	1.4	13.2	1.4
Cathuza Primary School (SE of Town)	14.0	1.5	13.6	1.5
Sizanani Pre Primary School	13.1	1.5	12.7	1.4
Hlobisa Primary School	13.3	1.4	12.9	1.4
Shukuma Primary School	13.3	1.4	12.9	1.4
Retsebile Primary School	13.1	1.4	12.8	1.4
Thuto-Thebe Secondary School	13.0	1.5	12.6	1.4
Jandrell Secondary School	13.2	1.5	12.8	1.4
Thobelani Secondary School	13.2	1.5	12.8	1.4
Standerton Tb Hospital	13.2	1.5	12.8	1.4
Thuthukani Pre Primary School	12.6	1.5	12.0	1.5
Ulwazi Primary School	12.6	1.5	12.0	1.5
Zikhetheleni Secondary School	12.5	1.5	12.0	1.5
Joubertsvlei Primary School (North of Tutuka)	12.3	1.6	11.9	1.5
Amalumgelo Primary School (NE of Tutuka)	12.6	1.7	12.2	1.6
Grootdraaidam Primary School	12.6	1.5	12.1	1.4
Laerskool Secunda	15.6	1.6	15.1	1.5
Laerskool Kruinpark	14.3	1.6	13.8	1.5
Laerskool Oranjegloed Primary	15.0	1.6	14.5	1.5
Curro Castle Combined School	15.2	1.6	14.6	1.5
Hoërskool Oosterland	14.8	1.6	14.3	1.5
Mediclinic Secunda (Hospital)	15.9	1.6	15.4	1.5
Mediclinic Highveld (Hospital_Trichardt, Secunda)	14.7	1.6	14.1	1.5
Daviescourt/Davieshof Old Age Home	15.4	1.6	14.9	1.5
Highveld Park High School	15.1	1.6	14.6	1.5
Hoerskool Secunda	15.5	1.6	14.9	1.5

Scenario B (2031)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**25**	**15**
Basizeni Special School	15.6	1.5	15.0	1.4
Maphala-Gulube Primary School	14.8	1.5	14.3	1.4
Shapeve Primary School	15.7	1.5	15.2	1.4
Thomas Nhlabathi Secondary School	15.1	1.5	14.5	1.4
Embalenhle Hospital / Clinic	14.9	1.5	14.4	1.4
Vukuzithathe Primary School	14.6	1.5	14.1	1.4
K I Twala Secondary	14.4	1.5	13.9	1.4
Allan Makunga Primary School	15.5	1.5	14.9	1.4
Evander Hospital Arv Clinic	15.9	1.6	15.3	1.5
Laerskool Hoeveld	15.8	1.6	15.2	1.5
Hoerskool Evander	15.8	1.6	15.1	1.5
Bernice Samuel Hospital	12.4	1.1	12.0	1.0
Hoerskool Delmas	12.5	1.1	12.0	1.0
Laerskool Delmas	12.6	1.1	12.1	1.0
Kangela Primary School (North of Delpark)	12.5	1.1	12.0	1.0
Savf Ons Eie Ouetehuis / Old Age Home	12.6	1.1	12.1	1.0
Laerskool Eloff	11.8	1.1	11.4	1.0
Rietkol Primary School	11.9	1.1	11.4	1.0
Bazani Primary School	12.2	1.1	11.7	1.0
Phaphamani Secondary School	12.0	1.1	11.6	1.0
Vezimfundo Primary School	11.8	1.1	11.4	1.0
Arbor Primary School	13.8	1.2	13.1	1.1
Ogies Combined School	16.0	1.4	15.2	1.3
Ogies Tb Clinic	15.7	1.4	15.0	1.3
Ogies Police Station	15.7	1.4	15.0	1.3
Hlangu Phala Primary School	15.5	1.3	14.7	1.2
Sukumani Primary School	15.6	1.3	14.9	1.2
Thuthukani Primary School	15.7	1.3	14.9	1.3
Mehlwana Secondary School	15.7	1.3	14.9	1.2
Makause Combined School	15.7	1.3	15.0	1.2
Sibongindawo Primary School	13.7	1.3	13.0	1.2
Laerskool Balmoral	14.2	1.1	13.7	1.1
Clewer Primary School	14.5	1.3	13.9	1.2
Witbank High School	16.2	1.3	15.6	1.2
Eden Park Retirement Village	14.5	1.3	14.0	1.2
Savf House Immergroen Old Age Home	16.1	1.3	15.5	1.2
Mthimkulu Housing for the Aged	15.3	1.3	14.8	1.2
Emalahleni Private Hospital	15.9	1.3	15.4	1.2
Life Cosmos Hospital	16.1	1.3	15.6	1.2
Duvha Primary School	14.9	1.3	14.3	1.2
Laerskool Taalfees	16.1	1.3	15.6	1.2
Witbank Provincial Hospital	16.0	1.3	15.5	1.2
Nancy Shiba Primary School (Vosman)	14.9	1.2	14.4	1.1
Wh De Klerk Skool	15.8	1.3	15.3	1.2
Laerskool Panorama	15.6	1.3	15.1	1.2
Laerskool Duvhapark	14.7	1.3	14.2	1.3
Laerskool Klipfontein	14.3	1.3	13.7	1.2
Cambridge Academy	15.9	1.3	15.3	1.2
Besilindile Primary School	14.7	1.2	14.1	1.1

Scenario B (2031)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**25**	**15**
Reynopark High School	14.2	1.3	13.7	1.3
Bakenveld Golf Estate	14.0	1.3	13.4	1.3
Allendale Secondary School	14.1	1.4	13.5	1.3
Khayalethu Primary School	15.3	1.3	14.7	1.2
Illanga Secondary School	14.2	1.4	13.3	1.3
Joy Creche (Duvha)	14.0	1.4	13.5	1.3
Linderus Old Age Home	13.4	1.3	12.8	1.2
Vergeet My Nie Old Age Home	13.6	1.3	13.0	1.2
Middleburg Frail Care Unit and Home For Elderly	13.8	1.2	13.2	1.2
Life Midmed Hospital	13.6	1.2	13.0	1.2
Middelburg Hospital	13.5	1.2	12.9	1.2
Makhathini Primary School	13.8	1.2	13.2	1.2
Laerskool Dennesig	13.8	1.2	13.2	1.2
Hoerskool Kanonkop	13.7	1.2	13.2	1.2
Laerskool Kanonkop	13.7	1.2	13.1	1.2
Steelcrest High School	13.6	1.2	13.0	1.2
Middelburg Primary	13.5	1.3	12.9	1.2
Middleburg Ext 6 Clinic	14.2	1.2	13.7	1.2
Sofunda Secondary School	14.0	1.2	13.4	1.2
Mhluzi Primary School	13.7	1.2	13.1	1.2
Highlands Primary School	13.1	1.3	12.6	1.2
Blinkpan Primary School	13.7	1.6	13.2	1.5
Laerskool Koornfontein	13.5	1.6	13.0	1.5
Blinkpan	13.6	1.6	13.1	1.5
Laerskool Kragveld	13.3	1.5	12.9	1.4
Pullens Hope	13.5	1.5	13.0	1.4
Arnot Colliery Primary School	13.0	1.4	12.5	1.3
Laerskool Rietkuil	13.1	1.4	12.6	1.3
Beestepan Agricultural School	12.9	1.3	12.5	1.2
Gekombineerde Skool Hendrina	12.7	1.6	12.3	1.5
Hendrina Primary School	12.6	1.6	12.2	1.5
Kwazamokuhle Secondary School	12.6	1.6	12.2	1.5
Ubuhle Bolwai Secondary School	12.2	1.6	11.8	1.6
Lothair Primary School	12.1	1.7	11.8	1.6
Warburton Combined School	12.1	1.6	11.8	1.5
Warburton Town	12.1	1.6	11.8	1.5
Kwachibikhulu Clinic	12.3	1.7	11.9	1.6
Kwachibikhulu Primary School	12.4	1.7	12.0	1.6
Carolina Hospital	12.9	1.5	12.5	1.5
Zinikeleni Secondary School (Silobela)	13.0	1.6	12.7	1.5
Volkskool Carolina	12.7	1.5	12.4	1.5
Sobuza Primary School	13.0	1.6	12.7	1.5
Ons Eie Ouetehuis (Old Age Home)	12.8	1.5	12.4	1.5
Laerskool Breyten	12.4	1.7	12.0	1.6
Siyazi Primary School (Kwazanele)	12.4	1.7	12.0	1.6
Masizakhe Secondary School (Kwazanele)	12.4	1.7	12.0	1.6
Belfast Rusoord (Old Age Home)	11.4	1.2	11.0	1.1
Belfast Hospital	11.5	1.2	11.1	1.1
Platorand School	11.4	1.2	11.0	1.1

Scenario B (2031)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**25**	**15**
Belfast Primary School (Siyathuthuka)	11.4	1.1	11.0	1.1
Siyathuthuka Clinic	11.4	1.1	11.0	1.1
Life Bethal Hospital	13.6	1.7	13.1	1.6
Hoerskool Hoogenhout	13.7	1.8	13.2	1.6
Jim Van Tonderskool	14.3	1.8	13.7	1.7
Bethal Independent Primary School	14.1	1.8	13.6	1.6
Laerskool Marietjie Van Niekerk	14.1	1.8	13.6	1.7
Laerskool Hm Swart	13.7	1.7	13.2	1.6
Sakhisizwe Primary School (Emzinoni)	14.3	1.7	13.8	1.6
Alpheus D Nkosi Secondary School (Emzinoni)	13.8	1.7	13.3	1.6
Silwerjare Old Age Home	13.6	1.7	13.1	1.6
Residentia Palm Oord	13.7	1.7	13.2	1.6
Bronkhorspruit Hospital	11.1	0.9	10.7	0.8
Cultura High School	12.1	0.9	11.7	0.9
Bronkhorspruit Primary School	11.2	0.9	10.8	0.8
Bronkhorspruit Dam	11.7	0.9	11.2	0.9
Hoerskool Erasmus	11.7	0.9	11.2	0.9
Althea Independent School	11.7	0.9	11.3	0.9
Kgoro Primary School (Zithobeni)	11.0	0.9	10.6	0.8
Zithobeni Secondary School (Zithobeni)	11.1	0.9	10.7	0.8
Vaal Power AH	10.8	0.9	10.3	0.9
Sasolburg Provincial Hospital	11.8	0.8	11.3	0.8
Moredou Old Age Home	11.5	0.8	11.0	0.8
Ons Gryse Jeug Old Age Home	11.7	0.8	11.2	0.8
Noord Primere Skool	11.8	0.8	11.3	0.8
Sasolburg High School	11.7	0.8	11.2	0.8
Sakhubusa Secondary School	11.6	0.8	11.1	0.8
Bekezela Primary School	11.1	0.8	10.6	0.8
Isaac Mhlambi Primary	11.4	0.8	10.9	0.8
Refenkgotso Primary School	10.5	1.0	10.1	0.9
Deneysville Primary School	10.5	1.0	10.2	0.9
Netcare Vaalpark Hospital	12.0	0.8	11.5	0.8
Vaalpark Articon Secondary School	11.9	0.8	11.4	0.8
Mediclinic Emfuleni	11.2	0.8	10.8	0.8
Jeugland Old Age Home	11.5	0.8	11.1	0.8
Herfsoord Huis Old Age Home	11.3	0.8	10.9	0.8
Huis Prinscilla	11.0	0.8	10.6	0.8
Laerskool Emfulenipark	11.6	0.8	11.1	0.8
Nw University_Vaal Campus	11.3	0.8	10.8	0.8
Emfuleni Primary School	11.0	0.8	10.6	0.7
Mediclinic Vereeniging	10.4	0.8	10.0	0.8
Kopanong Provincial Hospital (Duncanville)	10.5	0.8	10.1	0.8
Avondrus Eventide Old Age Home	10.4	0.8	10.1	0.8
Riviera On Vaal Resort	10.6	0.8	10.1	0.8
Sedibeng Tvet College	10.6	0.8	10.2	0.8
General Smuts High School	10.6	0.8	10.1	0.8
Eureuka School & Selbourne Primary	10.5	0.8	10.0	0.8
Midvaal Private Hospital (Three Rivers)	11.1	0.9	10.6	0.8
Three Rivers Retirement Village	11.1	0.9	10.6	0.8

Scenario B (2031)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**25**	**15**
Drie Riviere Aftreeoord Old Age Home	11.2	0.9	10.7	0.8
Riverside High School	11.2	0.9	10.7	0.8
Risiville Primary School	11.1	0.9	10.6	0.8
Sebokeng Hospital	11.2	0.8	10.8	0.7
Clinix-Naledzi Private Hospital	11.2	0.8	10.8	0.7
Mohloli Secondary School	11.0	0.8	10.5	0.8
Tshirela Primary School (Boipatong)	11.0	0.8	10.5	0.8
Tsoaranang Primary School (Thepiso)	10.7	0.8	10.2	0.8
Thepiso Primary School	10.6	0.8	10.2	0.8
Emmanuel Primary School	10.8	0.8	10.3	0.8
Rust Ter Vaal Combined School	10.9	0.8	10.5	0.8
Roshnee Primary School	10.9	0.8	10.5	0.8
Roshnee High School	10.9	0.8	10.5	0.8
Hoerskool Dr Malan	10.9	0.9	10.5	0.8
Laerskool Voorwaarts	11.1	0.9	10.7	0.9
Meyerton Secondary School	11.1	0.9	10.7	0.8
Ratasetjhaba Primary School	10.9	0.8	10.5	0.8
Meyerton Primary School	11.1	0.9	10.7	0.8
Oprah Leadership Academy	11.0	0.9	10.6	0.8
Henley River Retirement Village	11.0	0.9	10.6	0.8
Henley High & Preparatory School	10.9	0.9	10.5	0.8
Randvaal Clinic	10.9	0.9	10.5	0.8
Laerskool Japie Greyling	10.7	0.9	10.4	0.8
Thomas Nhlapo Primary	10.7	0.9	10.4	0.8
Randvaal Old Age Home	11.0	0.9	10.6	0.8
Laerskool Ag Visser	10.9	1.0	10.6	1.0
Lethaba Siyangobe	11.0	1.0	10.6	1.0
Shalimar Ridge Primary School	10.8	1.0	10.5	1.0
Jw Luckoff High School	11.0	1.0	10.7	1.0
Heidelberg Hospital	10.8	1.0	10.4	1.0
Thulatsatsi Operation (Rensburg)	10.9	1.0	10.6	1.0
Silwer Akker Tehuis	10.8	1.0	10.5	1.0
Riversands Retirement Village	10.8	1.0	10.4	1.0
Qhaqholla Primary School	10.8	1.0	10.4	1.0
Ratanda Primary School	10.8	1.0	10.5	1.0
Boneha Primary School	10.8	1.0	10.4	1.0
Sithokomele Primary School	10.8	1.0	10.4	1.0
Ratanda Bertha Gxowa Primary School	11.0	1.0	10.6	1.0
Khanya Lesedi Secondary School	10.8	1.0	10.5	1.0
Ratanda Secondary School	10.8	1.0	10.5	1.0
New Ratanda Secondary School	10.9	1.0	10.6	1.0
Kgoro Ya Thuto Secondary School	10.9	1.0	10.6	1.0
Ekurhuleni School for the Deaf	10.5	0.9	10.2	0.8
Pholosong Hospital	10.7	1.0	10.3	1.0
Tsakane Home For Aged	10.6	1.0	10.2	1.0
Mmuso Primary School	11.0	1.0	10.6	1.0
Michael Zulu Primary School	10.8	1.0	10.4	1.0
Nkabinde Primary School (Thembilisha)	10.9	1.0	10.5	1.0
Nigel Clinic	11.7	1.1	11.3	1.0

Scenario B (2031)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**25**	**15**
Tehuis Vir Bejaardes	11.7	1.1	11.3	1.0
Hoerskool John Vorster	11.7	1.1	11.4	1.0
Laerskool Hannes Visagie	11.8	1.1	11.4	1.0
Nigel Secondary School	12.1	1.1	11.8	1.1
Laerskool Dunnottar	10.8	1.0	10.5	1.0
Springs Retirement Village	10.9	1.0	10.5	1.0
Life Springs Parkland Hospital	11.0	1.0	10.6	1.0
Netcare N17 Hospital (Springs)	11.0	1.0	10.6	1.0
Springs Boys High School	11.0	1.0	10.6	1.0
Laerskool Selectionpark	11.1	1.0	10.7	1.0
Kwasa College Pre&Primary School	10.9	1.0	10.5	1.0
Edelweis Medical Centre	11.0	1.0	10.6	1.0
Laerskool Christiaan Beyers	11.0	1.0	10.6	1.0
Hoerskool Hugenote	10.9	1.0	10.5	0.9
Brakpan Primary School	10.9	1.0	10.6	0.9
Parkrand Primary School	10.4	0.9	10.0	0.9
Thabo Memorial Hospital	10.4	0.9	10.0	0.9
Sunward Park Hospital	10.4	0.9	10.0	0.9
Alberton High School	10.4	0.9	10.0	0.8
Netcare Clinton Hospital	10.3	0.8	9.9	0.8
Alberton Tuiste Vir Bejaardes	10.4	0.8	10.0	0.8
Bertha Gxowa Hospital	10.6	0.9	10.2	0.8
Linmed Hospital	10.5	0.9	10.1	0.9
Hoerskool Brandwag (Airfield)	10.4	0.9	10.0	0.9
Thepiso Noto Intermediate School	10.9	1.0	10.5	0.9
Laerskool Bredell	10.7	0.9	10.3	0.8
Sibonelo Primary School (Daveyton)	10.7	0.9	10.3	0.9
Petit High School (Kempton Park Nu)	10.8	0.9	10.4	0.9
Arwyp Medical Centre	10.3	0.8	9.9	0.8
Hoerskool Birchleigh	10.2	0.8	9.8	0.8
Curro Serengeti Acadamy	10.9	0.8	10.5	0.8
South Rand Hospital	11.0	0.9	10.6	0.8
Chris Hani Baragwanath Hospital	10.0	0.8	9.6	0.7
Thulani Primary School	9.4	0.7	9.1	0.7
University of Witwatersrand	10.9	0.8	10.5	0.8
Milpark Hospital	10.8	0.8	10.4	0.8
Charlotte Maxixe Academic Hospital	10.8	0.8	10.5	0.8
Thembisa West Secondary School (Thembisa)	10.2	0.8	9.8	0.7
Lenmed Zamokuhle Private Hospital (Thembisa)	10.3	0.8	9.9	0.7
Ikusasa Comprehensive School	10.4	0.8	10.0	0.8
Gem Village Old Age Home	10.3	0.7	10.0	0.7
Rustoord Old Age Home	10.0	0.7	9.6	0.7
Cornwell Hill College (Irene)	10.1	0.7	9.8	0.7
Kleinfontein Sorg Sentrum Old Age Home (Donkerhoek)	10.0	0.8	9.7	0.7
Valtaki AH (Rayton)	10.4	0.8	10.1	0.8
Laerskool Rayton (Rayton)	10.0	0.7	9.6	0.7
Tierkop AH	10.3	0.8	9.9	0.8
Redford House The Hills Private School (Mooikloof Glen)	10.1	0.8	9.7	0.8
Rietvlei View Country Estate	10.1	0.8	9.7	0.8

Scenario B (2031)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**25**	**15**
Hazeldean Curro School (Tyger Valley)	9.9	0.7	9.5	0.7
Tyger Valley College	9.8	0.7	9.4	0.7
Pretoria East Hospital (Moreletapark)	10.0	0.7	9.7	0.7
Groenkloof Old Age Home	9.6	0.7	9.3	0.6
Steve Biko Academic Hospital	9.5	0.6	9.2	0.6
Willow Ridge High School (Wilgers)	9.5	0.7	9.2	0.7
Hoerskool Waterkloof	10.0	0.7	9.6	0.7
Hoerskool Garsfontein	9.7	0.7	9.4	0.7
Afrikaanse Hoer Seunskool	9.5	0.7	9.2	0.6
Huis Silversig SAVF Old Age Home (Silverton)	9.4	0.7	9.1	0.6
Laersekool Meyerspark (Meyerspark)	9.5	0.7	9.2	0.6
Curro Academy Mamelodi	9.3	0.7	9.0	0.6
Impendulo Primary School	9.6	0.7	9.3	0.7
Nellmapius Ext 6 Primary School	9.5	0.7	9.2	0.6
Mamelodi Home For Aged	9.4	0.7	9.1	0.6

Predicted concentrations in µg/m³ at the sensitive receptors for Scenario C (2036), together with the limit value of the NAAQS

Scenario C (2036)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**25**	**15**
Elsie Ballot Memorial Hospital	11.4	1.4	11.0	1.3
Laerskool Amersfoort	11.2	1.4	10.8	1.3
Embuzane Primary School	11.6	1.5	11.0	1.4
Sangqotho Primary School	9.2	1.4	8.8	1.3
Amersfoort Combined School	11.3	1.4	10.9	1.3
Injubuko Primary School	10.2	1.4	9.8	1.3
Daggakraal Primary School	10.4	1.5	10.0	1.4
Sizenzele Primary School	10.0	1.5	9.5	1.4
Seme Secondary School	10.3	1.5	9.9	1.4
Louwra Primary School	9.4	1.2	9.0	1.2
Perdekop Agricultural School	10.4	1.3	10.0	1.2
Vukuzenzele Combined School	10.4	1.3	10.0	1.2
Gunwana Primary School	10.5	1.2	10.2	1.2
Amajuba Memorial Hospital	8.5	1.1	8.1	1.1
Volksrust High School	8.5	1.1	8.1	1.1
Volksrust Municipal Clinic	8.4	1.1	8.0	1.1
C V O Skool Amajuba	8.4	1.1	8.0	1.1
Qhubulwazi Combined School	8.5	1.1	8.1	1.1
Volksrust Primary School	8.6	1.2	8.3	1.1
New Ermelo	9.7	1.2	9.4	1.1
Ermelo Christian School	9.5	1.2	9.2	1.2
SAVF Home For Aged	9.5	1.2	9.2	1.1
Ermelo Hospital	9.4	1.2	9.1	1.1
Mediclinic Ermelo	9.5	1.2	9.1	1.1
Hoerskool Ermelo	9.4	1.2	9.1	1.1
Ermelo Indian Combined School	9.3	1.2	9.0	1.1
Lungelo Combined School (Outside Town)	9.5	1.2	9.1	1.1
New Ermelo Primary School	9.7	1.2	9.4	1.1
Kwashashe (Outside Town)	9.7	1.2	9.4	1.1
Hts Ligbron	9.5	1.2	9.2	1.1
Laerskool Ermelo	9.6	1.2	9.2	1.1
JJ Vd Merwe Pre-Primary School	9.4	1.2	9.1	1.1
Lindile Secondary School	9.2	1.2	8.9	1.1
Emthonjeni Clinic	9.3	1.2	9.0	1.1
Reggie Masuku Secondary School	9.0	1.2	8.7	1.1
Cebisa Secondary School	9.2	1.2	8.9	1.1
Camden	9.5	1.2	9.2	1.2
Camden Combined School	9.3	1.2	9.0	1.2
Camden School	9.6	1.2	9.3	1.2
Umzimvelo Secondary School (Rural Area)	9.3	1.2	9.0	1.2
Bhekimfundo Primary School (Rural Area)	9.6	1.2	9.2	1.2
Eshwileni Primary School (Rural Area)	8.8	1.3	8.5	1.2
Davel Combined School	8.6	1.1	8.3	1.1
Morgenzon Landbou Akademie	9.0	1.3	8.6	1.2
Nqobangolwazi Secondary School	9.1	1.3	8.6	1.2
Siqondekhaya Pre Primary School	9.1	1.3	8.6	1.2
Sizakhele Primary School	9.1	1.3	8.6	1.2

Scenario C (2036)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**25**	**15**
Phezukwentaba Primary School (South of Morgenzon)	8.9	1.3	8.5	1.2
Kwaggalaagte Primary School (North of Morgenzon)	9.6	1.2	9.2	1.1
Sizakhele Clinic/Hospital	9.1	1.3	8.6	1.2
Grootvlei	7.8	0.8	7.5	0.8
Olive Grove Country Lodge	8.0	0.8	7.7	0.8
Grootvlei Town (South of Power Station)	8.1	0.8	7.8	0.8
Laerskool Grootvlei	8.1	0.8	7.8	0.8
Tokoloho Primary School	8.1	0.8	7.8	0.8
Tshepeha Combined School	8.0	0.8	7.7	0.8
Warembo Lodge	7.9	0.9	7.6	0.8
Balfour	7.4	0.8	7.1	0.8
Siyathemba	7.5	0.9	7.2	0.8
Bonukukhanya Primary (Siyathemba)	7.6	0.9	7.3	0.8
Qalabocha Primary School (Siyathemba)	7.5	0.9	7.2	0.8
Vusumuzi Primary School	7.5	0.9	7.2	0.8
Gekombineerde Skool Balfour	7.6	0.9	7.3	0.8
Im Manchu Secondary School	7.5	0.8	7.2	0.8
Isifisosethu Secondary School (Siyathemba)	7.6	0.9	7.3	0.8
Setsheng Secondary School (Siyathemba)	7.5	0.9	7.2	0.8
Dr Nieuwoudt And Dr Kok	7.6	0.9	7.3	0.8
Balfour Clinic	7.5	0.8	7.2	0.8
Siyathemba Clinic	7.4	0.9	7.1	0.8
Mondoro Lodge	7.4	0.8	7.1	0.8
Wegelegen Manor	7.6	0.9	7.3	0.8
The Stone Cellar	7.0	0.8	6.7	0.7
Greylingstad	8.0	0.9	7.6	0.9
Nthorwane	8.1	0.9	7.8	0.9
Laerskool Greylingstad	8.0	0.9	7.7	0.9
Nthoroane Secondary School	8.1	0.9	7.7	0.9
Badgarleur Bush Lodge	8.2	0.9	7.9	0.8
Matla Village	9.6	1.0	9.1	0.9
Sifundise Primary School	9.6	1.0	9.1	0.9
Matla Coal Health Centre	9.6	1.0	9.1	0.9
Gweda Primary School	9.2	1.0	8.8	1.0
Zithobe Primary School	9.4	0.9	9.0	0.9
Kwanala Primary School	9.2	1.0	8.8	1.0
Reedstream Park	9.4	1.0	8.9	0.9
Rietspruit Clinic	9.1	1.0	8.7	0.9
Lehlaka Combined School	9.1	1.0	8.7	0.9
Mbali Coal/Blesboklaagte Housing	9.0	1.0	8.5	0.9
Kinross	9.2	1.0	8.9	0.9
Kinross Settlement	9.3	1.0	8.9	0.9
Kinross Municipal Clinic	9.2	1.0	8.9	0.9
Kriel	9.1	1.0	8.7	1.0
Eagles Nest Guest House	9.0	1.0	8.6	1.0
Merlin Park Primary School	8.9	1.0	8.6	1.0
Kriel Medical Centre	9.0	1.0	8.6	1.0
Laerskool Krielpark	9.0	1.0	8.6	1.0
Laerskool Onverwacht	9.0	1.0	8.6	1.0

Scenario C (2036)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**25**	**15**
Silwer Fleur Aftree Oord (Old Age Home)	9.0	1.0	8.6	1.0
Thubelihle	8.8	1.0	8.4	1.0
Sibongamandla Secondary School	8.7	1.0	8.4	1.0
Ga-Nala Clinic	8.9	1.0	8.6	1.0
Impilo Primary School	8.6	1.0	8.3	0.9
Bonginhlanhla Primary School	8.7	1.0	8.4	1.0
Sibongamandla Secondary School	8.7	1.0	8.4	1.0
Leandra	9.1	0.9	8.7	0.9
Eendracht	9.0	0.9	8.6	0.9
Sidingulwazi Primary School	8.9	0.9	8.6	0.9
Ss Mshayisa Primary School	8.9	0.9	8.6	0.9
Chief Ampie Mayisa Secondary School	8.9	0.9	8.5	0.9
Lebogang Clinic	9.0	0.9	8.6	0.9
Kleuterskool Haas Das	9.7	1.1	9.3	1.1
Standerton Primary School	9.7	1.1	9.3	1.1
Laerskool Jeugkrag	10.1	1.1	9.6	1.1
Laerskool Standerton	9.7	1.1	9.3	1.1
Laerskool Kalie De Haas	9.8	1.1	9.3	1.1
Hoerskool Standerton	9.7	1.1	9.3	1.1
Standerton Provincial Government Hospital	9.8	1.1	9.3	1.1
Mar-Peh Medicare Private Hospital	9.7	1.1	9.3	1.1
Standerton Retirement Home	9.7	1.1	9.3	1.1
Standerton Ouetehuis/Old Age Home	9.7	1.1	9.3	1.1
Holmdene Secondary School	9.2	1.0	8.8	1.0
Cathuza Primary School (SE of Town)	10.4	1.2	9.9	1.1
Sizanani Pre Primary School	10.0	1.1	9.6	1.1
Hlobisa Primary School	10.0	1.1	9.5	1.1
Shukuma Primary School	9.8	1.1	9.4	1.1
Retsebile Primary School	10.3	1.1	9.9	1.1
Thuto-Thebe Secondary School	10.2	1.1	9.8	1.1
Jandrell Secondary School	10.1	1.1	9.6	1.1
Thobelani Secondary School	10.1	1.1	9.7	1.1
Standerton Tb Hospital	9.8	1.1	9.4	1.1
Thuthukani Pre Primary School	10.6	1.1	9.9	1.0
Ulwazi Primary School	10.7	1.1	9.9	1.0
Zikhetheleni Secondary School	10.7	1.1	9.9	1.0
Joubertsvlei Primary School (North of Tutuka)	9.1	1.1	8.6	1.0
Amalumgelo Primary School (NE of Tutuka)	10.3	1.3	9.5	1.2
Grootdraaidam Primary School	9.8	1.1	9.3	1.1
Laerskool Secunda	9.0	1.0	8.7	1.0
Laerskool Kruinpark	9.0	1.0	8.7	1.0
Laerskool Oranjegloed Primary	9.0	1.0	8.7	1.0
Curro Castle Combined School	9.0	1.0	8.6	1.0
Hoërskool Oosterland	9.0	1.0	8.7	1.0
Mediclinic Secunda (Hospital)	9.0	1.0	8.7	1.0
Mediclinic Highveld (Hospital_Trichardt, Secunda)	8.9	1.0	8.6	1.0
Daviescourt/Davieshof Old Age Home	9.0	1.0	8.7	1.0
Highveld Park High School	9.1	1.0	8.8	1.0
Hoerskool Secunda	9.0	1.0	8.7	1.0

Scenario C (2036)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**25**	**15**
Basizeni Special School	8.9	1.0	8.6	0.9
Maphala-Gulube Primary School	8.9	1.0	8.5	0.9
Shapeve Primary School	8.9	1.0	8.6	0.9
Thomas Nhlabathi Secondary School	8.9	1.0	8.5	0.9
Embalenhle Hospital / Clinic	8.9	1.0	8.5	0.9
Vukuzithathe Primary School	8.9	1.0	8.6	0.9
K I Twala Secondary	8.9	1.0	8.6	0.9
Allan Makunga Primary School	8.9	1.0	8.6	0.9
Evander Hospital Arv Clinic	9.0	1.0	8.7	0.9
Laerskool Hoeveld	9.0	1.0	8.7	0.9
Hoerskool Evander	9.0	1.0	8.6	0.9
Bernice Samuel Hospital	8.4	0.7	8.0	0.7
Hoerskool Delmas	8.4	0.7	8.1	0.7
Laerskool Delmas	8.4	0.7	8.0	0.7
Kangela Primary School (North of Delpark)	8.6	0.7	8.2	0.7
Savf Ons Eie Ouetehuis / Old Age Home	8.4	0.7	8.0	0.7
Laerskool Eloff	8.3	0.7	7.9	0.7
Rietkol Primary School	8.3	0.7	7.9	0.7
Bazani Primary School	8.4	0.7	8.0	0.7
Phaphamani Secondary School	8.4	0.7	8.1	0.7
Vezimfundo Primary School	8.2	0.7	7.9	0.7
Arbor Primary School	8.6	0.8	8.0	0.8
Ogies Combined School	9.3	1.0	8.5	0.9
Ogies Tb Clinic	9.2	1.0	8.5	0.9
Ogies Police Station	9.2	1.0	8.5	0.9
Hlangu Phala Primary School	9.4	0.9	8.6	0.8
Sukumani Primary School	9.4	0.9	8.6	0.8
Thuthukani Primary School	9.4	0.9	8.6	0.8
Mehlwana Secondary School	9.4	0.9	8.7	0.8
Makause Combined School	9.4	0.9	8.7	0.8
Sibongindawo Primary School	9.2	0.9	8.5	0.8
Laerskool Balmoral	9.7	0.8	9.2	0.7
Clewer Primary School	9.3	0.8	8.8	0.8
Witbank High School	8.6	0.8	8.2	0.8
Eden Park Retirement Village	8.6	0.8	8.2	0.8
Savf House Immergroen Old Age Home	8.7	0.8	8.3	0.8
Mthimkulu Housing for the Aged	9.0	0.8	8.6	0.8
Emalahleni Private Hospital	8.8	0.8	8.4	0.8
Life Cosmos Hospital	8.5	0.8	8.1	0.8
Duvha Primary School	8.7	0.8	8.3	0.8
Laerskool Taalfees	8.6	0.8	8.2	0.8
Witbank Provincial Hospital	8.7	0.8	8.3	0.8
Nancy Shiba Primary School (Vosman)	9.5	0.8	9.1	0.7
Wh De Klerk Skool	8.5	0.8	8.2	0.8
Laerskool Panorama	8.7	0.8	8.3	0.7
Laerskool Duvhapark	8.6	0.8	8.3	0.8
Laerskool Klipfontein	8.6	0.8	8.2	0.8
Cambridge Academy	8.5	0.8	8.1	0.8
Besilindile Primary School	9.1	0.8	8.7	0.7

Scenario C (2036)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**25**	**15**
Reynopark High School	8.6	0.8	8.2	0.8
Bakenveld Golf Estate	8.4	0.8	8.0	0.8
Allendale Secondary School	8.7	0.9	8.3	0.8
Khayalethu Primary School	9.1	0.8	8.7	0.8
Illanga Secondary School	8.6	0.9	8.2	0.8
Joy Creche (Duvha)	8.7	0.9	8.4	0.8
Linderus Old Age Home	8.4	0.8	8.1	0.7
Vergeet My Nie Old Age Home	8.5	0.8	8.1	0.7
Middleburg Frail Care Unit and Home For Elderly	8.3	0.7	8.0	0.7
Life Midmed Hospital	8.3	0.8	8.0	0.7
Middelburg Hospital	8.4	0.8	8.1	0.7
Makhathini Primary School	8.3	0.7	8.0	0.7
Laerskool Dennesig	8.3	0.7	7.9	0.7
Hoerskool Kanonkop	8.3	0.7	8.0	0.7
Laerskool Kanonkop	8.3	0.7	8.0	0.7
Steelcrest High School	8.3	0.8	8.0	0.7
Middelburg Primary	8.4	0.8	8.1	0.7
Middleburg Ext 6 Clinic	8.4	0.8	8.1	0.7
Sofunda Secondary School	8.4	0.8	8.0	0.7
Mhluzi Primary School	8.3	0.7	8.0	0.7
Highlands Primary School	8.4	0.8	8.1	0.7
Blinkpan Primary School	8.6	1.0	8.3	0.9
Laerskool Koornfontein	8.6	1.0	8.2	0.9
Blinkpan	8.7	1.0	8.3	0.9
Laerskool Kragveld	8.7	0.9	8.3	0.9
Pullens Hope	8.7	0.9	8.4	0.9
Arnot Colliery Primary School	8.6	0.9	8.3	0.8
Laerskool Rietkuil	8.4	0.9	8.1	0.8
Beestepan Agricultural School	8.1	0.8	7.8	0.8
Gekombineerde Skool Hendrina	8.6	1.0	8.3	0.9
Hendrina Primary School	8.6	1.0	8.3	0.9
Kwazamokuhle Secondary School	8.5	1.0	8.2	0.9
Ubuhle Bolwai Secondary School	9.1	1.1	8.9	1.1
Lothair Primary School	9.4	1.1	9.1	1.1
Warburton Combined School	9.1	1.0	8.8	1.0
Warburton Town	9.1	1.0	8.8	1.0
Kwachibikhulu Clinic	8.8	1.1	8.5	1.0
Kwachibikhulu Primary School	8.9	1.1	8.6	1.0
Carolina Hospital	8.5	1.0	8.2	0.9
Zinikeleni Secondary School (Silobela)	8.5	1.0	8.2	0.9
Volkskool Carolina	8.5	1.0	8.2	0.9
Sobuza Primary School	8.5	1.0	8.2	0.9
Ons Eie Ouetehuis (Old Age Home)	8.4	1.0	8.2	0.9
Laerskool Breyten	9.0	1.1	8.7	1.0
Siyazi Primary School (Kwazanele)	9.0	1.1	8.7	1.1
Masizakhe Secondary School (Kwazanele)	9.0	1.1	8.7	1.1
Belfast Rusoord (Old Age Home)	6.7	0.7	6.5	0.7
Belfast Hospital	6.8	0.7	6.6	0.7
Platorand School	6.9	0.8	6.7	0.7

Scenario C (2036)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**25**	**15**
Belfast Primary School (Siyathuthuka)	6.7	0.7	6.4	0.7
Siyathuthuka Clinic	6.7	0.7	6.4	0.7
Life Bethal Hospital	8.7	1.1	8.3	1.0
Hoerskool Hoogenhout	8.6	1.1	8.2	1.0
Jim Van Tonderskool	8.6	1.1	8.3	1.0
Bethal Independent Primary School	8.6	1.1	8.3	1.0
Laerskool Marietjie Van Niekerk	8.7	1.1	8.4	1.0
Laerskool Hm Swart	8.7	1.1	8.3	1.0
Sakhisizwe Primary School (Emzinoni)	9.2	1.1	8.8	1.0
Alpheus D Nkosi Secondary School (Emzinoni)	9.2	1.1	8.8	1.0
Silwerjare Old Age Home	8.8	1.1	8.4	1.0
Residentia Palm Oord	8.7	1.1	8.3	1.0
Bronkhorspruit Hospital	7.4	0.6	7.1	0.5
Cultura High School	7.5	0.6	7.1	0.6
Bronkhorspruit Primary School	7.4	0.6	7.0	0.5
Bronkhorspruit Dam	7.6	0.6	7.2	0.6
Hoerskool Erasmus	7.5	0.6	7.2	0.6
Althea Independent School	7.6	0.6	7.2	0.6
Kgoro Primary School (Zithobeni)	7.5	0.6	7.2	0.5
Zithobeni Secondary School (Zithobeni)	7.5	0.6	7.2	0.5
Vaal Power AH	7.7	0.7	7.3	0.6
Sasolburg Provincial Hospital	8.4	0.6	7.9	0.6
Moredou Old Age Home	8.1	0.6	7.6	0.6
Ons Gryse Jeug Old Age Home	8.0	0.6	7.6	0.6
Noord Primere Skool	8.1	0.6	7.6	0.6
Sasolburg High School	7.9	0.6	7.4	0.6
Sakhubusa Secondary School	8.0	0.6	7.5	0.6
Bekezela Primary School	7.6	0.6	7.2	0.6
Isaac Mhlambi Primary	7.9	0.6	7.4	0.6
Refenkgotso Primary School	7.3	0.7	6.9	0.7
Deneysville Primary School	7.3	0.7	6.9	0.7
Netcare Vaalpark Hospital	8.5	0.6	8.0	0.6
Vaalpark Articon Secondary School	9.1	0.6	8.6	0.6
Mediclinic Emfuleni	7.5	0.6	7.2	0.5
Jeugland Old Age Home	7.6	0.6	7.2	0.5
Herfsoord Huis Old Age Home	7.5	0.6	7.1	0.5
Huis Prinscilla	7.4	0.6	7.0	0.5
Laerskool Emfulenipark	8.2	0.6	7.7	0.6
Nw University_Vaal Campus	7.9	0.6	7.4	0.6
Emfuleni Primary School	7.6	0.5	7.2	0.5
Mediclinic Vereeniging	7.3	0.6	7.0	0.6
Kopanong Provincial Hospital (Duncanville)	7.2	0.6	6.8	0.6
Avondrus Eventide Old Age Home	7.3	0.6	6.9	0.6
Riviera On Vaal Resort	7.5	0.6	7.0	0.6
Sedibeng Tvet College	7.4	0.6	7.0	0.6
General Smuts High School	7.5	0.6	7.1	0.6
Eureuka School & Selbourne Primary	7.5	0.6	7.1	0.6
Midvaal Private Hospital (Three Rivers)	7.6	0.6	7.1	0.6
Three Rivers Retirement Village	7.8	0.6	7.3	0.6

Scenario C (2036)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**25**	**15**
Drie Riviere Aftreeoord Old Age Home	7.6	0.6	7.2	0.6
Riverside High School	7.6	0.6	7.1	0.6
Risiville Primary School	7.5	0.6	7.1	0.6
Sebokeng Hospital	7.5	0.5	7.2	0.5
Clinix-Naledzi Private Hospital	7.2	0.5	6.9	0.5
Mohloli Secondary School	7.6	0.6	7.1	0.5
Tshirela Primary School (Boipatong)	7.2	0.6	6.9	0.5
Tsoaranang Primary School (Thepiso)	7.4	0.6	7.0	0.5
Thepiso Primary School	7.1	0.6	6.8	0.5
Emmanuel Primary School	7.5	0.6	7.0	0.5
Rust Ter Vaal Combined School	7.0	0.6	6.7	0.5
Roshnee Primary School	7.0	0.6	6.7	0.5
Roshnee High School	7.0	0.6	6.7	0.5
Hoerskool Dr Malan	6.9	0.6	6.6	0.6
Laerskool Voorwaarts	7.3	0.6	6.9	0.6
Meyerton Secondary School	7.1	0.6	6.7	0.6
Ratasetjhaba Primary School	6.9	0.6	6.6	0.6
Meyerton Primary School	6.9	0.6	6.6	0.6
Oprah Leadership Academy	6.8	0.6	6.5	0.6
Henley River Retirement Village	6.9	0.6	6.6	0.6
Henley High & Preparatory School	7.0	0.6	6.6	0.6
Randvaal Clinic	6.8	0.6	6.5	0.6
Laerskool Japie Greyling	6.9	0.6	6.6	0.6
Thomas Nhlapo Primary	7.0	0.6	6.7	0.6
Randvaal Old Age Home	6.9	0.6	6.6	0.6
Laerskool Ag Visser	6.9	0.7	6.6	0.7
Lethaba Siyangobe	6.9	0.7	6.6	0.7
Shalimar Ridge Primary School	6.9	0.7	6.6	0.7
Jw Luckoff High School	7.0	0.7	6.7	0.7
Heidelberg Hospital	7.0	0.7	6.7	0.7
Thulatsatsi Operation (Rensburg)	6.9	0.7	6.6	0.7
Silwer Akker Tehuis	6.9	0.7	6.6	0.7
Riversands Retirement Village	6.9	0.7	6.6	0.7
Qhaqholla Primary School	6.9	0.7	6.6	0.7
Ratanda Primary School	6.9	0.7	6.6	0.7
Boneha Primary School	6.9	0.7	6.6	0.7
Sithokomele Primary School	6.9	0.7	6.6	0.7
Ratanda Bertha Gxowa Primary School	6.9	0.7	6.6	0.7
Khanya Lesedi Secondary School	6.9	0.7	6.6	0.7
Ratanda Secondary School	6.9	0.7	6.6	0.7
New Ratanda Secondary School	6.9	0.7	6.6	0.7
Kgoro Ya Thuto Secondary School	6.9	0.7	6.6	0.7
Ekurhuleni School for the Deaf	7.1	0.6	6.9	0.6
Pholosong Hospital	8.0	0.7	7.7	0.6
Tsakane Home For Aged	8.0	0.7	7.7	0.7
Mmuso Primary School	7.9	0.7	7.6	0.7
Michael Zulu Primary School	8.0	0.7	7.7	0.7
Nkabinde Primary School (Thembilisha)	7.9	0.7	7.6	0.6
Nigel Clinic	7.6	0.7	7.3	0.7

Scenario C (2036)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**25**	**15**
Tehuis Vir Bejaardes	7.6	0.7	7.4	0.7
Hoerskool John Vorster	7.6	0.7	7.3	0.7
Laerskool Hannes Visagie	7.7	0.7	7.4	0.7
Nigel Secondary School	7.7	0.8	7.4	0.7
Laerskool Dunnottar	7.8	0.7	7.6	0.7
Springs Retirement Village	7.8	0.7	7.6	0.6
Life Springs Parkland Hospital	7.9	0.7	7.6	0.6
Netcare N17 Hospital (Springs)	8.0	0.7	7.7	0.6
Springs Boys High School	7.9	0.7	7.6	0.7
Laerskool Selectionpark	7.9	0.7	7.6	0.6
Kwasa College Pre&Primary School	7.8	0.7	7.5	0.7
Edelweis Medical Centre	7.8	0.7	7.5	0.7
Laerskool Christiaan Beyers	7.9	0.7	7.6	0.6
Hoerskool Hugenote	7.8	0.7	7.5	0.6
Brakpan Primary School	7.5	0.7	7.2	0.6
Parkrand Primary School	7.4	0.6	7.1	0.6
Thabo Memorial Hospital	7.2	0.6	6.9	0.6
Sunward Park Hospital	7.3	0.6	7.0	0.6
Alberton High School	7.2	0.6	6.9	0.6
Netcare Clinton Hospital	7.2	0.6	6.9	0.6
Alberton Tuiste Vir Bejaardes	7.2	0.6	6.9	0.6
Bertha Gxowa Hospital	7.3	0.6	7.0	0.6
Linmed Hospital	7.5	0.6	7.2	0.6
Hoerskool Brandwag (Airfield)	7.5	0.6	7.2	0.6
Thepiso Noto Intermediate School	7.4	0.6	7.1	0.6
Laerskool Bredell	7.2	0.6	6.9	0.6
Sibonelo Primary School (Daveyton)	7.6	0.6	7.3	0.6
Petit High School (Kempton Park Nu)	7.5	0.6	7.2	0.6
Arwyp Medical Centre	7.5	0.6	7.3	0.6
Hoerskool Birchleigh	7.3	0.6	7.0	0.5
Curro Serengeti Acadamy	7.2	0.6	6.9	0.5
South Rand Hospital	7.3	0.6	7.0	0.6
Chris Hani Baragwanath Hospital	6.5	0.5	6.3	0.5
Thulani Primary School	6.4	0.5	6.2	0.5
University of Witwatersrand	7.0	0.6	6.7	0.5
Milpark Hospital	6.9	0.6	6.6	0.5
Charlotte Maxixe Academic Hospital	7.0	0.6	6.7	0.5
Thembisa West Secondary School (Thembisa)	7.0	0.5	6.8	0.5
Lenmed Zamokuhle Private Hospital (Thembisa)	7.0	0.5	6.8	0.5
Ikusasa Comprehensive School	7.2	0.5	6.9	0.5
Gem Village Old Age Home	6.6	0.5	6.3	0.5
Rustoord Old Age Home	6.3	0.5	6.0	0.4
Cornwell Hill College (Irene)	6.5	0.5	6.2	0.5
Kleinfontein Sorg Sentrum Old Age Home (Donkerhoek)	6.8	0.5	6.6	0.5
Valtaki AH (Rayton)	6.9	0.5	6.6	0.5
Laerskool Rayton (Rayton)	6.6	0.5	6.3	0.5
Tierkop AH	7.0	0.6	6.7	0.5
Redford House The Hills Private School (Mooikloof Glen)	7.0	0.5	6.7	0.5
Rietvlei View Country Estate	7.0	0.5	6.7	0.5

Scenario C (2036)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**25**	**15**
Hazeldean Curro School (Tyger Valley)	6.8	0.5	6.5	0.5
Tyger Valley College	6.8	0.5	6.5	0.5
Pretoria East Hospital (Moreletapark)	6.7	0.5	6.4	0.5
Groenkloof Old Age Home	6.2	0.4	5.9	0.4
Steve Biko Academic Hospital	6.0	0.4	5.7	0.4
Willow Ridge High School (Wilgers)	6.6	0.5	6.3	0.4
Hoerskool Waterkloof	6.6	0.5	6.3	0.5
Hoerskool Garsfontein	6.7	0.5	6.4	0.5
Afrikaanse Hoer Seunskool	6.1	0.4	5.9	0.4
Huis Silversig SAVF Old Age Home (Silverton)	6.3	0.4	6.1	0.4
Laersekool Meyerspark (Meyerspark)	6.4	0.4	6.2	0.4
Curro Academy Mamelodi	6.2	0.4	6.0	0.4
Impendulo Primary School	6.4	0.5	6.2	0.4
Nellmapius Ext 6 Primary School	6.5	0.4	6.2	0.4
Mamelodi Home For Aged	6.4	0.4	6.1	0.4

Predicted concentrations in µg/m³ at the sensitive receptors for Scenario D (MES), together with the limit value of the NAAQS

Scenario D (MES)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**25**	**15**
Elsie Ballot Memorial Hospital	6.1	0.9	5.6	0.8
Laerskool Amersfoort	6.0	0.9	5.6	0.8
Embuzane Primary School	6.7	1.0	6.1	0.8
Sangqotho Primary School	6.0	0.9	5.6	0.8
Amersfoort Combined School	6.0	0.9	5.6	0.8
Injubuko Primary School	5.7	0.9	5.3	0.8
Daggakraal Primary School	6.0	0.9	5.6	0.8
Sizenzele Primary School	6.1	0.9	5.6	0.8
Seme Secondary School	5.9	0.9	5.5	0.8
Louwra Primary School	5.7	0.8	5.4	0.7
Perdekop Agricultural School	6.0	0.8	5.6	0.7
Vukuzenzele Combined School	5.9	0.8	5.6	0.7
Gunwana Primary School	6.0	0.8	5.6	0.7
Amajuba Memorial Hospital	5.6	0.7	5.3	0.7
Volksrust High School	5.6	0.7	5.2	0.6
Volksrust Municipal Clinic	5.5	0.7	5.2	0.6
C V O Skool Amajuba	5.5	0.7	5.2	0.6
Qhubulwazi Combined School	5.5	0.7	5.2	0.6
Volksrust Primary School	5.7	0.7	5.3	0.7
New Ermelo	5.7	0.8	5.4	0.7
Ermelo Christian School	5.8	0.8	5.5	0.8
SAVF Home For Aged	5.8	0.8	5.5	0.7
Ermelo Hospital	5.8	0.8	5.5	0.7
Mediclinic Ermelo	5.8	0.8	5.5	0.8
Hoerskool Ermelo	5.8	0.8	5.5	0.7
Ermelo Indian Combined School	5.9	0.8	5.5	0.7
Lungelo Combined School (Outside Town)	5.7	0.8	5.4	0.7
New Ermelo Primary School	5.8	0.8	5.5	0.7
Kwashashe (Outside Town)	5.8	0.8	5.5	0.8
Hts Ligbron	5.8	0.8	5.5	0.7
Laerskool Ermelo	5.8	0.8	5.4	0.7
JJ Vd Merwe Pre-Primary School	5.9	0.8	5.6	0.7
Lindile Secondary School	5.8	0.8	5.5	0.7
Emthonjeni Clinic	5.8	0.8	5.5	0.7
Reggie Masuku Secondary School	5.7	0.8	5.4	0.7
Cebisa Secondary School	5.8	0.8	5.4	0.7
Camden	5.9	0.8	5.6	0.8
Camden Combined School	5.8	0.8	5.5	0.8
Camden School	5.9	0.8	5.6	0.8
Umzimvelo Secondary School (Rural Area)	5.7	0.8	5.4	0.8
Bhekimfundo Primary School (Rural Area)	5.9	0.8	5.6	0.8
Eshwileni Primary School (Rural Area)	5.5	0.8	5.2	0.7
Davel Combined School	5.6	0.8	5.3	0.7
Morgenzon Landbou Akademie	5.6	0.8	5.1	0.7
Nqobangolwazi Secondary School	5.6	0.8	5.1	0.7
Siqondekhaya Pre Primary School	5.6	0.8	5.2	0.7
Sizakhele Primary School	5.6	0.8	5.1	0.7

Scenario D (MES)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**25**	**15**
Phezukwentaba Primary School (South of Morgenzon)	5.7	0.8	5.3	0.7
Kwaggalaagte Primary School (North of Morgenzon)	5.6	0.8	5.2	0.7
Sizakhele Clinic/Hospital	5.6	0.8	5.1	0.7
Grootvlei	4.9	0.5	4.6	0.5
Olive Grove Country Lodge	4.9	0.5	4.5	0.5
Grootvlei Town (South of Power Station)	4.7	0.5	4.4	0.5
Laerskool Grootvlei	4.7	0.5	4.4	0.5
Tokoloho Primary School	4.7	0.5	4.4	0.5
Tshepeha Combined School	4.7	0.5	4.4	0.5
Warembo Lodge	4.8	0.5	4.5	0.5
Balfour	5.2	0.6	4.9	0.5
Siyathemba	5.2	0.6	4.9	0.5
Bonukukhanya Primary (Siyathemba)	5.2	0.6	4.9	0.5
Qalabocha Primary School (Siyathemba)	5.3	0.6	5.0	0.5
Vusumuzi Primary School	5.3	0.6	5.0	0.5
Gekombineerde Skool Balfour	5.1	0.6	4.8	0.5
Im Manchu Secondary School	5.0	0.5	4.7	0.5
Isifisosethu Secondary School (Siyathemba)	5.2	0.6	4.9	0.5
Setsheng Secondary School (Siyathemba)	5.3	0.6	5.0	0.5
Dr Nieuwoudt And Dr Kok	5.0	0.6	4.7	0.5
Balfour Clinic	5.1	0.5	4.8	0.5
Siyathemba Clinic	5.2	0.6	4.9	0.5
Mondoro Lodge	4.9	0.5	4.6	0.5
Wegelegen Manor	5.3	0.6	5.0	0.5
The Stone Cellar	4.7	0.5	4.5	0.4
Greylingstad	5.4	0.6	5.1	0.6
Nthorwane	5.4	0.6	5.1	0.6
Laerskool Greylingstad	5.5	0.6	5.2	0.6
Nthoroane Secondary School	5.4	0.6	5.1	0.6
Badgarleur Bush Lodge	5.3	0.6	5.0	0.5
Matla Village	5.9	0.7	5.4	0.6
Sifundise Primary School	5.9	0.7	5.4	0.6
Matla Coal Health Centre	5.9	0.7	5.4	0.6
Gweda Primary School	6.0	0.7	5.6	0.7
Zithobe Primary School	5.9	0.7	5.5	0.6
Kwanala Primary School	6.2	0.8	5.8	0.7
Reedstream Park	6.4	0.8	5.9	0.7
Rietspruit Clinic	6.5	0.8	6.1	0.7
Lehlaka Combined School	6.6	0.8	6.1	0.7
Mbali Coal/Blesboklaagte Housing	6.6	0.8	6.0	0.6
Kinross	6.0	0.7	5.7	0.6
Kinross Settlement	6.0	0.7	5.6	0.6
Kinross Municipal Clinic	6.0	0.7	5.7	0.6
Kriel	5.9	0.7	5.5	0.7
Eagles Nest Guest House	5.9	0.7	5.5	0.7
Merlin Park Primary School	5.9	0.7	5.5	0.7
Kriel Medical Centre	5.8	0.7	5.5	0.7
Laerskool Krielpark	5.8	0.7	5.4	0.7
Laerskool Onverwacht	5.8	0.7	5.5	0.7

Scenario D (MES)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**25**	**15**
Silwer Fleur Aftree Oord (Old Age Home)	5.8	0.7	5.4	0.7
Thubelihle	5.9	0.7	5.5	0.7
Sibongamandla Secondary School	5.9	0.7	5.5	0.7
Ga-Nala Clinic	5.8	0.7	5.4	0.7
Impilo Primary School	5.7	0.7	5.4	0.7
Bonginhlanhla Primary School	5.9	0.7	5.5	0.7
Sibongamandla Secondary School	5.9	0.7	5.5	0.7
Leandra	6.3	0.6	5.9	0.6
Eendracht	6.2	0.6	5.9	0.6
Sidingulwazi Primary School	6.3	0.6	5.9	0.6
Ss Mshayisa Primary School	6.3	0.6	6.0	0.6
Chief Ampie Mayisa Secondary School	6.3	0.6	5.9	0.6
Lebogang Clinic	6.3	0.6	5.9	0.6
Kleuterskool Haas Das	6.0	0.7	5.5	0.6
Standerton Primary School	6.0	0.7	5.5	0.6
Laerskool Jeugkrag	6.0	0.7	5.5	0.6
Laerskool Standerton	6.0	0.7	5.5	0.6
Laerskool Kalie De Haas	6.2	0.7	5.7	0.6
Hoerskool Standerton	6.0	0.7	5.5	0.6
Standerton Provincial Government Hospital	6.0	0.7	5.5	0.6
Mar-Peh Medicare Private Hospital	6.0	0.7	5.5	0.6
Standerton Retirement Home	6.0	0.7	5.5	0.6
Standerton Ouetehuis/Old Age Home	6.0	0.7	5.6	0.6
Holmdene Secondary School	5.7	0.7	5.3	0.6
Cathuza Primary School (SE of Town)	6.5	0.7	6.0	0.7
Sizanani Pre Primary School	6.0	0.7	5.6	0.6
Hlobisa Primary School	5.9	0.7	5.5	0.6
Shukuma Primary School	6.0	0.7	5.5	0.6
Retsebile Primary School	6.1	0.7	5.6	0.6
Thuto-Thebe Secondary School	6.0	0.7	5.5	0.6
Jandrell Secondary School	6.0	0.7	5.6	0.6
Thobelani Secondary School	6.0	0.7	5.6	0.6
Standerton Tb Hospital	6.0	0.7	5.5	0.6
Thuthukani Pre Primary School	6.4	0.7	5.6	0.6
Ulwazi Primary School	6.4	0.7	5.6	0.6
Zikhetheleni Secondary School	6.4	0.7	5.6	0.6
Joubertsvlei Primary School (North of Tutuka)	5.7	0.7	5.2	0.7
Amalumgelo Primary School (NE of Tutuka)	6.3	0.8	5.5	0.7
Grootdraaidam Primary School	6.1	0.7	5.5	0.6
Laerskool Secunda	6.0	0.7	5.6	0.6
Laerskool Kruinpark	5.8	0.7	5.5	0.6
Laerskool Oranjegloed Primary	5.8	0.7	5.5	0.6
Curro Castle Combined School	5.8	0.7	5.5	0.6
Hoërskool Oosterland	5.8	0.7	5.5	0.6
Mediclinic Secunda (Hospital)	5.9	0.7	5.6	0.6
Mediclinic Highveld (Hospital_Trichardt, Secunda)	5.8	0.7	5.5	0.6
Daviescourt/Davieshof Old Age Home	5.9	0.7	5.6	0.6
Highveld Park High School	5.9	0.7	5.5	0.6
Hoerskool Secunda	5.9	0.7	5.6	0.6

Scenario D (MES)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**25**	**15**
Basizeni Special School	5.9	0.6	5.5	0.6
Maphala-Gulube Primary School	5.8	0.7	5.5	0.6
Shapeve Primary School	5.9	0.7	5.5	0.6
Thomas Nhlabathi Secondary School	5.9	0.6	5.6	0.6
Embalenhle Hospital / Clinic	5.8	0.6	5.5	0.6
Vukuzithathe Primary School	5.9	0.6	5.5	0.6
K I Twala Secondary	5.9	0.6	5.5	0.6
Allan Makunga Primary School	5.9	0.6	5.5	0.6
Evander Hospital Arv Clinic	6.0	0.7	5.7	0.6
Laerskool Hoeveld	6.0	0.7	5.7	0.6
Hoerskool Evander	6.0	0.7	5.7	0.6
Bernice Samuel Hospital	5.3	0.5	4.9	0.5
Hoerskool Delmas	5.3	0.5	4.9	0.5
Laerskool Delmas	5.3	0.5	5.0	0.5
Kangela Primary School (North of Delpark)	5.4	0.5	5.0	0.5
Savf Ons Eie Ouetehuis / Old Age Home	5.3	0.5	5.0	0.5
Laerskool Eloff	5.1	0.5	4.8	0.4
Rietkol Primary School	5.1	0.5	4.8	0.4
Bazani Primary School	5.4	0.5	5.0	0.4
Phaphamani Secondary School	5.3	0.5	4.9	0.4
Vezimfundo Primary School	5.2	0.5	4.9	0.4
Arbor Primary School	6.4	0.6	5.8	0.5
Ogies Combined School	6.5	0.7	5.8	0.6
Ogies Tb Clinic	6.6	0.7	5.8	0.6
Ogies Police Station	6.6	0.7	5.8	0.6
Hlangu Phala Primary School	6.9	0.7	6.1	0.6
Sukumani Primary School	6.9	0.7	6.1	0.6
Thuthukani Primary School	6.9	0.7	6.1	0.6
Mehlwana Secondary School	6.8	0.7	6.1	0.6
Makause Combined School	6.8	0.7	6.1	0.6
Sibongindawo Primary School	6.9	0.6	6.2	0.6
Laerskool Balmoral	6.9	0.5	6.4	0.5
Clewer Primary School	6.3	0.6	5.8	0.5
Witbank High School	5.9	0.6	5.5	0.5
Eden Park Retirement Village	5.7	0.6	5.4	0.5
Savf House Immergroen Old Age Home	6.0	0.6	5.6	0.5
Mthimkulu Housing for the Aged	6.1	0.6	5.7	0.5
Emalahleni Private Hospital	6.1	0.6	5.7	0.5
Life Cosmos Hospital	5.9	0.6	5.5	0.5
Duvha Primary School	5.8	0.6	5.4	0.5
Laerskool Taalfees	5.9	0.6	5.5	0.5
Witbank Provincial Hospital	5.9	0.6	5.5	0.5
Nancy Shiba Primary School (Vosman)	6.5	0.6	6.0	0.5
Wh De Klerk Skool	5.9	0.6	5.5	0.5
Laerskool Panorama	5.9	0.6	5.5	0.5
Laerskool Duvhapark	5.8	0.6	5.4	0.5
Laerskool Klipfontein	5.8	0.6	5.4	0.5
Cambridge Academy	5.7	0.6	5.3	0.5
Besilindile Primary School	6.6	0.5	6.1	0.5

Scenario D (MES)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**25**	**15**
Reynopark High School	5.8	0.6	5.4	0.5
Bakenveld Golf Estate	5.5	0.6	5.2	0.5
Allendale Secondary School	5.9	0.6	5.5	0.6
Khayalethu Primary School	6.1	0.6	5.7	0.5
Illanga Secondary School	5.8	0.6	5.4	0.6
Joy Creche (Duvha)	5.9	0.6	5.5	0.6
Linderus Old Age Home	5.5	0.5	5.2	0.5
Vergeet My Nie Old Age Home	5.5	0.5	5.2	0.5
Middleburg Frail Care Unit and Home For Elderly	5.4	0.5	5.1	0.5
Life Midmed Hospital	5.4	0.5	5.1	0.5
Middelburg Hospital	5.5	0.5	5.1	0.5
Makhathini Primary School	5.4	0.5	5.1	0.5
Laerskool Dennesig	5.4	0.5	5.1	0.5
Hoerskool Kanonkop	5.4	0.5	5.1	0.5
Laerskool Kanonkop	5.4	0.5	5.1	0.5
Steelcrest High School	5.4	0.5	5.1	0.5
Middelburg Primary	5.5	0.5	5.2	0.5
Middleburg Ext 6 Clinic	5.4	0.5	5.1	0.5
Sofunda Secondary School	5.4	0.5	5.0	0.5
Mhluzi Primary School	5.4	0.5	5.1	0.5
Highlands Primary School	5.5	0.5	5.2	0.5
Blinkpan Primary School	5.7	0.7	5.3	0.6
Laerskool Koornfontein	5.7	0.7	5.4	0.6
Blinkpan	5.7	0.7	5.3	0.6
Laerskool Kragveld	5.9	0.6	5.6	0.6
Pullens Hope	5.9	0.6	5.6	0.6
Arnot Colliery Primary School	5.4	0.6	5.1	0.6
Laerskool Rietkuil	5.5	0.6	5.2	0.6
Beestepan Agricultural School	5.6	0.6	5.3	0.5
Gekombineerde Skool Hendrina	5.6	0.7	5.3	0.6
Hendrina Primary School	5.6	0.7	5.4	0.6
Kwazamokuhle Secondary School	5.6	0.7	5.3	0.6
Ubuhle Bolwai Secondary School	5.6	0.7	5.4	0.7
Lothair Primary School	5.7	0.8	5.4	0.7
Warburton Combined School	5.5	0.7	5.2	0.7
Warburton Town	5.5	0.7	5.2	0.7
Kwachibikhulu Clinic	5.6	0.8	5.3	0.7
Kwachibikhulu Primary School	5.6	0.8	5.3	0.7
Carolina Hospital	5.4	0.7	5.2	0.6
Zinikeleni Secondary School (Silobela)	5.5	0.7	5.2	0.6
Volkskool Carolina	5.4	0.7	5.1	0.6
Sobuza Primary School	5.5	0.7	5.2	0.6
Ons Eie Ouetehuis (Old Age Home)	5.4	0.7	5.1	0.6
Laerskool Breyten	5.5	0.8	5.2	0.7
Siyazi Primary School (Kwazanele)	5.5	0.8	5.2	0.7
Masizakhe Secondary School (Kwazanele)	5.5	0.8	5.2	0.7
Belfast Rusoord (Old Age Home)	4.7	0.5	4.5	0.5
Belfast Hospital	4.8	0.5	4.5	0.5
Platorand School	4.8	0.5	4.6	0.5

Scenario D (MES)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**25**	**15**
Belfast Primary School (Siyathuthuka)	4.6	0.5	4.4	0.5
Siyathuthuka Clinic	4.6	0.5	4.4	0.5
Life Bethal Hospital	5.8	0.8	5.4	0.7
Hoerskool Hoogenhout	5.7	0.8	5.4	0.7
Jim Van Tonderskool	5.8	0.8	5.5	0.7
Bethal Independent Primary School	5.8	0.8	5.5	0.7
Laerskool Marietjie Van Niekerk	5.7	0.8	5.3	0.7
Laerskool Hm Swart	5.8	0.8	5.4	0.7
Sakhisizwe Primary School (Emzinoni)	5.8	0.8	5.4	0.7
Alpheus D Nkosi Secondary School (Emzinoni)	5.8	0.8	5.4	0.7
Silwerjare Old Age Home	5.8	0.8	5.5	0.7
Residentia Palm Oord	5.8	0.8	5.5	0.7
Bronkhorspruit Hospital	4.9	0.4	4.5	0.4
Cultura High School	5.1	0.4	4.7	0.4
Bronkhorspruit Primary School	4.9	0.4	4.6	0.4
Bronkhorspruit Dam	4.9	0.4	4.5	0.4
Hoerskool Erasmus	5.0	0.4	4.6	0.4
Althea Independent School	4.9	0.4	4.5	0.4
Kgoro Primary School (Zithobeni)	4.8	0.4	4.5	0.3
Zithobeni Secondary School (Zithobeni)	4.7	0.4	4.4	0.3
Vaal Power AH	4.9	0.4	4.4	0.4
Sasolburg Provincial Hospital	5.1	0.4	4.6	0.3
Moredou Old Age Home	5.1	0.4	4.6	0.3
Ons Gryse Jeug Old Age Home	5.1	0.4	4.6	0.3
Noord Primere Skool	5.1	0.4	4.6	0.3
Sasolburg High School	5.0	0.4	4.6	0.3
Sakhubusa Secondary School	5.1	0.4	4.6	0.3
Bekezela Primary School	4.8	0.4	4.4	0.3
Isaac Mhlambi Primary	5.0	0.4	4.6	0.3
Refenkgotso Primary School	4.7	0.4	4.3	0.4
Deneysville Primary School	4.8	0.5	4.4	0.4
Netcare Vaalpark Hospital	5.2	0.4	4.7	0.3
Vaalpark Articon Secondary School	5.3	0.4	4.8	0.3
Mediclinic Emfuleni	4.7	0.4	4.3	0.3
Jeugland Old Age Home	4.7	0.4	4.3	0.3
Herfsoord Huis Old Age Home	4.6	0.4	4.2	0.3
Huis Prinscilla	4.6	0.4	4.2	0.3
Laerskool Emfulenipark	5.0	0.4	4.5	0.3
Nw University_Vaal Campus	5.1	0.4	4.6	0.3
Emfuleni Primary School	4.5	0.4	4.1	0.3
Mediclinic Vereeniging	4.8	0.4	4.4	0.3
Kopanong Provincial Hospital (Duncanville)	4.7	0.4	4.4	0.3
Avondrus Eventide Old Age Home	4.8	0.4	4.4	0.3
Riviera On Vaal Resort	4.9	0.4	4.5	0.3
Sedibeng Tvet College	4.9	0.4	4.4	0.3
General Smuts High School	4.9	0.4	4.5	0.3
Eureuka School & Selbourne Primary	4.9	0.4	4.5	0.3
Midvaal Private Hospital (Three Rivers)	5.1	0.4	4.6	0.4
Three Rivers Retirement Village	5.1	0.4	4.6	0.4

Scenario D (MES)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**25**	**15**
Drie Riviere Aftreeoord Old Age Home	5.0	0.4	4.6	0.4
Riverside High School	5.1	0.4	4.7	0.4
Risiville Primary School	5.1	0.4	4.6	0.4
Sebokeng Hospital	4.5	0.4	4.2	0.3
Clinix-Naledzi Private Hospital	4.5	0.4	4.2	0.3
Mohloli Secondary School	5.0	0.4	4.6	0.3
Tshirela Primary School (Boipatong)	4.5	0.4	4.1	0.3
Tsoaranang Primary School (Thepiso)	4.8	0.4	4.4	0.3
Thepiso Primary School	4.5	0.4	4.2	0.3
Emmanuel Primary School	4.8	0.4	4.3	0.3
Rust Ter Vaal Combined School	4.5	0.4	4.1	0.3
Roshnee Primary School	4.5	0.4	4.2	0.3
Roshnee High School	4.5	0.4	4.1	0.3
Hoerskool Dr Malan	4.6	0.4	4.2	0.4
Laerskool Voorwaarts	4.7	0.4	4.3	0.4
Meyerton Secondary School	4.7	0.4	4.3	0.4
Ratasetjhaba Primary School	4.5	0.4	4.1	0.3
Meyerton Primary School	4.5	0.4	4.2	0.4
Oprah Leadership Academy	4.5	0.4	4.2	0.4
Henley River Retirement Village	4.5	0.4	4.2	0.4
Henley High & Preparatory School	4.4	0.4	4.1	0.4
Randvaal Clinic	4.3	0.4	4.0	0.4
Laerskool Japie Greyling	4.3	0.4	4.0	0.4
Thomas Nhlapo Primary	4.4	0.4	4.1	0.4
Randvaal Old Age Home	4.5	0.4	4.2	0.4
Laerskool Ag Visser	4.4	0.5	4.1	0.4
Lethaba Siyangobe	4.4	0.5	4.2	0.4
Shalimar Ridge Primary School	4.5	0.5	4.2	0.4
Jw Luckoff High School	4.5	0.5	4.2	0.4
Heidelberg Hospital	4.5	0.5	4.2	0.4
Thulatsatsi Operation (Rensburg)	4.4	0.5	4.1	0.4
Silwer Akker Tehuis	4.5	0.5	4.2	0.4
Riversands Retirement Village	4.5	0.5	4.2	0.4
Qhaqholla Primary School	4.4	0.5	4.1	0.4
Ratanda Primary School	4.3	0.5	4.1	0.4
Boneha Primary School	4.4	0.5	4.1	0.4
Sithokomele Primary School	4.4	0.5	4.1	0.4
Ratanda Bertha Gxowa Primary School	4.5	0.5	4.2	0.4
Khanya Lesedi Secondary School	4.3	0.5	4.1	0.4
Ratanda Secondary School	4.4	0.5	4.1	0.4
New Ratanda Secondary School	4.5	0.5	4.2	0.4
Kgoro Ya Thuto Secondary School	4.5	0.5	4.2	0.4
Ekurhuleni School for the Deaf	4.4	0.4	4.1	0.4
Pholosong Hospital	4.4	0.5	4.2	0.4
Tsakane Home For Aged	4.5	0.5	4.2	0.4
Mmuso Primary School	4.6	0.5	4.3	0.4
Michael Zulu Primary School	4.5	0.5	4.2	0.4
Nkabinde Primary School (Thembilisha)	4.5	0.5	4.2	0.4
Nigel Clinic	4.7	0.5	4.4	0.4

Scenario D (MES)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**25**	**15**
Tehuis Vir Bejaardes	4.8	0.5	4.5	0.4
Hoerskool John Vorster	4.7	0.5	4.5	0.4
Laerskool Hannes Visagie	4.8	0.5	4.6	0.4
Nigel Secondary School	4.8	0.5	4.5	0.5
Laerskool Dunnottar	4.6	0.5	4.3	0.4
Springs Retirement Village	4.6	0.5	4.3	0.4
Life Springs Parkland Hospital	4.6	0.5	4.3	0.4
Netcare N17 Hospital (Springs)	4.6	0.5	4.3	0.4
Springs Boys High School	4.6	0.5	4.3	0.4
Laerskool Selectionpark	4.6	0.5	4.3	0.4
Kwasa College Pre&Primary School	4.7	0.5	4.5	0.4
Edelweis Medical Centre	4.6	0.5	4.4	0.4
Laerskool Christiaan Beyers	4.7	0.5	4.4	0.4
Hoerskool Hugenote	4.6	0.4	4.3	0.4
Brakpan Primary School	4.4	0.4	4.1	0.4
Parkrand Primary School	4.5	0.4	4.2	0.4
Thabo Memorial Hospital	4.4	0.4	4.1	0.4
Sunward Park Hospital	4.4	0.4	4.1	0.4
Alberton High School	4.4	0.4	4.1	0.4
Netcare Clinton Hospital	4.4	0.4	4.1	0.4
Alberton Tuiste Vir Bejaardes	4.4	0.4	4.1	0.4
Bertha Gxowa Hospital	4.4	0.4	4.1	0.4
Linmed Hospital	4.4	0.4	4.1	0.4
Hoerskool Brandwag (Airfield)	4.5	0.4	4.2	0.4
Thepiso Noto Intermediate School	4.7	0.4	4.4	0.4
Laerskool Bredell	4.3	0.4	4.1	0.4
Sibonelo Primary School (Daveyton)	4.8	0.4	4.5	0.4
Petit High School (Kempton Park Nu)	4.5	0.4	4.2	0.4
Arwyp Medical Centre	4.4	0.4	4.1	0.4
Hoerskool Birchleigh	4.4	0.4	4.1	0.3
Curro Serengeti Acadamy	4.5	0.4	4.2	0.4
South Rand Hospital	4.8	0.4	4.4	0.4
Chris Hani Baragwanath Hospital	4.6	0.4	4.3	0.3
Thulani Primary School	4.6	0.3	4.3	0.3
University of Witwatersrand	4.7	0.4	4.4	0.4
Milpark Hospital	4.7	0.4	4.4	0.3
Charlotte Maxixe Academic Hospital	4.7	0.4	4.4	0.4
Thembisa West Secondary School (Thembisa)	4.2	0.4	4.0	0.3
Lenmed Zamokuhle Private Hospital (Thembisa)	4.4	0.4	4.1	0.3
Ikusasa Comprehensive School	4.4	0.4	4.1	0.3
Gem Village Old Age Home	4.3	0.3	4.0	0.3
Rustoord Old Age Home	4.1	0.3	3.9	0.3
Cornwell Hill College (Irene)	4.3	0.3	4.0	0.3
Kleinfontein Sorg Sentrum Old Age Home (Donkerhoek)	4.3	0.3	4.0	0.3
Valtaki AH (Rayton)	4.5	0.3	4.2	0.3
Laerskool Rayton (Rayton)	4.3	0.3	4.1	0.3
Tierkop AH	4.5	0.4	4.2	0.3
Redford House The Hills Private School (Mooikloof Glen)	4.5	0.4	4.2	0.3
Rietvlei View Country Estate	4.5	0.4	4.2	0.3

Scenario D (MES)	PM_{10} Total		$PM_{2.5}$ Total	
	24-hr	Ann	24-hr	Ann
Receptor	**75**	**40**	**25**	**15**
Hazeldean Curro School (Tyger Valley)	4.3	0.3	4.0	0.3
Tyger Valley College	4.2	0.3	4.0	0.3
Pretoria East Hospital (Moreletapark)	4.3	0.3	4.0	0.3
Groenkloof Old Age Home	4.1	0.3	3.8	0.3
Steve Biko Academic Hospital	4.0	0.3	3.7	0.3
Willow Ridge High School (Wilgers)	4.1	0.3	3.8	0.3
Hoerskool Waterkloof	4.3	0.3	4.0	0.3
Hoerskool Garsfontein	4.2	0.3	3.9	0.3
Afrikaanse Hoer Seunskool	4.1	0.3	3.8	0.3
Huis Silversig SAVF Old Age Home (Silverton)	4.0	0.3	3.7	0.3
Laersekool Meyerspark (Meyerspark)	4.0	0.3	3.8	0.3
Curro Academy Mamelodi	3.9	0.3	3.6	0.3
Impendulo Primary School	4.0	0.3	3.8	0.3
Nellmapius Ext 6 Primary School	4.1	0.3	3.8	0.3
Mamelodi Home For Aged	3.9	0.3	3.7	0.3

Appendix C

AIRSHED SPECIFIC HEALTH COST BENEFIT ANALYSIS

Public

Health impact focused cost benefit analyses for Medupi and Matimba Power Stations in the Waterberg-Bojanala Priority Area

For input into the Minimum Emission Standards Exemption Report Chapter 8

21 October 2024

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PREAMBLE

This study forms part of the project entitled, "Eskom MES Exemption Applications & Decommissioning AIRs" for WSP Group Africa (Pty) Ltd appointed by Eskom SOC Limited for the preparation of the Minimum Emission Standards (MES) exemption application report.

The study investigates the health benefits and implementation costs of mitigating air pollution emissions from Eskom coal-fired power stations, Matimba and Medupi, in the Waterberg-Bojanala Priority Area. The two stations may be retrofitted with air emission abatement technologies. Matimba is scheduled for closure by 2043 and Medupi is scheduled for closure by 2071.

The methodology used in this study is based on World Health Organisation guidelines.

In addition to the authors, the contributors to this analysis include:

- Dr Mark Zunckel and Atham Raghunandan from uMoya-NILU Consulting (Pty) Ltd who were responsible for CALPUFF modelling.
- Ms Rietha Oosthuizen (independent consultant) and Dr Caradee Wright (SA Medical Research Council) who provided advice for the epidemiological evidence used in the study.
- Mr Bryan McCourt and Mr Ebrahim Patel from Eskom provided important details on scenarios and abatement technology costs.

EXECUTIVE SUMMARY

The combustion of fossil fuels results in the emission of numerous atmospheric pollutants, that include but are not limited to sulphur dioxide (SO_2), particulate matter (PM), and nitrogen dioxide (NO_2). Atmospheric pollutants have numerous negative effects on human health and increase the risk of premature mortality.

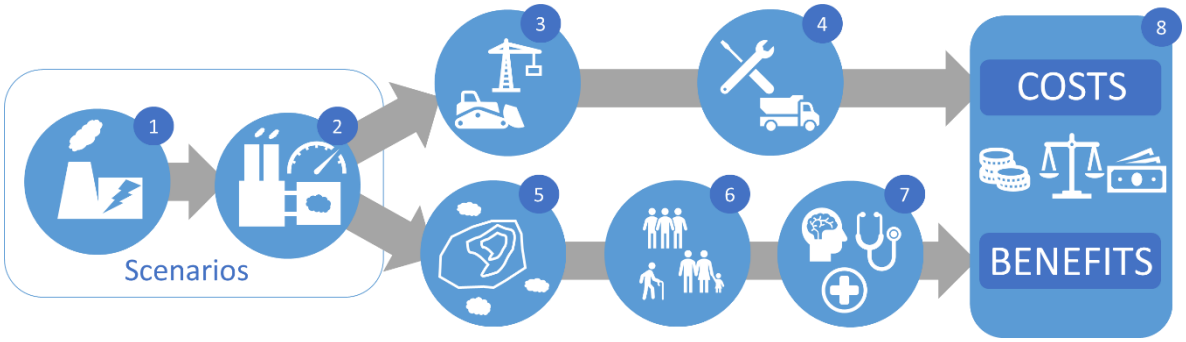
Technologies exist to reduce these emissions and therefore also their negative health effects. Abatement technologies for the power stations include wet and semi-dry Flue Gas Desulphurisation (FGD) for SO_2 reduction and installation of high-frequency power supply (HFPS) to improve Electrostatic Precipitator (ESP) efficiency and reduce PM emissions.

A benefit-cost analysis (BCA) allows for trade-offs between different scenarios to be compared to support decision making.

The aim of this study was to estimate the incremental health benefits associated with abatement technology options, to achieve or move towards compliance with the new Minimum Emission Standards (MES) of the Department of Forestry Fisheries and the Environment (DFFE).

Methodology

An integrated Air Pollution Health Risk Benefit Cost Analysis APHR-BCA model was developed to model the impacts of three different abatement scenarios as developed by Eskom. The APHR-BCA was developed following the General Principles of the World Health Organisation, WHO (WHO, 2016a), for performing air pollution health risk assessments (AP-HRA). The detailed methodology and assumptions are set out in section 2 below. In summary, the methodology proceeded through several steps, as set out in the schematic:



Health benefits resulting from air pollution abatement

The WHO (2016a) recommends that the health risk in a population, associated with air pollution, is to be estimated using exposure-response functions (ERFs). ERFs are based on Relative Risk (RR) estimates derived from primary epidemiological studies. These RR functions estimate the likelihood of health outcomes occurring in a population exposed to a higher level of air pollution relative to that in a population with a lower exposure level. RR is usually expressed as the proportional increase in the assessed health outcome risk incidence associated with a given increase in pollutant concentrations, measured in $\mu g/m^3$. The WHO (2016a) notes that "*the RR estimate cannot be assigned to a specific person; it describes risk in a defined population, not individual risk.*"

Ideally, ERF studies and their RRs should be determined based on primary epidemiological studies focussing on the exposed population. In the absence of such studies, as in the case of South Africa, the WHO (2016a) recommends using ERFs from other countries.

The health outcomes were selected based on the latest WHO systematic reviews from 2020 and 2021 that were conducted for the update of the WHO Global Air Quality guidelines. The health outcome that was considered in this study is all-cause mortality. Morbidity was not considered in this study as comprehensive data on morbidity studies is not widely available. Additionally, there are issues relating the transferability of data from one population to another in terms of country and culture as populations have different sensitivities to pollutant exposure (WHO 2000).

Pollution levels, chemical composition and health care systems are typically very different in other settings, and this would affect the accuracy of the ERFs. It is important to understand at what level interval the ERFs would result in significant differences in health outcome incidences. As a result, the WHO (2016a) advises performing an assessment of the uncertainty of the analysis; in this case therefore this requires an assessment related to a lack of knowledge about one or more components of the integrated Health BCA Model. Section 2.5 discusses each source of uncertainty and related limitations. Variation in the health outcome ERFs was dealt with through performing sensitivity analysis in the BCA (refer to section 2.4).

Interpretation of the risk of premature mortality has to be done with care. It is to be noted firstly that these numbers are indicators of health risk at a population level. The relative risk estimate inherent in the ERF is a metric of the likelihood of an adverse health outcome, and it cannot be attributed to an individual person. It can thus be used to quantify risk to a defined population (and not to an individual), (WHO 2016a) and how this risk would vary between various mitigation scenarios.

In this study, the ERFs obtained from the latest WHO systematic reviews, focused exclusively on mortality and thus a monetary measure of mortality was required in order to perform benefit-cost analyses. In air pollution benefit-cost analyses, the concept of value of a statistical life (VSL) is commonly used to monetise mortality related benefits of air pollution reduction. The concept of a VSL is frequently misunderstood. It does not measure the intrinsic value of a human life, and neither does it value the economic productivity of a human. Rather, VSL is estimated by dividing an individual's willingness to pay (WTP) to reduce health risk, by the likelihood of risk reduction. Robinson and Hammitt (2009) defines VSL to represent the rate at which an individual is willing to exchange their own income for a small reduction in their own mortality risk over a particular time period. VSL is not the value that a person, society or the government would place on reducing mortality rates with certainty, but it is rather a representation of the rate at which a person views a change in the money available for spending as equivalent to a small change in their own mortality risk (Robinson et al., 2018).

Primary WTP studies for mortality risk reductions have not been done in South Africa. The VSL for South Africa in the BCA was determined by using the methodology as advised by Viscusi and Masterman (2017) and Robinson et al. (2018) with a base VSL from the U.S, GNI per capita for income measures and adjusted by income elasticity. As advised by Robinson et al. (2018), a sensitivity analysis is conducted to explore various VSL estimates.

Scenario assessment

The three scenarios evaluated in the BCA study, against a baseline included:

- Scenario ERP 2024 A (PM reduction, generating load capped, air quality offsets and SO_2 reduction at Medupi)
- Scenario ERP 2024 B (As per ERP 2024 B)
- Scenario ERP 2024 C (Full compliance with MES for PM, NOx and SO_2 for both Medupi and Matimba)

The detailed emission abatement measures relevant to the scenarios are set out in Table 2-3 in Section 2.3.3. A key difference in the scenarios is the number of stations which are installed with SO_2 reduction technology in the form of wet-Flue Gas Desulphurisation (FGD) or semi-dry FGD. The focus on SO_2 reduction is important given the extent to which it is anticipated to impact on air quality and public health and the very significant cost of SO_2 reduction.

Health benefits associated with each scenario were calculated against the baseline (FY 25) that took into account the anticipated increase in loads in the coming years from 2025 and assumed no additional abatement technologies installed and both stations would continue to emit air pollution at their current rates until shutdown, repowering and repurposing.

- The health benefits of ERP 2024 A deliver immediate impact from 2024. At Medupi Wet FGD is commissioned from 2028 to 2032. Both stations already operate at NOx = 750 mg/Nm^3. Medupi already has Fabric Filter Plant (FFP) for PM reduction. Matimba station is equipped with ESP + HPPS for optimisation of PM reduction. These increase the associated health benefits until 2039. Hereafter the associated health benefits reduce as Matimba shutdown, repowering and repurposing is between 2039 and 2043. Medupi station shutdown, repowering and repurposing is much later from 2065 and the health benefits from the Wet FGD continue until final closure of the station.
- The health benefits of ERP 2024 B include those as discussed for ERP 2024 A above. In addition, efficiency and coal improvement projects reduce total sulphur and carbon emissions by 5% for Medupi and Matimba from 2024 onwards.
- The health benefits of ERP 2024 C include those as discussed for ERP 2024 A and B above. Semi-dry FGD is installed at Matimba by 2035, however the associated health benefits are effectively negated as Matimba starts to shut down in 2039.

With respect to the **abatement costs** associated with each scenario:

- The total Capex and Opex costs of abatement are identical to 2024.
- ERP 2024 A implementation starts in 2025 with Matimba ESP + HFPS technology and in 2028 with Medupi, Wet FGD installation. After 2032 only operational costs continue at Medupi.
- ERP 2024 B is the same as ERP 2024 A discussed above.

- ERP 2024 C is the same as described for ERP 2024 A and B. In addition, implementation starts in 2031 with Matimba semi-dry FGD. The Capex costs decrease after 2032 as Medupi Wet FGD is fully installed and only the Capex of the Matimba semi-dry FGD remains until 2035 whereafter only operational costs remain. After closure of Matimba in 2043 only Medupi continues to operate.

The BCA ratios need to be interpreted with care. They are meant only to provide a perspective on and inform the decision-making process underlying the scenarios. They are not meant to be interpreted as a definitive answer to making abatement decisions. Decisions involving human health have to be informed by non-economic criteria as well. In addition, with uncertainty inherent in the analysis, the cost benefit ratio should thus not be viewed as absolute, but rather as a relative value from which to compare scenarios.

The **BCA results** are provided in Table 0-1. In the upper estimates the lower costs and higher VSL are used and in the lower estimates the higher costs and lower VSL are used as recommended by Robinson et al. 2018.

- The BCA central ratio of ERP 2024 A is significantly less than 1, indicating that costs of abatement far exceed the health benefits. This ratio remains below 1 even in the most optimistic (upper) parameters of the sensitivity analysis. The reasons for this include the implementation of FGDs at Medupi in conjunction with the small population that benefits. This scenario has a total nominal cost of R58,660 million and is likely to increase electricity tariffs by 0.6% - 0.9% in ERP 2024 A.
- The BCA ratio of ERP 2024 B is also significantly less than 1, indicating that costs of abatement far exceed the health benefits. This ratio remains below 1 even in the most optimistic (upper) parameters of the sensitivity analysis. The same reasons apply as for ERP 2024 A above. This scenario has a total nominal cost of R58,660 million and is likely to increase electricity tariffs by 0.6% - 0.9% as in ERP 2024 A.
- The BCA ratio of ERP 2024 C is also significantly less than 1, indicating that costs of abatement far exceed the health benefits. This ratio remains below 1 even in the most optimistic (upper) parameters of the sensitivity analysis. This scenario has a larger discrepancy in NPV of health benefits and NPV of costs due to implementation of FGDs at both Medupi and Matimba and the small population that benefits. This scenario has a total nominal cost of R101,670 million and is likely to increase electricity tariffs by 0.9% - 1.2% in ERP 2024 C.
- Evaluation of the BCA ratios at a social discount rate of 2% delivers similar results, with all three scenarios ratios remaining less than 1.

Table 0-1: BCA ratios (lower and upper ranges) for each scenario (discounted at Eskom WACC)

	ERP 2024 A		ERP 2024 B		ERP 2024 C	
Million Rands	*Lower*	*Upper*	*Lower*	*Upper*	*Lower*	*Upper*
NPV of Costs	-18,970	-13,437	-18,970	-13,437	-27,716	-19,632
NPV of Benefits	3	17	8	39	16	83
NPV of Benefits minus Costs	-18,967	-13,420	-18,962	-13,398	-27,700	-19,549
Benefit:Cost Ratio (*range*)	0.0002	0.0012	0.0004	0.0029	0.0006	0.0042
Benefit:Cost Ratio (*central*)	0.0007		0.0017		0.0024	

ACRONYMS AND ABBREVIATIONS

AP-HRA	Air Pollution Health Risk Assessment
AQA	Air Quality Act
AQMS	Air Quality Monitoring Station
BCA	Benefit-Cost Analysis
CFOI	Census of Fatal Occupational Injuries (USA)
COI	Cost of Illness
DEA	Department of Environmental Affairs (now DFFE)
DFFE	Department of Forestry Fisheries & Environmental Affairs
DSI	Dry Sorbent Injection
ERF	Exposure Response Function
ESP	Electrostatic Precipitators
FFP	Fabric Filter Plants
FGD	Flue Gas Desulphurisation
GNI	Gross National Income
ICD	International Classification of Diseases
kW	Kilowatt
kWh	Kilowatt Hour
MES	Minimum Emissions Standards
NAAQS	National Ambient Air Quality Standard
NAQI	National Air Quality Index
NEMA	National Environmental Management Act
NO_2	Nitrogen Oxide
NPV	Net Present Value
PM	Particulate Matter
RR	Relative Risk
SAMRC	South African Medical Research Council
SO_2	Sulphur Dioxide
USA	United States of America
VSL	Value of a Statistical Life

WBPA	Waterberg-Bojanala Priority Area
WHO	World Health Organisation
WACC	Weighted Average Cost of Capital
WTP	Willingness to Pay

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1 INTRODUCTION

The Earth Summit[1] in Rio de Janeiro in 1991 raised the awareness of the linkages between environmental health and human wellbeing to a global agenda. In the three and half decades since the Summit, significant effort has gone into methods for quantifying these linkages, in all environmental spheres, and informing policy development. During the same period, we have seen an information technology revolution, which has radically improved our ability to collect and analyse large data sets. In the field of air quality health risk assessment specifically, there has been a rapid and continuously improving set of methodologies through which to analyse the linkages between air pollution and health risk.

The World Health Organisation (WHO) has been leading the development of health risk assessment methodology. Formally, air pollution health risk assessments (AP-HRA) are performed to provide quantifiable information for informing public policy decisions. The general principles for AP-HRAs have been published by the WHO (WHO, 2016a). An AP-HRA proceeds through three steps.

Firstly, it assesses the exposure of the target population to specific air pollutants. This requires a quantification of constituents in the atmosphere that are associated with human health risks. The atmosphere we breathe contains various such constituents, both from natural sources (e.g. sea salt and bio-aerosols) and anthropogenic sources (e.g. fuel combustion, suspension of fine particles, and industrial emissions) (refer to FRIDGE (2004) for a comprehensive discussion of pollution sources). When a particular policy option is analysed, specific indicator constituents need to be selected, and the incremental effect of the policy option needs to be estimated in terms of population exposure. In this study, incremental population exposure resulting from Eskom's coal-fired power plant emissions (from two stations in the Waterberg), was estimated through the use of dispersion modelling (uMoya-Nilu, 2024).

Secondly, the AP-HRA estimates the resultant incremental change in health risk. This requires the application of exposure-response functions (ERFs). ERFs quantify the incremental change in health outcomes (compared to the baseline incidence), based on changes in exposure to pollutants. ERFs are derived from epidemiological studies, which are large scale population health studies that compare health outcome incidence between populations exposed to different concentrations of pollution. In this study, ERFs from the latest systematic reviews from 2020 and 2021 that were conducted for the update of the WHO Global Air Quality guidelines were used (WHO 2020, 2021). AP-HRA results can be reported in terms of morbidity indicators (e.g. cost of medical treatment and lost economic productivity) or mortality indicators (e.g. premature mortality). These indicators can be converted to monetary impacts by applying cost of illness (COI) methodologies. In this study, premature mortality was evaluated, using a value of a statistical life (VSL) COI methodology.

Thirdly, the AP-HRA process requires the quantification and expression of the uncertainty of the estimated health effects. The WHO states that this step is "*an important and integral component of the results, and … vital to ensure both that the main message is not lost and that the results*

[1] http://www.un.org/geninfo/bp/enviro.html

produced are understandable by policy-makers and others who do not necessarily have a technical background or expertise in AP-HRA." This step requires "*the use of expert judgement (consensus) on the level of confidence of the results*".

This study investigates the health effects of air pollution resulting from two coal-fired power stations in the Waterberg-Bojanala Priority area and applies the AP-HRA methodology described above.

The indicator pollutants used included sulphur dioxide (SO_2), particulate matter (PM), and nitrogen dioxide (NO_2). These pollutants have several negative impacts on public health (WHO, 2016b).

The Department of Forestry, Fisheries and the Environment (DFFE) under the National Environmental Management Act (NEMA: AQA, 2004) sets ambient air quality standards. Where ambient air quality standards are exceeded, specific air quality mitigation actions would be required. Power generation is a Listed Activity in terms of Section 21 of the NEMA: AQA and Minimum Emission Standards (MES) are prescribed for existing and new stations. In 2018 amendments were made to the list of activities and associated minimum emission standards in terms of section 21 (4)(a). Eskom was granted MES postponements for SO_2 at Medupi and Matimba to 2025 (DEA, 2018 a & b). The May 2024 ruling by the Minister of the Department of Forestry, Fisheries and the Environment requires that Eskom submit application in terms of Section 59 of the National Environmental Management: Air Quality Act (NEMA: AQA), for the exemption of the MES for eight power stations that will continue to operate beyond 2030. Matimba and Medupi are included in these eight stations.

Technologies exist for the reduction of emissions and therefore the health effects. These abatement technologies include Flue Gas Desulphurisation (FGD) and Dry Sorbent Injection (DSI) to reduce SO_2, Electrostatic Precipitators (ESP) and high-frequency power supplies (HFPS) to improve Electrostatic Precipitators (ESP) efficiency to reduce PM, Low NO_X Burners (LNB) to reduce NO_2 and Fabric Filter Plants (FFP) to reduce PM.

The current study investigated three air pollution mitigation scenarios for Eskom, through a benefit-cost analysis (BCA). The BCA uses the AP-HRA methodology to estimate the likely changes in health costs resulting from each scenario. The BCA compares these benefits against the capital costs and operational costs of the mitigation options for each scenario (refer to section 2.3).

1.1 Other studies

Other studies have previously been conducted to estimate the health impacts of either fossil fuel power stations, air pollution in general or specific sources in South Africa. They estimated morbidity and mortality, and in some instances attributed costs to these health impacts. Studies of this nature can take either bottom up (deterministic) approaches or top down (stochastic) approaches to modelling pollution exposure with the latter usually preferable in data poor environments or large spatial domains (Dios et al., 2012). These studies also varied in geographic scale, ranging from selected areas to the national scale. Some of the most recent and relevant include:

The World Health Organisation estimated that, in South Africa, in 2009, the relative risk of premature mortality attributed to poor outdoor air quality was approximately 1,100 cases per year (WHO, 2009).

- Scale: National (All Air Pollution)
- Resolution: Course
- Health Outcomes: Mortality
- Modelling Approach: Top-down

The Centre for Research on Energy and Clean Air estimated that full Minimum Emissions Standard (MES) compliance at Eskom power stations remaining in operation until 2030 would reduce the relative risk of premature mortality from air pollution by 2,300 cases per year and economic costs of R42 billion per year (Myllyvirta & Kelly, 2023). The impacts of mercury were also estimated in the study.

- Scale: National (Power Station Air Pollution)
- Resolution: Medium
- Health Outcomes: Morbidity and Mortality
- Modelling Approach: Bottom-up

The Institute for Health Metrics and Evaluation listed air pollution as the 9th largest risk factor driving death and disability combined in 2016 in South Africa (IHME, 2016).

- Scale: National (All Air Pollution)
- Resolution: Medium
- Health Outcomes: Morbidity and Mortality
- Modelling Approach: Bottom-up

A study commissioned by Greenpeace in 2014 estimated air pollution emissions from Eskom's coal-fired power stations could increase the relative risk of premature mortality from air pollution by as much as 2,200 cases per year (Myllyvirta, 2014). The study also estimated the impacts of mercury pollution.

- Scale: National (Air Pollution from Coal-fired Power Stations)
- Resolution: Medium
- Health Outcomes: Morbidity and Mortality
- Modelling Approach: Bottom-up

A 2017 study commissioned by Groundwork, estimated the total impact of air pollution resulting from the coal-fired power stations at $2.4 billion of health costs annually in South Africa (Holland, 2017).

- Scale: National (Air Pollution from Coal-fired Power Stations)
- Resolution: Medium
- Health Outcomes: Morbidity and Mortality
- Modelling Approach: Bottom-up

Van Horen (1996) evaluated the health costs associated with Eskom's power stations as part of understanding the true costs of electricity generation. The valuation of morbidity outcomes was found to be small in terms of costs per kWh generated.

- Scale: National (Air Pollution from Coal-fired Power Stations)
- Resolution: Medium
- Health Outcomes: Morbidity and Mortality
- Modelling Approach: Bottom-up

The Fund for Research into Industrial Development Growth and Equity, in 2004, assessed the economic impact of air pollution in selected areas in South Africa. The study found that power generation was responsible for 51% of the 8,700 respiratory cases in Mpumalanga (FRIDGE, 2004).

- Scale: Selected Areas (All Air Pollution and Air Pollution from Power Stations)
- Resolution: Medium
- Health Outcomes: Morbidity and Mortality
- Modelling Approach: Bottom-up

A review by Spalding-Fecher and Matibe in 2003 aimed to calculate the external costs of electric power generation in South Africa. They estimated the health costs to be R1.1 billion per year (Spalding-Fecher and Matibe, 2003).

- Scale: National (Air Pollution from Power Stations)
- Resolution: Low
- Health Outcomes: Morbidity and Mortality
- Modelling Approach: Top-down.

The methodology used in this investigation is discussed in detail in Section 2 below.

2 METHODOLOGY AND INPUTS

2.1 Overview

An integrated Health BCA Model was developed that combined an AP-HRA with a BCA to assess three air pollution mitigation scenarios for two Eskom coal-fired power stations in the Waterberg region.

Figure 2-1 below provides an overview of the methodology, and Sections 2.2 - 2.5 provide a more detailed discussion of each component.

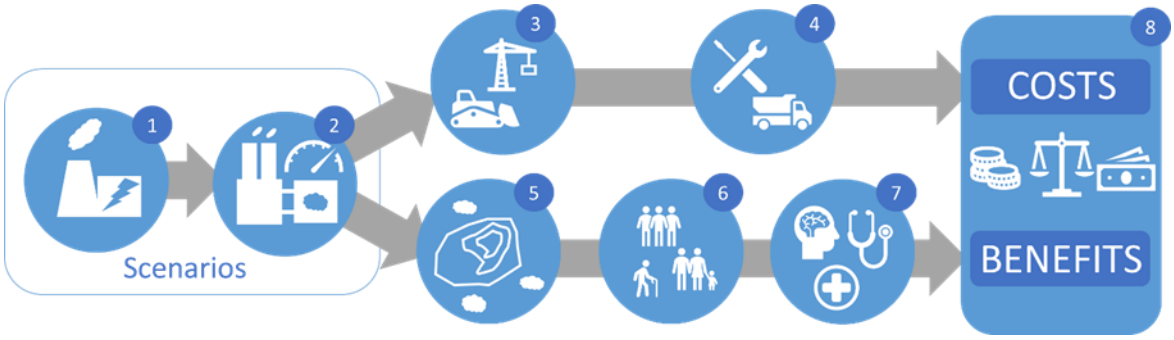


Figure 2-1: Overview of methodology and model architecture

With reference to Figure 2-1, the integrated Health BCA Model includes the following components:

1. Station lifetimes were described for two coal-fired power stations, Medupi and Matimba, and included commissioning and shutdown, repowering and repurposing dates (provided by Eskom).
2. Abatement technologies required for the two power-stations as required in each scenario were defined, by type and likely implementation schedule (refer to section 2.3.3).
3. Capital expenditure required for abatement in each scenario and was obtained from Eskom and attributed per station and per year (refer to section 2.3.4).
4. Operational expenditure required for abatement in each scenario was and was obtained from Eskom and attributed per station and per year (refer to section 2.3.4).
5. Dispersion modelling was done by uMoya-NILU Consulting (Pty) Ltd. This data was then segregated spatially, by municipal ward boundaries to align with population data. Two types of dispersion modelling were performed, one modelling the individual power station predicted ambient concentrations of SO_2, PM, and NO_2 per scenario and the other the cumulative predicted ambient concentrations of SO_2, PM, and NO_2 from both power stations per scenario. Note that for PM, the dispersion modelling predicted primary PM and secondary PM effects, resulting from NO_2 and SO_2 reactions in the atmosphere, as well as fugitive emissions (refer to Section 2.2).
6. Population exposure was estimated at a spatial resolution of municipal wards. At each municipal ward, the number of people exposed to different concentration

ranges were determined per scenario per year, based on Stats SA population estimates and United Nations population growth forecasts (refer to Section 2.2).

7. Health impacts were determined by using the AP-HRA methodology. Epidemiological evidence, in the form of Exposure-response functions (ERFs) and baseline incidence rates were obtained from the World Health Organization (WHO) systematic reviews (2020 & 2021) conducted by various researchers for the WHO as part of the WHO update to the Global Air Quality Guidelines (released in late of September 2021) (refer to Section 2.3). The ERFs were limited to mortality incidence. The Cost of Illness (COI) methodology used was the value of a statistical life (VSL). This method estimates the willingness to pay (WTP) of an individual for reducing their health risk. The VSL should not be interpreted as the intrinsic value of a life. Refer to Section 2.3.2 for a more detailed discussion.
8. The BCA compares the overall scenario health benefits achieved through abatement to the costs of implementation. The outputs of the AP-HRA, i.e. the health cost savings of each scenario, was used as the benefit. The analysis timeline spans 2024 – 2045. (refer to Section 2.4). Finally, an assessment of uncertainty of the results was done (refer to Section 2.5).

2.2 Exposure of the target population to specific air pollutants

2.2.1 Overview

This section comprises the first step of the AP-HRA and assesses the exposure of the target population to specific air pollutants.

This requires an incremental effects quantification of constituents in the atmosphere that are associated with human health risks. These pollutants include SO_2, PM, and NO_2 emitted by the two coal-fired power stations investigated. The emissions from these stations impact the Waterberg-Bojanala Priority area in the Limpopo province of South Africa.

Dispersion modelling combined with population distribution provided an estimate of the exposed population.

2.2.2 Pollutants analysed

The Waterberg-Bojanala Priority Area (WBPA) has three ambient Air Quality Monitoring Stations, Marapong, Medupi and Lephalale stations equipped for continuous monitoring of air quality and meteorological parameters. Marapong AQMS and Medupi AQMS were established by Eskom in 2006 and 2014 respectively and Lephalale is SAWS-DEA owned NAQI (National Air Quality Index) station that was established by DEA (now DFFE) in 2012.

The sections that follow provide a summary of the ambient concentrations of SO_2, NO_2 and PM in the period of 2021 to 2023 at the AQMS at Matimba and Medupi power stations. In the WBPA the main sources of air pollution include agriculture activities, domestic fuel and waste burning, vehicle emissions, mining activities and power generation.

2.2.2.1 Sulphur dioxide (SO_2)

Industrial processes and power generation are the main source of SO_2 in the atmosphere through the combustion or refining of sulphur containing fuels.

During the analysis period from 2021 to 2023, the hourly, daily and annual SO_2 ambient concentrations at Medupi and Lephalale monitoring stations were within the National Ambient Air Quality Standards (NAAQS). There were no exceedances recorded for this time period at Medupi and Lephalale monitoring stations. At Marapong AQMS the hourly, daily and annual SO_2 ambient concentrations were below the NAAQS for 2021 with no exceedances recorded. At this station data recovery for 2022 and 2023 was below 50% and thus not reflected in the analyses.

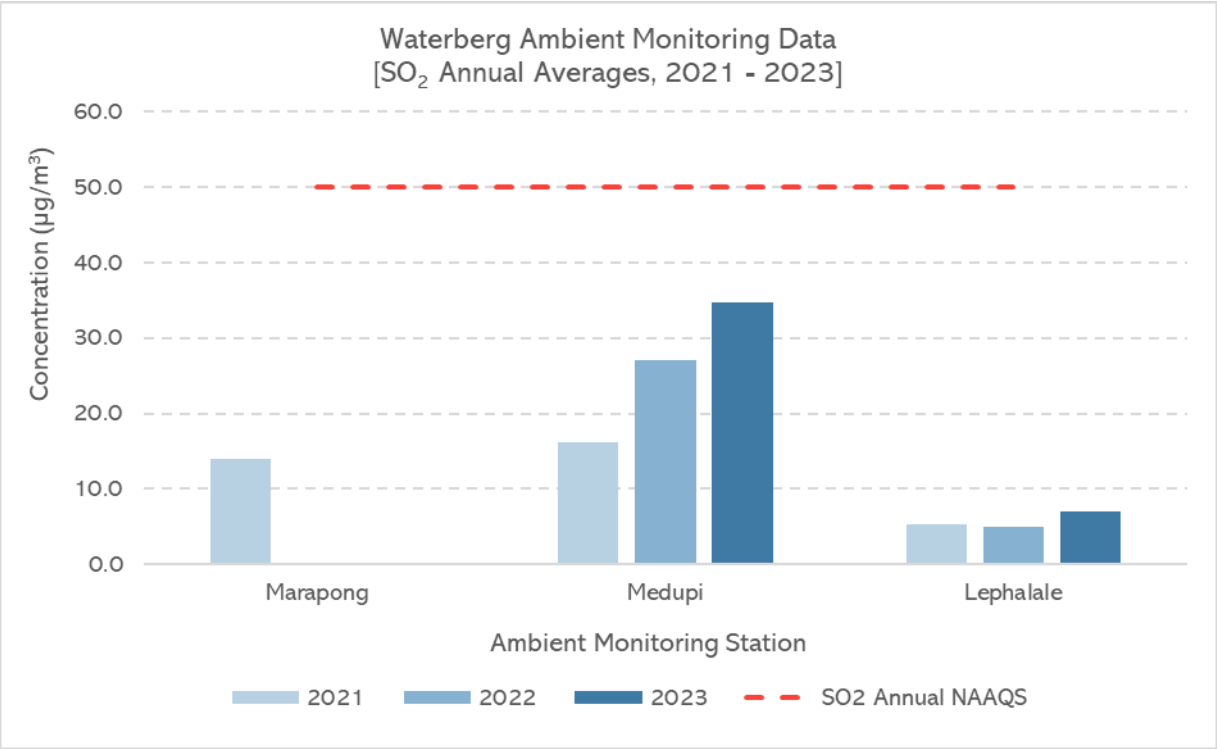


Figure 2-2: Annual average SO_2 concentrations at the Marapong, Medupi and Lephalale AQMS

2.2.2.2 Nitrogen dioxide (NO_2)

Industrial processes and power generation are the main source of NO_2 in the atmosphere through the combustion or refining of fossil fuels, with some contribution from motor vehicle emissions, residential fuel burning and biomass burning.

At Marapong the hourly concentrations for 2021 and 2022 were below NAAQS and no exceedances were recorded and the annual average concentrations were below the average NAAQS for 2021. The hourly concentrations and the annual average concentration for 2021 to 2023 at Medupi and Lephalale monitoring stations were below the average NAAQS with no hourly exceedances recorded.

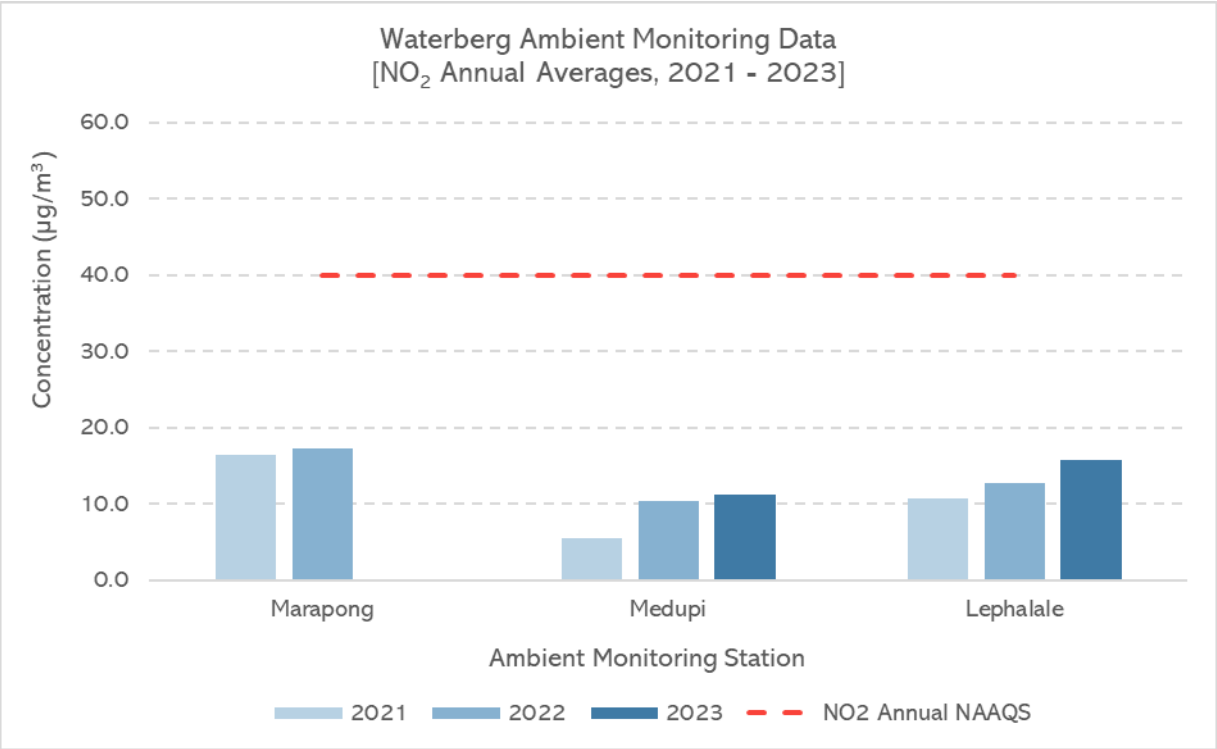


Figure 2-3: Annual average NO_2 concentrations at the Marapong, Medupi and Lephalale AQMS

2.2.2.3 Particulate matter (PM)

There are numerous sources of primary particulate matter, including power generation, industry, mining, biomass burning and agricultural activities, as well as natural sources such as wind entrainment. In addition, secondary PM is produced by NO_2 and SO_2 reactions in the atmosphere.

At the Marapong and Medupi monitoring stations the daily $PM_{2.5}$ and PM_{10} concentrations in 2021 and 2022 were non-compliant with the NAAQS with multiple exceedances reported. The annual average concentrations at Marapong station for PM_{10} in 2021 exceeded the NAAQS average and the annual average concentrations of $PM_{2.5}$ in 2021 and 2022 respectively exceeded NAAQS average and remain non-compliant. At Medupi station annual average concentrations of PM_{10} for 2021 to 2023 exceeded the average NAAQS and the 2021 concentrations for $PM_{2.5}$ also exceeded the average and is thus non-compliant for PM.

The daily and annual average PM_{10} concentrations at the Lephalale station remained below the NAAQS in 2021 and 2023 with one daily exceedance recorded in 2021 and no exceedances recorded in 2023, thus remaining compliant. The daily $PM_{2.5}$ concentrations in 2023 remained below the NAAQS with no exceedances recorded and in 2021 the annual average $PM_{2.5}$ concentrations remained below NAAQS and thus remains compliant. (WSP, 2024)

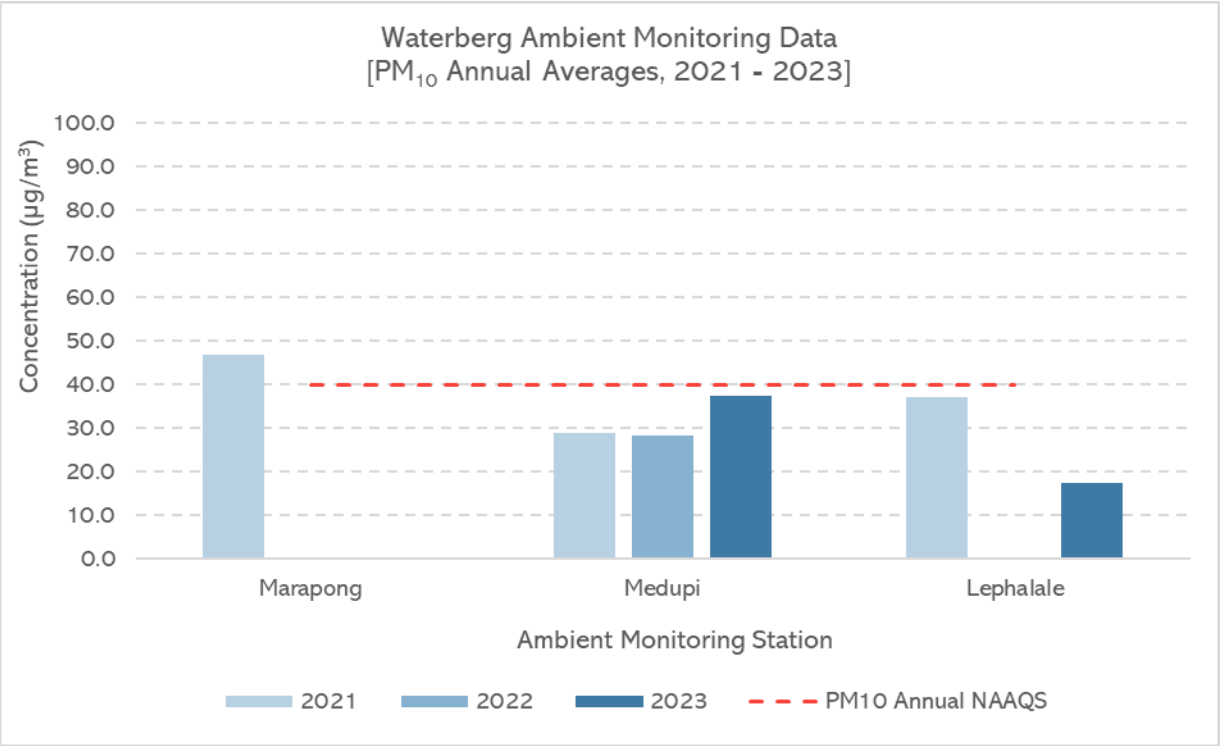


Figure 2-4: Annual average PM_{10} concentrations at the Marapong, Medupi and Lephalale AQMS in µg.m³

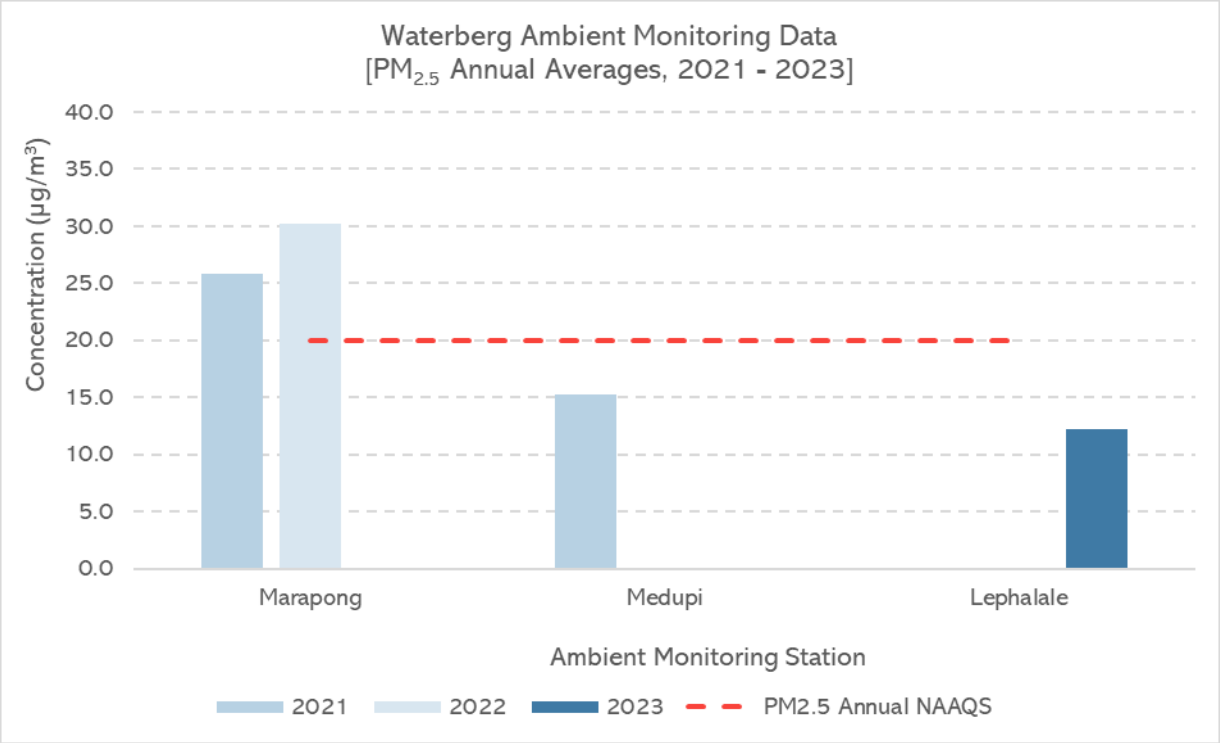


Figure 2-5: Annual average $PM_{2.5}$ concentrations at the Marapong, Medupi and Lephalale AQMS in µg.m³

2.2.3 Description of power stations

The Eskom power stations forming part of this study in the Waterberg-Bojanala Priority Area are Matimba and Medupi. These power stations will have a combined installed capacity of 8,754 MW and are listed in Table 2-1.

Table 2-1: Eskom coal-fired power stations, used in this study, and their installed capacity (Eskom, 2023)

Power Station	Province	Installed capacity (MW)
Matimba	Limpopo	3,990
Medupi	Limpopo	4,760

2.2.4 Dispersion modelling

Dispersion modelling is required to estimate the effects of stack emissions on ambient concentrations of pollutants and describe them spatially.

Dispersion modelling for this study was conducted by uMoya-NILU Consulting (Pty) Ltd and followed the requirements of the Code of Practice for Air Dispersion Modelling, DEA guideline (DEA, 2014).

The work modelled the dispersion of sulphur dioxide (SO_2), primary and secondary particulate matter (PM), fugitive emissions and nitrogen dioxide (NO_2) for the Matimba and the Medupi power stations. Dispersion modelling was performed using the CALPUFF suite of models. CALPUFF is a multi-layer, multi-species non-steady-state puff dispersion model that simulates the effects of time and space-varying meteorological conditions on pollution transport, transformation and removal. It includes algorithms for sub-grid scale effects, such as terrain effect, as well as longer range effects, such as pollutant removal due to wet scavenging and dry deposition, chemical transformation, and the formation of secondary particulate matter. The Air Pollution Model (TAPM) was used to model surface and upper air meteorological data for the study domain.

Two types of analysis were performed, individual and cumulative models. Individual station dispersion modelling results had a modelling domain covering 4,356 km^2 where the domain extends 66 km (west-east) by 66 km (north-south) and consists of a uniformly spaced receptor grid with 0.5 km spacing, giving 17,424 grid cells (132 x 132 grid cells). The cumulative station dispersion modelling results had a modelling domain that covers an area of 11,664 km^2, where the domain extends 108 km (west-east) by 108 km (north-south) and consists of a uniformly spaced receptor grid with 1 km spacing, giving 11,664 grid cells (108 x 108 grid cells).

There were two baseline scenarios modelled in CALPUFF that are used in the study. The first one (Scenario 1) represents the current performance of stations based on data over the three year period of 2021 to 2023. The second baseline (Scenario A baseline) took into account the anticipated increase in loads (due to several aspects such as economy requirements, possible delays in IPP projects coming online etc.) in the coming years from 2025 to 2030 and is a better

representation of what will be happening in the next five years. Scenario A baseline was used for comparison with the different scenarios in the BCA.

Individual power station models: Five emissions scenarios have been modelled for Matimba and Medupi Power Stations individually. These are (1) Scenario 21-23 Actual (Current Scenario 1 Current actual emissions), (2) Scenario FY25 (Baseline Scenario - Emission based on anticipated loads), (3) ERP 2024 A (Scenario B - 2031 planned stack emissions), and (4) ERP 2024 B (Scenario C - 2036 planned stack emissions), (5) Scenario D (Emissions in Full MES compliance 2036) Emissions sources at Matimba included stacks, coal stockpile and ash dump, while those at Medupi included stacks, coal stockpile, excess coal stockyard and ash dump.

Cumulative impact: The same five emissions scenarios listed above have been modelled for Matimba and Medupi Power Stations to assess the combined effect of these power stations on the ambient air quality.

Isopleth maps of predicted ambient SO_2, NO_2, PM_{10} and $PM_{2.5}$ concentrations are presented in Figure 2-6 to Figure 2-9. The predicted concentrations are shown as isopleths, lines of equal concentration, in $\mu g/m^3$ for the respective NAAQS averaging periods. The isopleths are depicted as coloured lines on the maps, corresponding to a particular predicted ambient concentration. Areas within red isopleths indicate an area where exceedances of the respective NAAQS limit value are predicted to occur. Exceedance is only seen for PM_{10} and $PM_{2.5}$ close to the stations. Sensitive receptors are represented by green squares and AQMS are represented by white dots on the maps. (uMoya-NILU, 2024).

National Ambient Air Quality Standards (NAAQS) (DEA, 2009, 2012) apply to the pollutants emitted by stations. The NAAQS consists of a 'limit' value and a permitted frequency of exceedance. The limit value is the fixed concentration level aimed at reducing the harmful effects of a pollutant and the permitted frequency of exceedance represents the acceptable number of exceedances of the limit value expressed as the 99th percentile. Compliance with the ambient standard implies that the frequency of exceedance of the limit value does not exceed the permitted tolerance. The NAAQS limits for the averaging period of 1 year for SO_2 is 50 $\mu g/m^3$, for NO_2 is 40 $\mu g/m^3$, for PM_{10} is 40 $\mu g/m^3$ and for $PM_{2.5}$ is 20 $\mu g/m^3$ (from 2030 is 15 $\mu g/m^3$).

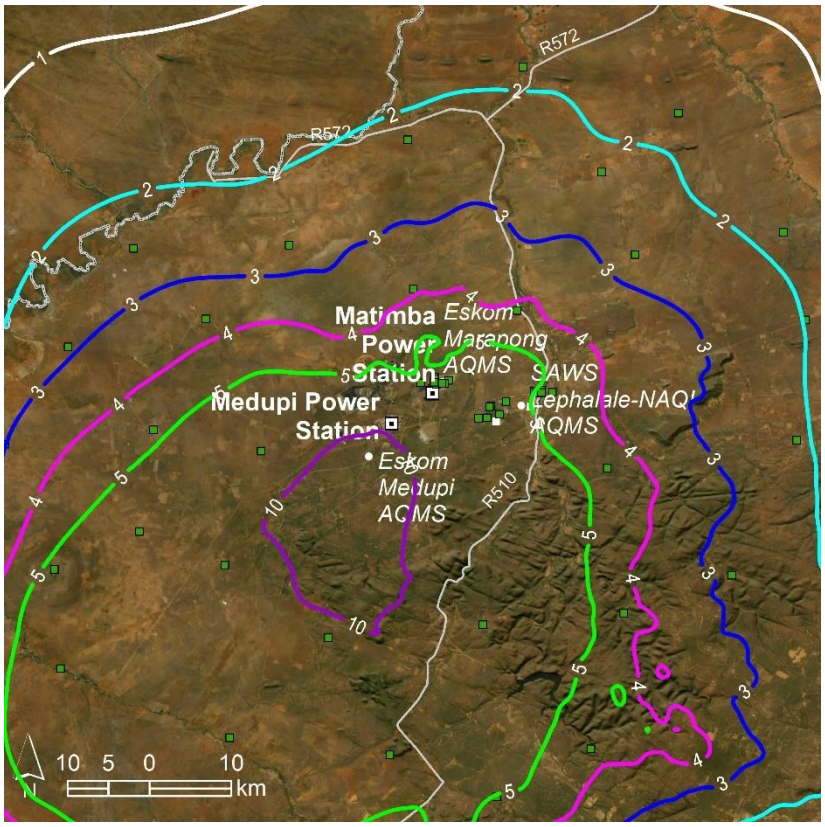


Figure 2-6: Cumulative predicted annual average SO_2 concentrations (µg/m³) for Matimba and Medupi Power Stations.

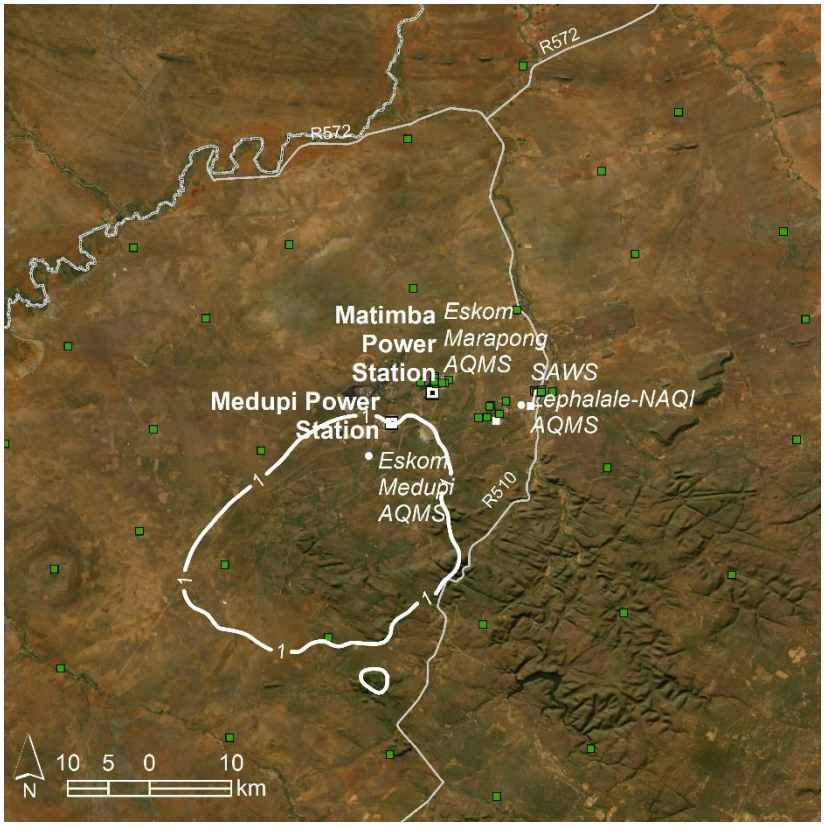


Figure 2-7: Cumulative predicted annual average NO_2 concentrations (µg/m³) for Matimba and Medupi Power Stations.

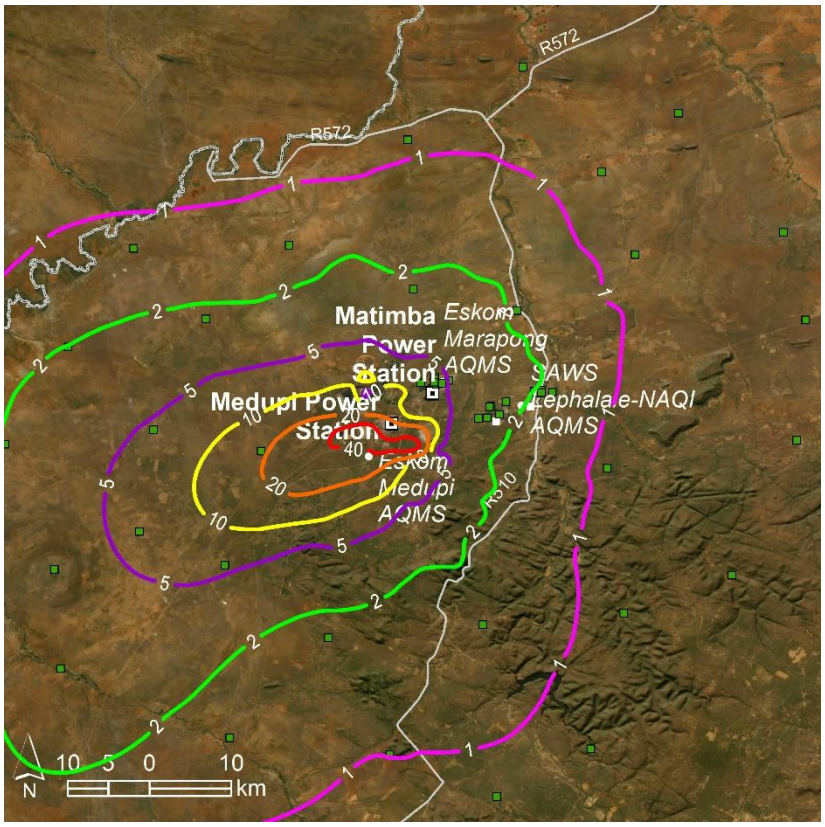


Figure 2-8: Cumulative predicted annual average PM_{10} concentrations ($\mu g/m^3$) for Matimba and Medupi Power Stations.

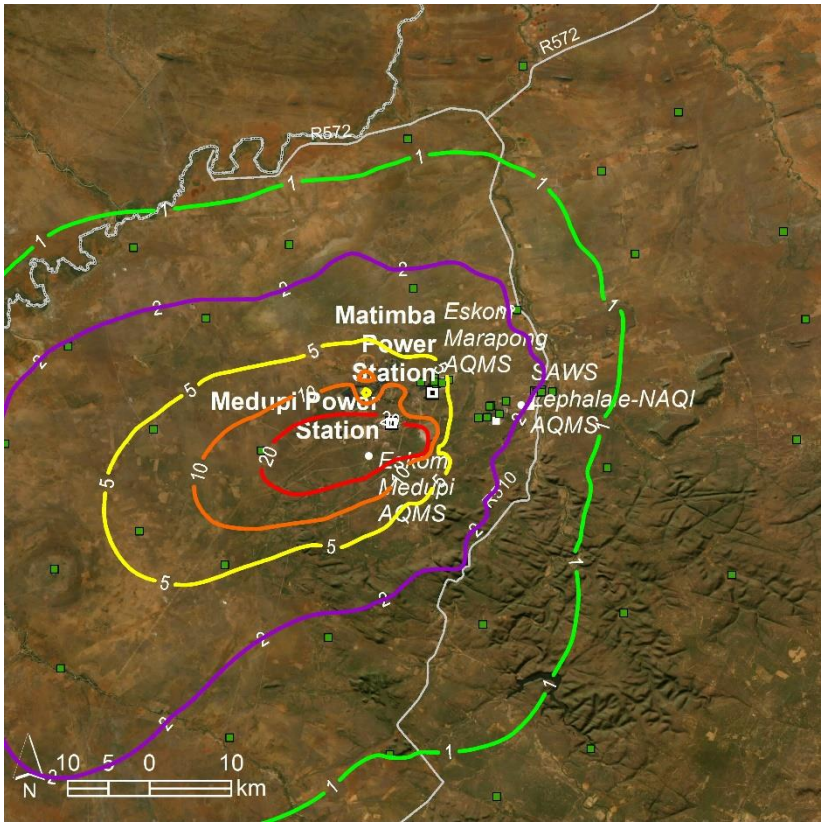


Figure 2-9: Cumulative predicted ambient PM_{10} concentrations ($\mu g/m^3$) for Matimba and Medupi Power Stations.

2.2.5 Population exposure

Population exposure was estimated at a spatial resolution of municipality and municipal wards. At each municipality or ward, the number of people exposed to different concentration ranges were determined based on Stats SA population estimates (Stats SA, 2012; Stats SA, 2024a,b) and United Nations population prospects growth forecasts (United Nations, 2024).

Population exposure was estimated at a spatial resolution of municipal wards for the data from the dispersion model runs. At each ward, the number of people exposed to different concentration ranges for each pollutant were determined per scenario per year. A small area of the model falls within Botswana and the number of people exposed within this area was also estimated and included in the model runs. Particulate matter (PM) in the model took the primary and secondary particulate matter into account.

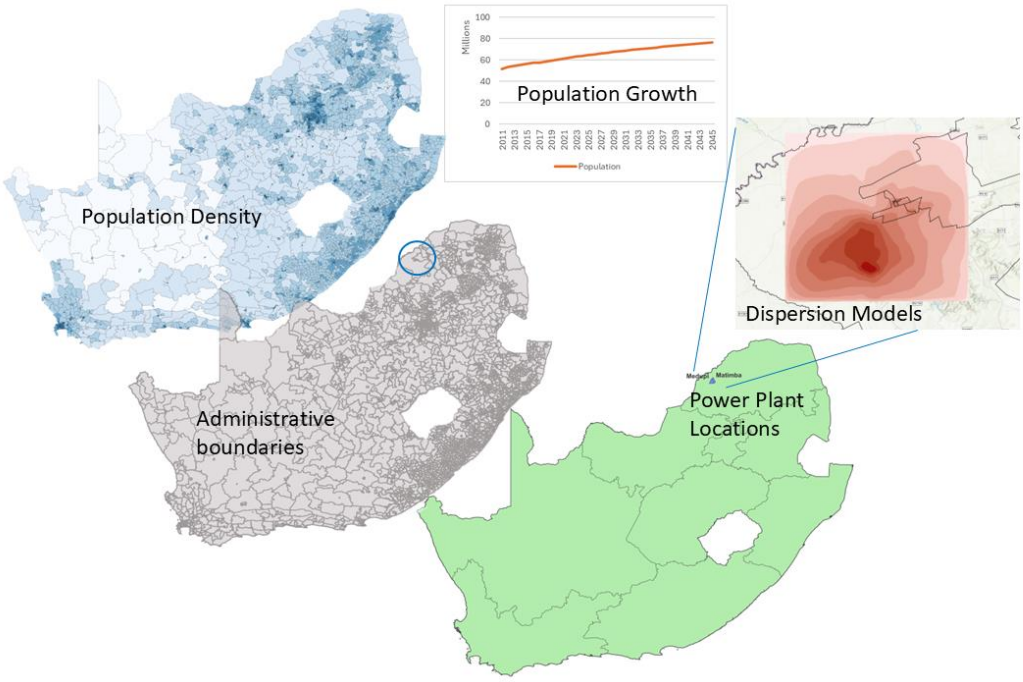


Figure 2-10: Overview of population exposure calculation

The integrated Health BCA model calculated pollution exposure as follows:

- Dispersion Model outputs were used to spatially apportion pollution concentrations. The co-ordinates (x;y) of receptors from the output files were attributed to specific administrative boundaries.
- Administrative boundaries used were municipalities and municipal wards. The predicted ambient concentrations for each pollutant were averaged for the entire spatial unit.
- Population density (population per ward) was obtained from the Census 2011 (Stats SA, 2012), given that the latest Census 2022 metadata which includes ward level numbers has not been released.
- Total population was obtained from the latest available mid-year population estimates (Stats SA, 2024a,b). Population data for Botswana was obtained from

Census/projection-disaggregated gridded Botswana population datasets (Bondarenko et al. 2020).

- Population growth forecasts were used to determine the growth in population exposure over time (United Nations, 2024). This was used to grow the population numbers in each year following 2024 to the end of the modelled timeframe year of 2045.
- Power station locations were used to determine the wards which were affected by each station, to estimate relative impacts of each power station to the cumulative impact modelled.

If one considers current emissions from Matimba and Medupi over the period 2021 to 2023, approximately 125,000 people in the population were exposed to concentration ranges above 1 µg/m^3 (mean annual average) of SO_2 due to the two power stations. Similarly, 81,000 people were exposed to more than an additional 1 µg/m^3 of PM. During this period there were no ambient concentrations of NO_2 exceeding 1 µg/m^3 from the power stations.

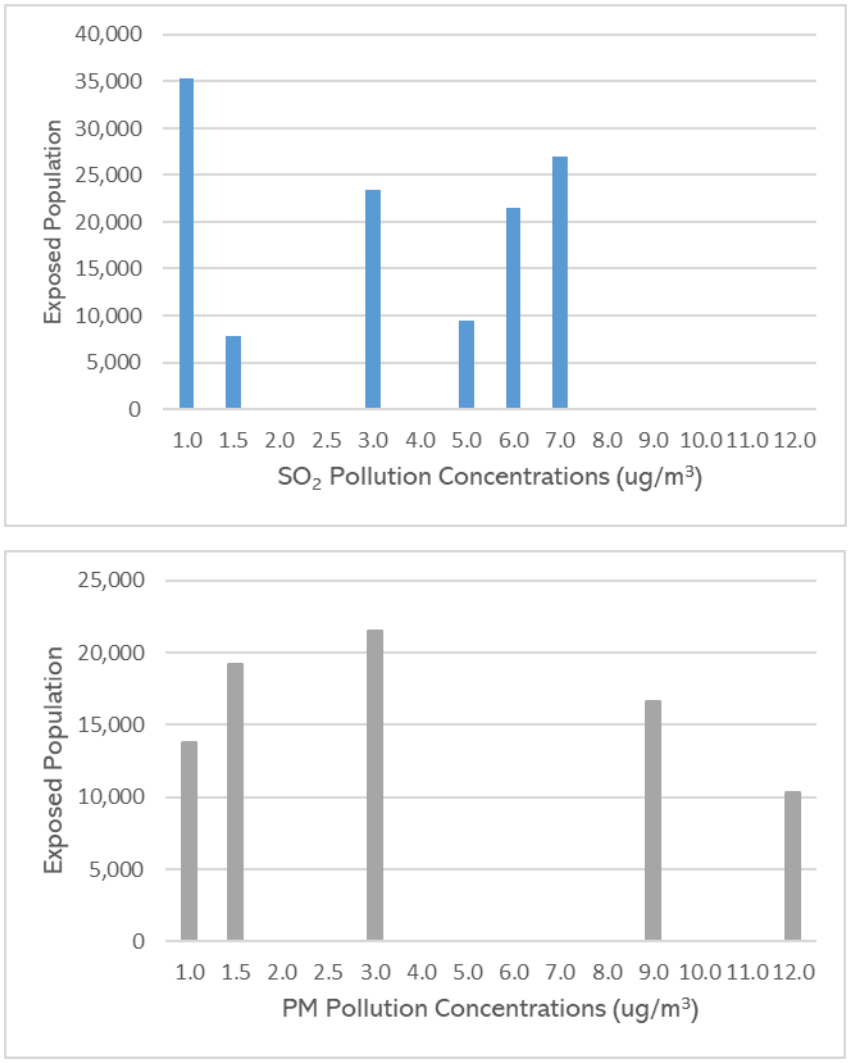


Figure 2-11: Population exposure to SO_2 and PM mean annual average concentration ranges above 1µg/m^3.

2.3 Incremental change in health risk

2.3.1 Health impacts

The WHO (2016a) recommends that the health risk in a population, associated with air pollution, is to be estimated using exposure-response functions (ERFs). ERFs are based on Relative Risk (RR) estimates derived from primary epidemiological studies.

These RR functions estimate the likelihood of health outcomes occurring in a population exposed to a higher level of air pollution relative to that in a population with a lower exposure level (WHO, 2016a). RR is usually expressed as the proportional increase in the assessed health outcome associated with a given increase in pollutant concentrations, measured in $\mu g/m^3$. The WHO (2016) notes that "*the RR estimate cannot be assigned to a specific person; it describes risk in a defined population, not individual risk.*"

Epidemiological studies are mostly based on evidence from population health studies that compare health outcome incidences of populations exposed to higher levels of air pollution to populations exposed to lower levels of air pollution. Most of these studies have been done in Europe and North America.

Ideally, ERF studies and their RRs should be determined based on primary epidemiological studies focussing on the exposed population. In the absence of such studies, as in the case of South Africa, the WHO (2016a) recommends using ERFs from other countries.

It is to be noted that there are inherently significant limitations in transferring ERF studies from other countries. Pollution levels, chemical composition and health care systems are typically very different in other settings, and this would affect the accuracy of the ERFs.

The health outcomes were selected based on the latest WHO systematic reviews from 2020 and 2021 that were conducted for the update of the WHO Global Air Quality guidelines. The health outcome considered in this study is all-cause mortality. Morbidity was not considered in this study as comprehensive data on morbidity studies is not widely available. Additionally, there are issues relating the transferability of data from one population to another in terms of country and culture as populations have different sensitivities to pollutant exposure (WHO 2000).

All-cause Mortality: This provides a measure of all the deaths that occur within the population from any natural causes. It includes natural deaths from all causes of death as provided in the WHO (2016b) International statistical classification of diseases and related health problems (ICD-10). In South Africa all-cause mortality makes up 88% of total deaths in South Africa (Stats SA, 2023).

In the AP-HRA, a health outcome must be attributed to an individual indicator pollutant. While health outcomes can be attributed to many different indicator pollutants, using all would result in double counting mixture effects in health impacts as these pollutants are associated with each other (WHO, 2016a, Malmqvist et al., 2018).

Table 2-2: Indicator pollutants, baseline incidence, and relative risks, of each health outcome (Source: WHO systematic reviews by various researchers & baseline incidence – Stats SA 2021)

Indicator Pollutant	Health Outcome	Baseline data	Relative Risk or Hazard Ratio per 10 µg/m³	Reference
$PM_{2.5}$	All-cause Mortality	0.687%	1.08	Chen & Hoek, 2020
PM_{10}	All-cause Mortality	0.687%	1.04	Chen & Hoek, 2020
SO_2	All-cause Mortality	0.687%	1.0059	Orellano et al., 2021
NO_2	All-cause Mortality	0.687%	1.02	Huangfu & Atkinson, 2020

The baseline incidence rates of these health outcomes were determined based on published data from the year 2019 from Stats SA (Stats SA, 2023). The ERFs describing the change in incidence in relation to changes in exposure (RRs) were obtained from the WHO latest systematic reviews for the update of the WHO Global Air Quality guidelines (WHO, 2020, 2021).

2.3.2 Health costs

The detrimental effects of air pollution on human health are borne in the economy by households, insurance companies, employers and public health programs (Romley et al., 2010).

The fundamental goal of health cost or cost of illness (COI) studies is to evaluate the economic burden that illness imposes on society as a whole (Jo, 2014). Rice (1967) and Rice et al. (1985), were instrumental in standardising methodologies for estimating COI, and these methodologies continue to be used internationally, and periodically updated (Rice, 1996; Rice, 2000).

COI studies contextualise adverse diseases effects into monetary terms, with the purpose of informing decision-making. Such decisions could include (a) to simply present the magnitude of disease in monetary terms; (b) to comparatively evaluate intervention programs; (c) to assist in the allocation of research funding on specific diseases; (d) to provide a basis for policy and planning relative to mitigation initiatives; and (e) to provide an economic framework for program evaluation (Rice, 2000).

The COI studies traditionally stratify costs into two categories: direct costs and indirect costs. Direct costs relate to the cost of medical treatment. This would include costs of visiting health care facilities, medicine and hospitalisation. Indirect costs comprise morbidity costs (the cost of lost economic productivity due to absenteeism or temporary or permanent disability) and mortality costs. With respect to mortality costs, valuing human life is contentious, as it can be seen as a judgement on the intrinsic value of life and involves complex ethical considerations. Often, cost-effectiveness analysis is used as an alternative (Muchapondwa, 2009). This side-steps the complexity of life valuation and uses disease or fatality incidence indicators to compare effectiveness of different policy or spending options.

[insert par on direct costs]

The health impact or health risk, associated with air pollution, is estimated using ERFs as described in section 2.3.1 above. In this study, the ERFs obtained from the latest WHO systematic reviews, focussed exclusively on mortality and thus a monetary measure of mortality was required in order to perform benefit-cost analyses. In air pollution benefit-cost analyses, the concept of value per statistical life (VSL) is commonly used to monetise mortality related benefits of air pollution reduction. The concept of a VSL is frequently misunderstood. It does not measure the intrinsic value of a human life, and neither does it value the economic productivity of a human. Rather, VSL is estimated by dividing an individual's willingness to pay (WTP) to reduce health risk, by the likelihood of risk reduction. Robinson and Hammitt (2009) defines VSL to represent the rate at which an individual is willing to exchange their own income for a small reduction in their own mortality risk over a particular time period. VSL is not the value that a person, society or the government would place on reducing the relative risk of mortality with certainty, but it is rather a representation of the rate at which a person views a change in the money available for spending as equivalent to a small change in their own mortality risk (Robinson et al., 2018).

Primary WTP studies for mortality risk reductions have not been done in South Africa. Most countries do not have reliable revealed preference or stated preference estimates of the VSL according to Viscusi and Masterman (2017) and primary research studies require considerable time and expense (Robinson et al., 2018). In these cases a "benefit transfer" method is used to

transfer values from other studies. Both the above authors recommend using a United States of America (USA) base VSL (calculated using labour market estimates from their Census of Fatal Occupational Injuries, CFOI, data) and then further adjust it for differences in income between the USA and the country of interest.

The VSL estimate in this study is determined by the following equation ((from Viscusi and Masterman (2017) and Robinson et al. 2018):

$$VSL_{target} = VSL_{base} \times \left(\frac{Income_{target}}{Income_{base}}\right)^{\text{elasticity}}$$

In the above equation the base country is the United States. The VSL is transferred using the income measure of GNI (Gross National Income) per capita from the World Bank which uses the Atlas method which is based on exchange rates and inflation rates.

Data for the US base VSL was obtained from the US Economic Research service and the federal register, the GNI value per capita was sourced from the World Bank. Exchange rates to convert the dollar value of the South African VSL into rands was taken from the annual average exchange rates from the South African Reserve Bank.

A sensitivity analysis was conducted in the BCA based on the recommendations of Robinson et al. 2018. The default values include:

VSL = 160 * GNI per capita of the target country

VSL = 100 * GNI per capita of the target country

VSL extrapolated from USA estimate to target country using an elasticity of 1.5.

Additionally, the sensitivity analysis uses the Masterman and Viscusi (2017) income elasticity of 1.0.

2.3.3 Pollution abatement options

2.3.3.1 Summary

Table 2-3 sets out the detailed abatement options per scenario assessed.

Abatement options include the installation of technologies to reduce emissions. Technologies include Flue Gas Desulphurisation (FGD), Dry Sorbent Injection (DSI), Electrostatic Precipitators (ESP), Low NOx Burners (LNB) and Fabric Filter Plants (FFP). FGD and DSI are used to reduce sulphur dioxide (SO_2) emissions. ESP and FFP are used to reduce particulate matter (PM) emissions, and LNB to reduce nitrogen dioxide (NO_2) emissions. The abatement technologies investigated in the scenarios for this current study in the Waterberg included FGD and Installation of high-frequency power supply (HFPS) to improve ESP efficiency.

The BCA model was setup to compare three different scenarios in terms of abatement technology implementation for the Matimba and Medupi power stations. The dispersion modelling was done for each of these scenarios and the results were used in the BCA model. The model was constructed to allow for a gradual change in pollutant emission concentrations over several years based on the capital and operational expenditure timeframe. This was done to reflect that not all retrofitted units will be operational at the same time. When the abatement technology of all units at a station is operational the model then reflects the compliance emission concentration values related to the specific scenario.

2.3.3.2 Eskom load curtailment strategy

With the proliferation of the alternate energy sources on to the national grid due to the IRP, the existing coal fired power stations are expected to move into a load following mode of operation. This essentially results in lower running load factors for these stations as the renewable energy sources will be given priority over the fossil fuelled stations. This equates to average load factors of 40-45% for stations operating in 2031 and between 40 to 55% for stations operating beyond 2035, i.e. after Matla and Duvha shutdown. The nett effect of this is that less coal will be burnt in the generation of South Africa's electricity which results in direct emissions reduction at no additional cost impact. This is the basis of Eskom's load based alternate emissions limits.

2.3.3.3 Station shutdown

Station lifetimes were described for the two power stations that were modelled. The shutdown, repowering and repurposing dates affect the emissions per year (reduces) in the years that the station units are being shutdown. Only Matimba power station has shutdown, repowering and repurposing dates that fall within the modelling timeframe. The shutdown period for Matimba power station is 2039 to 2043. Medupi will shut down from 2065 to 2071.

Shutdown dates are based on Eskom's present planning and technical requirements, dates are subject to review based on national energy requirements. Eskom will follow all necessary regulator and stakeholder engagement process prior to station shutdown.

2.3.3.4 PM reduction

Abatement technologies considered in the scenarios for PM reduction included Electrostatic Precipitators (ESP) and High Frequency Power Supplies (HFPS) to improve the efficiency of the ESP. An ESP removes particulate matter, from the flue gas using the force of an induced electrostatic charge. ESP upgrades or refurbishments can reduce particulate matter between 95-97%.

2.3.3.5 Flue Gas Desulphurisation (FGD) for SO_2 reduction

FGD is a set of technologies used to reduce SO_2 emissions. FGD systems typically include a fly ash removal and SO_2 removal. SO_2 (an acid gas) removal is facilitated by alkaline sorbents such as limestone to react with the gas. FGDs are typically separated into two types, semi-dry and wet, dependent on their water requirements, and can reduce SO_2 emissions by 90%. Based on coal qualities and station characteristics Eskom considers wet FGD suitable for Medupi and semi-dry FGD suitable for Matimba.

Table 2-3: Detail Summary Table of Scenarios (Source: Eskom)

Scenario	Abatement and additional information
Eskom plan - ERP 2024 A (Scenario B)	Predicted monthly tonnage emitted per stack in 2031 assuming: a. All planned PM emission reduction projects completed. Matimba PM upgrade ensures station continues to operate at PM=50 mg/Nm^3. b. NOx projects completed with Matimba, and Medupi at 750 mg/Nm^3. c. Medupi FGD constructed between 2028 and 2032. Medupi operates at SO_2 = 500 mg/Nm^3 to reduce total SO_2 load. AEL limit is 1,000 mg/Nm^3. d. Efficiency and coal improvement projects reduce total emissions by 5% at Matimba and Medupi. e. Load factor restricted to an average value per station per year (see Appendix A) h. This scenario is similar to the existing Eskom Emission Reduction Plan 2022.
Eskom plan - ERP 2024 B (Scenario C)	Predicted monthly tonnage emitted per stack in 2036 assuming: a. Efficiency and coal improvement projects reduce total sulphur and carbon emissions by 5% for Matimba and Medupi, b. Medupi FGD completed in 2032 Medupi operates at SO_2 = 500 mg/Nm^3 to reduce total SO_2 load. AEL limit is 1,000 mg/Nm^3 c. Load factor restricted to an average value per station per year (see Appendix A)
Full MES compliance – ERP 2024 C (Scenario D)	Predicted monthly tonnage emitted per stack in 2036 assuming: a. Both Matimba and Medupi as per the CDS (Rev 4) shut down schedule. b. All planned PM emission reduction projects completed (by 2028), and stations operate at PM=50 mg/Nm^3. c. Matimba FGD constructed between 2031 and 2036. d. Load factor restricted to an average value per station per year (see Appendix A)

2.3.4 Costs of implementation

Table 2-4: Summary of costs of implementation of abatement for the Waterberg power stations: costs of CAPEX and OPEX and estimated impacts on electricity tariffs

	Scenario	CAPEX and OPEX (Rand million Nominal)	Impact on Electricity Tariff (c/kWh)		Impact on Electricity Tariff (%)	
		-15% +20%	Lower	Upper	Lower	Upper
	ERP 2024 A - Other	1,400	0.036	0.051	0.02	0.03
+	ERP 2024 A – Medupi FGD	57,260	1.07	1.52	0.58	0.82
Sub-total	ERP 2024 A (WRP Sc B)	58,660	1.11	1.57	0.60	0.85
	ERP 2024 B	0	0.00	0.00	0.00	0.00
Sub-total	ERP 2024 B	58,660	1.11	1.57	0.60	0.85
+	ERP 2024 C – Matimba FGD	43,010	0.52	0.73	0.28	0.40
Total	ERP 2024 C	101,670	1.63	2.30	0.88	1.24

The total nominal cost of all Eskom abatement scenarios has been estimated by Eskom at a Class 2 accuracy implying a variance between -15% and +20%:

- ERP 2024 A = R58,660 million
- ERP 2024 B = R58,660 million
- ERP 2024 C = R101,670 million.
- Source: Eskom

We estimated the effect of these additional costs on electricity tariffs. This was based on a cashflow waterfall model set up for each scenario, solving for a tariff that would pay back the cost of abatement technology over the assessment period. This tariff margin may be thought of as an air emissions abatement levy:

- ERP 2024 A = 0.6% - 0.9%
- ERP 2024 B = 0.6% - 0.9%
- ERP 2024 C = 0.9% - 1.2%.
- Note: It is to be noted that these electricity impact tariffs were not sourced by Eskom but were estimated using the method described above.

2.4 Benefit-cost Analysis

A BCA is a widely used approach employed for decision-making support. This approach was formalized in the United States in 1958 with the purpose of justifying public expenditures on alternative investment options competing public funds such as water, roads, and other public utilities' networks construction projects. BCA methodology broadly advises on the treatment of income benefits and costs; externality costs; how to measure them conceptually; how future prices should be treated; the importance of using a discount rate; the proper period of analysis; and cost allocation procedures for projects.

The World Bank[2] defines a Social BCA as an extension of a financial analysis. Ideally, in extending the financial analysis, all relevant economic costs and benefits are quantified and analysed. The BCA pulls together the component analyses of the study to assess the overall impact for a set of scenario options (emission reduction measures).

The objective of the BCA is to comparatively analyse investments or scenarios (in this case interventions in air quality management). The BCA achieves this end by identifying and monetizing the costs and benefits and predicting the timing thereof over the same horizon as the projects' economic lifetime (National Treasury, 2017).

A BCA allows scenarios to be objectively compared according to the benefit:cost relationship to analyse the relative efficiency of various interventions and the magnitude of the benefits to identify the interventions that will have the largest impacts.

In this analysis, the BCA compares the scenario health benefits to capital and operational costs of abatement. This BCA does not capture all potential costs and benefits, both direct and indirect. (Refer to section 2.5.1 below for a discussion of BCA limitations.)

The analysis timeline spans 2024 – 2045. The base year was 2024, due to dispersion modelling timeframe. The BCA was performed in an Excel spreadsheet, which consolidated all data sources, which contains all calculations, to run the large spatial exposure estimates for each scenario for the review period. The benefit-cost analysis apportioned costs (capital and operation expenditure on abatement technologies) and benefits (health benefits) to the years in which they would be realised. Because costs and benefits are accrued in different years according to the intervention schedules, the net present values of costs and benefits, using Eskom's weighted average cost of capital (WACC) rate of 10.8% (Eskom, 2024) as the discount rate allows an objective comparison of scenarios.

The health cost benefits were estimated based on the outputs of the AP-HRA and followed the steps below (Section 3.2 provides the BCA results).

1. Each of the assessed Scenarios implemented an abatement schedule at the two power stations (refer to section 3 for details)
2. The dispersion effects modelled by uMoya-NILU (Pty) Ltd were used to estimate the change in population exposure over the timeline.

[2] http://documents.worldbank.org/curated/en/445971468767366310/pdf/multi-page.pdf

3. The change in population exposure resulting from step 2 above was applied to the ERFs identified in section 2.3.1 to estimate health impact outcomes (sensitivity analysis was performed in the BCA to develop a view on the uncertainty inherent in the ERFs, also refer to section 2.5.1)
4. The VSL (refer to section 2.3.2) was applied to the health impact outcomes for each scenario, to estimate change in health cost benefits.
5. Capital and operational cost estimates were used as the costs in the BCA (refer to section 2.3.4).
6. Sensitivity analysis was performed on the VSL, the health benefit and abatement cost estimates.

2.5 Uncertainty of the estimated health effects

2.5.1 Sources of uncertainty and limitations

The WHO (2016a) advises performing an assessment of the uncertainty of the analysis; in this case therefore this requires an assessment related to a lack of knowledge about one or more components of the integrated Health BCA Model. The sections below discuss each source of uncertainty and related limitations.

Air pollutants exist as a complex mixture: Despite improvements in the science underlying AP-HRAs, it is still not possible to estimate with complete certainty the effects of air pollution on health (WHO Regional Office for Europe, 2014 cited in WHO, 2016a). The observed adverse effects attributed to an individual air pollutant may well be (partly) attributable to other pollutants in the mixture which are correlated with the assessed pollutant (WHO Regional Office for Europe, 2013 cited in WHO 2016a). It is not possible to assess the uncertainty relating to this (WHO, 2016a).

Pollutants modelled: The analysis was limited to SO_2, $PM_{2.5}$ and NO_2 pollutants, , these are the criteria pollutants managed in terms of South African air quality legislation and of most recognised significance in the Priority Area. Other pollutants may also contribute to health risk and these were not modelled in the dispersion modelling. This may under-estimate health risks and thus benefits of health risk mitigation. However, no data or other information exists through which to assess this limitation.

Exposure response functions: ERFs are derived from epidemiological studies, in which the parameters of the epidemiological experiment and assumptions made during the experiment introduce some uncertainty into the results. More significantly, because primary epidemiological evidence on air pollution is not available for South Africa. This is a key limitation. As a result, inference has to be drawn from studies in other parts of the world. It is to be noted that health response per unit change in air pollution in environments with high ambient levels (such as the HPA) may differ from that observed in countries with lower pollution levels. In summary, the WHO (2016a) notes that extrapolated ERF information may not accurately describe the exposure-response relationship in the region to be assessed, leading to uncertainties in the results. In order to deal with these uncertainties, we used variances in ERF outcomes as a measure of BCA ratio variation.

Dispersion model accuracy (uMoya-Nilu, 2024): "Air quality models attempt to predict ambient concentrations based on "known" or measured parameters, such as wind speed, temperature profiles, solar radiation and emissions. There are, however, variations in the parameters that are not measured, the so-called "unknown" parameters as well as unresolved details of atmospheric turbulent flow. Variations in these "unknown" parameters can result in deviations of the predicted concentrations of the same event, even though the "known" parameters are fixed. In the present dispersion modelling conservative assumptions in terms of surface area of ashing facilities giving rise to fugitive emissions were made that have resulted in an over prediction of PM emissions in shorter time periods. Furthermore, for $PM_{2.5}$ and PM_{10} the predicted concentrations are attributed to stack emissions and low-level fugitive sources (ash dump). The inclusion of the fugitive sources was done assuming the entire area is exposed and available for entrainment, while in reality only a small portion of the modelled area would be exposed to entrainment due to the vegetated sides

and wet areas of the dump. This approach is extremely conservative. The PM emissions from stacks and fugitive sources are not speciated into PM_{10} and $PM_{2.5}$, rather all PM emitted is assumed to be PM_{10}, and all PM emitted is assumed to be $PM_{2.5}$.

There are also "reducible" uncertainties that result from inaccuracies in the model, errors in input values and errors in the measured concentrations. These might include poor quality or unrepresentative meteorological, geophysical and source emission data, errors in the measured concentrations that are used to compare with model predictions and inadequate model physics and formulation used to predict the concentrations. "Reducible" uncertainties can be controlled or minimised. This is done by using accurate input data, preparing the input files correctly, checking and re-checking for errors, correcting for odd model behaviour, ensuring that the errors in the measured data are minimised and applying appropriate model physics."

Baseline disease burden: The baseline cases of mortality used were for 2019, based on latest available Stats SA data. The data for this year is therefore accurate. Stats SA data for 2020 was not used as these numbers may be skewed by the effects of COVID. Uncertainty arises however because projections are made of population size growth in future, under the assumption that the relative ratio of mortality in the future remain constant.

Morbidity effects were not assessed: The costs of medical treatment (including visiting health care facilities, and costs of medicine and hospitalisation) and the loss of economic production due to sick-leave absenteeism or temporary or permanent disability, were not assessed. This is because of an absence of official data on health care visits and associated direct costs within both the public and private health care sectors; linked to suitable ERFs. As a result, the BCA underestimates the health benefits of the various scenarios. As before, within the BCA, this uncertainty remains constant across all scenarios and thus enables inter-scenario evaluation.

Value of a statistical life: VSLs are accurate when estimated based on primary data collected through willingness to pay studies specific to the exposed population. All VSL estimates for South Africa are derived and transferred from studies done in the United States of America. This introduces uncertainty in the BCA results. As before, within the BCA, this uncertainty remains constant across all scenarios and thus enables inter-scenario evaluation.

Timeline of dispersion modelling predicted concentrations: The data from the dispersion modelling in CALPUFF is from a specific point in time and is then interpolated for the timeline values that are required to run a benefit:cost analysis. Ideally the BCA model should have a CALPUFF run for each year used in the model timeline, however, to do this is not practical. This causes uncertainties in the results.

Cost uncertainty: Eskom uses a cost estimate classification matrix which has different estimate classes associated with different expected accuracy ranges for making project cost estimations (Eskom, 2020). Based on these classes the sensitivity analysis for costs estimates varied by +20% or -15% (Class 2). Eskom is constantly working to refine the accuracy of the emission reduction costing and this may result in internal updates of costing. Anticipated changes in cost are anticipated to fall within the range of variance (-15% and +20%).

The BCA does not capture economic externalities. These include both benefits and costs. The benefits of reduced health risk on households, employers and the health care and insurance

industries were not assessed. The costs of implementation of abatement technologies would put additional pressure on Eskom capital (and debt) requirements, and further on electricity price escalations. These would result in additional economic costs, and these were not assessed. Furthermore, the economic benefits and costs of transitioning from coal to alternatives were not assessed. A full electricity system modelling exercise was not completed as part of the Eskom exemption application process given time constraints. Capacity assessments undertaken indicate that attempting to install SO_2 reduction technologies simultaneously on Eskom stations will result in significant electricity supply shortfalls. These capacity shortfalls would need to be addressed by other generation sources, if these are available, which may have additional cost implications. If the capacity is not available then the country would be forced to endure further periods of load shedding with resultant economic, social and environmental impacts.

As above, within the BCA, this uncertainty remains constant across all scenarios and thus enables inter-scenario evaluation

Level of acceptable risk not quantified: The health benefits assessed are the total health benefits associated with all reductions in modelled ambient air quality as a result of abatement technology. It is to be noted however that the MES implies a level of acceptable health risk, and the quantum of the health costs associated with this level of acceptable risk were not assessed in the BCA.

2.5.2 Dealing with the uncertainties and limitations in the assessment of results

Several important considerations exist when interpreting the results of the integrated Health BCA.

Interpretation of premature mortality has to be done with care. It is to be noted firstly that these numbers are indicators of health risk at a population level. The relative risk estimate inherent in the ERF is a metric of the likelihood of an adverse health outcome, and it cannot be attributed to an individual person. It can thus be used to quantify risk to a defined population (and not to an individual), (WHO 2016) and how this risk would vary between various policy options of scenarios.

The various sources of uncertainty discussed above, affect the accuracy of the absolute values of the assessments. In the absence of primary ERF studies, it is not possible to judge the accuracy of the absolute values of the assessment with a high level of confidence. However, this report uses ranges to reflect uncertainty.

In spite of the various sources of uncertainty discussed above, the analysis still provides valuable insights into the comparison of scenarios tested in the BCA. This is because the uncertainty inherent in the analysis remains constant across all scenarios.

The description of uncertainty sources also serves as a basis for further work to be prioritised in improving future integrated Health BCAs.

3 RESULTS AND DICUSSION

3.1 Scenarios

Three scenarios were evaluated in this study (against a baseline of anticipated emissions 2025 - 2030). A brief description is provided in the sub-sections below and the detailed summary table (see Table 2-3).

3.1.1 ERP 2024 A

This scenario represents the Eskom ERP 2024 A plan. The scenario is similar to the existing Eskom Emission Reduction Plan (ERP) 2022. Abatement projects for emission reduction included in this scenario comprised of PM projects at Matimba and SO_2 projects at Medupi (see Table 2-3 for detailed information).

In this scenario it is additionally assumed:

- Medupi will operate at SO_2 500 mg/Nm^3 instead of the AEL limit of 1000 mg/Nm^3 to reduce total SO_2 emission load into the atmosphere
- Total emissions are reduced by 5% at Matimba and Medupi through efficiency and coal improvement projects.
- See Appendix A for load factors at the stations.

The commissioning and shutdown periods, and abatement technology installation schedules used in the BCA for this scenario are shown in Figure 3-1.

2031 emission snapshot

S1 ERP 2024 A	Plant Commissioning Period		Plant Decomissioning Period		Abatement Technology Installed (1 = yes)		Abatememt Technology Comissioning Period			
Plant	COD start	COD end	S1DS	S1DE	HFPS	FGD	HFPS-S	HFPS-E	FGD-S	FGD-E
Matimba	1987	1991	2038	2042	1		2025	2030		
Medupi	2015	2024	2065	2071		1			2028	2032

Figure 3-1: ERP 2024 A power plant commissioning and shutdown periods, and abatement technology installation schedules. An S-suffix denotes the start of an activity, and the E-suffix denotes the end of the activity. Abatement technologies are assumed to run as units are retrofitted from commissioning date to continue until the shutdown, repowering and repurposing date of the power plant.

3.1.2 ERP 2024 B

This scenario represents the Eskom ERP 2024 B plan. Abatement projects for emission reduction included in this scenario comprised of PM projects at Matimba and SO_2 projects at Medupi (see Table 2-3 for detailed information).

In this scenario it is additionally assumed:

- Efficiency and coal improvement projects reduce total sulphur and carbon emissions by 5% for Matimba and Medupi.

The commissioning and shutdown periods, and abatement technology installation schedules used in the BCA for this scenario are shown in Figure 3-2.

2036 emissions snapshot

S2 ERP 2024 B	Plant Commissioning Period		Plant Decomissioning Period		Abatement Technology Installed (1 = yes)		Abatememt Technology Comissioning Period			
Plant	COD start	COD end	S2DS	S2DE	HFPS	FGD	HFPS-S	HFPS-E	FGD-S	FGD-E
Matimba	1987	1991	2038	2042	1		2025	2030		
Medupi	2015	2024	2065	2071		1			2028	2032

Figure 3-2: ERP 2024 B power plant commissioning and shutdown periods, and abatement technology installation schedules. An S-suffix denotes the start of an activity, and the E-suffix denotes the end of the activity. Abatement technologies are assumed to run as units are retrofitted from commissioning date to continue until the shutdown, repowering and repurposing date of the power plant.

3.1.3 ERP 2024 C

This scenario represents the Eskom ERP 2024 C plan. In 2036 the operating stations will operate according to the Consistent Data Set (CDS) (Rev4) shut down schedule. Matimba will shut down in the period from 2039 to 2043. Abatement projects for emission reduction included in this scenario are comprised of PM projects and SO_2 projects (completed by 2035) (see Table 2-3 for detailed information).

The commissioning and shutdown periods, and abatement technology installation schedules used in the BCA for this scenario are shown in Figure 3-3.

Full MES compliance - 2036 emission snaphot

S3 ERP 2024 C	Plant Commissioning Period		Plant Decomissioning Period		Abatement Technology Installed (1 = yes)		Abatememt Technology Comissioning Period			
Plant	COD start	COD end	S3DS	S3DE	HFPS	FGD	HFPS-S	HFPS-E	FGD-S	FGD-E
Matimba	1987	1991	2038	2042	1	1	2025	2030	2031	2035
Medupi	2015	2024	2065	2071		1			2028	2032

Figure 3-3: ERP 2024 C power station commissioning and shutdown periods, and abatement technology installation schedules. An S-suffix denotes the start of an activity, and the E-suffix denotes the end of the activity. Abatement technologies are assumed to run as units are retrofitted from commissioning date to continue until the shutdown, repowering and repurposing date of the power station.

3.2 Summary

In 2024, approximately 157,000 people are exposed to air pollution from the two power stations modelled, that fall within the modelling domain. The mean additional annual average exposure to air pollution of the population within this domain, resulting from coal-fired power station emissions, was estimated by averaging dispersion modelling results over municipal boundaries. Approximately 145,000 people were exposed to more than an additional 1µg.m^3 (mean annual average) of SO_2.in the modelled area. Similarly, 81,000 and 48,000 people, were exposed to more than an additional 1µg.m^3 of PM and NO_2 and respectively.

Health benefits associated with each scenario were calculated against the baseline that took into account the anticipated increase in loads in the coming years from 2025 to 2030 and assumed no abatement technologies installed and both stations would continue to emit air pollution at their current rates until shutdown, repowering and repurposing.

The health benefits over time are summarised in Figure 3-4:

- The health benefits of ERP 2024 A deliver immediate impact from 2024. At Medupi Wet FGD is commissioned from 2028 to 2032. Both stations already operate at NOx = 750 mg/Nm^3. Medupi already has Fabric Filter Plant (FFP) for PM reduction. Matimba station is equipped with ESP + HPPS for optimisation of PM reduction. These increase the associated health benefits until 2039. Hereafter the associated health benefits reduce as Matimba shutdown, repowering and repurposing is between 2039 and 2043. Medupi station shutdown, repowering and repurposing is much later from 2065 and the health benefits from the Wet FGD continue until final closure of the station.
- The health benefits of ERP 2024 B include those as discussed for ERP 2024 A above. In addition, efficiency and coal improvement projects reduce total sulphur and carbon emissions by 5% for Medupi and Matimba from 2024 onwards.
- The health benefits of ERP 2024 C include those as discussed for ERP 2024 A and B above. Semi-dry FGD is installed at Matimba by 2035, however the associated health benefits are effectively negated as Matimba starts to shut down in 2039.

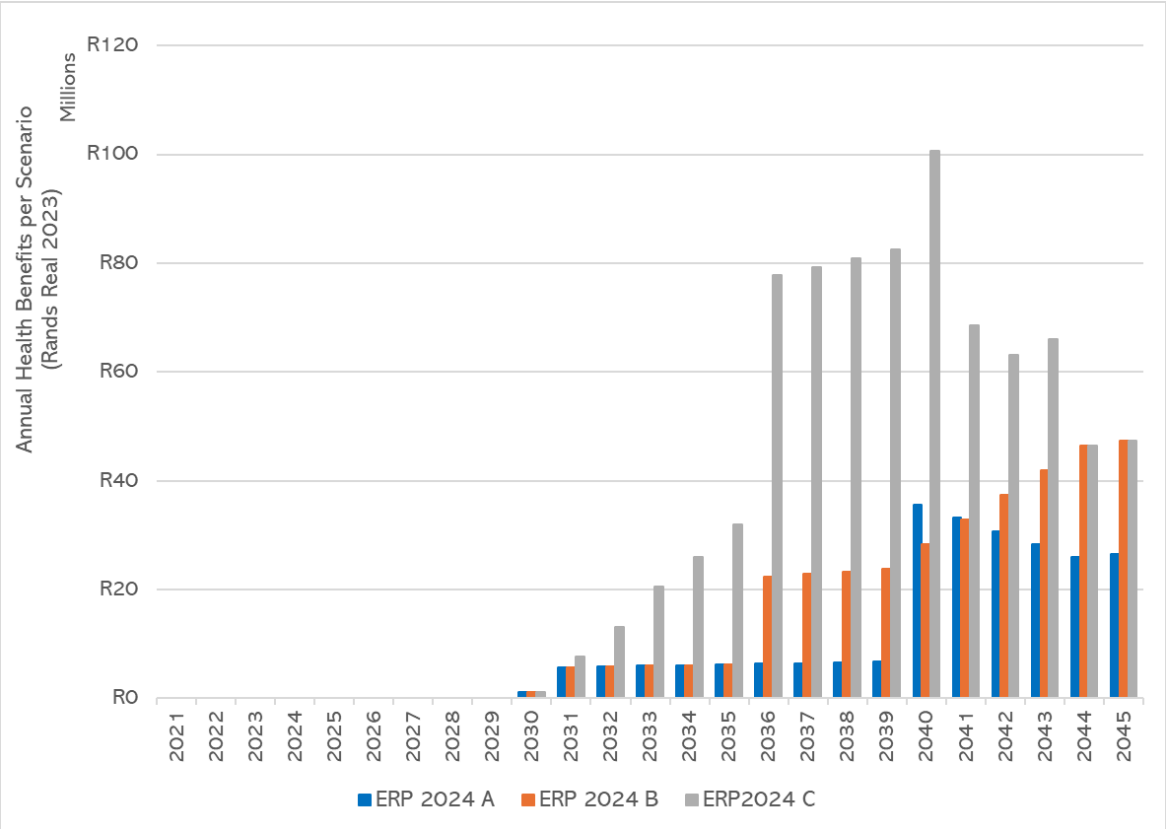


Figure 3-4: Annual health benefits per scenario illustrating the timeline of cumulative health benefits

The **abatement costs** associated with each scenario are set out in Figure 3-5 below:

- The total Capex and Opex costs of abatement are identical to 2024.
- ERP 2024 A implementation starts in 2025 with Matimba ESP + HFPS and in 2028 with Medupi, Wet FGD installation. After 2032 only operational costs continue at Medupi.
- ERP 2024 B is the same as ERP 2024 A discussed above.
- ERP 2024 C is the same as described for ERP 2024 A and B. In addition, implementation starts in 2031 with Matimba semi-dry FGD. The Capex costs decrease after 2032 as Medupi Wet FGD is fully installed and only the Capex of the Matimba semi-dry FGD remains until 2035 whereafter only operational costs remain. After closure of Matimba in 2043 only Medupi continues to operate.

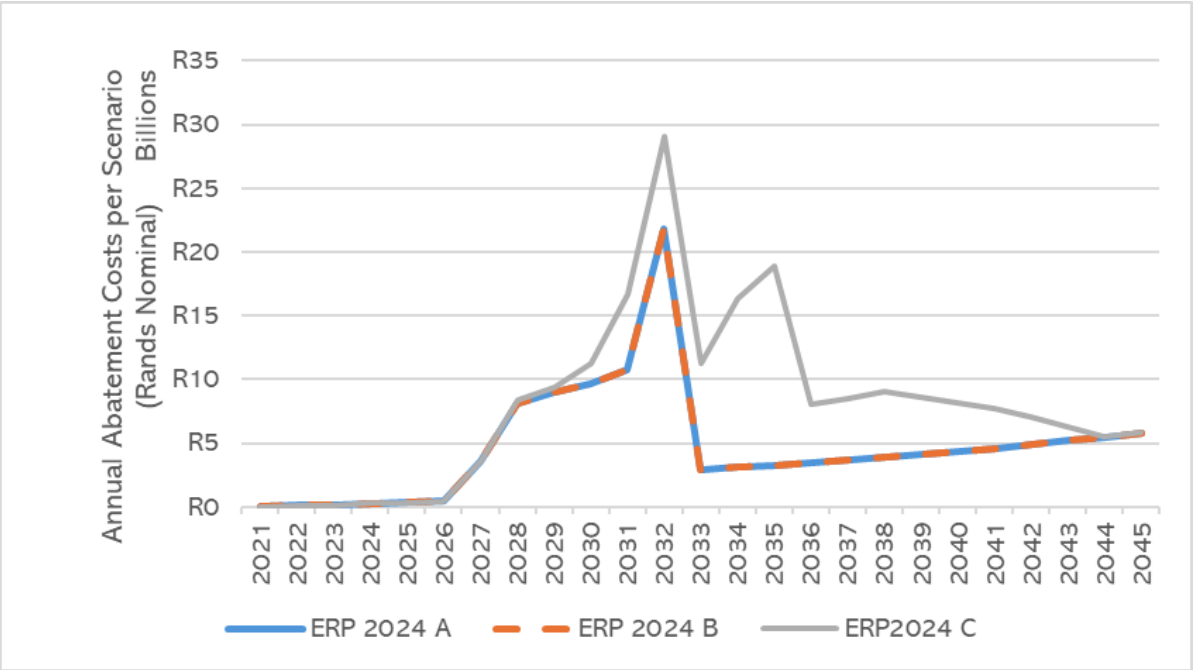


Figure 3-5: Total abatement costs (CAPEX and OPEX) associated with each scenario's abatement retrofits

Scenarios were compared in a benefit-cost analysis. The benefit-cost analysis apportioned costs (capital and operation expenditure on abatement technologies) and benefits (health benefits) to the years in which they would be realised. Because costs and benefits are accrued in different years according to the intervention schedules, the net present values of costs and benefits, used Eskom's weighted average cost of capital (WACC) rate of 10.8% as the discount rate (Eskom, 2024), and additional sensitivity analysis testing using a social discount rate of 2% (Stern, 2006) allowing for an objective comparison of scenarios.

The BCA ratios need to be interpreted with care. They are meant only to provide a perspective on and to inform the decision-making process underlying the scenarios. They are not meant to be interpreted as a definitive answer to making abatement decisions. Decisions involving human health must be informed by non-economic criteria as well. In addition, with uncertainty inherent in the analysis, the cost benefit ratio should thus not be viewed as absolute, but rather as a relative value from which to compare scenarios.

The **BCA results** are provided in Table 3-1. In the upper estimates the lower costs and higher VSL are used and in the lower estimates the higher costs and lower VSL are used as recommended by Robinson et al. 2018.

- The BCA central ratio of ERP 2024 A is significantly less than 1, indicating that costs of abatement far exceed the health benefits. This ratio remains below 1 even in the most optimistic (upper) parameters of the sensitivity analysis. The reasons for this include the implementation of FGDs at Medupi in conjunction with the small population that benefits. This scenario has a total nominal cost of R58,660 million and is likely to increase electricity tariffs by 0.6% - 0.9% in ERP 2024 A.

- The BCA ratio of ERP 2024 B is also significantly less than 1, indicating that costs of abatement far exceed the health benefits. This ratio remains below 1 even in the most optimistic (upper) parameters of the sensitivity analysis. The same reasons apply as for ERP 2024 A above. This scenario has a total nominal cost of R58,660 million and is likely to increase electricity tariffs by 0.6% - 0.9% as in ERP 2024 A.
- The BCA ratio of ERP 2024 C is also significantly less than 1, indicating that costs of abatement far exceed the health benefits. This ratio remains below 1 even in the most optimistic (upper) parameters of the sensitivity analysis. This scenario has a larger discrepancy in NPV of health benefits and NPV of costs due to implementation of FGDs at both Medupi and Matimba and the small population that benefits. This scenario has a total nominal cost of R101,670 million and is likely to increase electricity tariffs by 0.9% - 1.2% in ERP 2024 C.
- Evaluation of the BCA ratios at a social discount rate of 2% delivers similar results, with all three scenarios ratios remaining less than 1.

Table 3-1: BCA ratios (lower and upper ranges) for each scenario (discounted at Eskom WACC)

	ERP 2024 A		**ERP 2024 B**		**ERP 2024 C**	
Million Rands	*Lower*	*Upper*	*Lower*	*Upper*	*Lower*	*Upper*
NPV of Costs	-18,970	-13,437	-18,970	-13,437	-27,716	-19,632
NPV of Benefits	3	17	8	39	16	83
NPV of Benefits minus Costs	-18,967	-13,420	-18,962	-13,398	-27,700	-19,549
Benefit:Cost Ratio (*range*)	0.0002	0.0012	0.0004	0.0029	0.0006	0.0042
Benefit:Cost Ratio (*central*)	0.0007		0.0017		0.0024	

In the analyses above the benefits from closure form part of the baseline.

The cumulative health benefits over time of the baseline:

- The power stations planned shutdown schedule (Section 2.3.3 for the years in which this occurs) results in health benefits without associated abatement costs. These benefits are dependent on timing of the shutdown schedule.
- In order to contextualize the three scenarios that were analysed with respect to the baseline Figure 3-7, Figure 3-8 and Figure 3-9 show how each scenario contributes to cumulative health benefits over time. The green area in the figures illustrates the health benefit of Matimba shutdown compared to the baseline, as the station shuts down the population exposed to pollution decreases and the health benefits increase. The blue, orange and grey areas indicating the health benefits of the ERP scenarios described above. The figures illustrate that effectiveness of station shutdown in decreasing health impact and increasing health benefits.

- The health benefits from the respective scenarios contribute an additional 1.5 – 7.6 times the health benefits of the baseline (estimated on a net present value basis).
- The Figures below are shown in Real 2023 Rand terms to better demonstrate in 2023 terms, the relative benefit for scenarios ERP 2024 A, B and C and Matimba closure.

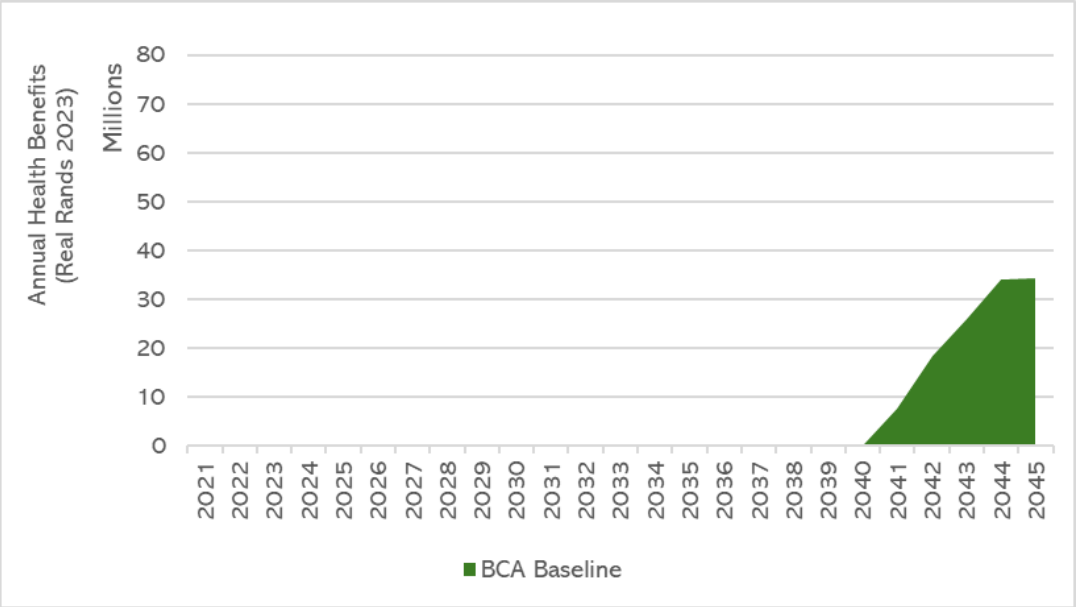


Figure 3-6: Cumulative annual health benefits in the baseline with planned power station shutdown of Matimba

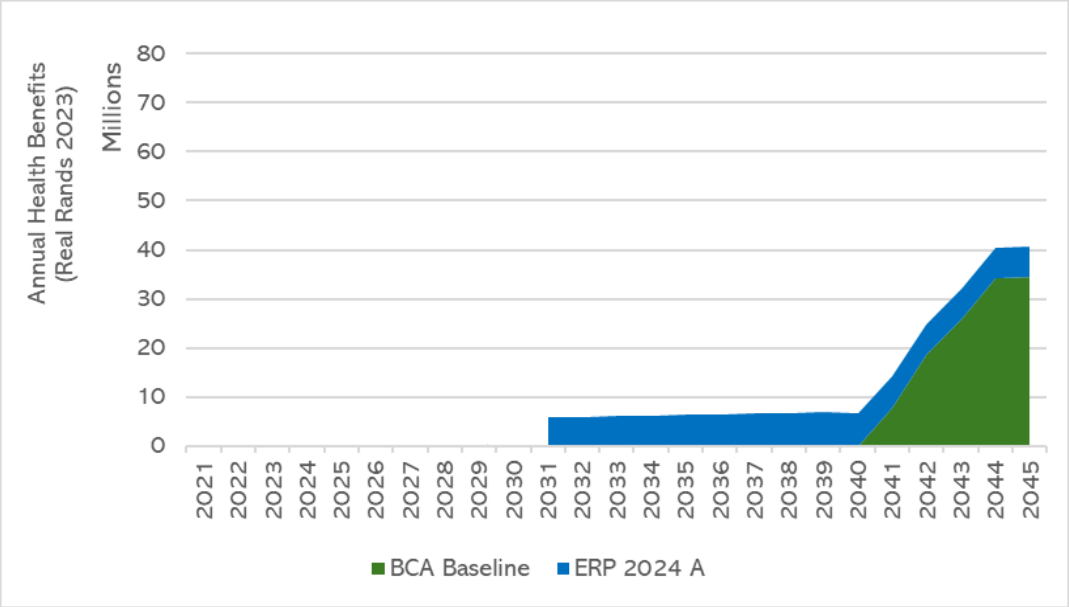


Figure 3-7: Cumulative health benefits of ERP 2024 A over the baseline

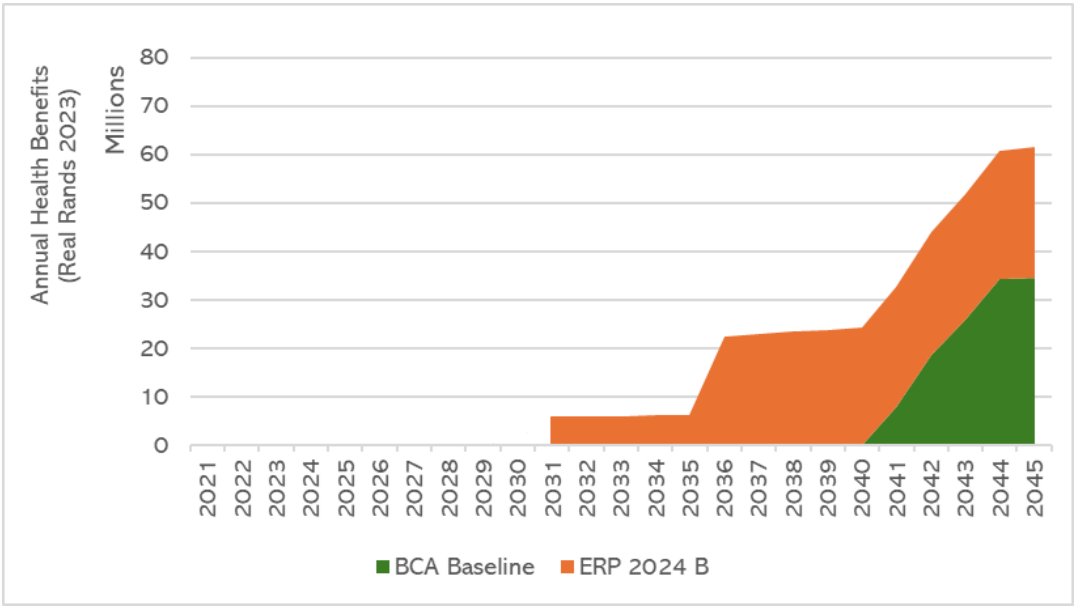


Figure 3-8: Cumulative health benefits of ERP 2024 B over the baseline

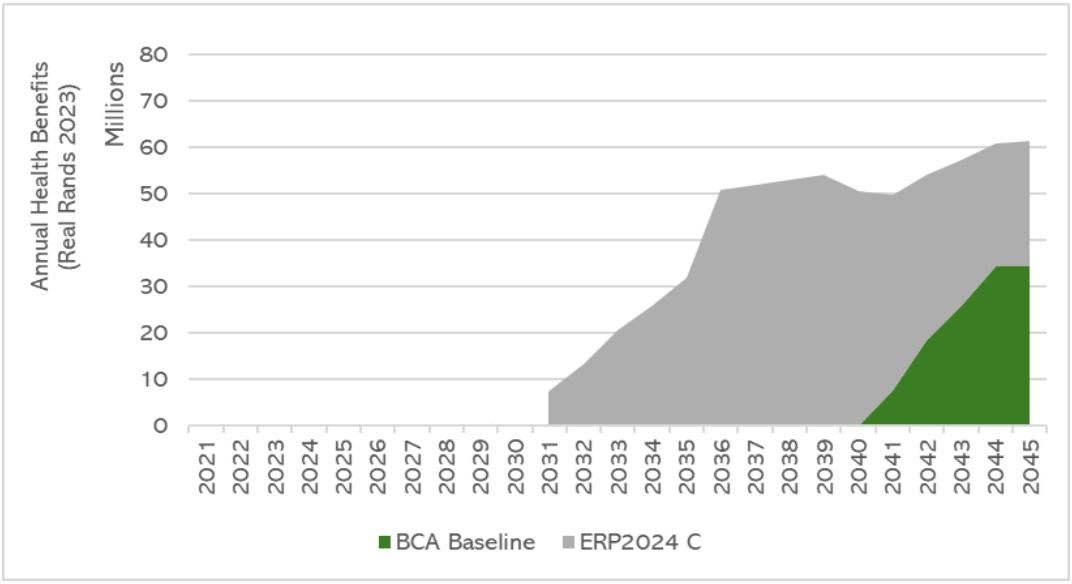


Figure 3-9: Cumulative health benefits of ERP 2024 C over the baseline

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5 APPENDIX A

The estimated calculated load factors for each station in the Waterberg:

Station	Medupi	Matimba
2025	81%	74%
2026	69%	57%
2027	60%	54%
2028	59%	55%
2029	54%	50%
2030	53%	49%
2031	64%	48%
2032	65%	49%
2033	68%	52%
2034	71%	51%
2035	70%	53%
2036	73%	55%
2037	76%	57%
2038	84%	61%
2039	88%	59%
2040	90%	39%
2041	95%	30%
2042	92%	17%
2043	93%	0%
2044	92%	0%
2045	94%	0%
2046	99%	0%
2047	97%	0%
2048	96%	0%
2049	97%	0%
2050	95%	0%

Air Pollution Health Risk Benefit Cost Analysis for exemption power stations in the Highveld Priority Area

For input into the Minimum Emission Standards Exemption Report Chapter 8

21 October 2024

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PREAMBLE

This study forms part of the project entitled, "Eskom MES Exemption Applications & Decommissioning AIRs" for WSP Group Africa (Pty) Ltd appointed by Eskom SOC Limited for the preparation of the Minimum Emission Standards (MES) exemption application report.

The study investigates the health benefits and implementation costs of mitigating air pollution emissions from 11 Eskom coal-fired power stations in the Highveld Priority Area. Five of these stations are earmarked for closure by 2030 (Arnot, Camden, Grootvlei, Hendrina and Kriel). The remaining six power stations may be retrofitted with air emission abatement technologies. These are Duvha, Kendal, Lethabo, Majuba, Matla and Tutuka.

The methodology used in this study is based on World Health Organisation guidelines.

In addition to the authors, the contributors to this analysis include:

- Dr Mark Zunckel and Atham Raghunandan uMoya-NILU Consulting (Pty) Ltd who were responsible for CALPUFF modelling
- Ms Rietha Oosthuizen (independent consultant) and Dr Caradee Wright (SA Medical Research Council) who provided advice for the epidemiological evidence used in the study.
- Mr Bryan McCourt and Mr Ebrahim Patel from Eskom provided important details on scenarios and abatement technology costs.

EXECUTIVE SUMMARY

The combustion of fossil fuels by power stations results in the emission of several atmospheric pollutants, that include particulate matter (PM), nitrogen dioxide (NO_2), and sulphur dioxide (SO_2). Atmospheric pollutants have numerous negative effects on human health and may increase the risk of premature mortality.

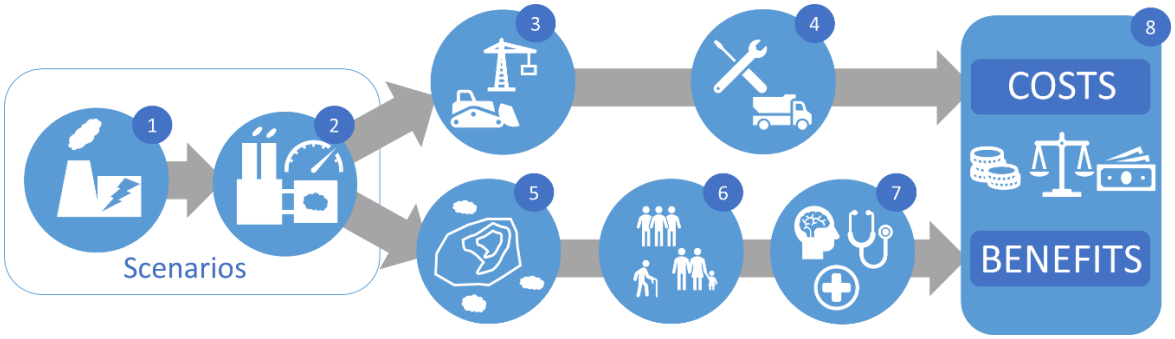
Technologies exist to reduce these emissions and therefore also their negative health effects. Abatement technologies for power stations include Flue Gas Desulphurisation (FGD) and Direct Sorbent Injection (DSI), for SO_2 reduction; installation of high-frequency power supply (HFPS) to improve Electrostatic Precipitator (ESP) efficiency to reduce PM emissions; and Low NO_X Burners (LNB) for NO_2 reduction.

A benefit-cost analysis (BCA) allows for trade-offs between different scenarios to be compared to support decision making.

The aim of this study was to estimate the incremental health benefits associated with abatement technology options as well as plant shutdown, repowering and repurposing, to achieve or move towards compliance with the new Minimum Emission Standards (MES) of the Department of Forestry Fisheries and the Environment (DFFE).

Methodology

An integrated Air Pollution Health Risk Benefit Cost Analysis APHR-BCA model was developed to model the impacts of three different abatement scenarios as developed by Eskom. The APHR-BCA was developed following the General Principles of the World Health Organisation, WHO (WHO, 2016a), for performing air pollution health risk assessments (AP-HRA). The detailed methodology and assumptions are set out in section 2 below. In summary, the methodology proceeded through several steps, as set out in the schematic:



Health benefits resulting from air pollution abatement

The WHO (2016a) recommends that the health risk in a population, associated with air pollution, is to be estimated using exposure-response functions (ERFs). ERFs are based on Relative Risk (RR) estimates derived from primary epidemiological studies. These RR functions estimate the likelihood of health outcomes occurring in a population exposed to a higher level of air pollution relative to that in a population with a lower exposure level. RR is usually expressed as the proportional increase in the assessed health outcome risk incidence associated with a given

increase in pollutant concentrations, measured in µg/m^3. The WHO (2016a) notes that "*the RR estimate cannot be assigned to a specific person; it describes risk in a defined population, not individual risk.*"

Ideally, ERF studies and their RRs should be determined based on primary epidemiological studies focussing on the exposed population. In the absence of such studies, as in the case of South Africa, the WHO (2016a) recommends using ERFs from other countries.

The health outcomes were selected based on the latest WHO systematic reviews from 2020 and 2021 that were conducted for the update of the WHO Global Air Quality guidelines. The health outcome that was considered in this study is all-cause mortality. Morbidity was not considered in this study as comprehensive data on morbidity studies is not widely available. Additionally, there are issues relating the transferability of data from one population to another in terms of country and culture as populations have different sensitivities to pollutant exposure (WHO 2000).

Pollution levels, chemical composition and health care systems are typically very different in other settings, and this would affect the accuracy of the ERFs. It is important to understand at what level interval the ERFs would result in significant differences in health outcome incidences. As a result, the WHO (2016a) advises performing an assessment of the uncertainty of the analysis; in this case therefore this requires an assessment related to a lack of knowledge about one or more components of the integrated Health BCA Model. Section 2.5 discusses each source of uncertainty and related limitations. Variation resulting from relevant uncertainty factors was assessed through performing sensitivity analysis in the BCA (refer to section 2.4).

Interpretation of the risk of premature mortality must be done with care. It is to be noted firstly that these numbers are indicators of health risk at a population level. The relative risk estimate inherent in the ERF is a metric of the likelihood of an adverse health outcome, and it cannot be attributed to an individual person. It can thus be used to quantify risk to a defined population (and not to an individual), (WHO 2016a) and how this risk would vary between various mitigation scenarios.

In this study, the ERFs obtained from the latest WHO systematic reviews, focussed exclusively on mortality and thus a monetary measure of mortality was required in order to perform benefit-cost analyses. In air pollution benefit-cost analyses, the concept of value of a statistical life (VSL) is commonly used to monetise mortality related benefits of air pollution reduction. The concept of a VSL is frequently misunderstood. It does not measure the intrinsic value of a human life, and neither does it value the economic productivity of a human. Rather, VSL is estimated by dividing an individual's willingness to pay (WTP) to reduce health risk, by the likelihood of risk reduction. Robinson and Hammitt (2009) defines VSL to represent the rate at which an individual is willing to exchange their own income for a small reduction in their own mortality risk over a particular time period. VSL is not the value that a person, society or the government would place on reducing mortality rates with certainty, but it is rather a representation of the rate at which a person views a change in the money available for spending as equivalent to a small change in their own mortality risk (Robinson et al., 2018).

Primary WTP studies for mortality risk reductions have not been done in South Africa. The VSL for South Africa in the BCA was determined by using the methodology as advised by Viscusi and

Masterman (2017) and Robinson et al. (2018) with a base VSL from the U.S, GNI per capita for income measures and adjusted by income elasticity. As advised by Robinson et al. (2018), a sensitivity analysis is conducted to explore various VSL estimates.

Scenario assessment

The three scenarios proposed by Eskom and evaluated in the BCA study were:

- Scenario ERP 2024 A (PM and NOx reduction, generating load capped, air quality offsets and SO_2 reduction at Kusile)
- Scenario ERP 2024 B (As per ERP 2024 A plus SO_2 reduction technology installed at Majuba and Kendal)
- Scenario ERP 2024 C (Full compliance with MES for PM, NOx and SO_2 for Kusile, Majuba, Kendal, Lethabo and Tutuka)

The detailed emission abatement measures relevant to the scenarios are set out in Table 2-6 in Section 2.3.3. A key difference in the scenarios is the number of stations which are installed with SO_2 reduction technology in the form of wet- Flue Gas Desulphurisation (FGD), semi-dry FGD, or Direct Sorbent Injection (DSI). The focus on SO_2 reduction is important given the extent which it is anticipated to impact on air quality and public health and the very significant cost of SO_2 reduction cost.

Health benefits associated with each scenario were calculated against the baseline that took into account the anticipated changes in loads in the coming years from 2025 and assumed no additional abatement technologies installed, and all stations would continue to emit air pollution at their current rates until shutdown, repowering and repurposing. The baseline also includes the health benefits derived from subsequent decrease in load as stations shut down as new alternate energy source capacity becomes available.

- The health benefits of ERP 2024 A deliver immediate impact from 2024. The benefits associated with this scenario start tapering off from 2030 onwards as Duvha and Matla shutdown, repowering and repurposing between 2031 and 2036, and the associated health benefits from the HFPS and LNB technologies reduces accordingly. Tutuka, Lethabo and Kendal shutdown, repowering and repurposing from 2036, 2037 and 2040 respectively. The Electrostatic Precipitators (ESP) plus High Frequency Power Supplies (ESP+HFPS) and Low NOx Burners (LNB) technologies at these stations (refer to Table 2-6) continue to provide health benefits until 2045. Majuba shutdown, repowering and repurposing starts in 2047 and the health benefits from the LNB technology continue until final closure. ERP 2024 A includes wet FGD at Kusile but the costs and benefits of this fall outside of the scope of this scenario assessment.
- The health benefits of ERP 2024 B include those as discussed for ERP 2024 A above. In addition, efficiency and coal improvement projects reduce total sulphur and carbon emissions by 5% for Kendal, Lethabo, Tutuka and Majuba contributing to the increase in health benefits in ERP 2024 B. In addition to the Kusile wet FGD (but the costs and benefits of this fall outside of the scope of this scenario

assessment), at Majuba DSI is commissioned from 2029 – 2033. Kendal is equipped with semi-dry FGD which is implemented from 2036, and this increases health benefits for a short period to 2040 whereafter Kendal shutdown, repowering and repurposing starts.

- The health benefits of ERP 2024 C include those as discussed for ERP 2024 A and B above. All planned PM emission reduction projects are completed (by 2028), and stations operate at PM=50 mg/Nm^3. NOx projects are completed at all stations (completed by 2032), and stations operate at NOx = 750 mg/Nm^3. In addition to the SO_2 reduction at Kendal and Majuba (and Kusile – however these effects are not part of the scenario assessment), semi-dry FGDs are installed at Tutuka and Lethabo by 2035, however, these stations start shutdown, repowering and repurposing from 2036 and 2037 respectively, thus effectively negating the health benefits from the FGD technologies.

With respect to the **abatement costs** associated with each scenario:

- The total Capex and Opex costs of abatement are identical to 2025.
- ERP 2024 B implementation starts in 2026 and 2027 with Majuba and Lethabo's LNB technology. From 2029 DSI installation starts at Majuba and in 2031 FGD starts at Kendal.
- ERP 2024 C builds on ERP 2024 B with implementation of SO_2 reduction technology starting in 2031 for both Lethabo and Tutuka.

The BCA ratios need to be interpreted with care. They are meant only to provide a perspective on and inform the decision-making process underlying the scenarios. They are not meant to be interpreted as a definitive answer to making abatement decisions. Decisions involving human health have to be informed by non-economic criteria as well. In addition, with uncertainty inherent in the analysis, the benefit cost ratio should thus not be viewed as absolute, but rather as a relative value from which to compare scenarios.

Benefits from station closure are included within the baseline so are not visible in the BCA directly. The shutdown of stations does however generally result in less pollution being emitted with increased health benefits compared to the baseline.

The **BCA results** are provided in Table 0-1. In the upper estimates the lower costs and higher VSL are used and in the lower estimates the higher costs and lower VSL are used as recommended by Robinson et al. 2018.

- The BCA central ratio in ERP 2024 A is more than 1 (1.74), showing a very clear benefit and the health benefits exceed the costs of abatement, implying that this is a sound abatement option for Eskom to pursue. This scenario has a total nominal cost of R18,500 million, and is likely to increase electricity tariffs by 0.4% - 0.6%. IN ERP 2024 A
- The central BCA ratio of ERP 2024 B (SO_2 reduction at Majuba and Kendal) is less than 1 although it approaches 1 in the most optimistic (upper) parameters of the sensitivity analysis. The key reason for this is the implementation of the

Kendal semi-dry FGD which is implemented from 2036, but only increases health benefits for a brief period to 2040 whereafter Kendal shutdown, repowering and repurposing starts. In this scenario the total nominal cost increases to R75,970 million (which adds to ERP A the additional cost of SO_2 reduction at Majuba and Kendal) and is likely to increase electricity tariffs by 1.0% - 1.4%.

- The BCA central ratio of ERP 2024 C (SO_2 reduction at Majuba, Kendal, Lethabo and Tutuka) is less than 1 (0.33) and remains below 1 even in the most optimistic (upper) parameters of the sensitivity analysis. The key reason for this is the implementation of FGDs at Tutuka and Lethabo by 2035, followed by immediate shutdown, repowering and repurposing from 2036 and 2037 respectively, thus effectively negating the health benefits from the FGD technologies. In this scenario the total nominal cost increases to R155,320 million (which adds to the ERP 2024 A and B costs the additional costs of SO_2 reduction at Lethabo and Tutuka), and is likely to increase electricity tariffs by 1.6% - 2.2%.
- Evaluation of the BCA ratios at a social discount rate of 2% delivers similar results, with ERP 2024 A above 1 and ERP 2024 B and C both less than 1. This is because of the limited health benefits achieved post 2036.

Table 0-1. **BCA ratios (lower and upper ranges) for each scenario (discounted at Eskom WACC)**

	ERP 2024 A		ERP 2024 B		ERP 2024 C	
Million Rands	*Lower*	*Upper*	*Lower*	*Upper*	*Lower*	*Upper*
NPV of Costs	-10,479	-7,423	-33,909	-24,019	-56,964	-40,349
NPV of Benefits	3,575	23,341	3,651	23,831	3,732	24,357
NPV of Benefits minus Costs	-6,904	15,918	-30,258	-188	-53,232	-15,993
Benefit:Cost Ratio (range)	0.34	3.14	0.11	0.99	0.07	0.60
Benefit:Cost Ratio (central)	1.74		0.55		0.33	

In the analyses above the benefits from station closure form part of the baseline.

The power stations planned shutdown schedule (see Table *2-7* in Section 2.3.3 for the years in which this occurs) results in health benefits without associated abatement costs. These benefits are dependent on timing of the shutdown schedule. These benefits have been assumed to form part of the BCA baseline and have therefore not been quantified directly in the BCA.

ACRONYMS AND ABBREVIATIONS

AP-HRA	Air Pollution Health Risk Assessment
AQA	Air Quality Act
AQMS	Air Quality Monitoring Station
BCA	Benefit-Cost Analysis
CFOI	Census of Fatal Occupational Injuries (USA)
COI	Cost of Illness
DEA	Department of Environmental Affairs
DFFE	Department of Forestry Fisheries & Environmental Affairs
ERF	Exposure Response Function
ESP	Electrostatic Precipitators
FFP	Fabric Filter Plants
FGD	Flue Gas Desulphurisation and
GNI	Gross National Income
HPA	Highveld Priority Area
ICD	International Classification of Diseases
kW	Kilowatt
kWh	Kilowatt Hour
LNB	Low NO_X Burners
MES	Minimum Emissions Standards
NAAQS	National Ambient Air Quality Standard
NAQI	National Air Quality Index
NEMA	National Environmental Management Act
NO_2	Nitrogen Oxide
NPV	Net Present Value
PM	Particulate Matter
RR	Relative Risk
SAMRC	South African Medical Research Council
SO_2	Sulphur Dioxide
USA	United States of America

VSL	Value of a Statistical Life
WHO	World Health Organisation
VTAPA	Vaal Triangle Airshed Priority Area
WACC	Weighted Average Cost of Capital
WTP	Willingness to Pay

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1 INTRODUCTION

The Earth Summit[1] in Rio de Janeiro in 1991 raised the awareness of the linkages between environmental health and human wellbeing to a global agenda. In the three and a half decades since the Summit, significant effort has gone into methods for quantifying these linkages, in all environmental spheres, and informing policy development. During the same period, we have seen an information technology revolution, which has radically improved our ability to collect and analyse large data sets. In the field of air quality health risk assessment specifically, there has been a rapid and continuously improving set of methodologies through which to analyse the linkages between air pollution and health risk.

The World Health Organisation (WHO) has been leading the development of health risk assessment methodology. Formally, air pollution health risk assessments (AP-HRA) are performed to provide quantifiable information for informing public policy decisions. The general principles for AP-HRAs have been published by the WHO (WHO, 2016a). An AP-HRA proceeds through three steps.

Firstly, it assesses the exposure of the target population to specific air pollutants. This requires a quantification of constituents in the atmosphere that are associated with human health risks. The atmosphere we breathe contains various such constituents, both from natural sources (e.g. sea salt and bio-aerosols) and anthropogenic sources (e.g. fuel combustion, suspension of fine particles, and industrial emissions) (refer to FRIDGE (2004) for a comprehensive discussion of pollution sources). When a particular policy option is analysed, specific indicator constituents need to be selected, and the incremental effect of the policy option needs to be estimated in terms of population exposure. In this study, incremental population exposure resulting from Eskom's coal-fired power plant emissions (from 11 stations), was estimated through the use of dispersion modelling (uMoya-NILU, 2024).

Secondly, the AP-HRA estimates the resultant incremental change in health risk. This requires the application of exposure-response functions (ERFs). ERFs quantify the incremental change in health outcomes (compared to the baseline incidence), based on changes in exposure to pollutants. ERFs are derived from epidemiological studies, which are large scale population health studies that compare health outcome incidence between populations exposed to different concentrations of pollution. In this study, ERFs from the latest systematic reviews from 2020 and 2021 that were conducted for the update of the WHO Global Air Quality guidelines were used (WHO 2020, 2021). AP-HRA results can be reported in terms of morbidity indicators (e.g. cost of medical treatment and lost economic productivity) or mortality indicators (e.g. premature mortality). These indicators can be converted to monetary impacts by applying cost of illness (COI) methodologies. In this study, premature mortality was evaluated, using a value of a statistical life (VSL) COI methodology.

Thirdly, the AP-HRA process requires the quantification and expression of the uncertainty of the estimated health effects. The WHO states that this step is "*an important and integral component of the results, and … vital to ensure both that the main message is not lost and that the results*

[1] http://www.un.org/geninfo/bp/enviro.html

produced are understandable by policy-makers and others who do not necessarily have a technical background or expertise in AP-HRA." This step requires "*the use of expert judgement (consensus) on the level of confidence of the results*".

This study investigates the health effects of air pollution resulting from coal-fired power stations in the Highveld Priority Area and applies the AP-HRA methodology described (see Section 2).

The indicator pollutants used included sulphur dioxide (SO_2), particulate matter (PM), and nitrogen dioxide (NO_2). These pollutants have several negative impacts on public health (WHO, 2016b).

The Department of Environmental Affairs (now Department of Forestry, Fisheries and the Environment, DFFE) under the National Environmental Management Act (NEMA: AQA, 2004) sets ambient air quality standards. The Highveld, containing most of South Africa's coal-fired power stations, often exceeds the National Ambient Air Quality Standards (NAAQS) (DEA, 2009 and 2012). As a result, the Minister of Environmental Affairs declared the Highveld Priority Area (HPA) in November 2007 in terms of Chapter 18 of the National Environment Management: Air Quality Act, 2004 (Act No. 39 of 2004) (NEMA: AQA). Where ambient air quality standards are exceeded, specific air quality mitigation actions would be required. Power generation is a Listed Activity in terms of Section 21 of the NEMA: AQA and Minimum Emission Standards (MES) are prescribed for existing and new stations. The May 2024 ruling by the Minister of the Department of Forestry, Fisheries and the Environment requires that Eskom submit applications in terms of Section 59 of the National Environmental Management: Air Quality Act (NEMA: AQA), for the exemption of the MES for eight power stations that will continue to operate beyond 2030. These are Duvha, Kendal, Lethabo, Majuba, Matla, Tutuka, Medupi and Matimba.

Technologies exist for the reduction of emissions and therefore the health effects. These abatement technologies include Flue Gas Desulphurisation (FGD) and Dry Sorbent Injection (DSI) to reduce SO_2, Electrostatic Precipitators (ESP) and high-frequency power supplies (HFPS) to improve Electrostatic Precipitator (ESP) efficiency to reduce PM, Low NO_X Burners (LNB) to reduce NO_2 and Fabric Filter Plants (FFP) to reduce PM.

The current study investigated three air pollution mitigation scenarios for Eskom, through a benefit-cost analysis (BCA). The BCA uses the AP-HRA methodology to estimate the likely changes in health costs resulting from each scenario. The BCA compares these benefits against the capital costs and operational costs of the mitigation options for each scenario (refer to section 2.3).

1.1 Other studies

Other studies have previously been conducted to estimate the health impacts of either fossil fuel power plants, air pollution in general or specific sources in South Africa. They estimated morbidity and mortality, and in some instances attributed costs to these health impacts. Studies of this nature can take either bottom up (deterministic) approaches or top down (stochastic) approaches to modelling pollution exposure with the latter usually preferable in data poor environments or large spatial domains (Dios et al., 2012). These studies also varied in geographic scale, ranging from selected areas to the national scale. Some of the most recent and relevant include:

The World Health Organisation estimated that, in South Africa, in 2009, the relative risk of premature mortality attributed to poor outdoor air quality was approximately 1,100 cases per year (WHO, 2009).

- Scale: National (All Air Pollution)
- Resolution: Course
- Health Outcomes: Mortality
- Modelling Approach: Top-down

The Centre for Research on Energy and Clean Air estimated that full Minimum Emissions Standard (MES) compliance at Eskom power stations remaining in operation until 2030 would reduce the relative risk of premature mortality from air pollution by 2,300 cases per year and economic costs of R42 billion per year (Myllyvirta & Kelly, 2023). The impacts of mercury were also estimated in the study.

- Scale: National (Power Station Air Pollution)
- Resolution: Medium
- Health Outcomes: Morbidity and Mortality
- Modelling Approach: Bottom-up

The Institute for Health Metrics and Evaluation listed air pollution as the 9th largest risk factor driving death and disability combined in 2016 in South Africa (IHME, 2016).

- Scale: National (All Air Pollution)
- Resolution: Medium
- Health Outcomes: Morbidity and Mortality
- Modelling Approach: Bottom-up

A study commissioned by Greenpeace in 2014 estimated air pollution emissions from Eskom's coal-fired power stations could increase the relative risk of premature mortality from air pollution by as much as 2,200 cases per year (Myllyvirta, 2014). The study also estimated the impacts of mercury pollution.

- Scale: National (Air Pollution from Coal-fired Power Stations)
- Resolution: Medium
- Health Outcomes: Morbidity and Mortality
- Modelling Approach: Bottom-up

A 2017 study commissioned by Groundwork, estimated the total impact of air pollution resulting from the coal-fired power stations at $2.4 billion of health costs annually in South Africa (Holland, 2017).

- Scale: National (Air Pollution from Coal-fired Power Stations)
- Resolution: Medium
- Health Outcomes: Morbidity and Mortality
- Modelling Approach: Bottom-up

Van Horen (1996) evaluated the health costs associated with Eskom's power stations as part of understanding the true costs of electricity generation. The valuation of morbidity outcomes was found to be small in terms of costs per kWh generated.

- Scale: National (Air Pollution from Coal-fired Power Stations)
- Resolution: Medium
- Health Outcomes: Morbidity and Mortality
- Modelling Approach: Bottom-up

The Fund for Research into Industrial Development Growth and Equity, in 2004, assessed the economic impact of air pollution in selected areas in South Africa. The study found that power generation was responsible for 51% of the 8,700 respiratory cases in Mpumalanga (FRIDGE, 2004).

- Scale: Selected Areas (All Air Pollution and Air Pollution from Power Stations)
- Resolution: Medium
- Health Outcomes: Morbidity and Mortality
- Modelling Approach: Bottom-up

A review by Spalding-Fecher and Matibe in 2003 aimed to calculate the external costs of electric power generation in South Africa. They estimated the health costs to be R1.1 billion per year (Spalding-Fecher and Matibe, 2003).

- Scale: National (Air Pollution from Power Stations)
- Resolution: Low
- Health Outcomes: Morbidity and Mortality
- Modelling Approach: Top-down.

The methodology used in this investigation is discussed in detail in Section 2 below.

2 METHODOLOGY AND INPUTS

2.1 Overview

An integrated Health BCA Model was developed that combined an AP-HRA with a BCA to assess three air pollution mitigation scenarios for 11 Eskom coal-fired power stations in the Highveld region.

Figure 2-1 below provides an overview of the methodology, and Sections 2.2 - 2.5 provide a more detailed discussion of each component.

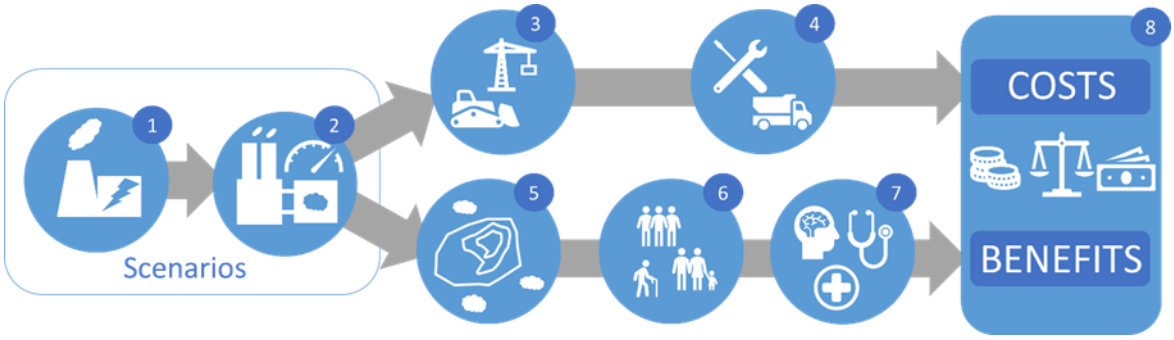


Figure 2-1: Overview of methodology and model architecture

With reference to Figure 2-1, the integrated Health BCA Model includes the following components:

1. Station lifetimes were described for 11 coal-fired power stations and included commissioning and shutdown, repowering and repurposing dates (provided by Eskom).
2. Abatement technologies for the six target power-stations, as required for each scenario, were defined, by type and implementation schedule (refer to section 2.3.3).
3. Capital expenditure required for abatement in each scenario was obtained from Eskom and attributed per plant and per year.
4. Operational expenditure required for abatement in each scenario was obtained from Eskom and attributed per plant and per year.
5. Dispersion modelling was done by uMoya-NILU Consulting (Pty) Ltd. This data was then segregated spatially, by municipal ward boundaries to align with population data. Two types of dispersion modelling were performed, one modelling the individual power station predicted ambient concentrations of PM, SO_2, and NO_2 per scenario and the other the cumulative predicted ambient concentrations of PM, SO_2, and NO_2 from all the power stations per scenario. Note that for PM, the dispersion modelling predicted primary PM and secondary PM effects, resulting from NO_2 and SO_2 reactions in the atmosphere, as well as fugitive emissions (refer to Section 2.2).
6. Population exposure was estimated at a spatial resolution of municipal wards. At each ward, the number of people exposed to different concentration ranges were determined per scenario per year, based on Stats SA population estimates and United Nations population growth forecasts (refer to Section 2.2).

7. Health impacts were determined by using the AP-HRA methodology. Epidemiological evidence, in the form of Exposure-response functions (ERFs) and baseline incidence rates were obtained from the World Health Organization (WHO) systematic reviews (2020 & 2021) conducted by various researchers as part of the WHO update to the Global Air Quality Guidelines (released late September 2021) (refer to Section 2.3). The ERFs were limited to mortality incidence. The Cost of Illness (COI) methodology used was the value of a statistical life (VSL). This method estimates the willingness to pay (WTP) of an individual for reducing their health risk. The VSL should not be interpreted as the intrinsic value of a life. Refer to Section 2.3.2 for a more detailed discussion.
8. The BCA compares the overall scenario health benefits achieved through abatement to the costs of implementation. The outputs of the AP-HRA, i.e. the health cost savings of each scenario, was used as the benefit. The analysis timeline spans 2024 – 2045. (refer to Section 2.4). Finally, an assessment of uncertainty of the results was done (refer to Section 2.5).

2.2 Exposure of the target population to specific air pollutants

2.2.1 Overview

This section comprises the first step of the AP-HRA. It assesses the exposure of the target population to specific air pollutants.

This requires an incremental effects quantification of constituents in the atmosphere that are associated with human health risks. These pollutants include PM, NO_2 and SO_2 emitted by the 11 coal-fired power stations investigated. The emissions from these stations impact the Highveld Priority Area (HPA) and the Vaal Triangle Airshed Priority Area (VTAPA).

Dispersion modelling combined with population distribution provided an estimate of exposed population.

2.2.2 Pollutants analysed

The Highveld Priority Area has several Air Quality Monitoring Stations (AQMS) located in proximity of the power stations equipped for continuous monitoring of air quality and meteorological parameters. These AQMS were established either by Eskom or are SAWS-DEA owned NAQI (National Air Quality Index) stations that were established by DEA (now DFFE).

The sections that follow provide a summary of the ambient concentrations of SO_2, NO_2 and PM in the period of 2021 to 2023 at the AQMS for the exemption power stations of Duvha, Kendal, Lethabo, Matla, Majuba and Tutuka. In the HPA and VTAPA the main sources of air pollution include agriculture activities, mining, domestic fuel and waste burning, vehicle emissions, industrial operations and power generation.

In summary a review of the ambient monitoring confirms that in respect of the NAAQS there is broad PM non-compliance in the area but that SO_2 and NO_x are in general compliance across the area.

2.2.2.1 Sulphur dioxide (SO_2)

Industrial processes and power generation are the main source of SO_2 in the atmosphere through the combustion or refining of sulphur containing fuels. Details at each AQMS are summarised in Table 2-1.

Table 2-1: SO_2 concentrations reported at the HPA AQMS from 2021 to 2023

Power Station	AQMS	Ambient SO_2
Duvha	Masakhane (Eskom)	Hourly, daily average and annual average concentrations below NAAQS with no exceedances
	eMalahleni (SAWS)	The hourly average had one exceedance in 2023. Daily average and annual average concentrations below NAAQS with no exceedances for 2021 and 2023
Kendal	Kendal K2 (Eskom)	Hourly average concentrations in 2023 exceeded the NAAQS three times out of the permitted 88 exceedances per year and remained compliant. Daily and annual average concentrations remained below average NAAQS in all years.

Power Station	AQMS	Ambient SO_2
	Eskom Chicken Farm (Eskom)	Hourly, daily and annual concentrations remained below the respective average NAAQS in all years remaining compliant.
Lethabo	Rand Water (Eskom)	Hourly, daily and annual average concentrations remained below the NAAQS in 2021 and 2023 with no exceedances recorded.
	Three Rivers (SAWS)	Hourly, daily and annual average concentrations remained below the NAAQS in 2021 and 2023 with no exceedances recorded.
	Sharpeville (SAWS)	Hourly concentrations exceeded NAAQS in 2021, 2022 and 2023 however remained within allowable exceedances per year. The daily average only exceeded once in 2022 remaining compliant within the allowable four exceedances per year. In 2021 and 2022 it remained below NAAQS and no exceedances recorded. The annual average concentrations remained below average NAAQS in 2021to 2023 remaining compliant
Matla	Kriel (Eskom)	In all years the hourly and annual average concentrations remained below the average NAAQS with no daily exceedances recorded and remains compliant.
Majuba	Majuba (Eskom)	Hourly, daily and annual concentrations remained below the respective average NAAQS in all the years remaining compliant.
Tutuka	Sivukile (Eskom)	Hourly concentrations remained below the average NAAQS in 2021 (only one exceedance recorded), 2022 and 2023 and remains compliant. The daily and annual concentrations remained below the average NAAQS in 2021 to 2023 and remains compliant.
	Grootdraai Dam (Eskom)	Hourly and daily concentrations remained below the average NAAQS in 2021 to 2023 with no recorded exceedances and the annual concentration also remained below average NAAQS and thus remains compliant.

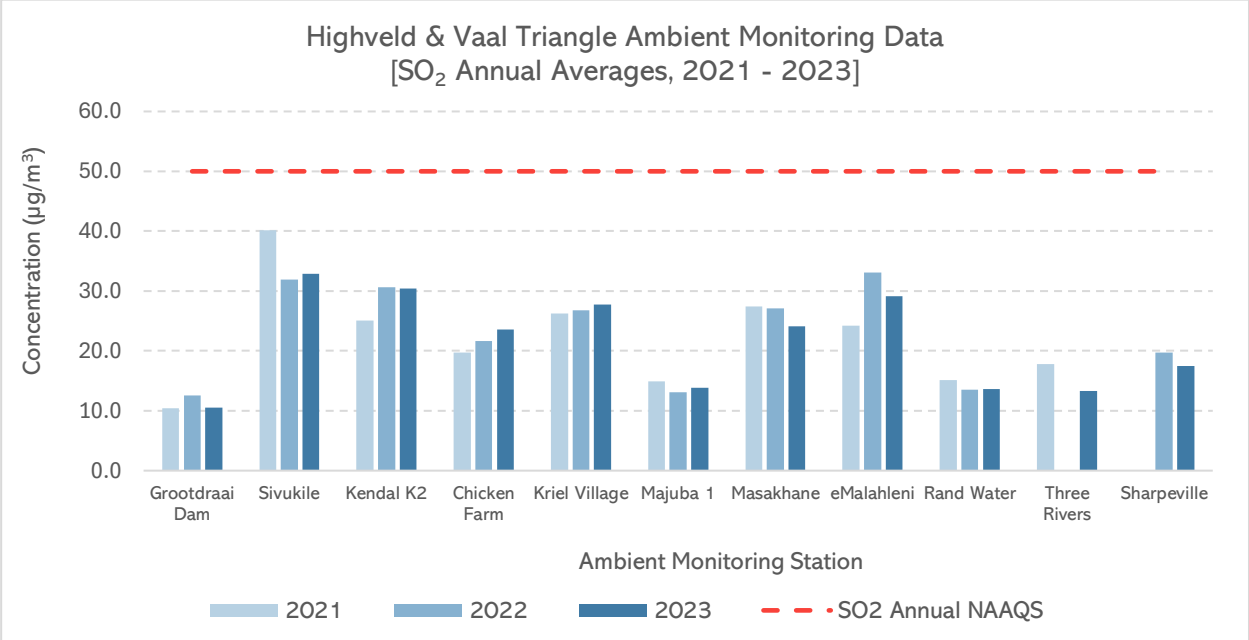


Figure 2-2: Annual average SO_2 concentrations at the Air Quality Monitoring Stations in the HPA in the period 2021 to 2023 in µg/m³

2.2.2.2 Nitrogen dioxide (NO_2)

Industrial processes and power generation are the main source of NO_2 in the atmosphere through the combustion or refining of fossil fuels, with some contribution from motor vehicle emissions, residential fuel burning and biomass burning. A summary of the NO_2 pollutant concentrations reported at the HPA AQMS is given in Table 2-2.

Table 2-2: NO_2 concentrations reported at the HPA AQMS from 2021 to 2023

Power Station	AQMS	Ambient NO_2
Duvha	Masakhane (Eskom)	The hourly average concentrations remained below NAAQS between 2021 and 2023. No exceedances recorded. Annual average concentrations for 2021 and 2023 remained below NAAQS.
	eMalahleni (SAWS)	The hourly concentrations remain below NAAQS in 2022 and 2023 with no exceedance recorded. The annual average concentrations for 2022 and 2023 remained below average NAAQS.
Kendal	Kendal K2 (Eskom)	Hourly and annual average concentrations remained below the average NAAQS remaining compliant.
	Eskom Chicken Farm (Eskom)	Hourly and annual average concentrations remained below the average NAAQS remaining compliant.
Lethabo	Rand Water (Eskom)	Hourly and annual average concentrations remained below the average NAAQS remaining compliant with no exceedances.
	Three Rivers (SAWS)	Hourly and annual average concentrations remained below the average NAAQS in 2021 and 2023 remaining compliant with no exceedances.
	Sharpeville (SAWS)	Hourly and daily average concentrations remained below average NAAQS in 2022 and 2023 with no exceedances recorded remaining compliant.
Matla	Kriel (Eskom)	Hourly and annual average concentrations remained below the average NAAQS remaining compliant with no exceedances.
Majuba	Majuba (Eskom)	Hourly and annual average concentrations remained below the average NAAQS remaining compliant with no exceedances.
Tutuka	Sivukile (Eskom)	Hourly and annual average concentrations remained below the average NAAQS remaining compliant with no exceedances.
	Grootdraai Dam (Eskom)	Hourly and annual average concentrations in 2021 and 2022 remained below the average NAAQS remaining compliant with no exceedances.

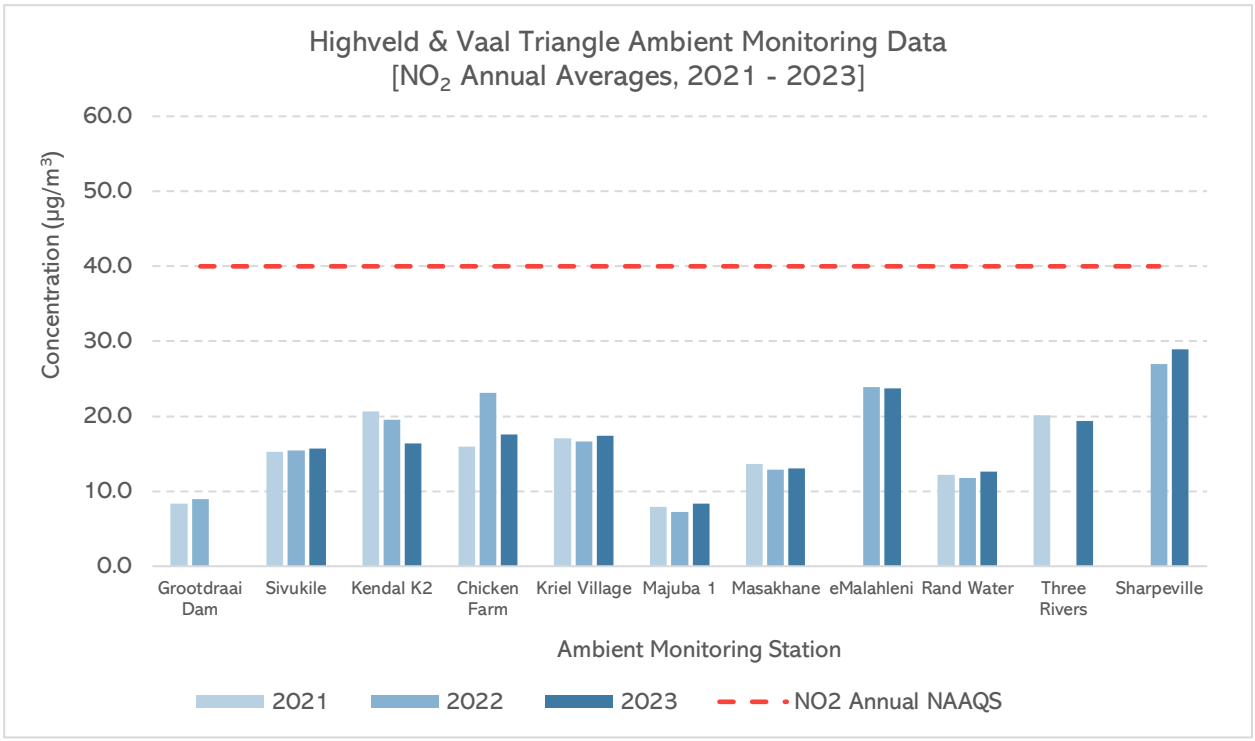


Figure 2-3: Annual average NO_2 concentrations at the HPA monitoring stations in µg/m³

2.2.2.3 Particulate matter (PM)

There are numerous sources of primary particulate matter, including power generation, industry, mining, residential fuel burning, biomass burning and agricultural, as well as natural sources such as wind entrainment. In addition, secondary PM is produced by NO_2 and SO_2 reactions in the atmosphere. The PM pollutant concentrations reported at the AQMS are summarised in Table 2-3.

Table 2-3: PM concentrations reported at the AQMS from 2021 to 2023

Power Station	AQMS	Ambient PM (PM_{10} and $PM_{2.5}$)
Duvha	Masakhane (Eskom)	PM_{10} daily average and annual average exceeded the daily average NAAQS in 2022 and 2023 and is non-compliant with more than the permitted four exceedances per year. The daily and annual $PM_{2.5}$ concentrations exceeded the average NAAQS in 2021 and non-compliant with more than four exceedances, however in 2022 the daily and annual average $PM_{2.5}$ concentrations were below the average NAAQS with no exceedances recorded.
	eMalahleni (SAWS)	The daily average PM_{10} and $PM_{2.5}$ concentrations exceeded the NAAQS in 2021 and 2023 and non-compliant with multiple exceedances reported. The annual average concentrations of both PM_{10} and $PM_{2.5}$ exceeded the annual average NAAQS for 2022 and 2023 but were lower than the NAAQS and compliant in 2021.
Kendal	Kendal K2 (Eskom)	Daily and annual average PM_{10} concentrations exceeded the daily and annual average NAAQS in all years and thus remains non-compliant for PM_{10}.

Power Station	AQMS	Ambient PM (PM_{10} and $PM_{2.5}$)
		In 2021 and 2022 the station remained compliant for $PM_{2.5}$ with only four exceedances for daily average in 2022 and the annual average concentrations in 2021 and 2022 were below the NAAQS.
	Eskom Chicken Farm (Eskom)	Daily PM_{10} concentrations remained below average NAAQS with four exceedances in 2021, none in 2022 remaining compliant but non-compliant in 2023 with eight exceedances. Daily average $PM_{2.5}$ remained below NAAQS in 2023 with one exceedance reported. Annual average PM_{10} and $PM_{2.5}$ were below average NAAQS in 2023 and remain compliant.
Lethabo	Rand Water (Eskom)	Daily $PM_{2.5}$ concentrations exceeded the daily average NAAQS in 2021 and 2022 with more than four exceedances and in 2022 it remained compliant with only four exceedances recorded. Annual average $PM_{2.5}$ remained below average NAAQS in 2021 and 2023 and remains compliant.
	Three Rivers (SAWS)	In 2021 and 2023 the daily and annual average PM_{10} and $PM_{2.5}$ concentrations exceeded the respective daily and annual average NAAQS remaining non-compliant.
	Sharpeville (SAWS)	In 2021 and 2023 the daily and annual average PM_{10} and $PM_{2.5}$ concentrations exceeded the respective daily and annual average NAAQS and remains non-compliant
Matla	Kriel (Eskom)	The daily average PM_{10} and $PM_{2.5}$ concentrations exceeded the NAAQS in 2021 and 2023 and non-compliant with multiple exceedances reported. Annual average concentrations of PM_{10} in 2021 and 2023 and those of $PM_{2.5}$ in 2021 and 2022 exceeded the annual average NAAQS. The 2023 $PM_{2.5}$ concentrations remained below NAAQS and remained compliant in that year.
Majuba	Majuba (Eskom)	Daily and annual average PM_{10} concentrations exceeded the average NAAQS in 2022 and thus non-compliant. Daily average $PM_{2.5}$ concentrations exceeded daily average NAAQS twice in 2021 but remained complaint with under four exceedances. In 2022 and 2023 the daily average $PM_{2.5}$ concentrations exceeded the average NAAQS with multiple exceedances and thus non-compliant. In 2021 the annual average $PM_{2.5}$ was below the annual Average NAAQS and compliant.
Tutuka	Sivukile (Eskom)	Daily concentrations of PM_{10} exceeded the daily average NAAQS with multiple exceedances reported and thus non-compliant. Annual average concentrations in 2021 remained below average NAAQS remaining compliant, however, in 2022 and 2023 the annual average concentrations of PM_{10} exceeded annual average NAAQS
	Grootdraai Dam (Eskom)	Data recovery at the station was below 50% and not reported.

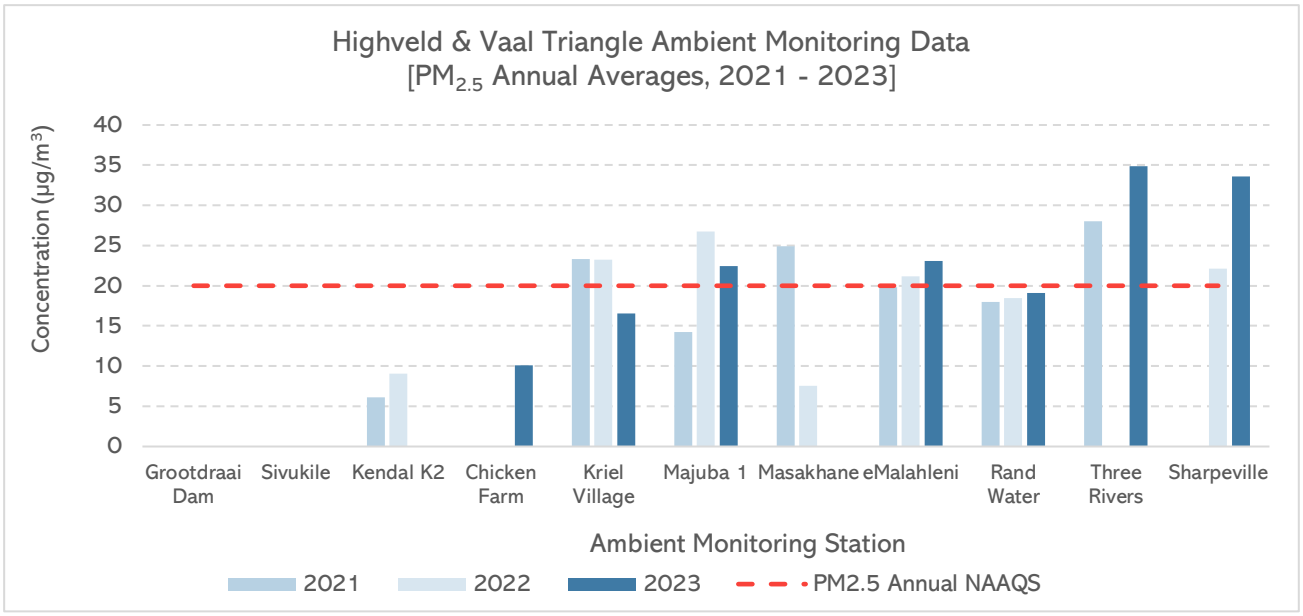


Figure 2-4: Annual average $PM_{2.5}$ concentrations for the HPA in µg/m³

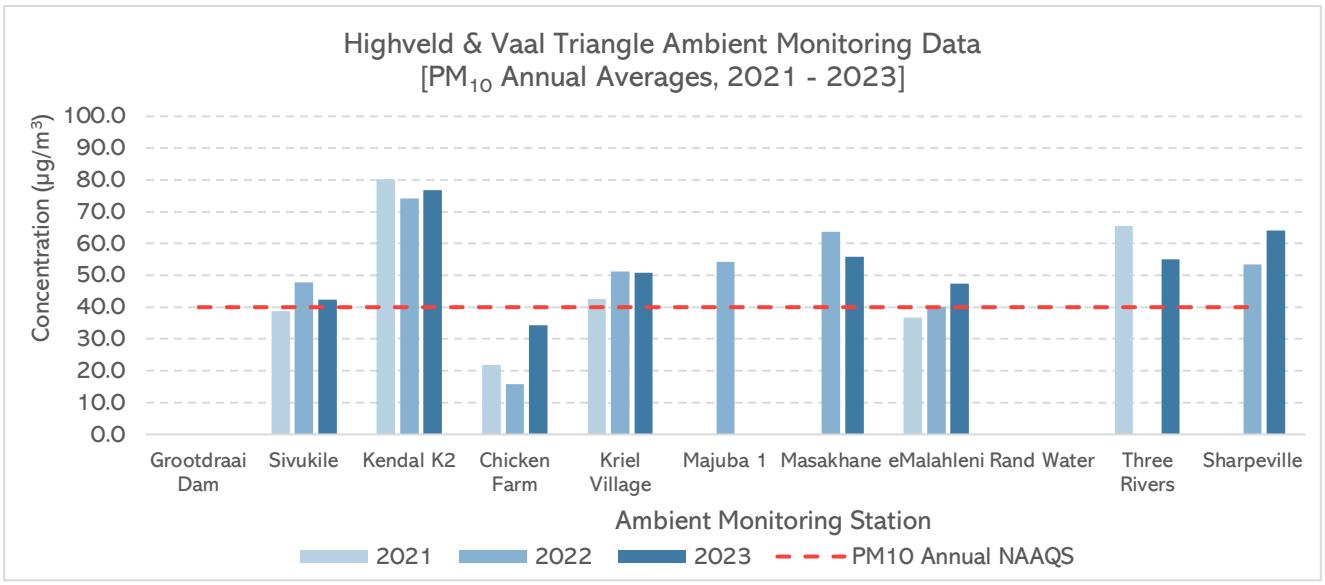


Figure 2-5: Annual average PM_{10} concentrations for the HPA in µg/m³

2.2.3 Description of power stations

The coal-fired power stations forming part of the current HPA and VTAPA study are listed in Table *2-4*. These power stations have a combined installed capacity of 35 848 MW.

Table 2-4: Eskom coal-fired power stations, used in this study, and their installed capacity (Eskom, 2023).

Power Station	Province	Installed capacity (MW)
Arnot	Mpumalanga	2 220
Camden	Mpumalanga	1 561
Duvha	Mpumalanga	3 000
Grootvlei	Mpumalanga	1 180
Hendrina	Mpumalanga	1 723
Kendal	Mpumalanga	4 116
Komati	Mpumalanga	990*
Kriel	Mpumalanga	2 790
Kusile	Mpumalanga	4 796 (on completion of last unit)
Lethabo	Free State	3 708
Majuba	Mpumalanga	4 110
Matla	Mpumalanga	3 600
Tutuka	Mpumalanga	3 654
*All units have been shut down. The last unit was shut down 1 November 2022		

2.2.4 Dispersion modelling

Dispersion modelling is required to estimate the effects of stack emissions on ambient concentrations of pollutants and describe them spatially.

Dispersion modelling for this study was conducted by uMoya-NILU Consulting (Pty) Ltd and followed the requirements of the Code of Practice for Air Dispersion Modelling, DEA guideline (DEA, 2014).

The work modelled the dispersion of sulphur dioxide (SO_2), primary and secondary particulate matter (PM), fugitive emissions and nitrogen dioxide (NO_2) for the Highveld power stations. Dispersion modelling was performed using the CALPUFF suite of models. CALPUFF is a multi-layer, multi-species non-steady-state puff dispersion model that simulates the effects of time and space-varying meteorological conditions on pollution transport, transformation and removal. It includes algorithms for sub-grid scale effects, such as terrain effect, as well as longer range effects, such as pollutant removal due to wet scavenging and dry deposition, chemical transformation, and the formation of secondary particulate matter. The Air Pollution Model (TAPM) was used to model surface and upper air meteorological data for the study domain.

Two types of analysis were performed, individual and cumulative models. Individual station dispersion modelling domain covers an area of 4,356 km^2, where the domain extends 66 km (west-east) by 66 km (north-south). It consists of a uniformly spaced receptor grid with 0.5 km spacing, giving 17,424 grid cells (132 x 132 grid cells). The cumulative modelling domain covers an area of 97,200 km^2, where the domain extends 360 km (west-east) by 270 km (north-south). It consists of a uniformly spaced receptor grid with 2 km spacing, giving 24,300 grid cells (180 x 135 grid cells).

There were two baseline scenarios modelled in CALPUFF that are used in the study. The first one (Scenario 1) represents the current performance of stations based on actual data over the three year period of 2021 to 2023. The second baseline (Scenario A baseline) took into account the anticipated increase in loads (due to several aspects such as economy requirements, possible delays in IPP projects coming online etc.) in the coming years from 2025 to 2030 and is a better representation of what will be happening in the next five years. Scenario A baseline was used for comparison with the different scenarios in the BCA.

Individual power station models: Five emissions scenarios have been modelled for Highveld Power Stations individually. These are (1) Current Scenario 1 (Current actual emissions), (2) Baseline Scenario (Emission based on anticipated loads), (3) Scenario B (2031 planned stack emissions), and (4) Scenario C (2036 planned stack emissions), (5) Scenario D (Emissions in Full MES compliance 2036).

Cumulative impact: The same five emissions scenarios listed above have been modelled across stations to assess the combined effect of these power stations on the ambient air quality.

Isopleth maps of predicted ambient SO_2, NO_2, PM_{10} and $PM_{2.5}$ concentrations are presented in Figure 2-6 to Figure 2-9. The predicted concentrations are shown as isopleths, lines of equal concentration, in $\mu g/m^3$ for the respective NAAQS averaging periods. The isopleths are depicted as coloured lines on the maps, corresponding to a particular predicted ambient concentration. Areas within red isopleths indicate an area where exceedances of the respective NAAQS limit value are predicted to occur. Sensitive receptors are represented by green squares and AQMS are represented by white dots on the maps. (uMoya-NILU, 2024)

National Ambient Air Quality Standards (NAAQS) (DEA, 2009, 2012) apply to the pollutants emitted by stations. The NAAQS consists of a 'limit' value and a permitted frequency of exceedance. The limit value is the fixed concentration level aimed at reducing the harmful effects of a pollutant and the permitted frequency of exceedance represents the acceptable number of exceedances of the limit value expressed as the 99th percentile. Compliance with the ambient standard implies that the frequency of exceedance of the limit value does not exceed the permitted tolerance. The NAAQS limits for the averaging period of 1 year for SO_2 is 50 $\mu g/m^3$, for NO_2 is 40 $\mu g/m^3$, for PM_{10} is 40 $\mu g/m^3$ and for $PM_{2.5}$ is 20 $\mu g/m^3$ (from 2030 is 15 $\mu g/m^3$).

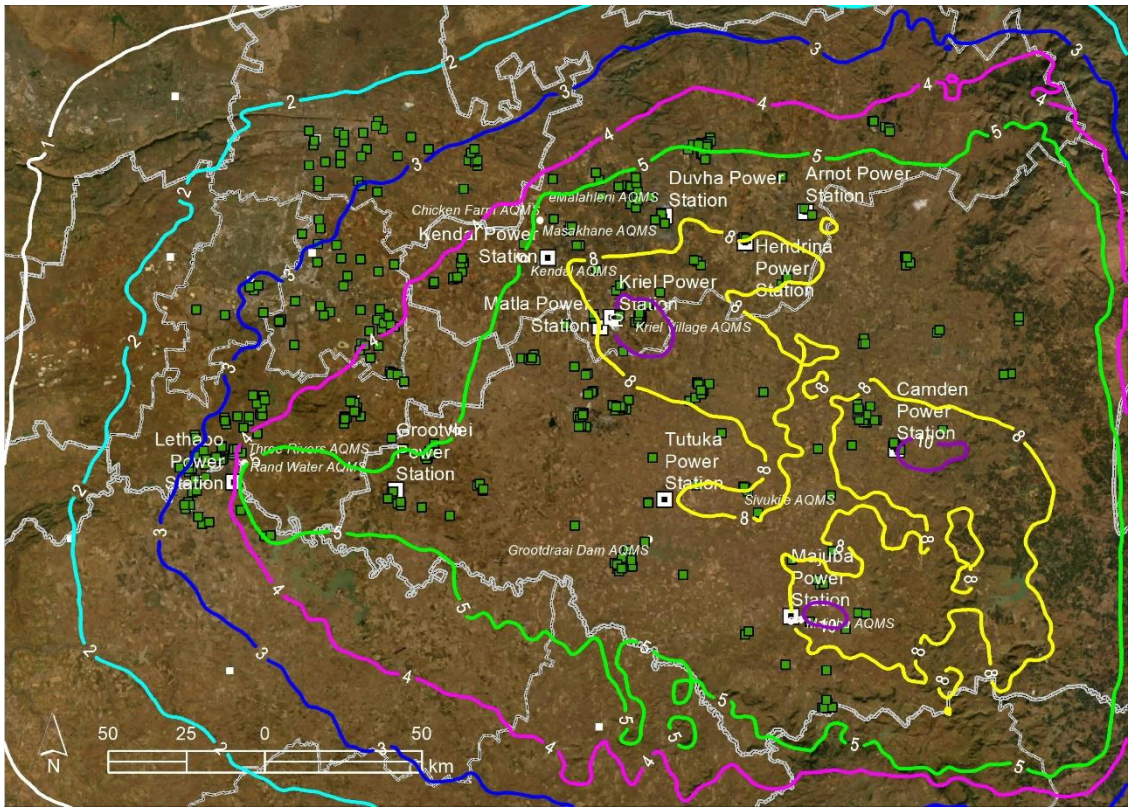


Figure 2-6: Cumulative predicted annual average SO_2 concentrations (µg/m³) for the Highveld Power Stations

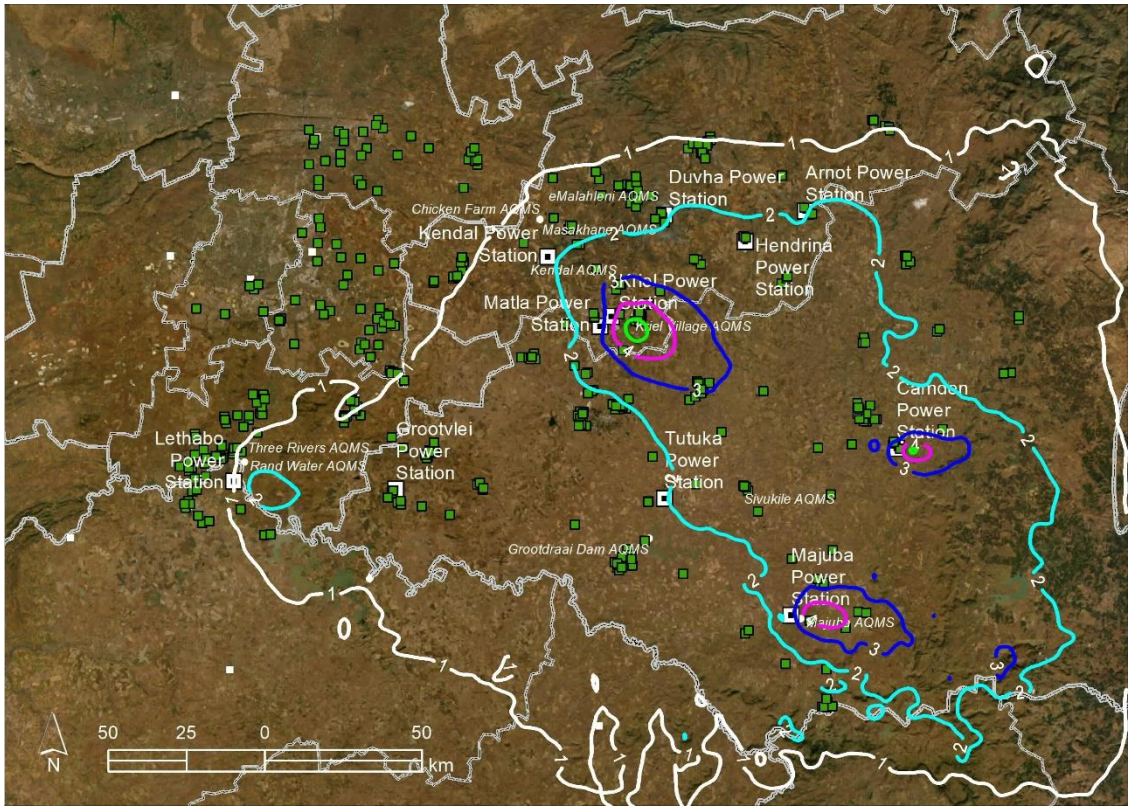


Figure 2-7: Cumulative predicted annual average NO_2 concentrations (µg/m³) for the Highveld Power Stations

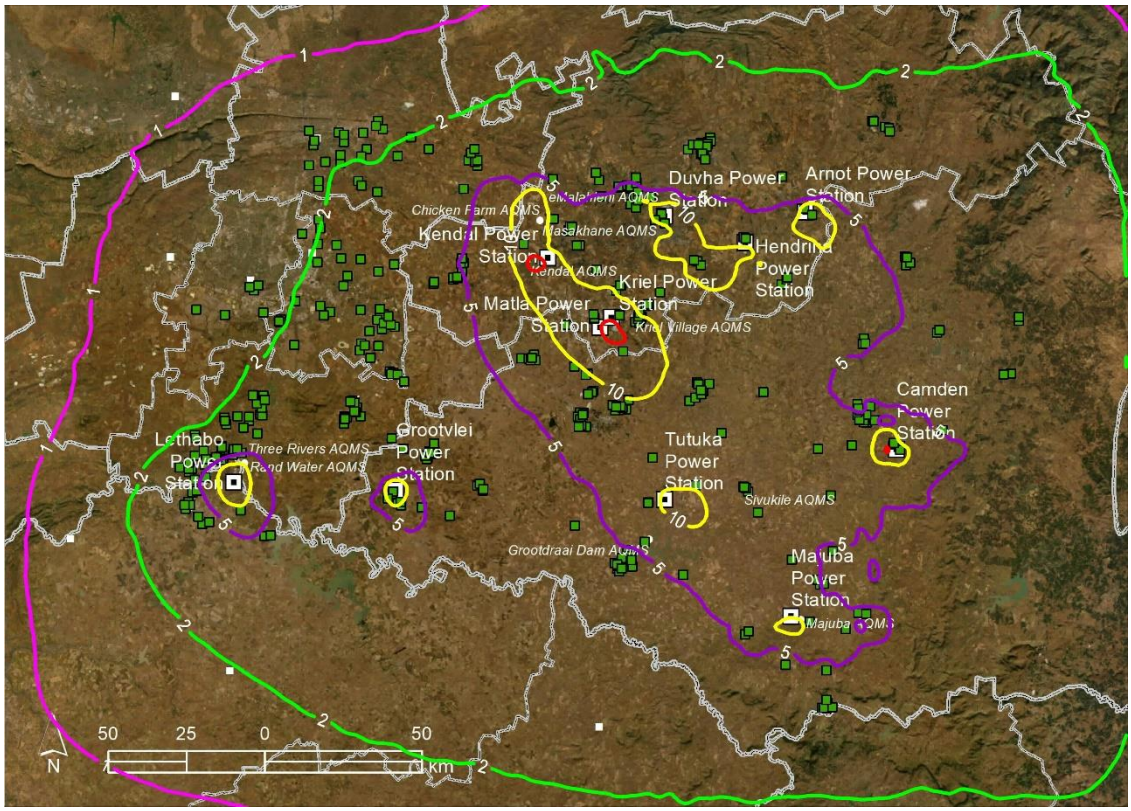


Figure 2-8: Cumulative predicted annual average PM_{10} concentrations (µg/m³) for the Highveld Power Stations

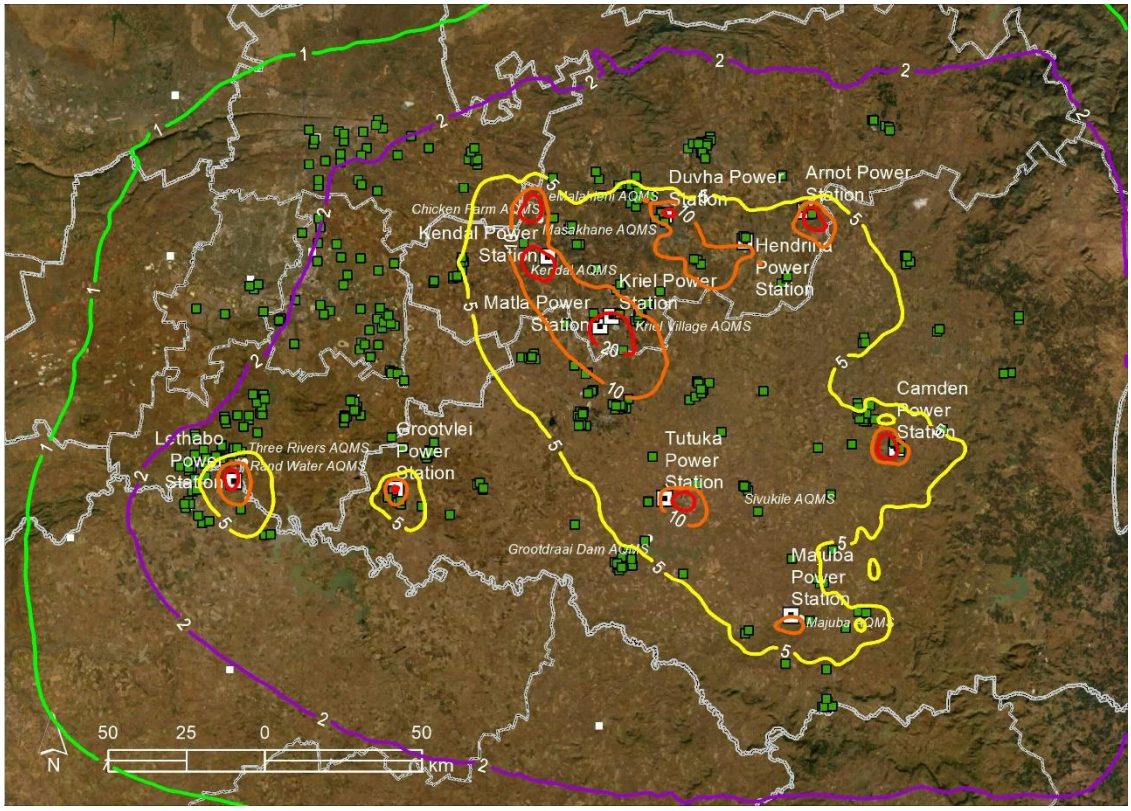


Figure 2-9: Cumulative predicted ambient $PM_{2.5}$ concentrations (µg/m³) for the Highveld Power Stations

2.2.5 Population exposure

Population exposure was estimated at a spatial resolution of municipality and municipal wards. At each municipality or ward, the number of people exposed to different concentration ranges were determined based on Stats SA population estimates (Stats SA, 2012; Stats SA, 2024a,b) and United Nations population prospects growth forecasts (United Nations, 2024).

Population exposure was estimated at a spatial resolution of municipal wards for the data from the dispersion model runs. At each ward, the number of people exposed to different concentration ranges for each pollutant were determined per scenario per year. Particulate matter (Total PM) in the model took the primary and secondary particulate matter into account.

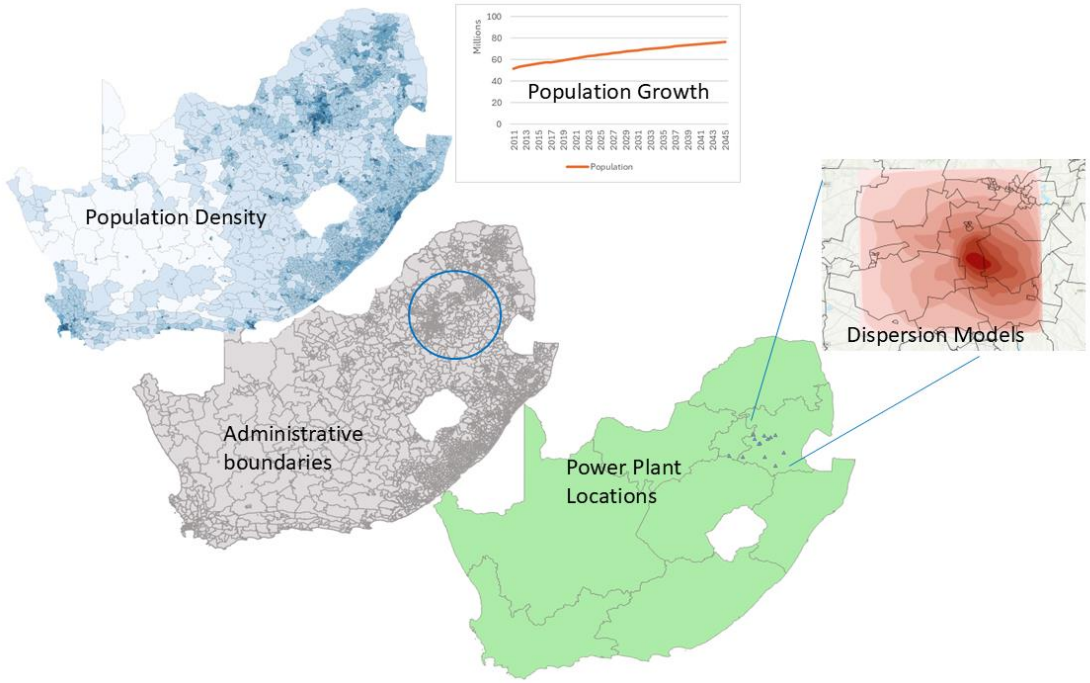


Figure 2-10: Overview of population exposure calculation

The integrated Health BCA model calculated pollution exposure as follows:

- Dispersion Model outputs were used to spatially apportion pollution concentrations. The co-ordinates (x;y) of receptors from the output files were attributed to specific administrative boundaries.
- Administrative boundaries used were municipalities and municipal wards. The predicted ambient concentrations for each pollutant were averaged for the entire spatial unit.
- Population density (population per ward) was obtained from the Census 2011 (Stats SA, 2012), given that the latest Census 2022 metadata which includes ward level numbers has not been released.
- Total population was obtained from the latest available mid-year population estimates (Stats SA, 2024a,b).

- Population growth forecasts were used to determine the growth in population exposure over time (United Nations, 2024). This was used to grow the population numbers in each year following 2024 to the end of the modelled timeframe year of 2045.
- Power station locations were used to determine the wards which were affected by each station, to estimate relative impacts of each power station to the cumulative impact modelled.

Considering the current emission over the period from 2021 to 2023, approximately 15.8 million people were population exposed to more than an additional 1 µg/m^3 (mean annual average) of PM due to the 11 power stations. Similarly, 2.2 and 15.9 million people were exposed to more than an additional 1 µg.m^3 of NO_2 and SO_2, respectively.

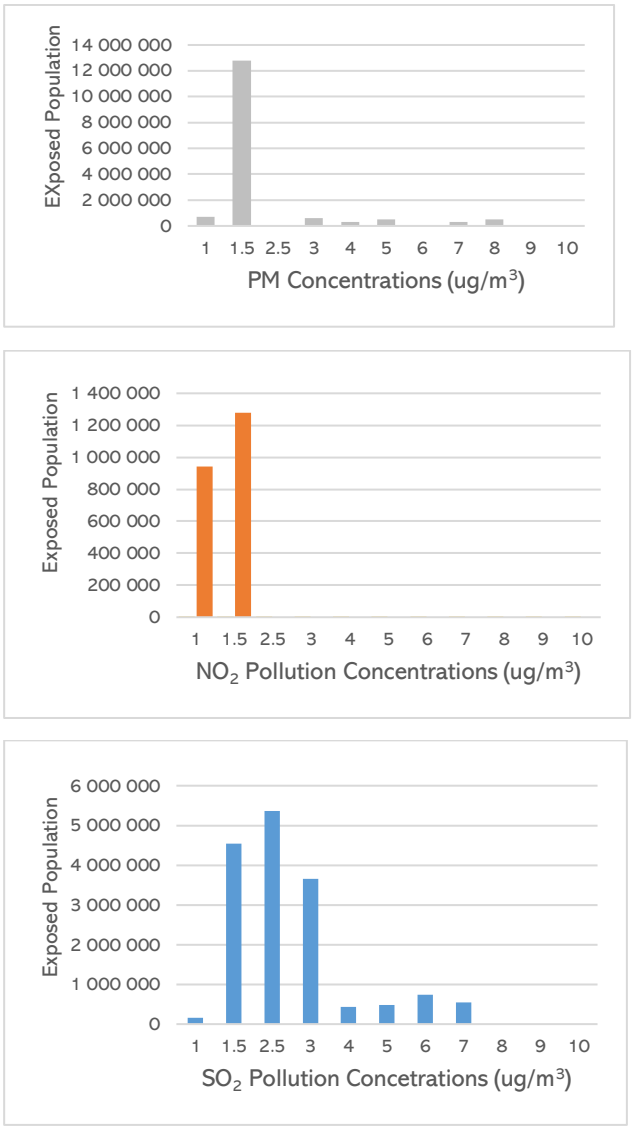


Figure 2-11 Population exposure to PM, SO_2 and NO_2mean annual average concentration ranges.

2.3 Incremental change in health risk

2.3.1 Health impacts

The WHO (2016a) recommends that the health risk in a population, associated with air pollution, is to be estimated using exposure-response functions (ERFs). ERFs are based on Relative Risk (RR) estimates derived from primary epidemiological studies.

These RR functions estimate the likelihood of health outcomes occurring in a population exposed to a higher level of air pollution relative to that in a population with a lower exposure level (WHO, 2016a). RR is usually expressed as the proportional increase in the assessed health outcome associated with a given increase in pollutant concentrations, measured in $\mu g/m^3$. The WHO (2016a) notes that "*the RR estimate cannot be assigned to a specific person; it describes risk in a defined population, not individual risk.*"

Epidemiological studies are mostly based on evidence from population health studies that compare health outcome incidences of populations exposed to higher levels of air pollution to populations exposed to lower levels of air pollution. Most of these studies have been done in Europe and North America.

Ideally, ERF studies and their RRs should be determined based on primary epidemiological studies focussing on the exposed population. In the absence of such studies, as in the case of South Africa, the WHO (2016a) recommends using ERFs from other countries.

It is to be noted that there are inherently significant limitations in transferring ERF studies from other countries. Pollution levels, chemical composition and health care systems are typically very different in other settings, and this would affect the accuracy of the ERFs.

The health outcomes were selected based on the latest WHO systematic reviews from 2020 and 2021 that were conducted for the update of the WHO Global Air Quality guidelines. The health outcome considered in this study is all-cause mortality. Morbidity was not considered in this study as comprehensive data on morbidity studies is not widely available. Additionally, there are issues relating the transferability of data from one population to another in terms of country and culture as populations have different sensitivities to pollutant exposure (WHO 2000).

All-cause Mortality: This provides a measure of all the deaths that occur within the population from any natural causes. It includes natural deaths from all causes of death as provided in the WHO (2016b) International statistical classification of diseases and related health problems (ICD-10). In South Africa all-cause mortality makes up 88% of total deaths in South Africa (Stats SA, 2023).

In the AP-HRA, a health outcome must be attributed to an individual indicator pollutant. While health outcomes can be attributed to many different indicator pollutants, using all would result in double counting mixture effects in health impacts as these pollutants are associated with each other (WHO, 2016a, Malmqvist et al., 2018).

Table 2-5: Indicator pollutant, baseline incidence, and relative risks for all-cause mortality (Source: WHO systematic reviews by various researchers & baseline incidence – Stats SA 2023)

Indicator Pollutant	Health Outcome	Baseline data	Relative Risk or Hazard Ratio per 10 µg/m³	Reference
$PM_{2.5}$	All-cause Mortality	0.687%	1.08	Chen & Hoek, 2020
PM_{10}	All-cause Mortality	0.687%	1.04	Chen & Hoek, 2020
SO_2	All-cause Mortality	0.687%	1.0059	Orellano et al., 2021
NO_2	All-cause Mortality	0.687%	1.02	Huangfu & Atkinson, 2020

The baseline incidence rate of the health outcome was determined based on published data from the year 2019 from Stats SA (Stats SA, 2023). The ERFs describing the change in incidence in relation to changes in exposure (RRs) were obtained from the WHO latest systematic reviews for the update of the WHO Global Air Quality guidelines (WHO, 2020, 2021).

2.3.2 Health costs

The detrimental effects of air pollution on human health are borne in the economy by households, insurance companies, employers and public health programs (Romley et al., 2010).

The fundamental goal of health cost or cost of illness (COI) studies is to evaluate the economic burden that illness imposes on society as a whole (Jo, 2014). Rice (1967) and Rice et al. (1985), were instrumental in standardising methodologies for estimating COI, and these methodologies continue to be used internationally, and periodically updated (Rice, 1996; Rice, 2000).

COI studies contextualise adverse diseases effects into monetary terms, with the purpose of informing decision-making. Such decisions could include (a) to simply present the magnitude of disease in monetary terms; (b) to comparatively evaluate intervention programs; (c) to assist in the allocation of research funding on specific diseases; (d) to provide a basis for policy and planning relative to mitigation initiatives; and (e) to provide an economic framework for program evaluation (Rice, 2000).

The COI studies traditionally stratify costs into two categories: direct costs and indirect costs. Direct costs relate to the cost of medical treatment. This would include costs of visiting health care facilities, medicine and hospitalisation. Indirect costs comprise morbidity costs (the cost of lost economic productivity due to absenteeism or temporary or permanent disability) and mortality costs. With respect to mortality costs, valuing human life is contentious, as it can be seen as a judgement on the intrinsic value of life and involves complex ethical considerations. Sometimes, cost-effectiveness analysis is used as an alternative (Muchapondwa, 2009). This side-steps the complexity of life valuation and uses disease or fatality incidence indicators to compare effectiveness of different policy or spending options.

The health impact or health risk, associated with air pollution, is estimated using ERFs as described in section 2.3.1 above. In this study, the ERFs obtained from the latest WHO systematic reviews, focussed exclusively on mortality and thus a monetary measure of mortality was required in order to estimate the health costs and to perform benefit-cost analyses. In air pollution benefit-cost analyses, the concept of value of a statistical life (VSL) is commonly used to monetise mortality related benefits of air pollution reduction. The concept of a VSL is frequently misunderstood. It does not measure the intrinsic value of a human life, and neither does it value the economic productivity of a human. Rather, VSL is estimated by dividing an individual's willingness to pay (WTP) to reduce health risk, by the likelihood of risk reduction. Robinson and Hammitt (2009) defines VSL to represent the rate at which an individual is willing to exchange their own income for a small reduction in their own mortality risk over a particular time period. VSL is not the value that a person, society or the government would place on averting mortality risk with certainty, but it is rather a representation of the rate at which a person views a change in the money available for spending as equivalent to a small change in their own mortality risk (Robinson et al., 2018).

Primary WTP studies for mortality risk reductions have not been done in South Africa. Most countries do not have reliable revealed preference or stated preference estimates of the VSL (Viscusi and Masterman, 2017) and primary research studies require considerable time and expense (Robinson et al., 2018). In these cases, a "benefit transfer" method is used to transfer values from other studies. Both the above sets of authors recommend using a United States of

America (USA) base VSL (calculated using labour market estimates from the USA's Census of Fatal Occupational Injuries, CFOI, data) and then further adjust it for differences in income between the USA and the country of interest.

The VSL estimate in this study is determined by the following equation (from Viscusi and Masterman (2017) and Robinson et al. 2018):

$$VSL_{target} = VSL_{base} \times \left(\frac{Income_{target}}{Income_{base}}\right)^{\text{elasticity}}$$

In the above equation the base country is the United States. The VSL is transferred using the income measure of GNI (Gross National Income) per capita from the World Bank which uses the Atlas method which is based on exchange rates and inflation rates.

Data for the US base VSL was obtained from the US Economic Research service and the federal register, the GNI value per capita was sourced from the World Bank. Exchange rates to convert the dollar value of the South African VSL into rands was taken from the annual average exchange rates from the South African Reserve Bank.

A sensitivity analysis was conducted in the BCA based on the recommendations of Robinson et al. 2018. The default values include:

VSL = 160 * GNI per capita of the target country

VSL = 100 * GNI per capita of the target country

VSL extrapolated from USA estimate to target country using an elasticity of 1.5.

Additionally, the sensitivity analysis uses the Masterman and Viscusi (2017) income elasticity of 1.0.

2.3.3 Pollution abatement options

2.3.3.1 Summary

Table 2-6 sets out the detailed abatement options per scenario assessed.

Abatement options include limiting generating load, improving plant efficiencies and the installation of technologies to reduce emissions. Technologies include Flue Gas Desulphurisation (FGD), Dry Sorbet Injection (DSI), Electrostatic Precipitators (ESP), Low NOx Burners (LNB) and Fabric Filter Plants (FFP). ESP and FFP are used to reduce particulate matter (PM) emissions, LNB to reduce nitrogen dioxide (NO_2) emissions and FGD and DSI to reduce sulphur dioxide (SO_2) emissions. The model required that each abatement technology applied in each plant in each scenario was described in terms of commissioning periods. The abatement technologies investigated in the scenarios for this current study included FGD, DSI, Low NOx Burners (LNB) and Installation of high-frequency power supply (HFPS) to improve ESP efficiency.

The BCA model was setup to compare three different scenarios in terms of abatement technology implementation for specific Highveld power stations. The dispersion modelling was done for each of these scenarios and the results were used in the BCA model. The model was constructed to allow for a gradual change in pollutant emission concentrations over several years based on operational timeframe. This was done to reflect that not all retrofitted units will be operational at the same time. When the abatement technology of all units at a plant is operational the model then reflects the specific scenario compliance emission concentration values related to the specific scenario.

2.3.3.2 Eskom load curtailment strategy

With the proliferation of the alternate energy sources on to the national grid due to the IRP, the existing coal fired power stations are expected to move into a load following mode of operation. This essentially results in lower running load factors for these stations as the renewable energy sources will be given priority over the fossil fuelled stations. This equates to average load factors of 40-45% for stations operating in 2031 and between 40 to 55% for stations operating beyond 2035, i.e. after Matla and Duvha shutdown. The nett effect of this is that less coal will be burnt in the generation of South Africa's electricity which results in direct emissions reduction at no additional cost impact. This is the basis of Eskom's load based alternate emissions limits.

Table 2-6: Detailed summary of Scenarios (Source: Eskom)

Scenario	Abatement and additional information
Eskom plan - ERP 2024 A	Predicted monthly tonnage emitted per stack in 2031 assuming: a. Komati, Grootvlei, Hendrina, Camden, Arnot and Kriel no longer operating. b. All planned PM emission reduction projects completed, and stations operate at PM=50 mg/Nm^3. c. NOx projects completed with Matimba, Kendal, Kusile, Medupi, Lethabo, Tutuka and Majuba at 750 mg/Nm^3. Matla and Duvha continue to operate at 1,100 mg/Nm^3. d. Kusile and Medupi operate at SO_2 = 500 mg/Nm^3 to reduce total SO_2 load. e. All other stations operate at requested alternate SO_2 levels (Kendal, Majuba, Tutuka at 3,000 mg/Nm^3 and Duvha, Matla and Lethabo at 2,600 mg/Nm^3 – annual tonnage average will be 20% below limit value). f. Load factor restricted to an average value per station per year (see Appendix A) g. Efficiency and coal improvement projects reduce total emissions by 5% at Matimba, Kendal, Kusile, Medupi, Lethabo, Tutuka and Majuba (not Matla and Duvha). h. Implementation of expanded air quality offset programme (35,000 + households) i. This scenario is similar to the existing Eskom Emission Reduction Plan 2022.
Eskom plan - ERP 2024 B	Predicted monthly tonnage emitted per stack in 2036 assuming: a. As per Scenario B but at 2036 energy output, and: b. Duvha and Matla no longer operating c. Efficiency and coal improvement projects reduce total sulphur and carbon emissions by 5% for Matimba, Kendal, Kusile, Medupi, Lethabo, Tutuka and Majuba. d. Direct Sorbent Injection (DSI) at Majuba giving a 20% SO_2 reduction (completed by 2031). e. Semi-dry FGD at Kendal giving a 70% SO_2 reduction (completed by 2035).
Full MES compliance – ERP 2024 C	Predicted monthly tonnage emitted per stack in 2036 assuming: a. Komati, Grootvlei, Hendrina, Camden, Arnot and Kriel no longer operating. b. Duvha and Matla no longer operating. c. Operating stations are Majuba, Matimba, Kendal, Kusile, Medupi, Lethabo, Tutuka, as per the CDS (Rev 4) shut down schedule. d. All planned PM emission reduction projects completed (by 2028), and stations operate at PM=50 mg/Nm^3. e. NOx projects completed at all stations (completed by 2032), and stations operate at NOx = 750 mg/Nm^3. f. SO_2 reduction to new plant limit of 1000 mg/Nm^3 completed at all stations (completed by 2035). implementation of existing air quality offset programme (35,000 households).

2.3.3.3 Power station shutdown

Station lifetimes were described for the power stations modelled. The shutdown dates affect the pollution emissions per year in the model (reduction of emissions) in the years when plant units are shutdown. The shutdown dates are shown in Table 2-7.

Table 2-7 Shutdown periods for different scenarios

Power Station	Shutdown Period	
	Start	End
Arnot	2029	2030
Camden	2029	2030
Duvha	2031	2036
Grootvlei	2029	2030
Hendrina	2029	2030
Kendal	2040	2045
Komati	2020	2022
Kriel	2029	2030
Kusile	2069	2073
Lethabo	2037	2042
Majuba	2047	2052
Matla	2031	2036
Tutuka	2036	2041

These station lifetimes were used to describe the base emission rates for each scenario in the integrated model. Shutdown dates are based on Eskom's present planning and technical requirements, dates are subject to review based on national energy requirements. Eskom need to follow all necessary regulator and stakeholder engagement process prior to station shutdown. Shutdown of power stations do result in a reduction of pollutants and an increased health benefit – these are discussed in section 3.2.

2.3.3.4 PM reduction

Abatement technologies considered in the scenarios for PM reduction included Electrostatic Precipitators (ESP) and High Frequency Power Supplies (HFPS) to improve the efficiency of the ESP. An ESP removes particulate matter, from the flue gas using the force of an induced electrostatic charge. ESP upgrades or refurbishments can reduce particulate matter between 95-97%.

2.3.3.5 Low NOx Burners (LNB) for NO_2 reduction

LNBs are an abatement technology to reduce NO_2 emissions. LNBs are designed to control fuel and air mixing to reduce peak flame temperature and thereby reduce NO_2 formation. LNBs can reduce NO_2 emissions by approximately 30%.

2.3.3.6 Flue Gas Desulphurisation (FGD) for SO_2 reduction

FGD is a set of technologies used to reduce SO_2 emissions. FGD systems typically include a fly ash removal and SO_2 removal. SO_2 (an acid gas) removal is facilitated by alkaline sorbents such as limestone to react with the gas. FGDs are typically separated into two types, semi-dry and wet, dependent on their water requirements, and can reduce SO_2 emissions by 90%.

2.3.3.3 Dry Sorbent Injection (DSI) for SO_2 reduction

DSI is also a set of technologies used to reduce SO_2 emissions. DSI systems consist of direct injection of alkaline (sorbent)materials, for example sodium bicarbonate trona or less frequently hydrated lime into the flue gas stream to control SO_2 and other acidic gases (Sahu, 2013; Sahu, 2019). The DSI systems may reduce SO_2 emission by between 45% and 80%. Reduction is dependent on various factors such as sorbent mass injection rate, length of time the sorbent is present in the flue gas stream (dependent on the injection location), sorbent penetration and mixing with flue gases, what type of particulate control device is used, the flue gas temperature profile, and the particle size of the sorbent (Sahu, 2013).

2.3.4 Costs of implementation

Table 2-8. Summary of costs of implementation of abatement for the Highveld power stations: costs of CAPEX and OPEX and estimated impacts on electricity tariffs

	Scenario	CAPEX and OPEX (Rand million Nominal)	Impact on Electricity Tariff (c/kWh)		Impact on Electricity Tariff (%)	
		-15% +20%	Lower	Upper	Lower	Upper
	ERP 2024 A	R18,500	0.78	1.10	0.4%	0.6%
+	ERP 2024 B (Majuba)	R13,100	0.49	0.69	0.3%	0.4%
+	ERP 2024 B (Kendal)	R44,360	0.61	0.86	0.3%	0.5%
Sub-Total	ERP 2024 A + B	R75,970	1.88	2.65	1.0%	1.4%
+	ERP 2024 C (Lethabo)	R39,970	0.54	0.76	0.3%	0.4%
+	ERP 2024 C (Tutuka)	R39,390	0.51	0.73	0.3%	0.4%
Total	ERP 2024 A+B+C	R155,320	2.93	4.14	1.6%	2.2%

The total nominal cost of all Eskom abatement scenarios has been estimated by Eskom at a Class 2 accuracy implying a variance between -15% and +20%.

- ERP 2024 A = R18,500 million
- ERP 2024 B = R75,970 million
- ERP 2024 C = R155,320 million.
- Source: Eskom

We estimated the effect of these additional costs on electricity tariffs. This was based on a cashflow waterfall set up for each scenario, solving for a tariff that would pay back the cost of abatement technology over the assessment period. This tariff margin may be thought of as an air emissions abatement levy:

- ERP 2024 A = 0.4% - 0.6%
- ERP 2024 B = 1.0% - 1.4%
- ERP 2024 C = 1.6% - 2.2%.
- Note: Electricity impact tariffs were not sourced from Eskom but were estimated using the method described above.

2.4 Benefit-Cost Analysis

A BCA is a widely used approach employed for decision-making support. This approach was formalized in the United States in 1958 with the purpose of justifying public expenditures on alternative investment options competing public funds such as water, roads, and other public utilities' networks construction projects. BCA methodology broadly advises on the treatment of income benefits and costs; externality costs; how to measure them conceptually; how future prices should be treated; the importance of using a discount rate; the proper period of analysis; and cost allocation procedures for projects.

The World Bank[2] defines a Social BCA as an extension of a financial analysis. Ideally, in extending the financial analysis, all relevant economic costs and benefits are quantified and analysed. The BCA pulls together the component analyses of the study to assess the overall impact for a set of scenario options (emission reduction measures).

The objective of the BCA is to comparatively analyse investments or scenarios (in this case interventions in air quality management). The BCA achieves this end by identifying and monetizing the costs and benefits and predicting the timing thereof over the same horizon as the projects' economic lifetime (National Treasury, 2017).

A BCA allows scenarios to be objectively compared according to the benefit:cost relationship to analyse the relative efficiency of various interventions and the magnitude of the benefits to identify the interventions that will have the largest impacts.

In this analysis, the BCA compares the scenario health benefits to capital and operational costs pf abatement. This BCA does not capture all potential costs and benefits, both direct and indirect. (Refer to section 2.5.1 below for a discussion of BCA limitations)

The analysis timeline spans 2024 – 2045. The base year was 2024, due to dispersion modelling timeframe. The BCA was performed in an Excel spreadsheet, which consolidated all data sources, which contains all calculations, and was macro-enabled to run the large spatial exposure estimates for each scenario for the review period. The benefit-cost analysis apportioned costs (capital and operation expenditure on abatement technologies) and benefits (health benefits) to the years in which they would be realised. Because costs and benefits are accrued in different years according to the intervention schedules, the net present values of costs and benefits, using Eskom's weighted average cost of capital (WACC) rate of 10.8% (Eskom, 2024) as the discount rate allows an objective comparison of scenarios.

The health cost benefits were estimated based on the outputs of the AP-HRA and followed the steps below:

1. Each of the assessed Scenarios implemented an abatement schedule at specific power stations (refer to section 3 for details)
2. The dispersion effects modelled by uMoya-NILU (Pty) Ltd were used to estimate the change in population exposure over the timeline.

[2] http://documents.worldbank.org/curated/en/445971468767366310/pdf/multi-page.pdf

3. The change in population exposure resulting from step 2 above was applied to the ERFs identified in section 2.3.1 to estimate health impact outcomes (sensitivity analysis was performed in the BCA to develop a view on the uncertainty inherent in the ERFs, also refer to section 2.5.1).
4. The VSL (refer to section 2.3.2) was applied to the health impact outcomes for each scenario, to estimate change in health cost benefits.
5. Capital and operational cost estimates were used as the costs in the BCA (refer to section 2.3.4).
6. Sensitivity analysis was performed on the VSL, the health benefit and abatement cost estimates.

Section 3.2 provides the BCA results.

2.5 Uncertainty of the estimated health effects

2.5.1 Sources of uncertainty and limitations

The WHO (2016a) advises performing an assessment of the uncertainty of the analysis; in this case therefore this requires an assessment related to a lack of knowledge about one or more components of the integrated Health BCA Model. The sections below discuss each source of uncertainty and related limitations.

Air pollutants exist as a complex mixture: Despite improvements in the science underlying AP-HRAs, it is still not possible to estimate with complete certainty the effects of air pollution on health (WHO Regional Office for Europe, 2014, cited in WHO 2016a). The observed adverse effects attributed to an individual air pollutant may well be (partly) attributable to other pollutants in the mixture which are correlated with the assessed pollutant (WHO Regional Office for Europe, 2013, cited in WHO 2016a). It is not possible to assess the uncertainty relating to this (WHO, 2016a).

Pollutants modelled: The analysis was limited to PM, SO_2, and NO_2 pollutants, these are the criteria pollutants managed in terms of South African air quality legislation and of most recognised significance in the Priority Area. Other pollutants may also contribute to health risk and these were not modelled in the dispersion modelling. This may under-estimate health risks and thus benefits of health risk mitigation. However, no data or other information exists through which to assess this limitation.

Exposure response functions: ERFs are derived from epidemiological studies, in which the parameters of the epidemiological experiment and assumptions made during the experiment introduce some uncertainty into the results. More significantly, because primary epidemiological evidence on air pollution is not available for South Africa. This is a key limitation. As a result, inference has to be drawn from studies in other parts of the world. It is to be noted that health response per unit change in air pollution in environments with high ambient levels (such as the HPA) may differ from that observed in countries with lower pollution levels. In summary, the WHO (2016a) notes that extrapolated ERF information may not accurately describe the exposure-response relationship in the region to be assessed, leading to uncertainties in the results. In order to deal with these uncertainties, we used variances in ERF outcomes as a measure of BCA ratio variation.

Dispersion model accuracy (uMoya-Nilu, 2024): "Air quality models attempt to predict ambient concentrations based on "known" or measured parameters, such as wind speed, temperature profiles, solar radiation and emissions. There are, however, variations in the parameters that are not measured, the so-called "unknown" parameters as well as unresolved details of atmospheric turbulent flow. Variations in these "unknown" parameters can result in deviations of the predicted concentrations of the same event, even though the "known" parameters are fixed. In the present dispersion modelling conservative assumptions in terms of surface area of ashing facilities giving rise to fugitive emissions were made that have resulted in an over prediction of PM emissions in shorter time periods. Furthermore, for $PM_{2.5}$ and PM_{10} the predicted concentrations are attributed to stack emissions and low-level fugitive sources (ash dump). The inclusion of the fugitive sources was done assuming the entire area is exposed and available for entrainment, while in reality only a small portion of the modelled area would be exposed to entrainment due to the vegetated sides

and wet areas of the dump. This approach is extremely conservative. The PM emissions from stacks and fugitive sources are not speciated into PM_{10} and $PM_{2.5}$, rather all PM emitted is assumed to be PM_{10}, and all PM emitted is assumed to be $PM_{2.5}$. Further, considering the proximity of the exceedances to Lethabo, as noted in the uMoya-Nilu AIR, the elevated PM can mostly be attributed to the low-level fugitive sources, which have poor buoyancy and disperse poorly, as opposed to the stack emissions which are released at a height of 200 m above ground-level, with considerable buoyancy, and so disperse well.

There are also "reducible" uncertainties that result from inaccuracies in the model, errors in input values and errors in the measured concentrations. These might include poor quality or unrepresentative meteorological, geophysical and source emission data, errors in the measured concentrations that are used to compare with model predictions and inadequate model physics and formulation used to predict the concentrations. "Reducible" uncertainties can be controlled or minimised. This is done by using accurate input data, preparing the input files correctly, checking and re-checking for errors, correcting for odd model behaviour, ensuring that the errors in the measured data are minimised and applying appropriate model physics."

Baseline disease burden: The baseline cases of mortality used were for 2019, based on latest available Stats SA data. The data for this year is therefore accurate. Stats SA data for 2020 was not used as these numbers may be skewed by the effects of COVID. Uncertainty arises however because projections are made of population size growth in future, under the assumption that the relative ratio of mortality in the future remain constant.

Morbidity effects were not assessed: The costs of medical treatment (including visiting health care facilities, and costs of medicine and hospitalisation) and the loss of economic production due to sick-leave absenteeism or temporary or permanent disability, were not assessed. This is because of an absence of official data on health care visits and associated direct costs within both the public and private health care sectors; linked to suitable ERFs. As a result, the BCA underestimates the health benefits of the various scenarios. As before, within the BCA, this uncertainty remains constant across all scenarios and thus enables inter-scenario evaluation.

Value of a statistical life: VSLs are accurate when estimated based on primary data collected through willingness to pay studies specific to the exposed population. All VSL estimates for South Africa are derived and transferred from studies done in the United States of America. This introduces uncertainty in the BCA results. As before, within the BCA, this uncertainty remains constant across all scenarios and thus enables inter-scenario evaluation.

Timeline of dispersion modelling predicted concentrations: The data from the dispersion modelling in CALPUFF is from a specific point in time and is then interpolated for the timeline values that are required to run a benefit:cost analysis. Ideally the BCA model should have a CALPUFF run for each year used in the model timeline, however, to do this is not practical. This causes uncertainties in the results.

Cost uncertainty: Eskom uses a cost estimate classification matrix which has different estimate classes associated with different expected accuracy ranges for making project cost estimations (Eskom, 2020). Based on these classes the sensitivity analysis for costs estimates varied by +20% or -15% (Class 2).

Eskom is constantly working to refine the accuracy of the emission reduction costing and this may result in internal updates of costing. Anticipated changes in cost are anticipated to fall within the range of variance (-15% and +20%).

The BCA does not capture economic externalities. These include both benefits and costs. The benefits of reduced health risk on households, employers and the health care and insurance industries were not assessed. The costs of implementation of abatement technologies would put additional pressure on Eskom capital (and debt) requirements, and further on electricity price escalations. These would result in additional economic costs, and these were not assessed. Furthermore, the economic benefits and costs of transitioning from coal to alternatives were not assessed. A full electricity system modelling exercise was not completed as part of the Eskom exemption application process given time constraints. Capacity assessments undertaken indicate that attempting to install SO_2 reduction technologies simultaneously on Eskom stations will result in significant electricity supply shortfalls. These capacity shortfalls would need to be addressed by other generation sources, if these are available, which may have additional cost implications. If the capacity is not available then the country would be forced to endure further periods of load shedding with resultant economic, social and environmental impacts.

As above, within the BCA, this uncertainty remains constant across all scenarios and thus enables inter-scenario evaluation.

Level of acceptable risk not quantified: The health benefits assessed are the total health benefits associated with all reductions in modelled ambient air quality as a result of abatement technology. It is to be noted however that the MES implies a level of acceptable health risk, and the quantum of the health costs associated with this level of acceptable risk were not assessed in the BCA.

2.5.2 Dealing with the uncertainties and limitations in the assessment of results

Several important considerations exist when interpreting the results of the integrated Health BCA.

Interpretation of premature mortality must be done with care. It is to be noted firstly that these numbers are indicators of health risk at a population level. The relative risk estimate inherent in the ERF is a metric of the likelihood of an adverse health outcome, and it cannot be attributed to an individual person. It can thus be used to quantify risk to a defined population (and not to an individual), (WHO 2016) and how this risk would vary between various policy options of scenarios.

The various sources of uncertainty discussed above, affect the accuracy of the absolute values of the assessments. In the absence of primary ERF studies, it is not possible to judge the accuracy of the absolute values of the assessment with a high level of confidence. However, this report uses ranges to reflect uncertainty.

In spite of the various sources of uncertainty discussed above, the analysis still provides valuable insights into the comparison of scenarios tested in the BCA. This is because the uncertainty inherent in the analysis remain constant across all scenarios.

The description of uncertainty sources also serves as a basis for further work to be prioritised in improving future integrated Health BCAs.

3 RESULTS AND DICUSSION

3.1 Scenarios

Three scenarios were evaluated in this study (against a baseline of anticipated emissions 2025 - 2030). A brief description is provided in the sub-sections below and the detailed summary table (see Table *2-6*).

3.1.1 ERP 2024 A

This scenario represents the Eskom ERP 2024 A plan. The scenario is similar to the existing Eskom Emission Reduction Plan (ERP) 2022. In this scenario the Grootvlei, Hendrina, Camden, Arnot and Kriel power stations will no longer be operating post 2030. The power stations that operate in this scenario include Duvha, Kendal, Kusile, Lethabo, Majuba, Matla and Tutuka. Abatement projects for emission reduction included in this scenario comprised of PM projects and NOx projects at specific stations. Kusile is the only station with SO_2 reduction although the associated costs and benefits are not assessed in these scenarios. (see Table *2-6* for detailed information).

In this scenario it is additionally assumed:

- All stations operate at the requested alternate SO_2 levels (see Table *2-6*)
- Load factor restricted to an average per station per year (see Appendix A).
- Total emissions are reduced by 5% at Kendal, Kusile, Lethabo, Tutuka and Majuba through efficiency and coal improvement projects. Matla and Duvha are excluded from this.

The commissioning and shutdown periods, and abatement technology installation schedules used in the BCA for this scenario are shown in Figure 3-1.

S1
Scenario ERP 2024 A

	Plant Commissioning Period		Plant Decomissioning Period		Abatement Technology Installed (1 = yes)			Abatememt Technology Comissioning Period					
Plant	COD Start	COD End	S1DS	S1DE	ESP/HFPS	LNB	FGD	ESP/HFPS-S	ESP/HFPS-E	LNB-S	LNB-E	FGD-S	FGD-E
Duvha	1980	1984	2031	2036	1			2022	2023				
Kendal	1988	1992	2040	2045	1			2021	2025				
Lethabo	1985	1990	2037	2042	1	1		2022	2026	2027	2031		
Majuba	1996	2001	2047	2052		1				2026	2030		
Matla	1979	1983	2031	2036	1			2023	2028				
Tutuka	1985	1990	2036	2041	1	1		2023	2028	2023	2028		

Figure 3-1: ERP 2024 A power plant commissioning and shutdown periods, and abatement technology installation schedules. An S-suffix denotes the start of an activity, and the E-suffix denotes the end of the activity. Abatement technologies are assumed to run as units are retrofitted from commissioning date to continue until the shutdown date of the power plant.

3.1.2 ERP 2024 B

This scenario represents the Eskom ERP 2024 B plan. In this scenario the Komati, Grootvlei, Hendrina, Camden, Arnot and Kriel power stations will no longer be operating post 2030. The power stations that operate in this scenario include, Kendal, Kusile, Lethabo, Majuba, and Tutuka.

Duvha and Matla shutdown in the period between 2031 and 2036. Abatement projects for emission reduction included in this scenario comprised of PM projects for PM, NOx projects at specific stations and SO_2 projects at Kusile (as stated for ERP 2024 A costs and associated benefits are not assessed), Majuba and Kendal (see Table *2-6* for detailed information).

The commissioning and shutdown periods, and abatement technology installation schedules used in the BCA for this scenario are shown in Figure 3-2.

S2 Scenario ERP 2024 B	Plant Commissioning Period		Plant Decomissioning Period		Abatement Technology Installed (1 = yes)			Abatememt Technology Comissioning Period					
Plant	COD Start	COD End	S2DS	S2DE	ESP/HFPS	LNB	FGD	ESP/HFPS-S	ESP/HFPS-E	LNB-S	LNB-E	FGD-S	FGD-E
Duvha	1980	1984	2031	2036	1			2022	2023				
Kendal	1988	1992	2040	2045	1		1	2021	2025			2031	2035
Lethabo	1985	1990	2037	2042	1	1		2022	2026	2027	2031		
Majuba	1996	2001	2047	2052		1	1			2026	2030	2029	2033
Matla	1979	1983	2031	2036	1			2022	2023				
Tutuka	1985	1990	2036	2041	1	1		2023	2028	2023	2028		

Figure 3-2: ERP 2024 B power plant commissioning and shutdown periods, and abatement technology installation schedules. An S-suffix denotes the start of an activity, and the E-suffix denotes the end of the activity. Abatement technologies are assumed to run as units are retrofitted from commissioning date to continue until the shutdown date of the power plant.

3.1.3 ERP 2024 C

This scenario represents the Eskom ERP 2024 C plan. In this scenario there are seven stations that will be shut down and these are Arnot, Camden, Duvha, Grootvlei, Hendrina, Kriel and Matla. Duvha and Matla Shutdown in the period between 2031 and 2036. Post 2036 the operating stations will shut down as per Figure 3-3 Abatement projects for emission reduction included in this scenario are comprised of PM projects (completed by 2028), NOx projects (completed by 2032) and SO_2 projects (completed by 2035) at Kusile, Majuba, Kendal, Lethabo and Tutuka (see Table *2-6* for detailed information).

The commissioning and shutdown periods, and abatement technology installation schedules used in the BCA for this scenario are shown in Figure 3-3.

S3 Scenario ERP 2024 C	Plant Commissioning Period		Plant Decomissioning Period		Abatement Technology Installed (1 = yes)			Abatememt Technology Comissioning Period					
Plant	COD Start	COD End	S3DS	S3DE	ESP/HFPS	LNB	FGD	ESP/HFPS-S	ESP/HFPS-E	LNB-S	LNB-E	FGD-S	FGD-E
Duvha	1980	1984	2031	2036	1			2022	2023				
Kendal	1988	1992	2040	2045	1		1	2021	2025			2031	2035
Lethabo	1985	1990	2037	2042	1	1	1	2022	2026	2027	2031	2031	2035
Majuba	1996	2001	2047	2052		1	1			2026	2030	2029	2033
Matla	1979	1983	2031	2036	1			2022	2023				
Tutuka	1985	1990	2036	2041	1	1	1	2023	2028	2023	2028	2031	2035

Figure 3-3: Eskom ERP 2024 C power plant commissioning and shutdown periods, and abatement technology installation schedules. An S-suffix denotes the start of an activity, and the E-suffix denotes the end of the activity. Abatement technologies are assumed to run as units are retrofitted from commissioning date to continue until the shutdown date of the power plant.

3.2 Summary

Approximately 17.4 million people are exposed to air pollution from the 11 power stations remaining in operation in the baseline scenario modelled, and that fall within the modelling domain. The mean additional annual average exposure to air pollution of the population within this domain, resulting from coal-fired power station emissions, was estimated by averaging dispersion modelling results over municipal boundaries. Approximately 15.9 million people were exposed to more than an additional 1µg.m^3 (mean annual average) of PM (including primary and secondary PM). Similarly, 5.7 and 16.9 million people, respectively, were exposed to more than an additional 1µg.m^3 of NO_2 and SO_2.

Health benefits associated with each scenario were calculated against the baseline that took into account the anticipated increase in loads in the coming years from 2025 and assumed no abatement technologies installed and all stations would continue to emit air pollution at their current rates until shutdown, repowering and repurposing, The baseline also includes the health benefits derived from subsequent decrease in load as stations shutdown as new alternate energy source capacity becomes available.

The health benefits over time as modelled in the BCA are summarised in Figure 3-4:

- The health benefits of ERP 2024 A deliver immediate impact from 2024 (the BCA base year is 2024 and the effects in 2021 to 2023 are not modelled here). The benefits start tapering off from 2030 onwards as Duvha and Matla shutdown, repowering and repurposing between 2031 and 2036, and the associated health benefits from the HFPS and LNB technologies reduces accordingly. Tutuka, Lethabo and Kendal shutdown, repowering and repurposing is from 2036, 2037 and 2040 respectively. The ESP+HFPS and LNB technologies at these stations (refer to Table *2-6*) continue to provide health benefits until 2045 Majuba shutdown, repowering and repurposing starts in 2047 and the health benefits from the LNB technology continue until final closure.
- The health benefits of ERP 2024 B include those as discussed for ERP 2024 A above. In addition, efficiency and coal improvement projects reduce total sulphur and carbon emissions by 5% for Kendal, Lethabo, Tutuka and Majuba contributing to the increase in health benefits in ERP 2024 B. At Majuba DSI is commissioned from 2029 – 2033. Kendal is equipped with semi-dry FGD which is implemented from 2036, and this increases health benefits for a brief period to 2040 whereafter Kendal shutdown, repowering and repurposing starts.
- The health benefits of ERP 2024 C include those as discussed for ERP 2024 A and B above. All planned PM emission reduction projects completed (by 2028), and stations operate at PM=50 mg/Nm^3. NOx projects completed at all stations (completed by 2032), and stations operate at NOx = 750 mg/Nm^3. In addition to the SO_2 reduction at Kendal and Majuba, semi-dry FGDs are installed at Tutuka and Lethabo by 2035, however, these stations start shutdown, repowering and repurposing from 2036 and 2037 respectively, thus effectively negating the health benefits from the FGD technologies.

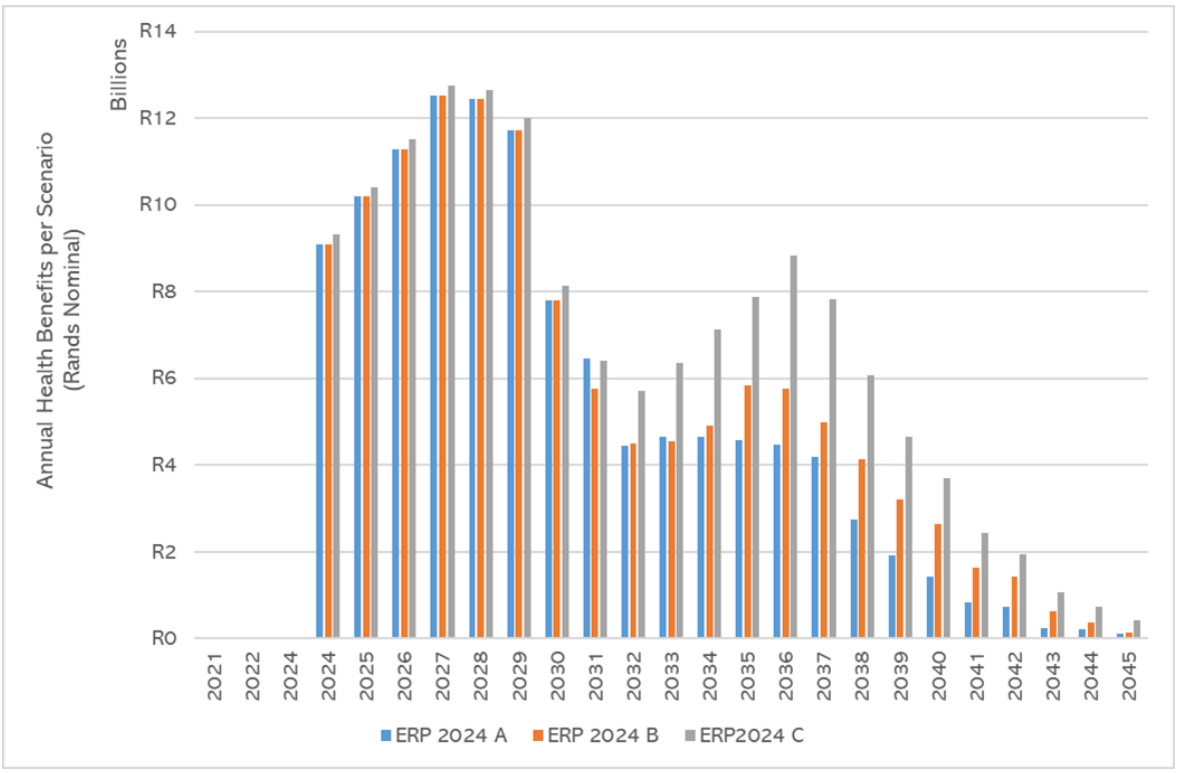


Figure 3-4: Annual health benefits per scenario illustrating the timeline of cumulative health benefits

The **abatement costs** associated with each scenario compared in the BCA are set out in Figure 3-5 below.

- The total Capex and Opex costs of abatement are identical to 2025.
- ERP 2024 B implementation starts in 2026 and 2027 with Majuba and Lethabo's LNB technology. From 2029 DSI installation starts at Majuba and in 2031 FGD starts at Kendal.
- ERP 2024 C builds on ERP 2024 B with implementation of SO_2 reduction technology starting in 2031 for both Lethabo and Tutuka.

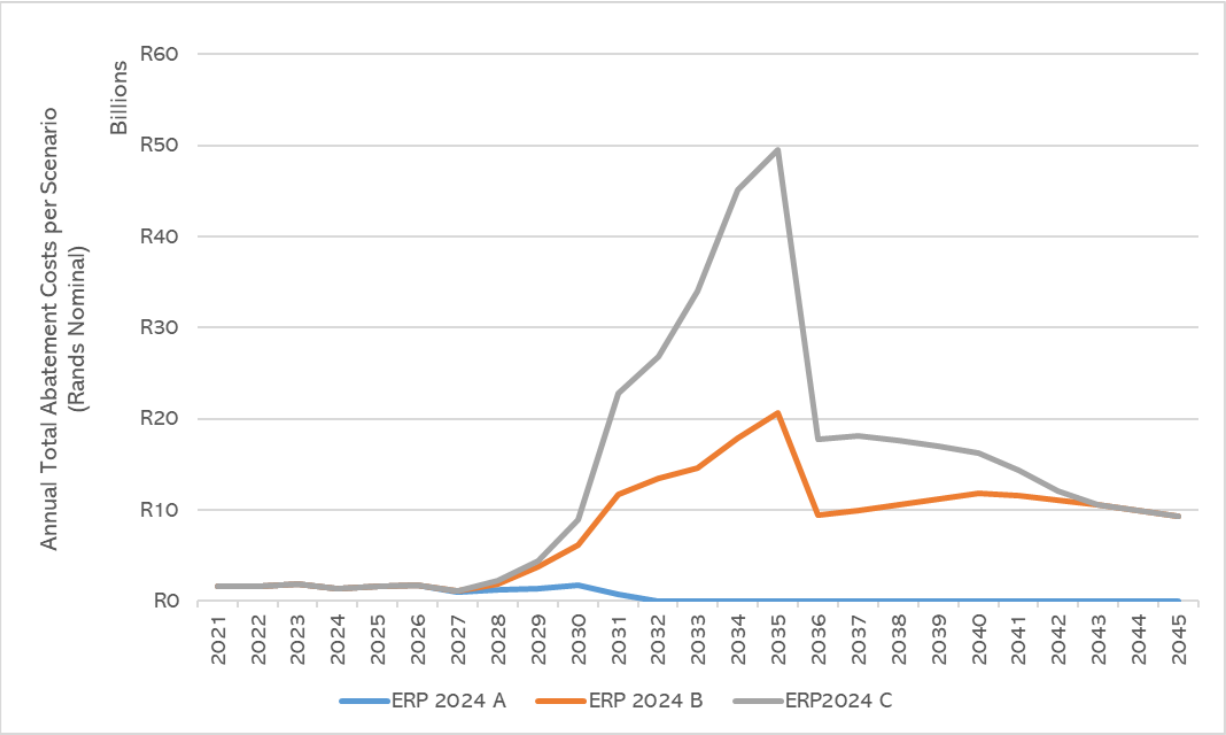


Figure 3-5 Total abatement costs (CAPEX and OPEX) associated with each scenario's abatement retrofits

Scenarios were compared in the benefit-cost analysis. The benefit-cost analysis apportioned costs (capital and operation expenditure on abatement technologies) and benefits (health benefits) to the years in which they would be realised. Because costs and benefits are accrued in different years according to the intervention schedules, the net present values of costs and benefits, used Eskom's weighted average cost of capital (WACC) rate of 10.8% as the discount rate (Eskom, 2024), and additional sensitivity analysis testing using a social discount rate of 2% (Stern, 2006) allowing for an objective comparison of scenarios.

The BCA ratios need to be interpreted with care. They are meant only to provide a perspective on and inform the decision-making process underlying the scenarios. They are not meant to be interpreted as a definitive answer to making abatement decisions. Decisions involving human health has to be informed by non-economic criteria as well. In addition, with uncertainty inherent in the analysis, the cost benefit ratio should thus not be viewed as absolute, but rather as a relative value from which to compare scenarios.

The **BCA results** are provided in Table 3-1. In the upper estimates the lower costs and higher VSL are used and in the lower estimates the higher costs and lower VSL are used as recommended by Robinson et al. 2018.

- The BCA central ratio in ERP 2024 is more than 1 (1.74), showing a very clear benefit and the health benefits exceed the costs of abatement, implying that this is a sound abatement option for Eskom to pursue. This scenario has a total nominal cost of R18,500 million, and is likely to increase electricity tariffs by 0.4% - 0.6%. IN ERP 2024 A

- The central BCA ratio of ERP 2024 B (SO_2 reduction at Majuba and Kendal) is less than 1 although it approaches 1 in the most optimistic (upper) parameters of the sensitivity analysis. The key reason for this is the implementation of the Kendal semi-dry FGD which is implemented from 2036, but only increases health benefits for a brief period to 2040 whereafter Kendal shutdown, repowering and repurposing starts. In this scenario the total nominal cost increases to R75,970 million (which adds to ERP A the additional cost of SO_2 reduction at Majuba and Kendal) and is likely to increase electricity tariffs by 1.0% - 1.4%.
- The BCA central ratio of ERP 2024 C (SO_2 reduction at Majuba, Kendal, Lethabo and Tutuka) is less than 1 (0.33) and remains below 1 even in the most optimistic (upper) parameters of the sensitivity analysis. The key reason for this is the implementation of FGDs at Tutuka and Lethabo by 2035, followed by immediate shutdown, repowering and repurposing from 2036 and 2037 respectively, thus effectively negating the health benefits from the FGD technologies. In this scenario the total nominal cost increases to R155,320 million (which adds to the ERP 2024 A and B costs the additional costs of SO_2 reduction at Lethabo and Tutuka), and is likely to increase electricity tariffs by 1.6% - 2.2%.
- Evaluation of the BCA ratios at a social discount rate of 2% delivers similar results, with ERP 2024 A above 1 and ERP 2024 B and C both less than 1. This is because of the limited health benefits achieved post 2036.

Table 3-1 BCA ratios (lower and upper ranges) for each scenario (discounted at Eskom WACC)

	ERP 2024 A		ERP 2024 B		ERP 2024 C	
Million Rands	*Lower*	*Upper*	*Lower*	*Upper*	*Lower*	*Upper*
NPV of Costs	-10,479	-7,423	-33,909	-24,019	-56,964	-40,349
NPV of Benefits	3,575	23,341	3,651	23,831	3,732	24,357
NPV of Benefits min Costs	-6,904	15,918	-30,258	-188	-53,232	-15,993
Benefit:Cost Ratio (range)	0.34	3.14	0.11	0.99	0.07	0.60
Benefit:Cost Ratio (central)	1.74		0.55		0.33	

In the analyses above the **health benefits associated with closure of power stations** form part of the baseline.

Thus, the cumulative health benefits over time are not reflected in the BCA ratios presented above. The power stations planned shutdown schedule (see Table *2-7* in Section 2.3.3 for the years in which this occurs) results in health benefits without associated abatement costs. These benefits are dependent on timing of the shutdown schedule. These benefits have been assumed to form part of the BCA baseline and have therefore not been quantified directly in the BCA.

- The power stations planned shutdown schedule (see Table *2-7* in Section 2.3.3 for the years in which this occurs) results in health benefits without associated abatement costs. These benefits are dependent on timing of the shutdown schedule.

- In order to contextualize the three scenarios that were analysed with respect to the baseline Figure 3-7, Figure 3-9 to Figure 3-9 show how each scenario contributes to cumulative health benefits over time. The green area in the figures illustrates the health benefit of station shutdown compared to the baseline, as the stations shutdown the population exposed to pollution decreases and the health benefits increase. The blue, orange and grey areas indicating the health benefits of the ERP scenarios described above. The figures illustrate that effectiveness of station shutdown in decreasing health impact and increasing health benefits. Extending the life of Majuba or Kendal stations would likely improve station financial viability, however this would reduce the health benefit as shutting down of stations is more effective than retrofits for health benefits.
- In this study no variation in shutdown dates was modelled, and the health benefits of shutdown are considered equivalent in all scenarios and as such are not visible in the benefit graphs in Figure 3-4.
- The health benefits from closure of power stations contribute an additional 2.1 – 2.3 times the health benefits of the respective scenarios (estimated on a net present value basis).
- It is further to be noted that the health benefits assessed are the total health benefits associated with all reductions in modelled ambient air quality as a result of abatement technology. It is to be noted however that the MES implies a level of acceptable health risk, and the quantum of the health costs associated with this level of acceptable risk were not assessed in the BCA. The quantum of this acceptable risk falls within the baseline.
- The Figures below are shown in Real 2023 Rand terms to contextualise the benefits in current value.

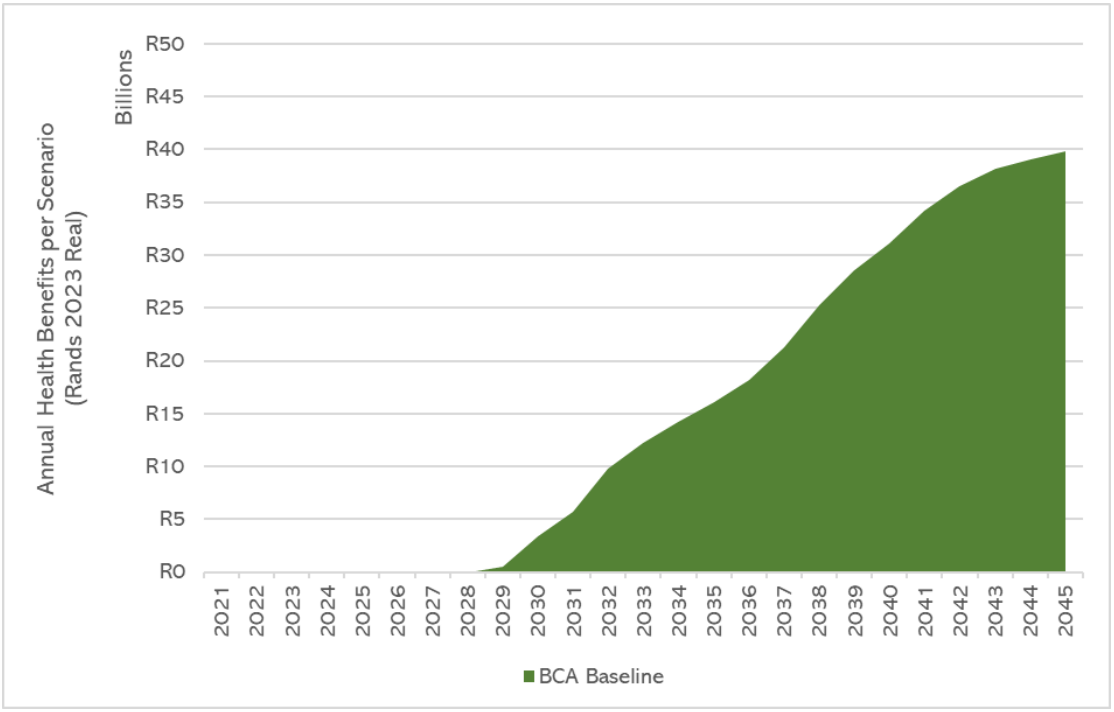


Figure 3-6: Cumulative annual health benefits in the baseline with planned power station shutdowns

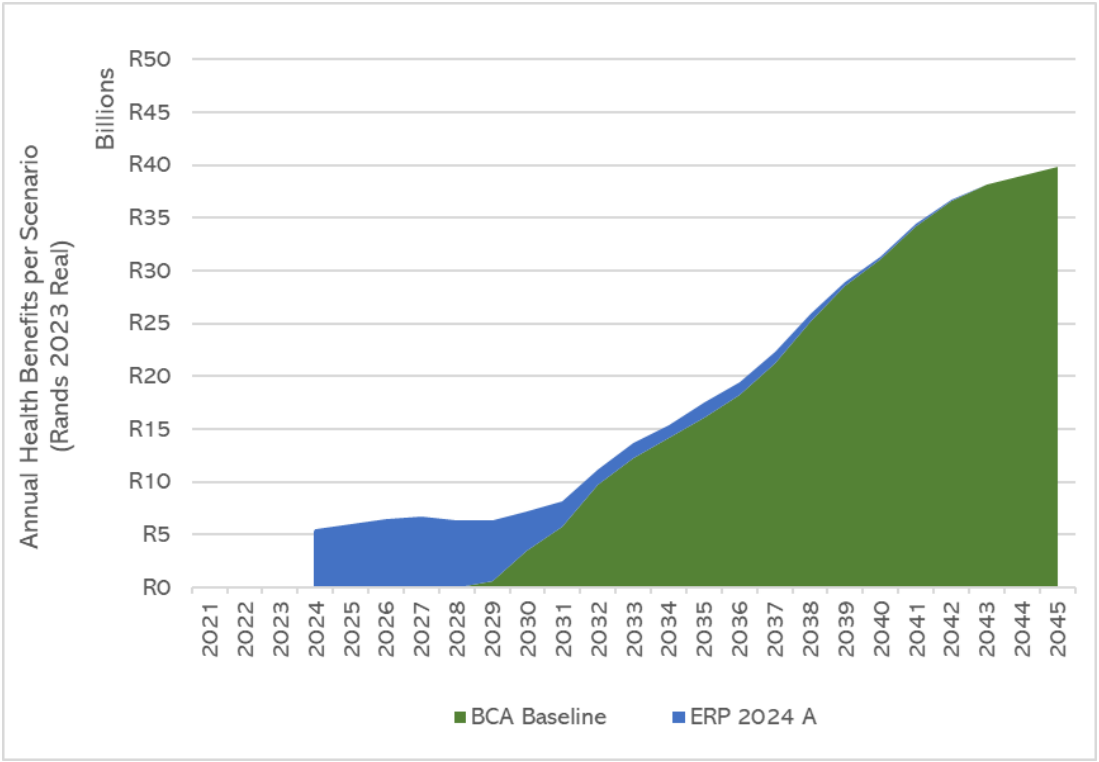


Figure 3-7: Cumulative health benefits of ERP 2024 A over the baseline

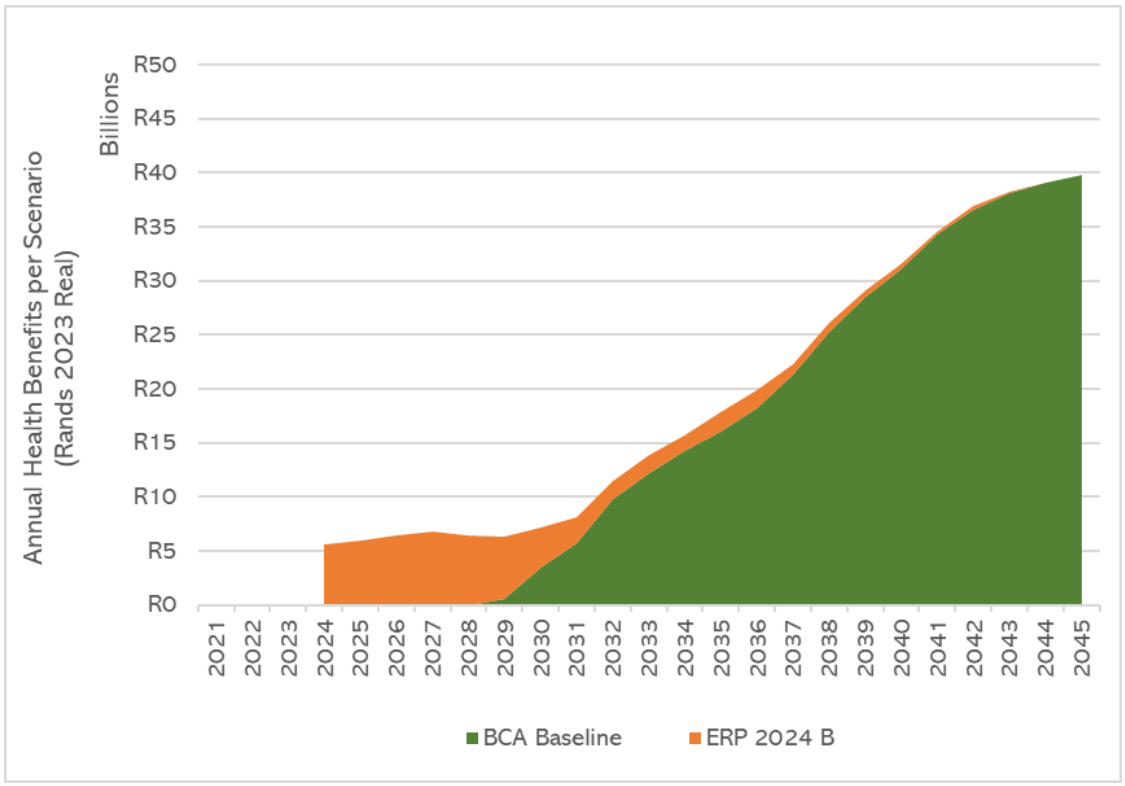


Figure 3-8: Cumulative health benefits of ERP 2024 B over the baseline

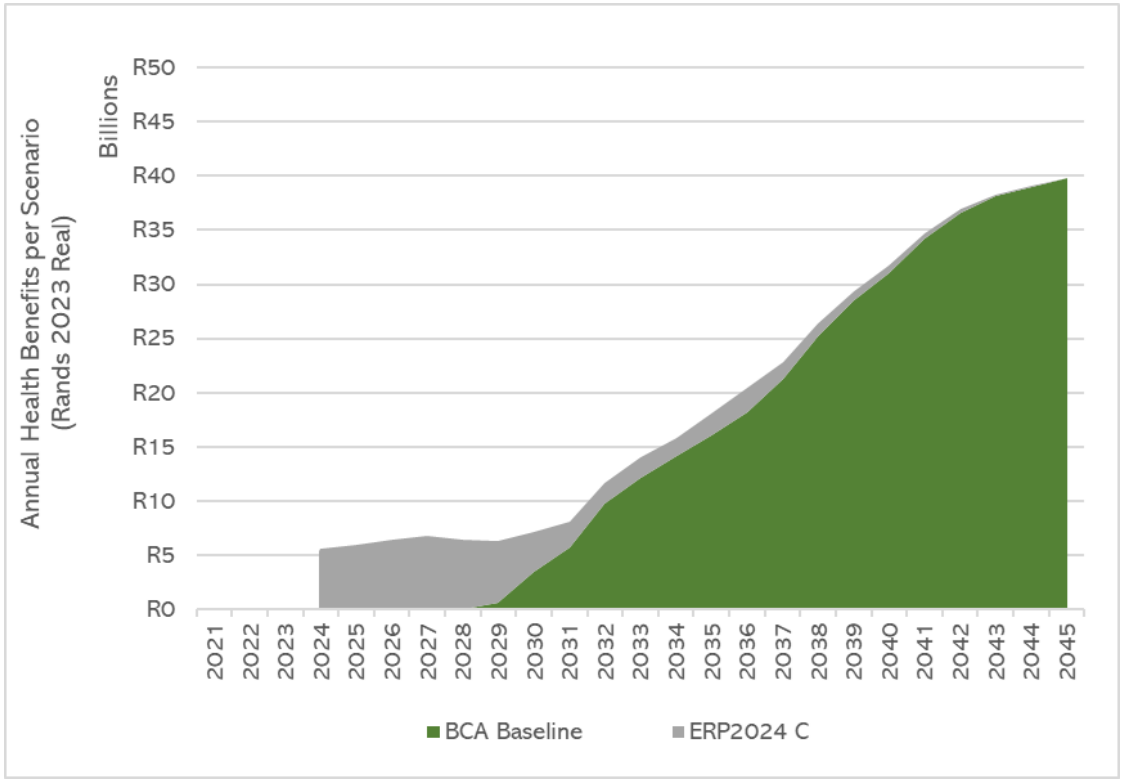


Figure 3-9: Cumulative health benefits of ERP 2024 A and ERP 2024 C over the baseline

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5 APPENDIX A

The estimated calculated load factors for each station in the Highveld:

Station;	Lethabo	Matla	Duvha	Tutuka	Kendal	Majuba
2025	70%	52%	38%	27%	52%	47%
2026	57%	50%	38%	34%	47%	44%
2027	54%	44%	34%	26%	51%	49%
2028	45%	42%	26%	14%	44%	34%
2029	46%	35%	23%	9%	42%	30%
2030	47%	30%	13%	10%	40%	30%
2031	42%	41%	35%	9%	45%	37%
2032	44%	31%	30%	20%	45%	39%
2033	45%	20%	24%	21%	45%	40%
2034	48%	12%	9%	26%	50%	41%
2035	46%	3%	0%	38%	49%	48%
2036	47%	0%	0%	33%	53%	49%
2037	53%	0%	0%	30%	51%	48%
2038	30%	0%	0%	26%	58%	51%
2039	27%	0%	0%	18%	63%	58%
2040	21%	0%	0%	16%	63%	64%
2041	14%	0%	0%	10%	60%	71%
2042	0%	0%	0%	7%	52%	70%
2043	0%	0%	0%	0%	43%	68%
2044	0%	0%	0%	0%	21%	69%
2045	0%	0%	0%	0%	0%	68%
2046	0%	0%	0%	0%	0%	69%
2047	0%	0%	0%	0%	0%	59%
2048	0%	0%	0%	0%	0%	47%
2049	0%	0%	0%	0%	0%	36%
2050	0%	0%	0%	0%	0%	23%

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