GOVERNMENT NOTICES • GOEWERMENTSKENNISGEWINGS

DEPARTMENT OF ENVIRONMENTAL AFFAIRS

NO. 1207 **09 DECEMBER 2015**

NATIONAL ENVIRONMENTAL MANAGEMENT: AIR QUALITY ACT, 2004
(ACT NO. 39 OF 2004)

WATERBERG BOJANALA PRIORITY AREA AIR QUALITY MANAGEMENT PLAN

I, Bomo Edith Edna Molewa, Minister of Environmental Affairs, hereby publish the Waterberg Bojanala Priority Area Air Quality Management Plan in terms of section 19(5) of the National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004), as set out in the Schedule hereto.

BOMO EDITH EDNA MOLEWA
MINISTER OF ENVIRONMENTAL AFFAIRS

SCHEDULE

environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

The Waterberg-Bojanala Priority Area Air Quality Management Plan and Threat Assessment

The Waterberg-Bojanala Priority Area Air Quality Management Plan and Threat Assessment

This report has been produced for Department of Environmental Affairs (DEA) by uMoya-NILU Consulting (Pty) Ltd. The authors of the report are Mark Zunckel, Yegeshni Moodley, Atham Raghunandan, Sarisha Perumal, Benton Pillay and Farryn Moodley.

The authors would like to acknowledge the leadership and contribution received from the following team during the development of Waterberg-Bojanala Priority Area (WBPA) Air Quality Management Plan (AQMP) and Threat Assessment:

- National Air Quality Officer : Dr Thuli N. Mdluli;
- Project Director : Elizabeth Masekoameng;
- Project Management Team:, Ricca Marowe, Oscar Makhale, and Nelvia Phala;
- Waterberg-Bojanala Priority Area Authorities: Percy Matlapeng from North West Province; Phumudzo Thivhafuni and Trevor Mphahlele from Limpopo Province; Thapelo Mathekga from Bojanala Platinum District Municipality; Stanley Koenaite from Waterberg District Municipality; and
- DEA Project Steering Committee and all members of the Waterberg-Bojanala Priority Area Multi Stakeholder Reference Group for providing management and administrative guidance to the compilation of the WBPA AQMP.

This document should be cited as follows:

Department of Environmental Affairs (DEA), Waterberg-Bojanala Priority Area Air Quality Management Plan and Threat Assessment, June 2015.

EXECUTIVE SUMMARY

Background

The Minister declared the Waterberg–Bojanala Priority Area (WBPA) on 15 June 2012 as the third National Priority Area (DEA, 2012a), crossing the North West and Limpopo provincial borders. The WBPA covers an area of 67 837 km^2, bordering with Botswana. It includes the Waterberg District Municipality (WDM) in Limpopo Province and parts of the Bojanala Platinum District Municipality (BPDM) in the North West Province, with nine Local Municipalities (LM) (Table E-1).

Table E-1: Municipalities within WBPA

Province	**District Municipality**	**Local Municipality**
Limpopo	Waterberg	Thabazimbi
		Modimolle
		Mogalakwena
		Bela-Bela
		Mookgopong
		Lephalale
North West	Bojanala Platinum	Moses Kotane
		Rustenburg
		Madibeng

The WDM and Botswana have significant coal reserves that are largely unexploited, with the Matimba Power Station and Morupule Power Station currently in operation. The National Development Plan 2030 acknowledges that the lack of stable power to meet the energy demands is an impediment to economic growth in the region, proposing Strategic Infrastructure Projects (SIPs) to accelerated growth and development in the WDM. In addition, the Government of Botswana requires that the energy sector be augmented through the development of new coal-fired power plant generation capacity. The energy-based development initiatives in South Africa and Botswana pose a threat to the current state of ambient air quality in the region. Management planning in the WBPA therefore needs to consider the current and future threats to air quality.

uMoya-NILU Consulting (Pty) Ltd was appointed by the Department of Environmental Affairs (DEA) to develop the Air Quality Management Plan (AQMP) for the WBPA. The AQMP development process included three main components. Firstly, the characterisation of the baseline air quality in the WBPA. Secondly, the quantification of the potential threats posed to ambient air quality by emissions from future energy-based projects in the WDM and in Botswana up to 2030. Thirdly, the development of the WBPA AQMP and its supporting Implementation Plan. These three components are summarised here.

BASELINE ASSESSMENT

The air quality baseline assessment for the WBPA includes the characterisation of emissions from different source types, a description of the state of ambient air quality based on data from monitoring stations and from dispersion modelling, and the status of capacity to fulfil the mandated air quality functions. The baseline description provides the means to identify gaps and air quality issues in the WBPA.

Emissions

The emission summary for the WBPA shows the dominant sectors with regard to the major pollutants considered in the baseline assessment (Table E-2). SO_2 is primarily sourced from industry in the area, with 99.9% of total emissions generated by this sector. Minimal SO_2 contributions are observed from motor vehicles and the residential sectors. Total SO_2 emissions for the priority area are estimated at almost 397 000 tons per annum. For NO_x, the industrial contribution to the overall pollutant load is 87%, and the contribution from motor vehicles is 13%. Total WBPA NO_x emissions are estimated at approximately 87 000 tons per annum. For PM_{10}, mining contributes the greatest proportion of emissions, approximately 60 000 tons per annum, and over 70% of total emissions. Industry contributions are lower but still significant at 27%. Total priority area PM_{10} emissions are estimated at approximately 83 000 tons per annum.

Table E-2: Total emissions for WBPA (in tpa)

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

Ambient air quality monitoring

Ambient air quality monitoring is relatively limited in the WBPA with only nine government-owned monitoring stations, some industry-owned monitoring stations and one short passive monitoring campaign. Due to higher levels of industrial and mining activity, ambient air quality monitoring is concentrated in the Bojanala Platinum DM. The return of high-quality ambient air quality monitoring data from the various networks is not consistent, and, unfortunately, considerable data has either not been captured or is of low quality. Nevertheless, available data provides some insights into the state of ambient air quality in the WBPA. These are:

- Ambient SO_2 concentrations in the Waterberg DM are relatively low compared to the limit value of the National Ambient Air Quality Standard (NAAQS) as there are few SO_2 emission sources. The effects of domestic fuel burning on ambient SO_2

concentrations in residential areas is evident in the diurnal cycle of monitored ambient data at Marapong and to some extent at Mokopane;

- Ambient SO_2 concentrations in the Bojanala-Platinum DM are low compared to the limit value of the NAAQS, as there are relatively few sources. The effects of fuel burning on air quality in residential areas is evident at Marikana, Thlabane and Damonsville;
- Ambient NO_2 concentrations are low relative to the limit value of the NAAQS throughout the WBPA;
- Ambient PM_{10} concentrations in the Waterberg DM are relatively low compared to the limit value of the NAAQS. The effects of domestic fuel burning on ambient PM_{10} concentrations in residential areas is evident at Marapong and to some extent at Mokopane;
- Ambient PM_{10} concentrations in the Waterberg DM are generally below the limit value of the NAAQS, but exceed the 2015 limit value often at Marapong and Mokopane. The main contributing sources appear to be fuel burning in residential areas, with contributions from mining and industrial activities. The same is evident for ambient $PM_{2.5}$ concentrations.
- Ambient PM_{10} concentrations in the Bojanala-Platinum DM are generally below the limit value of the NAAQS, but exceed the 2015 limit value often at most monitoring stations, particularly Marikana and Thlabane. The main contributing source at these monitoring stations appears to be domestic fuel burning in residential areas; with a contribution from mining and industry. The same is evident for the ambient concentrations of $PM_{2.5}$.
- Ambient PM_{10} concentrations, near industrial and mining sources, in the Bojanala Platinum DM are relatively high with exceedances of the NAAQS.
- Ambient benzene concentrations in the Bojanala Platinum DM are well below the limit value of the NAAQS.

Air quality modelling

In the WDM, the predicted annual average SO_2 concentrations resulting from all sources comply with the limit value of the NAAQS of 50 $\mu g/m^3$. Similarly, the predicted 99^{th} percentile of the 24-hour and 1-hour SO_2 concentrations comply with the limit values of the NAAQS throughout the WDM. In the BPDM, the predicted annual average SO_2 concentrations generally comply with the NAAQS, but exceedances are predicted in the area surrounding Rustenburg, extending approximately 20 km to the north, and north west of Mooinooi. Similarly, the predicted 99^{th} percentile of the 24-hour and 1-hour SO_2 concentrations generally comply with the limit values of the NAAQS in the BPDM, but exceedances are predicted in an area centred on Rustenburg, north of Mooinooi and near Brits.

In the three-year modelling period, more than 12 exceedances of the 24-hour limit value for SO_2 are predicted in these same areas. Likewise, more than 264 exceedances of the 1-hour limit value are predicted. Non-compliance with the NAAQS in the BPDM indicates that emissions of SO_2 from industrial sources and the potential impacts on health are an issue in the BPDM. It is clear that emissions from the Listed Activity source category dominate the resultant ambient concentrations.

The predicted annual average NO_2 concentrations resulting from emissions from all sources comply with the limit value of the NAAQS of 40 µg/m^3 throughout the WBPA. They are somewhat higher in BPDM than the WDM because of the difference in release height of the pollutant. The 99th percentile of the predicted 1-hour NO_2 concentrations complies with the limit value of the NAAQS (200 µg/m^3) throughout the WBPA, except in three small areas between Brits and Rustenburg.

For the three-year modelling period, the areas where more than 264 exceedances are predicted (88 per year) are localised close to the respective sources. It is clear that emissions from the Listed Activity source category dominate the resultant ambient concentrations.

In the WDM, the predicted annual average PM_{10} concentrations resulting from all sources generally comply with the limit value of the NAAQS of 50 µg/m^3. However, exceedances are predicted in the immediate vicinity of mining activity. Similarly, the predicted 99th percentile of the 24-hour PM_{10} concentration generally complies with the 24-hour limit value of 120 µg/m^3, except in the vicinity of mining activity. In the 3-year modelling period, more than 12 exceedances (four per year) are predicted to occur. Non-compliance with the NAAQS in the vicinity of the mines indicates that emissions of PM_{10} from mining and the potential impact on health is an issue in the WDM. It is clear that emissions from the Mining source category dominates the resultant ambient concentrations.

In the BPDM, the predicted annual average PM_{10} concentrations generally comply with the limit value of the NAAQS of 50 µg/m^3, but exceedances are predicted in between Brits and Rustenburg, extending towards the north west. Similarly, the predicted 99th percentile of the 24-hour concentration generally complies with the limit value of the NAAQS of 120 µg/m^3 in the BPDM, but exceedances are predicted in the area between Brits and Rustenburg due to the concentration of mining activity, but extending to the north west of the Moses Kotane LM. In the 3-year modelling period, more than 12 exceedances (four per year) of the 24-hour limit value are predicted throughout the same area. Non-compliance with the NAAQS in the BPDM indicates that emissions of PM_{10} from mining and potential impacts on human health are an issue.

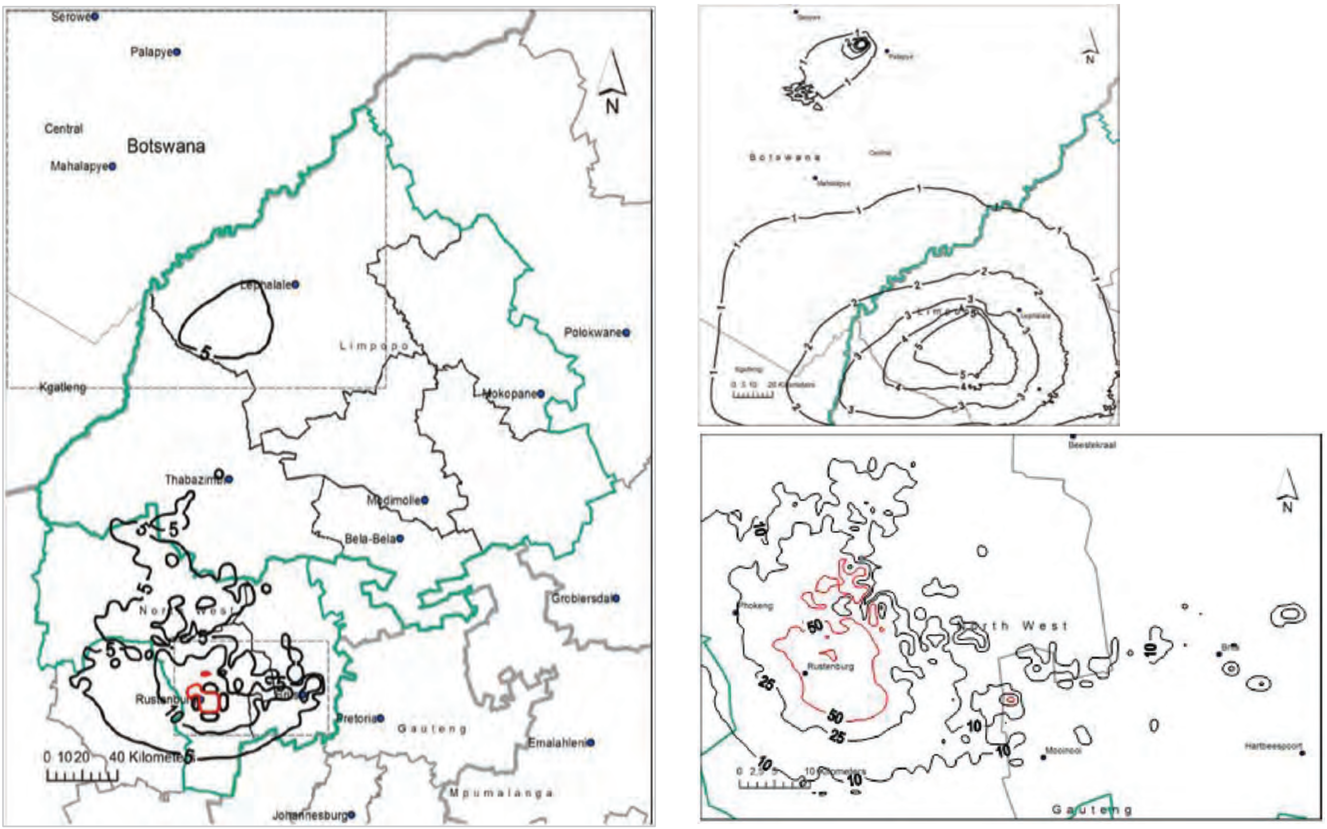


Figure E-1: Predicted average annual concentrations of SO_2 resulting from Listed Activities, Residential Fuel Burning and trans-boundary emissions in the WBPA (left), the Waterberg-Botswana domain (top right) and the Rustenburg-Brits domain (bottom right). The red isopleth indicates the NAAQS.

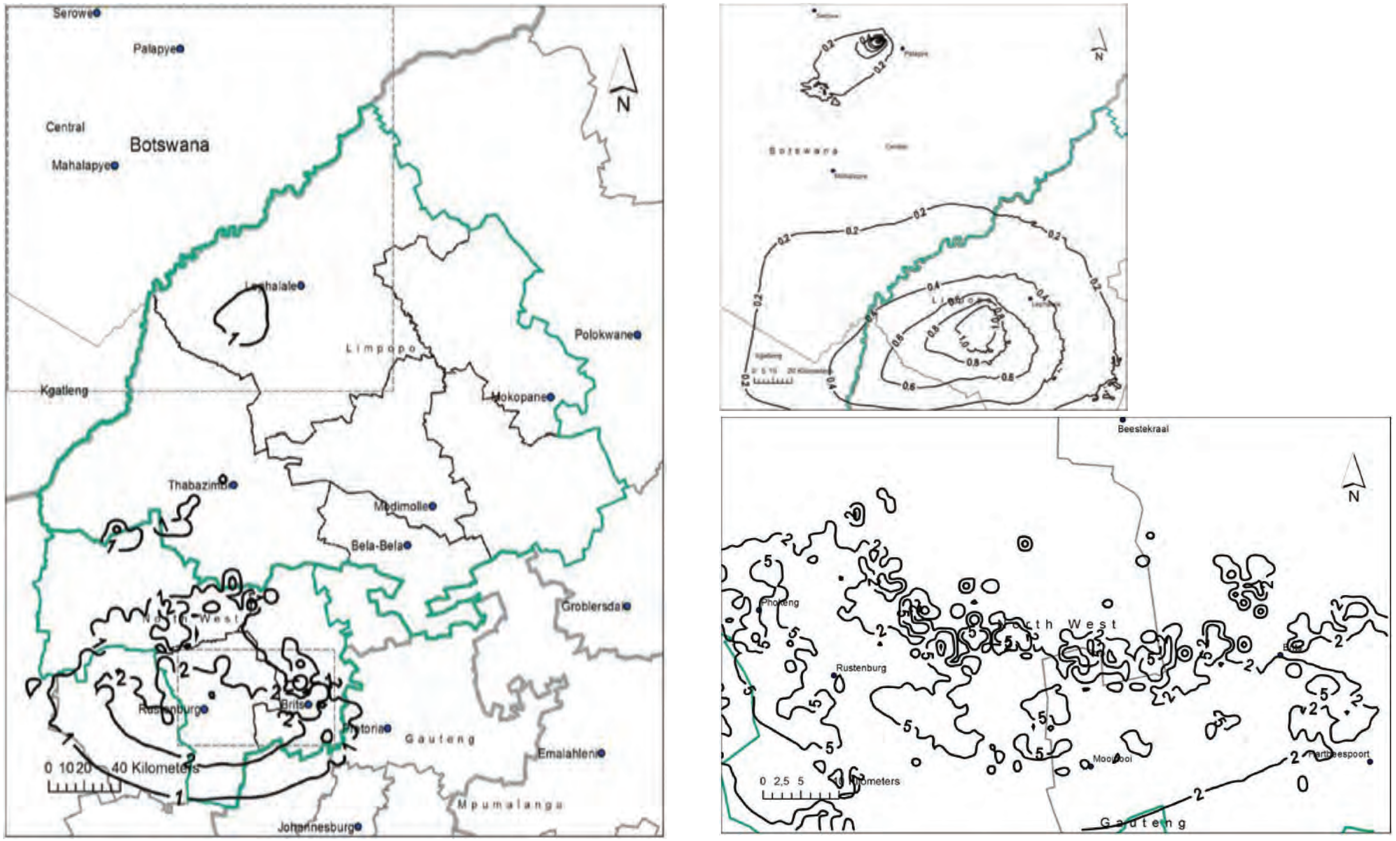


Figure E-2: Predicted average annual concentrations of NO_2 resulting from Listed Activities, Residential Fuel Burning and trans-boundary emissions in the WBPA (left), the Waterberg-Botswana domain (top right) and the Rustenburg-Brits domain (bottom right)

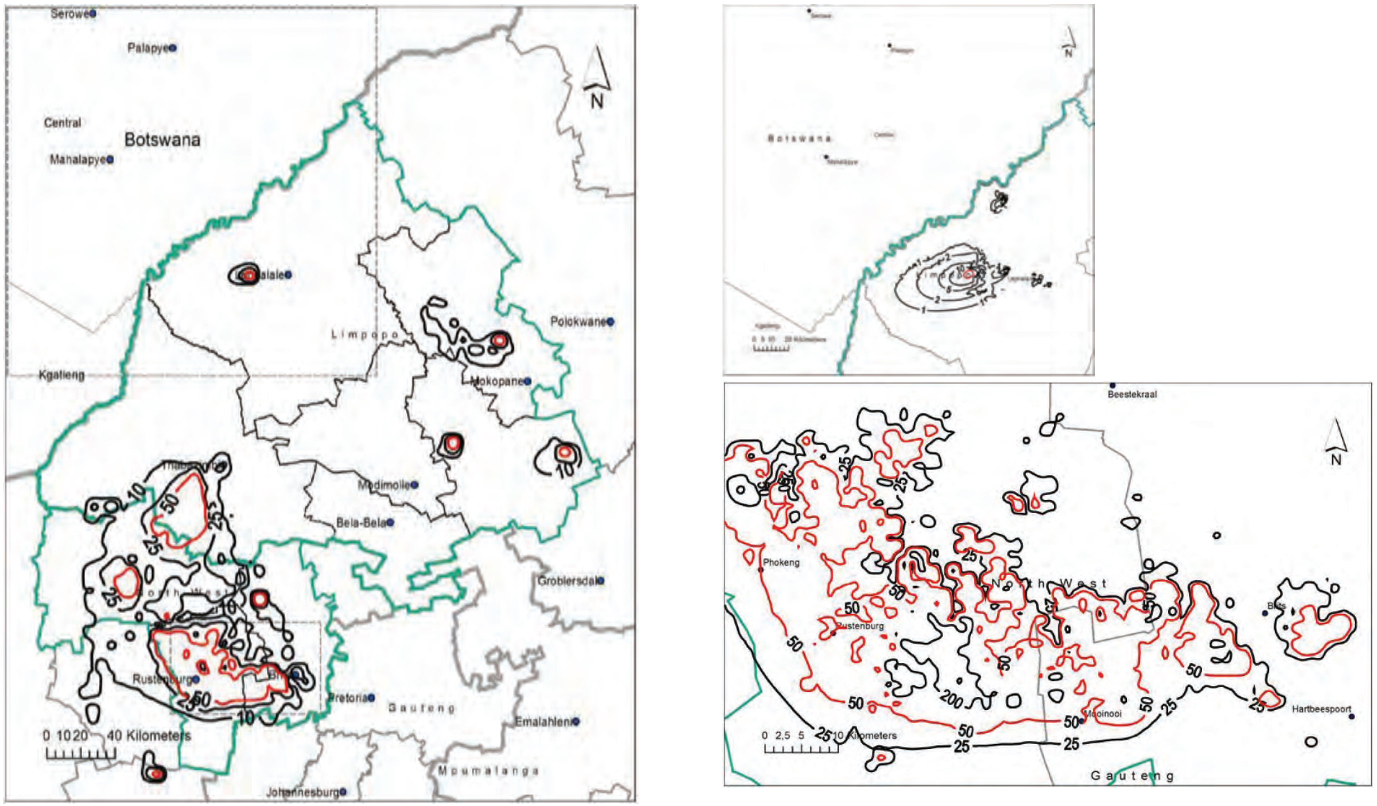


Figure E-3: Predicted average annual concentrations of PM_{10} resulting from Listed Activities, Residential Fuel Burning, Mining and trans-boundary emissions in the WBPA (left), the Waterberg-Botswana domain (top right) and the Rustenburg-Brits domain (bottom right). The red isopleth indicates the NAAQS.

Capacity

The following overarching issues are identified regarding capacity within the WBPA authorities:

- Structural assessments show the provincial capacity to be strong with local authorities requiring greater attention to support effective air quality management (AQM) function. This capacity difference could be linked to lags in AQMP implementation.
- Stemming from the AQMP implementation, a defined approach and indicators for systems capacity are needed. Ambient air quality monitoring is carried out to varying levels and requires a coordinated approach across the WBPA. The South African Air Quality Information System (SAAQIS) needs to be strengthened to provide an effective framework for data management and quality control. The management of controlled emitters requires further guidance.
- Atmospheric Emission License (AEL) functions need to be extended to Waterberg DM when capacity development is undertaken.
- Skills capacity across the WBPA authorities is at a good level, with most authorities having a strong background for AQM activities and accessing training within the department and from outside parties. Technical and management skills development requires greater focus to bolster AQM activity implementation.
- Incentives are not applied in a uniform manner across the WBPA authorities. Certain authorities have access to salary incentives and a suitable work environment, whereas others are not able to access the same level of institutional capacity.
- AQMP development needs to be aligned with the DEA AQMP Planning Manual to ensure all critical elements are addressed. Implementation requires assistance from a cooperative process that draws in higher management as well. Plan ownership and flexibility could be improved by the effective internalisation of the AQMP as a departmental planning tool, i.e. a 'living document'. Monitoring, evaluation and review processes require greater regulation and oversight activity by the authorities.
- Interrelationships could be strengthened within authorities and with related outside authorities. This includes planning departments in particular, but also transport, housing, and minerals development. Opportunities are available for work with academic institutions; however, civic associations, ward committees, and environmental NGO's could be explored further.

Gaps and issues

As an outcome of the status quo assessment, key issues and gaps need to be identified in each major section to be taken forward into the AQMP development process. The issues and gaps are listed in Table E-3.

Table E-3: Gaps and issues for each AQM aspect in the WBPA

Gaps	Issues
Governance	
Capacity at Local Government is not sufficient to carry out all AQM functions	Incumbent resources are limited and lack competence for some functions
Co-operative governance through AQM tiers (National, Provincial, Local Government) is not optimal	Weak co-operative governance inhibits effective AQM
Roles and responsibilities for AQM are not well understood at Local Government, i.e. between B & C Municipalities	Lack of understanding of roles and responsibilities leads either to duplication of effort or functions not being performed
Insufficient financial resources are available for AQM at all spheres of government	AQM is not prioritised in at all spheres of government inhibiting effective function
Co-operative governance through departmental structures (e.g. departments with AQM responsibilities) is not optimal	Weak co-operative governance and communications inhibits effective AQM function
The AEL function is not fulfilled by the WDM WBPA	The Provincial Department is acting as AELAs due to a lack of capacity and competence in WDM
Tools	
Emission inventories are incomplete and unreliable: i.e. Listed activities: Not all sources are captured, some data are questionable Controlled emitters: Limited number of sources are captured Mining: Top-down approach for WBPA project needs to be refined and kept current Domestic fuel burning: Top-down approach for WBPA project needs refining spatially and temporally, and kept current Motor vehicles: Requires annual updating for effective planning	Poor emission inventories inhibit effective AQM function
Maintenance of ambient air quality monitoring stations is generally inadequate	Ambient air quality data is generally poor and therefore unreliable
The monitoring network is relatively sparse	Baseline air quality characterisation in all areas is not possible, particularly in areas where development is planned, e.g. WDM-Botswana border
Impact management	
There is no health baseline with respect to air pollution in the WBPA and ecological impacts are not understood, i.e. with modelling and monitoring, efforts focus on industry, mining and residential fuel burning. Emissions from small boilers, biomass burning, waste management and transport were excluded	Ambient air quality monitoring indicates areas where the limit value of the NAAQS for PM_{10} are exceeded, particularly as a result of domestic fuel burning
	Dispersion modelling indicates areas where the limit value of the NAAQS for PM_{10} are exceeded, particularly in the Rustenburg-Brits corridor as a result of mining emissions

Gaps	Issues
	Dispersion modelling indicates areas where the limit value of the NAAQS for SO_2 are exceeded, particularly in the Rustenburg-Brits corridor as a result of industrial emissions
	Transport, controlled emitters, biomass burning, and waste management require more in-depth study
	Development in the WDM and Botswana has the potential to result in exceedances of the NAAQS
Planning	
Earlier AQMPs (NWP, WDM) are out-of-date and do not comply with the DEA AQMP manual (DEA, 2012). The AQMP for Limpopo and WDM lacking implementation. Monitoring and review of AQMP has not been done	AQMP included in the relevant IDPs, but is not considered as a priority in environmental planning and implementation, resulting in inadequate resource allocation and inadequate implementation
Awareness and communication	
There is generally a poor understanding of air quality and potential impacts on human and ecological health	AQM activities and emission reduction initiatives are difficult to implement

THREAT ASSESSMENT

For the Threat Assessment, feasible development scenarios concerning energy-based projects and mining were developed for the WDM and neighbouring Botswana for 2015, 2020, 2025 and 2030. Qualitative future emission inventories were developed for these scenarios and dispersion modelling was used to predict future ambient concentrations of SO_2, NO_2 and PM_{10} resulting from the emissions.

The development scenarios for the Threat Assessment initially considered the energy-based projects listed in the Regional Environmental and Social Assessment (RESA) feasibility study. They were further refined to ensure agreement between the future scenarios and those developed for the World Bank-funded RESA study, which used information provided by the Department of Energy (DoE) and the Botswana Department of Energy, Department of Environmental Affairs, Eskom and the Botswana Power Corporation. Important exclusions from the scenario development and hence the Threat Assessment are the potential increase in emissions from the concomitant growth in urban settlements, motor vehicle traffic, the beneficiation industry and related secondary industry. The projects that are included in the 2015, 2020, 2025 and 2030 scenarios are listed in Table E-4.

Table E-4: Energy-based and mining projects for the Threat Assessment scenarios. New project in each scenario are shown in bold

2012 Baseline	2015	2020	2025	2030
Matimba Power Station Grootegeluk Coal Mine Morupule B Power Station Morupule Coal Mine	Matimba Power Station Grootegeluk Coal Mine Morupule B Power Station Morupule Coal Mine	Matimba Power Station Morupule B Power Station (Phase 1)	Matimba Power Station Morupule B Power Station (Phase 1)	Matimba Power Station Morupule B Power Station (Phase 1)
	Medupi Power Station **Grootegeluk Coal Mine expanded** **Morupule A Power Station (recommissioned) Morupule Coal Mine expanded**	Medupi Power Station (no FGD) Grootegeluk Coal Mine expanded Morupule A Power Station (recommissioned) Morupule Coal Mine expanded	Grootegeluk Coal Mine expanded Morupule A Power Station (recommissioned) Morupule Coal Mine expanded	Grootegeluk Coal Mine expanded Morupule A Power Station (recommissioned) Morupule Coal Mine expanded
		IPP: Thabametsi Power Station **Thabametsi Coal Mine** **Sekoko Coal Mine** **IPP: Boikarabelo Power Station (Phase 1)** **Boikarabelo Coal Mine** **IPP: Unknown IPP Power Station (Phase 1)** **Morupule B Power Station (Phase 2)** **Greenfields IPP Power Station** **Mookane Coal Mine**	IPP: Thabametsi Power Station Thabametsi Coal Mine Sekoko Coal Mine IPP: Boikarabelo Power Station (Phase 1) Boikarabelo Coal Mine IPP: Unknown IPP Power Station (Phase 1) Morupule B Power Station (Phase 2) Greenfields IPP Power Station Mookane Coal Mine	IPP: Thabametsi Power Station Thabametsi Coal Mine Sekoko Coal Mine IPP: Boikarabelo Power Station (Phase 1) Boikarabelo Coal Mine IPP: Unknown IPP Power Station (Phase 1) Morupule B Power Station (Phase 2) Greenfields IPP Power Station Mookane Coal Mine
			Medupi Power Station (with FGD) **IPP: Boikarabelo Power Station (Phase 2)** **Boikarabelo Coal Mine expanded** **IPP: Unknown IPP Power Station (Phase 2)** **Thabametsi Coal Mine expanded** **Mmamabula Power Station (Phase 1)** **Mmamabula Power Station (Phase 2)** **Mookane Coal Mine expanded**	Medupi Power Station (with FGD) IPP: Boikarabelo Power Station (Phase 2) Boikarabelo Coal Mine expanded IPP: Unknown IPP Power Station (Phase 2) Thabametsi Coal Mine expanded Mmamabula Power Station (Phase 1) Mmamabula Power Station (Phase 2) Mookane Coal Mine expanded
				Coal 3 Power Station **New Pulverised Fuel Power Station** **New CTL** **Mmamantswe Power Station** **Mmamantswe Coal Mine**

The proposed expansion of energy-based projects and mining in the WDM and neighbouring Botswana are recognised as a potential threat to ambient air quality in the region. Hence, the declaration of the Waterberg-Bojanala Priority Area in June 2012. The potential increase in annual emissions from the current situation to 2030 for SO_2 of 370%, for NO_x of 640% and for PM_{10} of 530%, justifies the declaration of the priority area (Table E-5).

Table E-5: Cumulative emissions from energy-based sources and mining from the baseline to 2030 in tons per annum

Scenario	Energy-based projects			Mining
	SO_2	NO_x	Particulate	Particulate
Baseline	325 932	77 038	5 830	671
2015	825 995	172 002	14 166	1 342
2020	1 062 126	293 923	16 815	1 878
2025	651 299	310 741	18 954	2 280
2030	1 234 904	536 273	34 230	2 414

The threat to ambient air quality manifests in the associated increase in ambient concentrations of SO_2, NO_2 and PM_{10} and their potential impact on human health and the ecological environment. The increase in emissions from the base year (2012) to 2015 and from 2015 to 2020 results in a general increase in ambient concentrations on a regional scale. The largest increase occurs in the vicinity of the main sources near Lephalale and Palapye. Emissions from elevated power station stacks affect a large area, but dilution is effective and there is general compliance with the NAAQS, except close to the source areas where SO_2 and PM_{10} exceedances are predicted. Emissions from mines result in localised effects where exceedances of the NAAQS for PM_{10} are predicted.

Flue Gas Desulphurisation (FGD) results in reduction in SO_2 and particulate emissions. This is evident in 2025 with the marked reductions in SO_2 emissions when FGD is implemented at Medupi. The resulting reduction in PM_{10} emissions is offset by an increase in PM_{10} emissions from mining. The emission reductions result in regional decreases in predicted ambient concentrations and general compliance with NAAQS for SO_2 and NO_2. Ambient PM_{10} concentrations increase in 2025, particularly in a band extending westward from Lephalale to the Botswana border with exceedances of the NAAQS.

From the relatively low emissions base established in 2025 with the implementation of FGD, there is a significant increase in emissions to 2030. This results in a regional scale increase in ambient SO_2 and PM_{10} concentrations. The largest increase in ambient concentrations is in the vicinity of the main sources near Lephalale and extending westward towards Botswana. The elevated emissions from the new power stations and the coal-to-liquid plant affect a large area, but dilution is effective and there is general compliance with the NAAQS, except close to the source areas, wherein SO_2 and PM_{10} exceedances are predicted. Emissions from mines result in localised effects where exceedances of the NAAQS for PM_{10} are predicted.

It should be borne in mind that the Threat Assessment excludes the contribution of emissions from the potential increase in residential fuel burning and motor vehicles. The outputs of the

Threat Assessment modelling most likely indicate a best-case scenario without these two contributing source types. In other words, the future scenarios are likely to be under-predicted. Emissions from residential fuel burning are released close to ground level and have a relatively localised effect, albeit a potentially significant effect on ambient concentrations. The effect of motor vehicle emissions is also limited and resulting ambient concentrations are generally much lower.

The Threat Assessment has however indicated a number of important points for air quality management in the region. These are:

- Development in the region will increase ambient concentrations of pollutants on a regional scale.
- The areas of greatest concern are where the NAAQS for SO_2 and PM_{10} are predicted to be exceeded, concentrated in the Lephalale area and extending towards Botswana.
- Tall stacks emissions affect air quality on a more regional scale, but ground level concentrations are generally low compared to the NAAQS.
- Low-level emissions from mining result in local scale effects, and ground level concentrations are relatively high compared to the NAAQS.
- FGD brings about significant reductions in SO_2 emissions and the resultant ambient concentrations when implemented in 2025.
- The magnitude of the predicted threat to ambient air quality can be mitigated through well designed air quality management interventions and the application of appropriate technologies and emission control measures.
- The likelihood of impacts on ambient air quality in the WDM from sources in Botswana is very low. Rather, sources in the WDM are likely to affect ambient concentrations in Botswana considering the prevailing easterly wind and proximity of these sources to the Botswana border.
- The current resources in all tiers of government responsible for AQM in the WBPA are not adequate to cope effectively with the imminent changes.

WBPA AQMP

The AQMP for the WBPA aims to address the gaps and issues identified in the baseline characterisation, and to address the challenges posed to air quality and the management thereof by the planned development of energy-based projects in the region.

The overall objective of the WBPA AQMP recognises that ambient air quality currently does not comply with NAAQS throughout the Priority Area, and the proposed expansion of energy-based projects in the WDM and Botswana poses a risk to future air quality. It states that:

Ambient air quality in the Waterberg Bojanala Priority Area is brought into full compliance with national ambient air quality standards by 2020 and the state is maintained as the region develops

The Overall Objective of the WBPA AQMP is to be realised through the attainment of five related goals. These are:

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

A number of outcomes-based objectives are set for each of the goals to steer the implementation of the WBPA AQMP. Activities are then defined, which upon their completion will ensure that the objectives are realised, and in turn, the goal is realised. An Implementation Plan accompanies the AQMP. It includes the responsibility of executing the work required in each activity through assigning mandatory and participatory roles.

The implementation of the WBPA commences when the AQMP has been accepted by the Minster and has been published in the Government Gazette. The implementation of the WBPA AQMP recognises the existing provincial and municipal AQMPs, their implementation and the current roles and responsibilities of the incumbent officials.

The monitoring of progress with implementation of the WBPA AQMP is an on-going process that assesses all aspects of the plan. Monitoring allows issues to be addressed timeously so that implementation is not hindered and aspects do not lag, and are reported routinely to the Minister. Evaluation aims to measure the success of the WBPA AQMP implementation with an annual evaluation coinciding with the NAQO State of Air Report to the Minister. A mid-term review of the WBPA AQMP is recommended after 2 years to examine the successes and failures of implementation.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

℃	degrees Celsius
$\mu g/m^3$	micrograms per cubic metre
µm	micrometres
AEL	Atmospheric Emission Licence
AELA	Atmospheric Emission Licence Authority
AOT	Atmospheric optical thickness
AQM	Air Quality Management
AQMP	Air Quality Management Plan
AQO	Air Quality Officer
AQOF	Air Quality Officer's Forum
B Municipality	Local municipality
BPC	Botswana Power Corporation
BPDM	Bojanala Platinum District Municipality
C Municipality	District Municipality
CNG	Compressed natural gas
CO	Carbon monoxide
CO_2	Carbon dioxide
COGHSTA	Department of Co-operative Governance, Human Settlements and Traditional Affairs
COPD	Chronic obstructive pulmonary disease
CSIR	Council for Scientific and Industrial Research
DEA	Department of Environmental Affairs
DDG	Deputy Director-General
DG	Director-General
DM	District Municipality
EIA	Environmental Impact Assessment
EIP	Environmental Implementation Plan
g/kg	grams per kilogram
GDP	Gross Domestic Product
GIS	Geographic Information System
HAP	Hazardous air pollutant
HDV	Heavy-duty vehicle
HFO	Heavy fuel oil
HPA	Highveld Priority Area
IDP	Integrated Development Plan
IPCC	Inter-governmental Panel on Climate Change
LDEDET	Limpopo Department of Economic Development, Environment and Tourism
LM	Local municipality
LPG	Liquid Petroleum Gas
m/s	metres per second
MEC	Member of Executive Council

mm	millimetre
MP	McElroy-Pooler
MSRG	Multi-stakeholder Reference Group
MW	MegaWatt
N_2O	Nitrous oxide
NAAQS	National ambient air quality standards
NAPCoF	North West Air Pollution Control Forum
NEM: AQA	National Environmental Management: Air Quality Act
NNW	North north-west
NO_2	Nitrogen dioxide
NO_X	Oxides of nitrogen
NWDACE	North-West Department of Agriculture, Conservation and Environment
NWREAD	North-West Department of Rural, Environmental and Agricultural Development
O_3	Ozone
PA	Priority Area
Pb	Lead
PCB	Polychlorinated biphenyls
PM	Particulate matter
PM_{10}	Particulate matter of aerodynamic diameter less than 10 micrometres
$PM_{2.5}$	Particulate matter of aerodynamic diameter less than 2.5 micrometres
ppb	parts per billion
PSC	Project Steering Committee
RESA	Regional Environmental and Social Assessment
SAAQIS	South African Air Quality Information System
SAMINDABA	South African Mineral Deposits Database
SANBI	South African National Biodiversity Institute
SAWIC	South African Waste Information Centre
SAWS	South African Weather Service
SIP	Strategic Infrastructure Project
SLA	Service Level Agreement
SO_2	Sulphur dioxide
tpa	Tons per annum
ToR	Terms of reference
VOCs	Volatile organic compounds
VTAPA	Vaal Triangle Airshed Priority Area
Bojanala Priority Area	
WDM	Waterberg District Municipality
WHO	World Health Organisation
WWTW	Wastewater treatment works

GLOSSARY OF TERMS AND DEFINITIONS

Term	**Definition**
Ambient air	Outdoor air in the troposphere, excluding work places. According the National Environmental Management Act, (Act no. 39 of 2004) **"ambient air"** excludes air regulated by the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993).
Averaging period	A period of time over which an average value is determined.
Compliance date	A date when compliance with the standard is required. This provides a transitional period that allows activities to be undertaken to ensure compliance date.
Bottom-up	Refers to the emission estimation technique using detailed information at the level of individual sources, e.g. fuel used by an appliance, and specific emission factors
Criteria air pollutants	A term used internationally to describe air pollutants that have been regulated and are used as indicators of air quality.
Exposure	An event that occurs when there is contact a human and a contaminant of a specific concentration in the environment for an interval of time (Ott, 1995)
Frequency of exceedance	A frequency (number/time) related to a limit value representing the tolerated exceedance of that limit value, i.e. if exceedances of limit value are within the tolerances, then there is still compliance with the standard.
Hazardous air pollutants	Also known as toxic air pollutants or air toxics, are those pollutants that cause or may cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental and ecological effects.
Limit values	A numerical value associated with a unit of measurement and averaging period that forms the basis of the standard.
Standard	A standard may have many components that define it as a "standard". These components may include some or all of the following; Limit values, averaging periods, the frequency of exceedances, and compliance dates.
Top-down	Refers to the emission estimation technique using high-level information for a source sector, e.g. annual fuel used in a province, and generic emission factors for all appliances.
Morbidity	The incidence rate, or the prevalence of a disease or medical condition.
Mortality	The mortality rate of a condition is the proportion of people dying during a given time interval.

1 INTRODUCTION

1.1 Background

Section 18(1) of the National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) (NEM: AQA) provides for the declaration of a Priority Area. The Minister responsible for Environmental Affairs may declare a Priority Area if she reasonably believes that ambient air quality standards are being, or may be exceeded in the area or a situation exists which is causing, or may cause, a significant impact on air quality in the area. Therefore, a specific air quality management (AQM) is required to address the situation. The priority area tools allow for the concentration of limited AQM capacity (human, technical and financial) to deal with acknowledged problem areas in order to obtain measurable air quality improvements in the short-, medium-, and long-term; prescribe a corporative governance approach; and allow for the implementation of AQM methodologies that consider all contributors to the air pollution problem.

The Vaal Triangle Air-Shed Priority Area (VTAPA) was declared on 21 April 2006, followed by the Highveld Priority Area (HPA) on 23 November 2007 (Figure 1-1). The initiatives are aimed at managing poor air quality in air pollution "hotspot" areas that cross the Gauteng and Free State provincial boundaries in the case of the VTAPA, the Gauteng and Mpumalanga provincial boundaries for the HPA. The Minister declared the Waterberg–Bojanala Priority Area (WBPA) on 15 June 2012 as the third National Priority Area (DEA, 2012a), crossing the border of the North West and Limpopo Provinces.

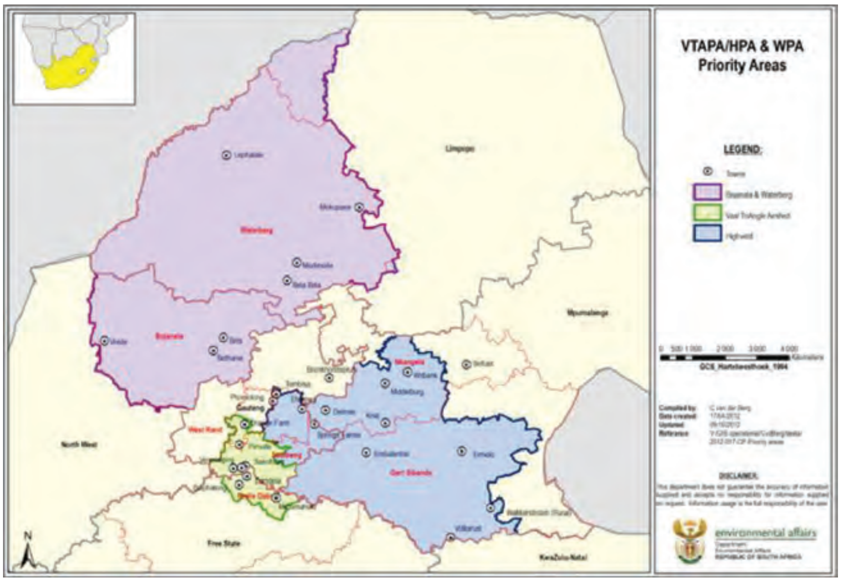


Figure 1-1: Location of the three national Priority Areas

The WBPA is not an air pollution "hotspot", but the declaration is in line with the precautionary principle of the National Environmental Management Act (Act No. 107 of 1998) that entails the application of preventative measures in situations of scientific uncertainty, where a course of action may cause harm to the environment. The likelihood of trans-boundary air pollution between Botswana and South Africa, due to planned energy developments along the border, is of both national and regional concern with potential negative impacts on air quality.

1.2 Priority Area AQMP development process

The physical extent of national priority areas implies AQM roles and responsibilities for the three spheres of government, i.e. National, Provincial and Municipal. These are defined in the National Framework for the different phases of the environmental governance cycle (DEA, 2012b) and are summarised in Table 1-1.

Table 1-1: Typical government functions relating to air quality management in National Priority Areas (DEA, 2012b)

Function	**NEM:AQA Ref.**	**DEA**	**Prov.**	***Municipalities***		
				Metro	**Dist.**	***Local***
Typical NEM:AQA governance functions relating to information management						
Establish and maintain national standards for the collection and management of data necessary to assess, amongst others: (i) the performance of organs of state in respect of air quality management plans and priority area air quality management plans; and (ii) the impact of, and compliance with, air quality management plans and priority area air quality management plans.	8(c)	PR	I	I	I	*I*
The compilation and submission of an annual report including information on, amongst others, (a) compliance with any applicable priority area air quality management plans	17	PR	PR	I	I	*I*
Typical NEM:AQA governance functions relating to problem identification and prioritisation						
The declaration of an area as a priority area if ambient air quality standards are being, or may be, exceeded in the area, or any other situation exists which is causing, or may cause, a significant negative impact on air quality in the area; and	S.18(1)	PR	PR	I	I	*I*

Function	NEM:AQA Ref.	DEA	Prov.	*Municipalities* Metro	Dist.	*Local*
the area requires specific air quality management action to rectify the situation						
Typical NEM:AQA governance functions relating to strategy development						
The development of Priority Area Air Quality Management Plans	S.19	PR	PR	I	I	*I*
Typical NEM:AQA governance functions relating to standard setting						
The setting of national standards for the collection and management of data necessary to assess, amongst others, the performance of organs of state in respect of air quality management plans and priority area air quality management plans; and the impact of, and compliance with, air quality management plans and priority area air quality management plans.	8(c)	PR	I	I	I	*I*
Typical NEM:AQA governance functions relating to policy and regulation development						
The development and promulgation of regulations necessary for implementing and enforcing approved priority area air quality management plans, including: funding arrangements; measures to facilitate compliance with such plans; penalties for any contravention of or any failure to comply with such plans; and regular review of such plans.	S.7(1)(e)	PR	PR	I	I	*I*
Typical NEM:AQA governance functions relating to environmental impact management						

Through environmental impact assessment, the safety, health and environmental impacts of developments and activities are scrutinised. This process encourages participation by all stakeholders and provides decision-makers with detailed information to determine whether an activity may proceed or not, and in the case of an approval provides information on the mitigation measures that must be introduced to ensure that safety, health and environmental impacts are kept to acceptable levels. Reference to impact management is made in a number of sections of the NEM: AQA, including:

- An AQO may require any person to submit an Atmospheric Impact Report if it is reasonably believed that the person has contravened or failed to comply with the NEM:AQA or any conditions of a licence and the contravention has had, or may have, a detrimental effect on the environment (Section 30(a));
- An AQO may require any person to submit an Atmospheric Impact Report if a review of a licence is undertaken (Section 30(b));

Function	NEM:AQA Ref.	DEA	Prov.	*Municipalities* Metro	Dist.	*Local*
• The application for an AEL, when the effect or likely effect of the pollution emitted or likely to be emitted by a Listed Activity on the environment must be considered (Section 39(b)); and, • Significant trans-boundary impacts require management through preventative, control or corrective measures (Section 50(2)).						
Typical NEM:AQA governance functions relating to authorisations and compliance monitoring						
Monitoring compliance with emission standards, with directives for atmospheric impact reports or pollution prevention plans, conditions or requirements for an AEL, and information provided to an AQO, amongst others	S.51(1)(a)-(h)	PR	PR	PR	PR	*I*
Typical NEM:AQA governance functions relating to enforcement						
The NEM: AQA is regarded as a "specific environmental management Act" under the NEMA and, as such, may be enforced by the Environmental Management. Furthermore, enforcement is also addressed in the following sections of NEM:AQA: ▪ The Minister or MEC may prescribe penalties for any contravention of or any failure to comply with Priority Area AQMPs (Section 20(c)); ▪ An AEL must specify the penalties for non-compliance (Section 43(1)(k)), and can include other measures necessary for enforcement (Section 43(1)(m)); and, ▪ Sections on offences (Section 51) and penalties (Section 52 and Section 55(2))						

Key: PR - Principle Responsibility in relevant jurisdiction I - Input O - **Oversight**

1.3 Process for developing the WBPA AQMP

The merits of a 3rd national Priority Area were first suggested in April 2011 and, with input from stakeholders, including the research community, the area was demarcated allowing for the declaration in June 2012. Following the declaration of a Priority Area, the National Air Quality Officer (NAQO) must prepare a priority area air quality management plan (AQMP) for the area, for submission and approval by the Minister.

At the inception of the WBPA AQMP project, a Project Steering Committee (PSC) was established to provide management and administrative guidance as well as an Air Quality Officers Forum (AQOF), to provide governance and technical guidance. The initial PSC comprised of the Department of Environmental Affairs (DEA) officials. The authorities had a broader scope and included representatives from other relevant and affected national government departments and other affected provincial departments. The AQOF was subsequently invited to become members of the PSC and attend project management meetings. A Multi Stakeholder Reference Group (MSRG) was established following the publication of the declaration of the WBPA to include other stakeholders in the WBPA AQMP development.

The timeline of events from prior to the WBPA declaration is listed in Table 1-2.

Table 1-2: Key milestones of the development of the WBPA AQMP

Date	Milestone
April 2010	Desktop research on Waterberg air quality status-quo finalised
27 May 2010	Governance inception meeting, Lephalale
21 June 2010	Ministerial intent submission initiated
31 August 2010	Minister intent submission approved
1 September 2010	Letters to municipal managers/ MECs on Ministerial intention
8/10 October 2010	Waterberg intent published in Government Gazette and Sunday Times newspaper respectively
8 November 2010	All public comments collated
19 January 2011	Chief Directorate Workshop to finalise the recommendations on public comments to the Minister
11 April 2011	Proposed Waterberg Bojanala Priority Area Governance meeting
24 August 2011	Minister's 2nd intention to declare the expanded Waterberg Bojanala Priority Area incorporating Bojanala Platinum district municipality gazetted, published for public comments on 30th September 2011 (Gazette No. 34631)
03 October 2011	DEA and Department of Human Settlements Inception meeting to present proposed WBPA and outline Department's role
05 December 2011/ 16 January 2012	1st and 2nd Internal WBPA AQMP & Threat Assessment Terms of reference workshops respectively
2 March 2012	Minister's approve/sign notice declaring expanded Waterberg Bojanala Priority Area, in terms of Section 18 of the National Environment Management: Air Quality Act, 2004 (Act No.39 of 2004)
27 March 2012	Air Quality Seminar meeting between PAP and Outreach section
13 April 2012	Pre planning meeting for Air Quality Outreach event for Proposed Waterberg Bojanala PA between DEA, Dept. Local Government & Traditional Affairs (North West Province) and COGHSTA (Limpopo Province)
17 May 2012	Air Quality Seminar meeting between PAP and Outreach section
28 May 2012	WBPA Air Quality Research Seminar, Burgerspark Hotel
11 May 2012	Proposed WBPA Emission Inventory Team meeting
15 & 17 June 2012	WBPA declared and published in Sunday Times and Government Gazette (Gazette No.35435, Notice No 495 of June 2012)
21 June 2012	Pre-planning WBPA Outreach event meeting, launch of WBPA air quality monitoring station, Forever Resort Warmbaths
12 July 2012	2nd Pre-planning WBPA Outreach event meeting, launch of WBPA air quality monitoring station, Forever Resort Warmbaths
20 July 2012	Deputy Minister Rejoice Mabudafhasi addresses launch of WBPA Air Quality Monitoring Station at Mahwelereng, Mogalakwena Municipality
06 August 2012	Waterberg-Bojanala PA MSRG inception meeting after declaration, Rustenburg Phokeng Conference centre
04 September 2012	DG approved Waterberg Bojanala PA AQMP terms of reference
16 November 2012	2nd MSRG WBPA meeting, Forever Resorts
22 February 2013	3rd MSRG WBPA meeting, Brits
08 March 2013	Minister changed name to Waterberg-Bojanala National Priority Area

Date	**Milestone**
26 August 2013	DDG approved request for Bid Specifications Committee establishment for Waterberg Bojanala Priority Area Term of Reference
21 August 2013	WBPA Authorities meeting informing of project approach change was held
09 September 2013	WBPA Bid Specification Committee meeting was held
07 November 2013	DG approved ToR for development of WBPA AQMP & Threat Assessment
15 November 2013	WBPA Tender E1268 was advertised in Government gazette and DEA website
25 November 2013	Compulsory WBPA Tender briefing session was held
13 December 2013	DDG approved request Bid Specifications Committee establishment for evaluating Waterberg Bojanala Priority Area Bids/Tender
13 December 2013	Bid Evaluation committee meeting was held
21 January 2014	DAC committee meeting to appoint potential service provider was held
24 January 2014	Appointed uMoya-NILU as Service provider
3 February 2014	SLA was signed
25 February 2014	Held inception meeting and PSC Establishment, project plan presentation
13 March 2014	WBPA Authorities meeting introducing uMoya-NILU and project progress report
25 March 2014	A draft baseline assessment report was received from the service provider.
23 May 2014	The 2nd PSC meeting was held at DEA old Building (5th Floor South Tower)
20 June 2014	The 2nd WBPA Authorities meeting was held at the old DEA building (12th floor ST)
26 June 2014	The draft WBPA Baseline Assessment report was workshoped at the 4th WBPA MSRG meeting held at the Sanrock Resort and Conference Centre in Modimolle
07 August 2014	Threat Assessment Scenario Building workshop was held at DEA new building (Environmental House: 473 Steve Biko Street Arcadia Pretoria:)
08 August 2014	The Draft WBPA AQMP Baseline Assessment Report was published on SAAQIS for comments.
28 August 2014	Logical Framework Approach (LFA) workshop was held at the Hunters Rest Hotel in Rustenburg.
04 - 05 September 2014	LFA follow-up meeting was held at uMoya-Nilu offices in Durban.
09 September 2014	Report on the proceedings of the LFA workshop was circulated
31 October 2014	Round table meeting with industries and key Departments was held at the Protea Hotel Capital for the purpose of developing intervention strategies.
12 November 2014	A follow up Round table meeting to discuss Energy /Household emissions was held at the Department of Energy –Corner Visagies and Paul Kruger street
13 November 2014	5th MSRG meeting to discuss AQMP Interventions was held at the Sanrock Resort and Conference Centre in Modimolle
05 December 2014	A Ministerial request to Gazette the draft WBPA AQMP imitated (EDMS140409)
24 April 2015	Draft AQMP was published for comments
25 May 2015	Public comment closing date
03 June 2015	Internal CD meeting to analyse comments
19 June 2015	6th MSRG meeting to discuss public comments was held at the Hunters Rest Hotel in Rustenburg.

The development of WBPA AQMP followed the process defined in the Manual for Air Quality Management Planning (DEA, 2012c) and outlined in the National Framework (DEA, 2012b).

Undertaking an AQMP is a six-step process, i.e.:

i. Establishing stakeholder groups and the baseline air quality,
ii. Undertaking a gap and problem analysis,
iii. Developing air quality vision and goals,

iv. Developing an implementation plan, or intervention strategies and rules for implementation,
v. Implementing the intervention strategies, and
vi. Monitoring, reporting and evaluating progress against the goals.

1.4 Report structure

As part of the development of the WBPA AQMP, the baseline assessment addresses Steps (i) and (ii), i.e. the characterisation of the air quality baseline and the gap and problem analysis. In so doing, the air quality baseline assessment evaluates, amongst others, the nature of the receiving environment, sources of emissions of air pollutants, ambient air quality in the WBPA and the capacity in government to fulfil the air quality management mandate. An understanding of the gaps and issues regarding air quality is thus developed which provides input to Steps (iii) and (iv), i.e. the development of the WBPA AQMP (DEA, 2014).

The second chapter provides essential background on the priority area in terms of political, geographical, meteorological, and socio-economic setting. The third chapter summarises the historical air quality information available for the WBPA as described in AQMP's. The fourth chapter examines the emission sources, ambient air quality monitoring, model-predicted air quality, and the capacity assessment for the WBPA. An indication of prospective development in the WBPA is given in Chapter 5. The gaps, issues and needs are summarised in Chapter 6. Chapter 7 highlights the way forward. References are listed thereafter. A number of appendices are included to the report, describing additional information of interest.

2 THE WATERBERG-BOJANALA PRIORITY AREA

2.1 Political demarcation

The WBPA is located in the north west of South Africa, bordering with Botswana, and covers an area of 67 837 km^2. It includes the Waterberg District Municipality (WDM) in Limpopo Province and parts of the Bojanala Platinum District Municipality (BPDM) in the North West Province (Figure 2-1). The nine Local Municipalities (LM) included in the WBPA are listed in Table 2-1.

Table 2-1: Municipalities within WBPA

Province	**District Municipality**	**Local Municipality**
Limpopo	Waterberg	Thabazimbi
		Modimolle
		Mogalakwena
		Bela-Bela
		Mookgopong
		Lephalale
North West	Bojanala Platinum	Moses Kotane
		Rustenburg
		Madibeng

Figure 2-1: The WBPA showing the Bojanala-Platinum and Waterberg District Municipalities and local municipalities

The WDM is the largest of the five districts in the Limpopo Province, located in the west of the province, covering an area of 49 504 km^2. It comprises six Local Municipalities, all of which are included in the WBPA. The main urban centres are the towns of Mokopane, Bela-Bela, Lephalale, Modimolle, Mogalakwena, Mookgophong and Thabazimbi. The BPDM is the largest of the four District Municipalities in the North West Province and covers an area of approximately 18 333 km^2. It comprises five LMs, three of which are included in the WBPA (Table 2-1).

2.2 Topography and land use

There are four main landscape features in the Waterberg district, namely the Waterberg Plateau, the Transvaal plateau basin, the Pietersburg plain and the Limpopo depression (WDM, 2010). The Waterberg Mountain Range is the most prominent topographical feature in the district (WDM, 2009) (Figure 2-2). Prominent economic activities include mining, agriculture and tourism. The mining industry is a major contributor to economic development and the district is the largest platinum production area in the Limpopo Province. Coal mining and petroleum development in Lephalale has also increased (WDM, 2010). The coal resource in the Waterberg field is estimated at 76 billion tons, which is more than 40% of the national coal reserve. There is also the manufacture of cement and mining for iron in the municipal area. The Waterberg area hosts 70% of the Limpopo Province's platinum reserves. The platinum mining activity is concentrated at Mogalakwena and Thabazimbi (WDM, 2010). South Africa's largest opencast coal mine is found in Lephalale, and currently the Matimba Power Station is the largest dry-cooled power station in the world. Bela-Bela, Modimolle and Mookgopong are associated with mixed dryland agricultural activities.

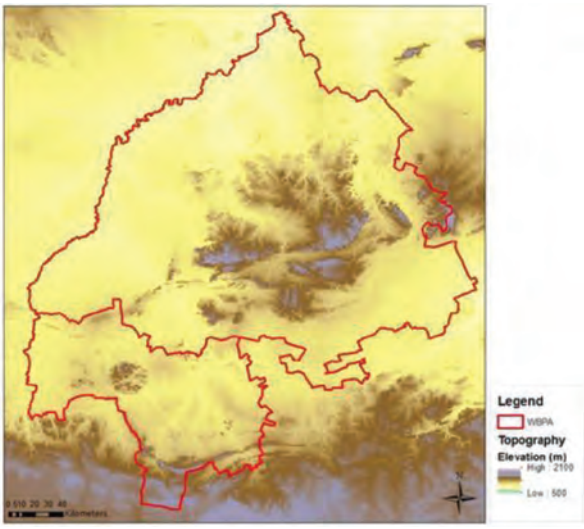


Figure 2-2: Topography of WBPA

The Bojanala region lies in the north east of North West Province and borders Gauteng and the Limpopo Province. A large part of the municipal district is in the Bushveld basin, with savannah bush vegetation (BPDM, 2010) (Figure 2-3). Prominent economic activities within BPDM include mining, agriculture, manufacturing, wholesale and retail trade and tourism. Mining plays an important role in the economy of the region, and provides the district's main source of employment. Most of the mining activities are concentrated in a band, i.e. the Merensky Reef, which stretches from west of the Pilanesberg, southwards through the Bafokeng area and parallel to the Magaliesberg towards Marikana and Brits in the east. There are several supplementary manufacturing industries co-located in the area. The two largest platinum mines in the world, Anglo Platinum and Impala Platinum, are situated in the district (BPDM, 2010). Chrome, lead, marble, granite and slate are also produced in the area.

The BPDM is a major economic centre in the North West Province and contributes significantly to total production output and employment opportunities within the province. The proportional contribution of the mining sector to total economic output increased from 42.3% in 1996 to 59.5% in 2001. The mining sector is also the main source of employment in the Rustenburg magisterial district, accounting for more than 50% of formal employment opportunities. The dry climate favours primary agricultural activities such as livestock and small stock farming, as well as cultivation of citrus and irrigated crops such as tobacco and wheat, flowers and plant nurseries. Water for irrigation is supplied from the Hartbeespoort Dam. The dam is also a popular tourist attraction and a recreational area for water sports (BPDM, 2005).

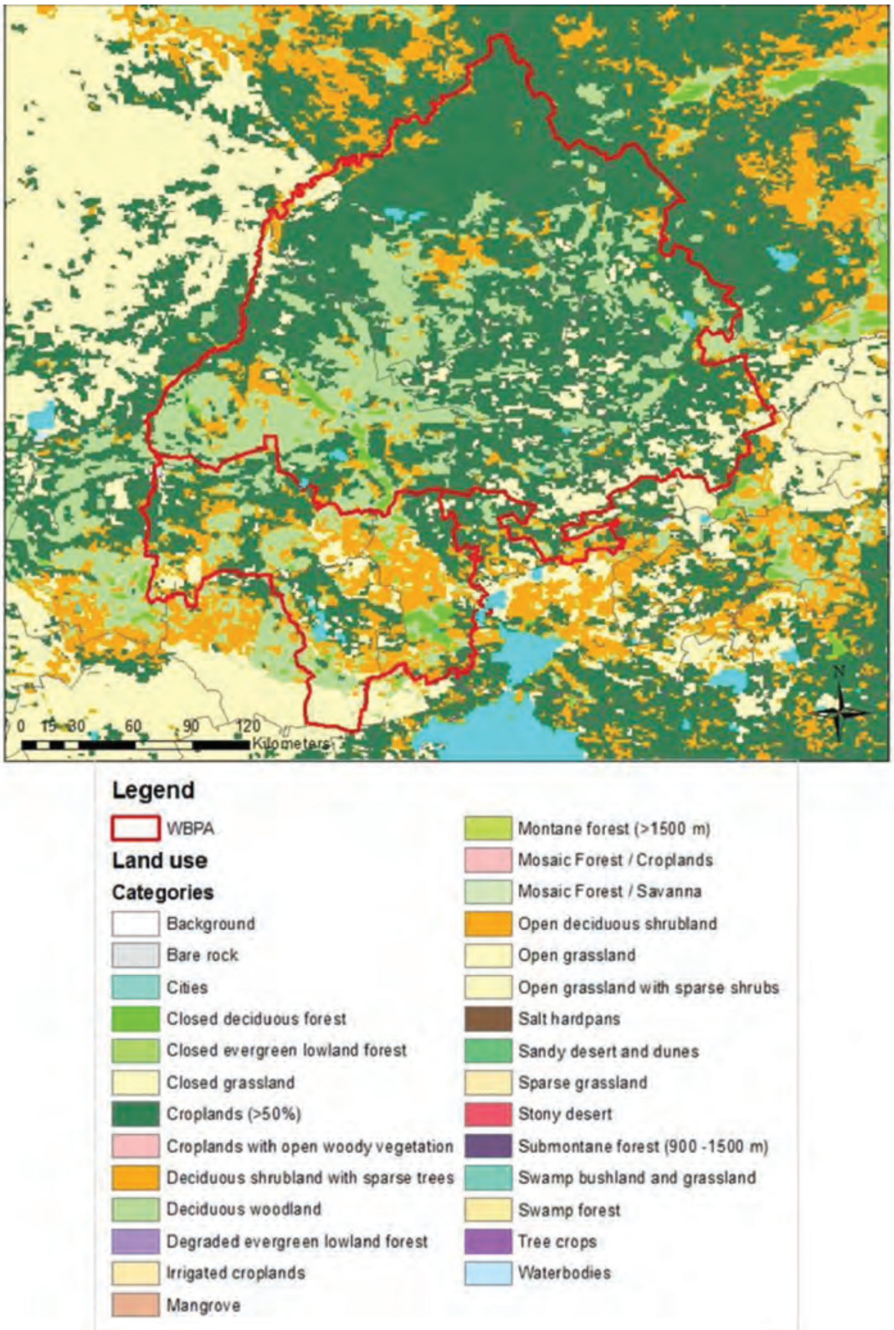


Figure 2-3: Land uses in WBPA

2.3 Climate and regional scale transport

The climatology of any particular place is controlled principally by the latitude, which determines the amount of solar radiation that is received, the relative position from the sea and the height above sea level. Secondary influences are the general circulation of the atmosphere and variations, the nature of the underlying surface, vegetation cover and orientation relative to topographical features. The WBPA lies between latitudes 22º 16' S and 26º 05' S in the central interior of Southern Africa. It is bordered on the north western side by the Limpopo River where the altitude varies between 800 m and 900 m above sea level, increasing to between 1 100 m and 1 300 m above sea level in the east.

The mean circulation of the atmosphere over Southern Africa is anticyclonic throughout the year due to the dominance of semi-permanent, subtropical high-pressure cells (anticyclones) over the subcontinent. Seasonal changes in the intensity and position of the high-pressure cells, together with the influence of the easterlies in the north and westerlies in the south, control the climate of southern Africa. The frequency of occurrence of anticyclones reaches a maximum over the interior plateau in June and July with the minimum in December.

The WBPA therefore experiences a temperate climate. Winters are generally mild and dry, but cold at night. Summers are hot, but mild at night. Rainfall occurs almost exclusively in summer in the form of convective showers or thundershowers because of low-pressure troughs over the central plateau. As the WBPA is a very large area, the climate varies across the region. The western and northern parts of the WBPA are generally warmer than the eastern and southern parts and receive less rainfall. The average monthly maximum, minimum and daily temperatures and average monthly rainfall for the 30-year period, 1961 to 1990, at South African Weather Service (SAWS) climate stations in the WBPA are shown in Figure 2-4.

The annual average maximum temperature increase from 26.4 ºC at Rustenburg in the south to 27.9 ºC at Thabazimbi and 29.1 ºC further north at Lephalale. The northern and western parts of the WBPA receive less rainfall than the southern and eastern parts. Annual average rainfall varies from 435 mm at Lephalale in the north to 574 mm at Thabazimbi, and 633 mm at Bela-Bela in the east and 680 mm at Rustenburg in the south of the WBPA.

The winds in the northern WBPA show a predominant easterly tendency (Mafuta, Marapong) and the winds are light and generally under 6 m/s. Over the central parts of the WBPA, at Thabazimbi and Mokopane, winds are predominantly northerly, with occasional north westerly winds. Again, all winds are light and rarely exceed 6 m/s. This predominant northerly wind is also evident at Bela-Bela, the eastern edge of the WBPA. There are a number of monitoring stations in the southern part of the WBPA, in the area between Brits and Rustenburg. These are shown in Figure 2-5 by the wind roses at Boitekong and Marikana. In this part of the

WBPA, the winds are more varied, but rarely blow from the west. Northerly to north westerly winds are common, as are winds from the south to south east. Easterly winds also occur in the southern WBPA.

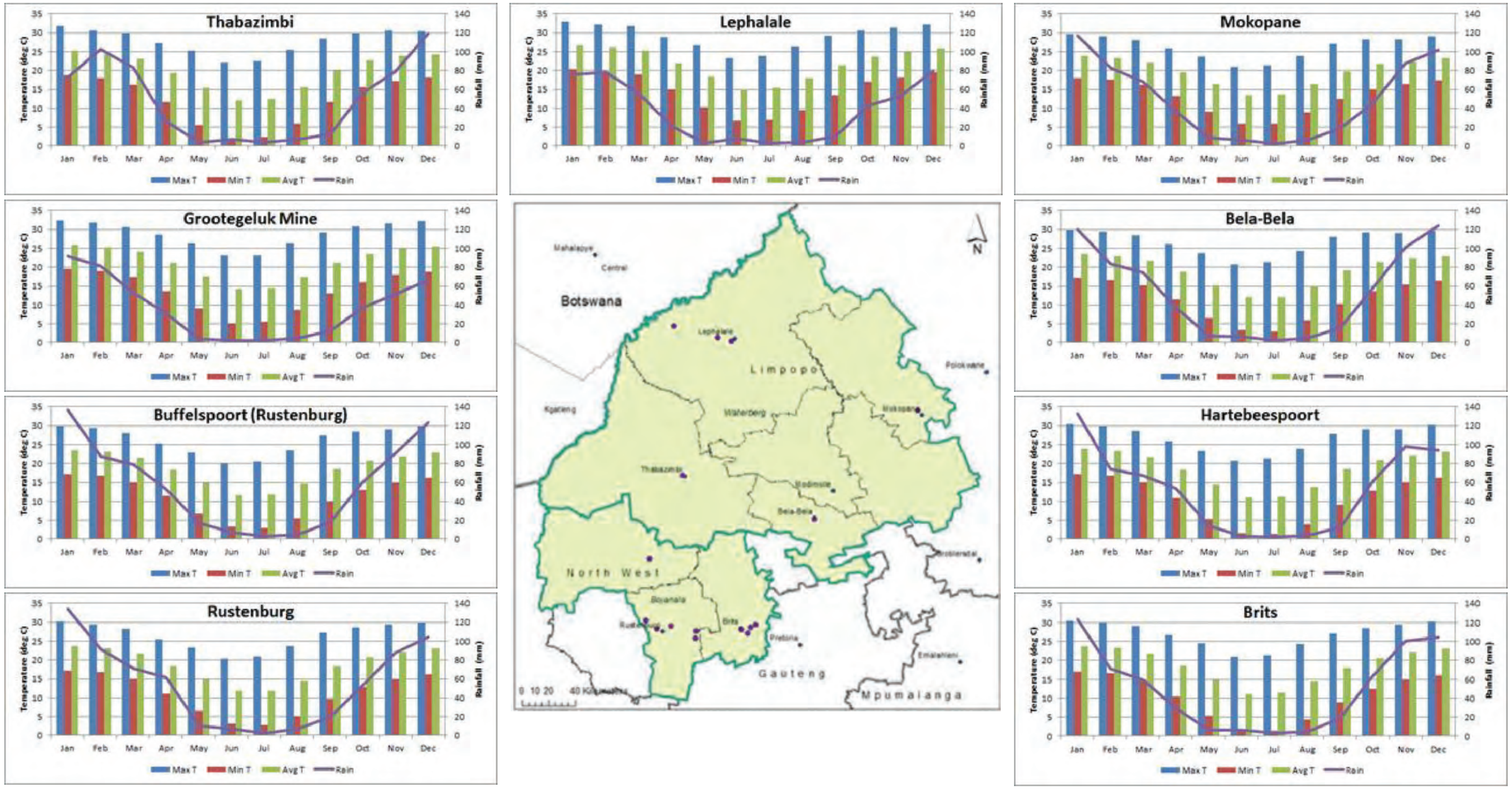


Figure 2-4: Average monthly maximum, minimum and daily temperatures (in ºC) and average monthly rainfall (in mm) for the 30-year period 1961 to 1990 (SAWS, 1998)

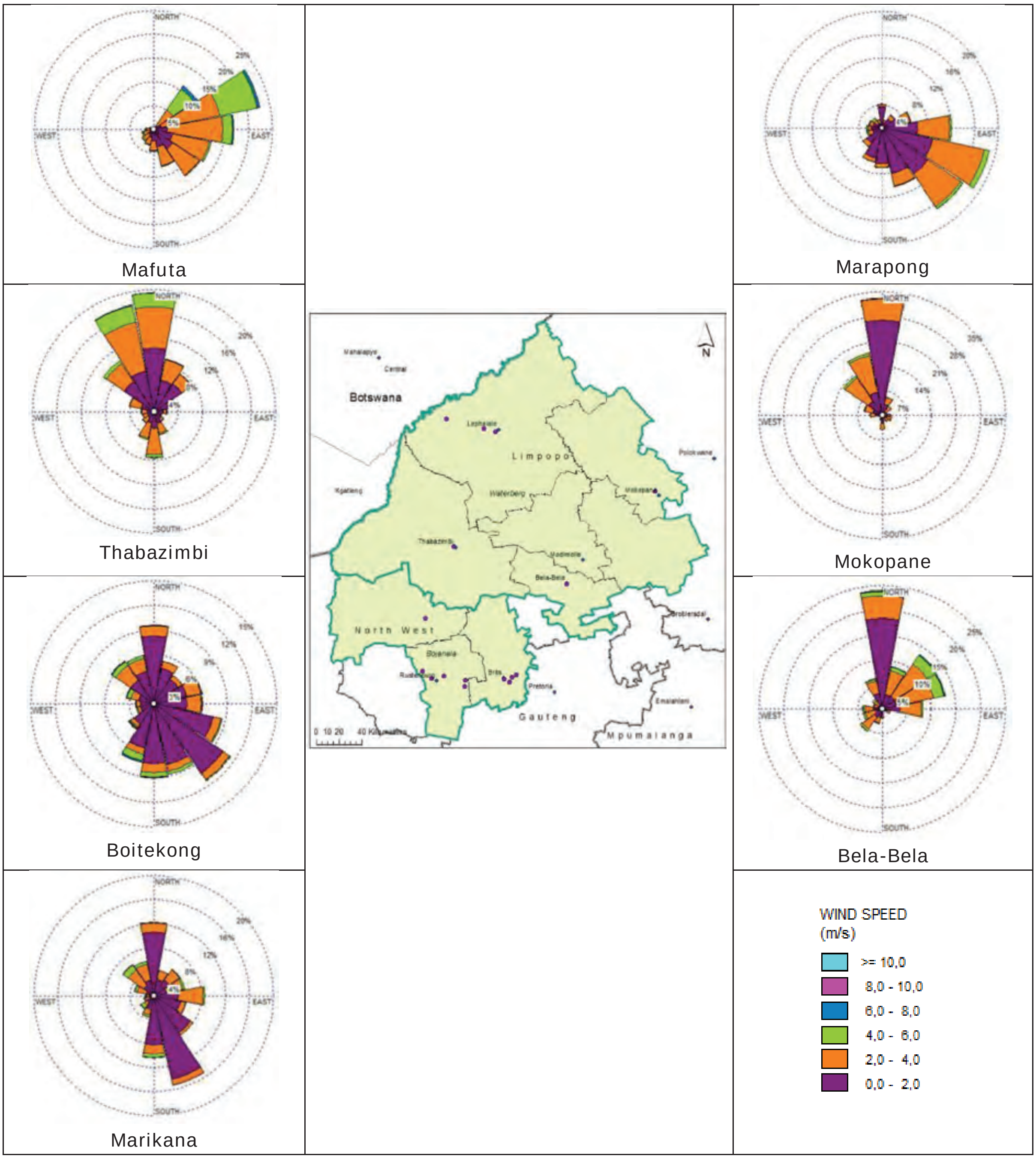


Figure 2-5: Annual wind roses at selected monitoring stations in the WBPA for 2010 to 2012

2.4 Atmospheric transport into the WBPA

Two regional-scale sources of pollutants are important when considering the long-range transport of air pollutants over Southern Africa. These are biomass burning and industrial emissions. Biomass burning is seasonal and starts in June near the equator and moves southward, reaching a maximum in South Africa and neighbouring countries in September every year. The SAFARI 2000 (Garstang *et al.*, 1996; Tyson *et al.*, 1996) experiment showed that biomass burning emissions are transported from lower latitudes and impact on the air quality throughout Southern Africa including South Africa. The long-range transport of industrial emissions from the central and eastern Mpumalanga Highveld has also been shown to have regional-scale effects on ambient air quality (Freiman and Piketh, 2003). The long-range transport of pollutants from industrial and mining sources in Botswana is also likely to have some regional-scale effects.

The frequency of occurrence of air moving southward from lower latitudes is highest during spring, which coincides with the peak in biomass burning in that region of the subcontinent. From August to October, it is likely that ambient air quality in the WBPA will be affected by the transport of pollutants associated with biomass burning emissions, including particulates. During this period, it is likely that industrial and mining emissions in Botswana will add to the pollutant loading and affect ambient air quality in the WBPA.

Freiman and Piketh (2003) identified two main transport modes out of the HPA region (Figure 2-6). In the direct transport mode, material is transported out of the HPA region with little decay in a westerly (39% to the Indian Ocean), easterly (14% to the Atlantic Ocean), southerly (6% to the south Indian Ocean), or northerly (8% to equatorial Africa). The second mode is re-circulated transportation where material re-circulates over the subcontinent towards the point of its origin, on a regional or sub-continental scale (33%).

The overall re-circulating time ranges from 2 - 9 days, depending on the scale of the re-circulation. Atmospheric transport to the WBPA could occur directly through the easterly mode or by the recirculation mode. The air might also pass over other source areas (e.g. Johannesburg) and accumulate pollutants. The concentrations of the pollutants will vary depending on the time of atmospheric transport. Under this mode, it is likely that ambient air quality in southern Botswana will also be affected.

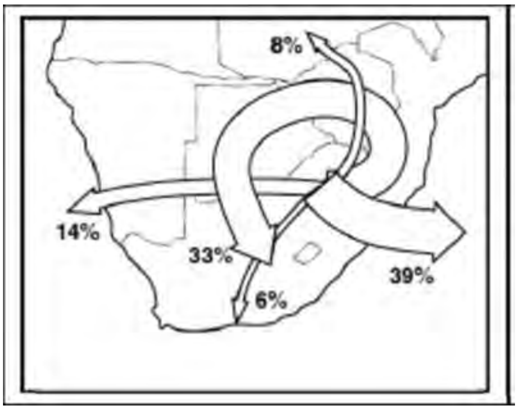


Figure 2-6: Transport from the Highveld industrial region showing percentage of transport occurring (Freiman and Piketh, 2003)

2.5 Dispersion potential of the WBPA

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 stability of the atmosphere and the depth of the surface mixing layer define the vertical component. The horizontal dispersion of pollution in the boundary layer is primarily a function of the wind field 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 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), 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 lower 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 WBPA, the dispersion potential is expected to be relatively good during the day in the winter and summer as a result of hot daytime temperatures and a relatively high frequency of moderate winds. Dispersion potential will be better in summer than winter for several reasons. Summer rainfall is an important removal mechanism for air pollutants, thermal mixing is stronger and night-time temperature inversions are weaker and less persistent. There is a higher frequency of stronger winds in summer than in winter. Generally, higher ambient air pollution concentrations are expected in winter than in the summer in the WBPA.

2.6 Socio-economy

The BPDM population constitutes approximately 32% of the province's total population. About 35% of the total households in the province are located within the BPDM, with 44% in rural areas and 22% in urban areas. Based on the Census 2011, the BPDM has a total population of approximately 1 507 506 (Stats SA, 2014) (Figure 2-7). There is also a fair distribution between male and female individuals at the district level, with a moderately larger male population. Rustenburg LM has the largest population in the district (45%), followed closely by Madibeng LM with 36% of the district's population. Moses Kotane LM hosts 19% of the district's population.

Based on the Census 2011, the WDM has a total population of approximately 679 336 (Stats SA, 2014) (Figure 2-7). There is also a fair distribution between male and female individuals at the district level, with a moderately larger male population. Mogalakwena LM has the largest population in the district (49%). Lephalale LM has (16%) of the population with most of the population located in Lephalale town. Modimolle LM has (12%) of the population with the majority of the population located in Modimolle town. Thabazimbi and Bela-Bela LMs have 10% and 8%, respectively, of the population within the district. The smallest population group (3%) is found in Mookgopong LM.

The population distribution in the WBPA is dominated by the BPDM as it hosts 66% of the priority area's population, with 34% living in the Waterberg District.

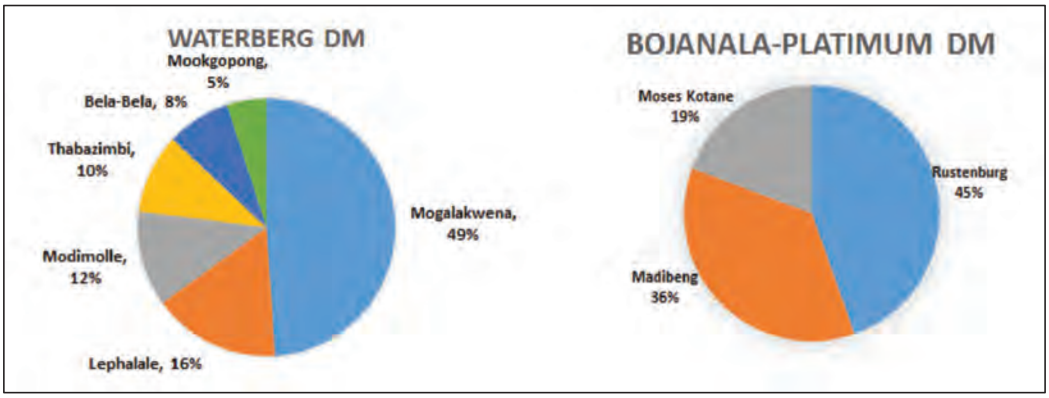


Figure 2-7: **Population summary across the WBPA (After StatsSA, 2014)**

Income distribution in the WBPA shows a large percentage of the population has no income (42%) (StatsSA, 2014) Figure 2-8). In addition, 58% of the priority area's population earn less than R1 600 a month. This highlights the need for secondary and tertiary employment opportunities in the priority area, which must be balanced with environmental goals.

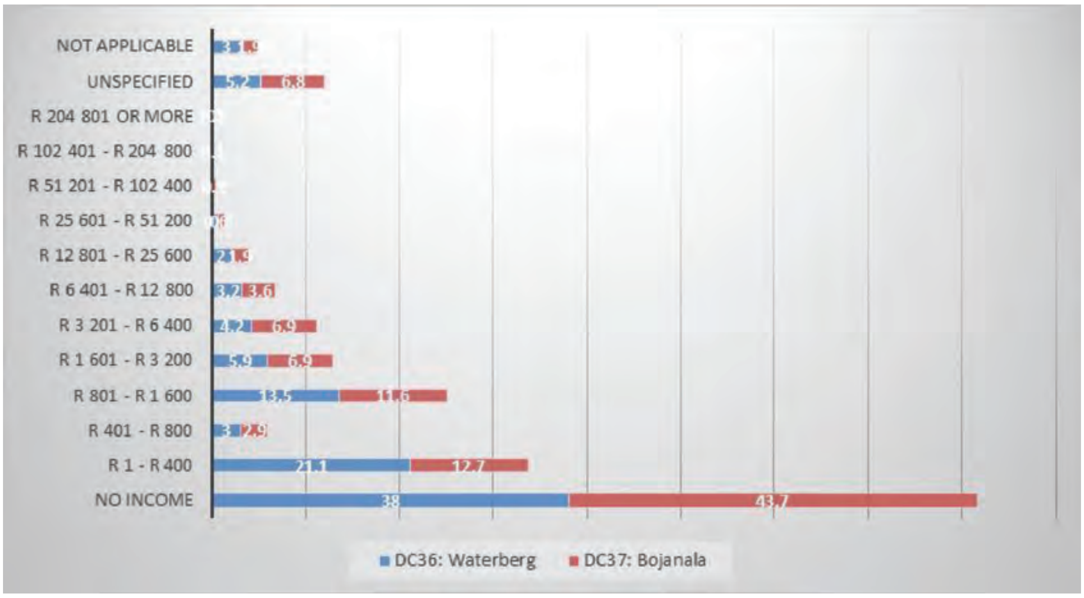


Figure 2-8: **Individual monthly income breakdown (After StatsSA, 2014)**

3 STATUS OF AIR QUALITY MANAGEMENT

This section interrogates the existing sources of documented information available for the WBPA, as described in AQMPs. No further processing was done and the data are presented as historical input into the baseline characterisation for the WBPA.

3.1 Existing AQMPs

AQMPs were developed for the WDM (Waterberg DM, 2009), BPDM (Bojanala-Platinum DM, 2011), Limpopo Province (LDEDET, 2013) and the North West Province (NWDACE, 2009).

The section considers:

- AQMP activities and data included,
- Issues and challenges described and the influence on the WBPA AQMP,
- AQMP goals for the different authorities in the region.

3.1.1 North West Provincial AQMP

The North West Provincial AQMP was compiled in 2009, prior to the guideline to air quality management planning being developed by the DEA in 2012 (DEA, 2012c).

The baseline assessment was informed by various air quality studies and reports, information from the existing monitoring network, an emission inventory, which is flagged as not conclusive, and the registration certificates for all scheduled industrial processes in the North West. The main information source was the North West Clean Air report compiled in 2008. Issues and challenges identified from the baseline assessment are summarised in Table 3-1 and discussed further here.

Air quality issues

There was no comprehensive, accurate and up to date emission inventory for the province at the time of the AQMP compilation. Therefore, the identification of emission sources and pollutants of concern was limited. The baseline assessment findings were:

- Motor vehicle emissions are confined to urban areas and are associated with Pb, SO_2, NO_x, CO and noise.
- Human settlements and residential fuel burning activities are identified as substantial contributors of emissions.
- Industrial activities are associated with scheduled process related emissions, unscheduled process related emissions and power generation.
- Mining activities are identified as sources of PM, asbestos fibres, heavy metals, odours and noise.

- Other sources not categorised were emissions from landfill sites and informal waste burning. These sources could be potentially significant and should be investigated further when the AQMP is updated in the 2014 review.

Ambient air quality monitoring

The baseline assessment identified a need for a continuous ambient air quality monitoring network within the province to inform decision-making. Ambient air quality data was limited to the main industrial areas (i.e. Brits and Rustenburg), with no ambient quality data for the other industrial and mining areas, and rural areas. The assessment used ambient air quality monitoring data collated from private networks of AngloGold Ashanti, Anglo Platinum, Impala Platinum, and Lonmin Platinum, as well as the provincial government network. The ambient air quality monitoring was mainly restricted to PM_{10}, SO_2 and dust fallout, measured by the private networks. The government-operated networks measured SO_2, NO_x, PM_{10} and O_3.

Other issues

The baseline assessment stated that the capacity of provincial and municipal AQO's to execute their statutory AQM functions needs to be at appropriate levels. This should ensure successful provincial AQMP development and implementation, and for subsequent municipal AQMPs. A lack of air quality awareness was also identified as an issue, as well as lack of monetary resources to fund air quality initiatives. The overarching goals were outlined in the AQMP are depicted in Table 3-2.

3.1.2 Limpopo Provincial AQMP

The Limpopo AQMP, developed in 2013, included a baseline assessment and an emission inventory report. The baseline assessment identified current source groups in the province and provided a status quo of ambient air quality. Issues and challenges identified from the baseline assessment are summarised in Table 3-1.

Emission sources

Source groups assessed in the Limpopo provincial AQMP included industry, mining, domestic fuel burning, motor vehicles and biomass burning. Contributions from these source sectors were found to vary across districts, with the Waterberg and Capricorn DMs having the most source locations. Meteorological data was sourced from SAWS and information on current industry permits and AELs was obtained from SAAQIS and various government departments. Census data and Environmental Impact Assessments (EIA) also informed the status quo assessment for the province.

Ambient air quality monitoring and modelling

Monitoring networks in the province were concentrated in urban and industrial areas with few background sites. Four areas were selected for dispersion modelling based on the locations of significant sources and available emissions data.

- Polokwane region because of the high incidence of sources;
- Lephalale region because it was the only region in the province with power stations and large scale coal mining operations;
- Phalaborwa region is the only region with fertiliser manufacturers, a copper smelter and two large open cast mining operations;
- Steelport Valley is an area with a significant number of mining activities.

They identified high SO_2 concentrations affecting towns as the main concern in the Phalaborwa region. The area around Lephalale posed a concern for the future, and PM_{10} concentrations were predicted to exceed the NAAQS near human settlements.

Other issues

A capacity assessment of existing AQM revealed a lack of capacity at both provincial and district levels. Assumptions used in the AQMP, that potentially decreased the accuracy of information presented, included the use of generic information for emission sources where information was unavailable, and the inclusion of the provisional WBPA emission inventory as the inventory was still being developed. The AQMP recommended revision in two years to update this information.

The AQMP contained strategic goals and objectives for the province, which informed the compilation of the WBPA AQMP. These are summarised in Table 3-2. Updated and accurate emissions information will have to be used to formulate the AQMP for the WBPA.

3.1.3 Waterberg DM AQMP

The WDM AQMP, developed in 2009, included a status quo assessment, feasibility study, AQMP, and stakeholder engagement. Issues and challenges identified from the baseline assessment are summarised in Table 3-1.

Emission sources

An emissions inventory for the Waterberg District was compiled from air pollution sources where information was available or where emission factors could be applied to quantify emissions. Lephalale LM had the highest industrial emissions, contributing to approximately 96% of emissions in the district. Matimba Power Station and Grootegeluk Coal Mine are the main contributing sources of emissions in this municipality.

Power generation was identified as a main source of SO_2 emissions and PM_{10} emissions (68%) in the district, although this is likely to have been overestimated as most mines did not provide their emissions data, and therefore it was not possible to fully quantify emissions from mining. Power generation was also reported as the main contributing source to NO_2 emissions in the district, contributing to 93 – 95% of total emission loading. Fugitive dust emissions were attributed to mining activities. Industrial emissions from small boiler sources and brickworks contributed to PM_{10} and SO_2 concentrations.

Domestic burning of coal and paraffin occurs in informal settlements such as Mahwelereng (Mogalakwena LM), Marapong (Lephalale LM), and Regorogile and Ipeleng (Thabazimbi LM). Mogalakwena LM was the largest contributor to domestic fuel burning emissions in the district, contributing to approximately 52% of emissions.

Vehicles were not considered a significant air pollution source in the district; petrol and diesel vehicles mostly travel along major roads and the N1 highway. Emissions from vehicle entrainment of dust from paved and unpaved roads have not been quantified as part of the district AQMP. Thabazimbi and Lephalale LMs were the main contributors to vehicle emissions, contributing 28% and 24%, respectively. However, the contribution of Bela-Bela, Modimolle, Mogalakwena and Mookgopong LMs to vehicle emissions may have been underestimated as vehicle volumes on the N1 highway could not be obtained.

Although not quantified, agricultural activities were considered an important source of ambient particulate matter concentrations. Thabazimbi LM was the main contributor to agricultural activities in the district, contributing to almost 40% of the district's GDP. Biomass burning was also not quantified, but was also considered an important contributor to particulate matter concentrations, particularly during the burning season.

Seven licenced general waste landfill facilities were identified in the district. Waste disposal could be a source of air pollution. Emissions have not been quantified for other fugitive dust sources, such as wind erosion of exposed areas.

WDM AQMP elements

The vision of the WDB AQMP is the:

> "Attainment and maintenance of good air quality for the benefit of all inhabitants and natural environmental ecosystems within the Waterberg District Municipality".

The mission to achieve this is:

- To ensure the maintenance of good air quality through proactive and effective management principles that take into account the need for sustainable development in the future.

- To work in partnership with communities and stakeholders to ensure the air is healthy to breathe and is not detrimental to the well-being of persons in the district.
- To ensure that future developments (transportation, housing, etc.) incorporate air quality impacts.
- To reduce the potential for damage to sensitive natural environmental systems from air pollution, both in the short and long-term.
- To facilitate intergovernmental communication at the Local, Provincial and National levels to ensure effective air quality management and control in the Waterberg District (Waterberg DM, 2009).

The strategic goals are listed in Table 3-2.

The plan gives guidance for the implementing authority and seeks to uphold the NEM: AQA through the identification of priority sources and pollutants, the assessment of the air quality status quo and the derivation of emission reduction strategies in the implementation plan. These strategies are accompanied by timeframes and responsibilities. The importance of intergovernmental cooperation is reflected in the plan with different spheres of government assigned different roles and responsibilities.

There is a need for specific by-laws for the district. A monitoring, evaluation and review process is lacking in the WDM AQMP. The AQMP states that Province must provide support and guidance for implementation to the WDM. Time frames and responsibilities should be clarified further. This includes removing responsibilities for other spheres of government and stakeholders. The Manual for Air Quality Management Planning has been revised (DEA, 2012c) and the AQMP should be reviewed to incorporate these changes. The WBPA AQMP should further unpack the role of the district and local municipalities as well as the guidance and support role of the provincial authority.

3.1.4 Bojanala Platinum DM AQMP

The AQMP was compiled in 2011. The BPDM was identified as an area of poor air quality in the 2007 National Framework, and the baseline assessment confirmed this statement, highlighting the industrial area of Brits. Issues and challenges identified from the baseline assessment are summarised in Table 3-1.

Air quality issues and emission sources

Air quality impacts were found to extend from Rustenburg towards Brits, up the eastern boundary. The majority of industrial and domestic fuel burning sources are located in this area. The other local municipalities were found to have relatively low pollution loads.

Emissions from industrial operations were largely attributed to small boiler sources and industries such as galvanising works and autocatalytic manufacturing. The main pollutants generated from these processes are PM_{10}, $PM_{2.5}$, CO, NO_x, SO_2, and Pb. Agriculture is the dominant land use in the region and these activities are associated with emissions of PM_{10} and $PM_{2.5}$. Moses Kotane LM was found to be the largest contributor to biomass burning emissions, associated with emissions of PM_{10}, $PM_{2.5}$, CO, NO_x, and SO_2. The use of wood, coal and paraffin was confined to low-income, densely populated rural areas and informal settlements.

The main area of concern for motor vehicle emissions was noted to be along the N4 highway. High vehicle emissions were reported in Rustenburg and Madibeng LMs, as the most industrialised municipalities within the district.

There are several landfill sites in operation in the district; these were identified as sources of heavy metals, dioxin and furan emissions. Trans-boundary emissions were also identified as a source of pollutants in the district, but specific pollutants were not listed.

Ambient air quality monitoring and modelling

Ambient air quality monitoring data were sourced from Anglo Platinum, Impala Platinum and Wesizwe Platinum. These stations monitor SO_2 and PM_{10}. There are four monitoring stations in Rustenburg LM, however, ambient air quality monitoring data from these stations was not used to inform the baseline assessment. Dispersion modelling was used to determine the spatial extent of ambient concentrations within the district. The emissions data used for modelling was provided by NAPCoF. The model results show that by excluding industrial emissions, no exceedances of both the PM_{10} and SO_2 levels would be experienced throughout the district.

The strategic goals for the Bojanala Platinum DM AQMP are summarised in Table 3-2. The emissions inventory was not comprehensive and BPDM should establish a district level emissions inventory. For effective air quality management and control, an accurate emissions inventory needs to be established and regularly updated and maintained.

3.1.5 Summary of AQMP issues and challenges in WBPA

Several common shortcomings were noted through the AQMP review. Some AQMPs were compiled prior to the 2012 revision of the Manual for Air Quality Management Planning (DEA, 2012c). As such, they did not reflect these changes, and require updating. These are first generation AQMPs. While the context for each district and organisational level differs, the AQMPs reviewed in this section highlighted similar issues.

Emission sources

- Emissions of SO_2, PM and NO_x from industry and power generation were identified as a potential threat to ambient air quality.
- Motor vehicle emissions were only an air pollution problem in built-up areas and along busy roadways.
- Emissions from mining activities were identified in all the AQMPs and the WBPA AQMP should investigate this further with updated and accurate information.
- Domestic fuel burning in rural areas was also identified as a source of emissions.
- Trans-boundary movement of air pollutants was identified in both the North West and WDM AQMPs but were not quantified.
- Other sectors not quantified, but highlighted as potentially significant sources of emissions in all the AQMPs were waste disposal and informal burning of waste, agricultural activities and biomass burning.

AQMP elements

- Many of the AQMPs required a greater emphasis on the monitoring, evaluation and review component.
- Roles and responsibilities needed to be clearly defined according to the requirements of the National Framework (DEA, 2007).
- Capacity building is an important component of AQMP development, especially for local governments who are now faced with numerous responsibilities and challenges that require highly specialised skills (Naiker *et al.*, 2012; Murray, 2013; Davies, 2008).

The scope of this review did not include the efficacy of AQMP implementation, but of the AQMP contents and structure across different spheres of governance. The Manual for Air Quality Management Planning (DEA, 2012c) provides a set of key questions to be considered when evaluating the efficacy of AQMP interventions. This step usually takes place on a yearly basis and the AQMP is refined to incorporate the review findings. Appropriate indicators need to be developed in the plan to monitor progress towards achieving compliance goals (DEA, 2012c). After five years, the AQMP is revisited and the development process repeated. The WBPA AQMP will consider the efficacy of implementation measures, particularly with regard to cooperative governance strategies, to ensure that Provincial, District and Local AQM initiatives are aligned.

3.1.6 Considerations for AQMP development

Based on this review, the following focus areas were identified for the development of the WBPA AQMP:

- The designation of roles and responsibilities for AQM is the first step in the implementation of NEM: AQA. The success of the AQMP is hinged on extensive capacity building.
- Cooperative governance between the different spheres of government is key to avoiding ambiguity over functions, and optimising resources, where there are competing or overlapping air pollution priorities. This also encourages stronger and more effective policy and planning decisions that have the ability to address complex air quality issues (Murray, 2013).
- Key stakeholders need to play a role in implementation, e.g. industries and civil society, as active stakeholder engagement strengthens the AQMP process.
- The devolution of specific aspects of AQM control of a local government level, with the intervention of provincial and national authorities, where necessary, creates an opportunity to bring together diverse air quality views, and ensures compliance with NEM: AQA. There has been a greater degree of success in the implementation of AQMPs where local governments as regulators participate actively in the management of air quality and enforce legislation (Murray, 2013).

Table 3-1: Issues and challenges for WBPA authorities

Region	**Emissions and sources**	**Ambient air quality monitoring**	**Governance**
Limpopo (LDEDET,2013)	• Industry, Power Generation • Brickworks • Incinerators • Small boilers • Wood treatment • "Back-yard" aluminium smelting • Waste disposal • Domestic fuel burning • Vehicles	• Lephalale area – Waterberg DM	• One of the major obstacles identified at national, provincial and local levels is capacity in terms of resources, tools and finances for AQM. • This should be a priority strategy objective as part of the AQMP.
North-West (NWDACE, 2009)	• Motor vehicle emissions • Human settlements • Veld fires • Industrial activities • Mining • Agriculture • Regional air movements between provinces • Greenhouse gas emissions • Informal burning • Landfill sites, incinerators	• Damonsville Community Centre-Madibeng • Phokeng Civic Centre • Moruleng Community Centre – Bakgatla • Jouberton • NWREAD Offices: Agricentre Building • Private monitoring by industry and mines	• Most municipalities did not have capacities to determine the extent of capacity requirements. • NWREAD needs to identify suitable courses that air quality officers, technicians and atmospheric scientists need to attend to ensure execution of the AQMP**.**
Waterberg (WDM,2009)	• Power generation • Mining • Industrial emissions • Domestic fuel burning • Vehicle emissions • Agricultural activities • Biomass burning • Waste Treatment/ Disposal	• An ambient air quality monitoring station should be installed in the district and should measure a range of pollutant and meteorological parameters	• Local Municipalities do not have enough capacity in terms of personnel, budget or equipment to undertake their air quality functions in terms of NEM: AQA. • Few AQM or control functions are undertaken by the Local Municipalities. Air quality support is

	• Vehicle entrainment of dust • Other fugitive dust sources		provided to the Local municipalities from Province and District.
Bojanala-Platinum (BPDM,2011)	• Industrial operations • Agricultural activities • Mining activities • Biomass burning • Domestic fuel burning • Vehicle tailpipe emissions • Waste treatment/ disposal • Trans-boundary transport	• Anglo platinum • Impala platinum • Wesizwe platinum • Boitekong • Marikana • Thlabane	• Shortage of personnel, skills and tools required for effective and co-ordinated air quality management.

Table 3-2: Strategic AQMP Goals and Objectives for Different Authorities in the WBPA

Region	**Goals**
Limpopo (LDEDET,2013)	1. Manage and control atmospheric emissions from major sources within the province to ensure compliance with emission limits and ambient air quality standards
	2. Establish an effective AQM system in the province
	3. Establish and maintain sustainable AQM practices within the province incorporating all relevant stakeholders and role players
North West (NWDACE,2009)	1. To develop and maintain institutional arrangements that support sound AQM and governance in the Province.
	2. To reduce the negative impact on human health and environment of poor air quality
	3. To reduce impacts of fossil fuels in residential applications
	4. To address the effects of emissions from industrial sources
	5. To quantify and reduce transport air emissions within the Province
	6. To ensure effective communication and public participation in pursuant to legal requirements
Waterberg (WDM,2009)	1. Implementing the AQMP within the district
	2. Assigning clear responsibilities and functions for AQM at both the district and local levels
	3. Air quality training of current and future air quality personnel
	4. Obtaining the necessary resources and funding for AQM in the district
	5. Preliminary monitoring of identified 'hotspot' areas in the district to determine air pollutant concentrations
	6. Undertaking continuous ambient air quality monitoring to obtain a long-term record of air quality in the district
	7. Maintaining good air quality within the boundaries of the Waterberg district, with specific emphasis on PM_{10} and SO_2 concentrations
	8. Compliance monitoring and enforcement of air quality legislation, policies and regulations in the district
	9. The contribution of mining to ambient air quality in the district
	10 Assessing the contribution of agriculture to ambient air quality and establishing measures to control emissions from these sources
Bojanala-Platinum (BPDM,2011)	1. Achievement of acceptable air quality levels
	2. Compliance to legal requirements
	3. To reduce emissions
	4. To continually improve air quality for the area

3.2 Emission inventories from previous AQMPs

Emission inventories were compiled for the AQMPs for the WDM and BPDM (BPDM, 2011; WDM, 2009). The BPDM AQMP uses emission data prepared in the period 2008-2011, and the WDM AQMP was prepared in 2009 using limited data. The BPDM emission inventory data show the three municipalities that form part of the WBPA. Madibeng and Rustenburg LMs contribute significantly across all pollutants considered, i.e. PM_{10}, NO_x, and SO_2. NO_x and SO_2. The relative emissions of particulates from mining in the BPDM are shown in Table 3-4. The fraction of fine particles in the particulate emission is higher in Rustenburg LM than the coarser 10 µm fraction. This is a further indication of the industrial emission source contributions in this area, as finer particulates are generated through combustion and similar processing.

Table 3-3: Historic emissions for major existing industrial sources in Bojanala Platinum DM (Bojanala Platinum DM, 2011)

Municipality	**PM_{10}**	**(%)**	**$PM_{2.5}$**	**(%)**	**NO_x**	**(%)**	**SO_2**	**(%)**
Madibeng	648.8	55.78	279.8	55.37	2 398.6	27.54	6 758.5	22.47
Moses Kotane	40.1	3.45	1.3	0.26	495.3	5.69	51.3	0.17
Rustenburg	423.3	36.39	205.5	40.67	5 815.3	66.77	23 230.2	77.23

Table 3-4: Historic emissions for major existing mining sources in Bojanala Platinum DM (Bojanala Platinum DM, 2011)

	Tailings				**Open mining areas**			
	PM_{10} (tpa)	$PM_{2.5}$ (tpa)	Surface area (km^2)	No.	PM_{10} (tpa)	$PM_{2.5}$ (tpa)	Surface area (km^2)	No.
Madibeng	24 916.77	3 737.52	3.93	36	1 624.20	243.63	6.01	23
Moses Kotane	251.60	37.74	0.05	1	0.00	0.00	0.00	0
Rustenburg	27 808.80	4 171.32	3.13	32	2 074.10	311.11	8.29	20
BPDM (Total)	56 861.69	8 529.25	7.51	73	3 728.55	559.28	14.37	45

The inventory for the WDM showed power generation activities as the greatest contributor to PM_{10}, NO_2 and SO_2 (Table 3-5). Smaller contributions were from mining activities to PM_{10} in particular and SO_2 to a lesser degree. Other industrial activities contribute to PM_{10} emissions. Vehicles make a minor contribution to NO_2 emissions in the district.

Table 3-5: Historic emissions for major existing sources in Waterberg DM (Waterberg DM, 2009)

Sector	SO_2	%	PM_{10}	%	NO_2	%
Power generation	304 217	95	8 226	68	69 096	93
Industry	114	0	1 171	10	1 034	1
Mining	14 664	5	2 067	17	72	0
Vehicles	400	0	190	2	4 222	6
Domestic	21	0	444	4	55	0
Total	**319 416**		**12 098**		**74 479**	

According to WDM's AQMP (2009), Lephalale was the main contributing Municipality to PM_{10} (86%), SO_2 (95%) and NO_2 (94%) emissions in the District, predominantly due to emissions from Grootegeluk Coal Mine and Matimba Power station. Mogalakwena was the second largest contributor to PM_{10} emissions (12%) due to emissions from small industries and brickworks. Thabazimbi was the second largest contributing municipality to SO_2 emissions (5%), mainly due to emissions from the Northam Platinum Mine. Emissions from activities such as the Thabazimbi Iron Ore Mine were not included in the inventory and therefore contributions per municipality, and the inventory as a whole, may not be accurate.

3.3 Ambient air quality monitoring

The Amplats stations at Brakspruit, Paardekraal and Klipfontein showed many exceedances of the 24-hour limit value for PM_{10}. A similar profile was evident at Implats stations with numerous exceedances of the 24-hour PM_{10} limit value. Luka and Boshoek showed regular high concentrations, with a poor data record at Services for the period reviewed. Luka showed a distinct domestic fuel burning profile compared to the other Implats stations.

In the WDM, Eskom operated a monitoring station at Grootstryd, later moving it to Marapong near the Matimba power station. Monitoring results are presented in Table 3-6. The Grootstryd ambient air quality monitoring results were representative of maximum ground level concentrations immediately downwind of the Matimba Power Station, whereas results from Marapong represented conditions upwind of Matimba, which were strongly influenced by local activities in Marapong. There was compliance with SO_2 ambient air quality standards at both monitoring stations, although exceedances of the SO_2 limit values were noted at both sites during the monitoring period. There was non-compliance with the PM_{10} 24-hour standard at Marapong from 2011 to 2013, but there was compliance from 2007 to 2010 and the 2014.

Hourly exceedances were noted for SO_2 at both sites during the monitoring period, and an exceedance of the PM_{10} 24-hour limit value was also noted at Marapong. Further analysis also showed 24-hourly PM_{10} exceedances at Grootstryd throughout the monitoring period, and further exceedances in following years at Marapong. Annual averages for SO_2 and NO_2 were low overall across all sites. This was contrasted against high PM_{10} values annually at both siting locations.

Table 3-6: Historical monitoring results from Eskom's monitoring station in Lephalale (after Waterberg DM, 2009)

		Grootstryd		**Marapong**		
	Year	*PM_{10} (µg/m³)*	*SO_2 (ppb)*	*PM_{10} (µg/m³)*	*SO_2 (ppb)*	*NO_2 (ppb)*
Max. 1-hr average	2005	510.8	**206.0**			
	2006	628.0	**178.0**	280.7	101.9	
	2007			675.3	**156.7**	
	2008			562.4	**178.3**	45.99
Max. 24-hr average	2005	*141.3*	43.5			
	2006	*135.1*	27.6	64.4	20.4	
	2007			*137.8*	44.8	
	2008			**181.4**	24.8	16.0
Annual average	2005	40.3	5.1			
	2006					
	2007			32.8	3.1	
	2008			41.2	3.5	5.8

NB. Grootstryd monitoring station was decommissioned in August 2006 and re-located to Marapong.
Exceedances are shown in bold type.

3.4 Research

Compared with the VTAPA and the HPA, relatively little air quality research has been conducted in the WBPA. The most comprehensive study is the Regional Environmental and Social Assessment (RESA), which examines the cumulative environmental and socio-economic impacts of all the planned and existing energy sector investments on both sides of the border between Botswana and South Africa (DEA, 2012d). Other research done in the area was presented at the DEA WBPA research seminar, held in Pretoria on 28 May 2012. An overview is presented here.

3.4.1 Regional Environmental and Social Assessment

Cumulative and potential cross border effects are typically not assessed in project specific EIAs. Given the scale and potential rapidity of development of energy projects in the Botswana-South Africa border, cumulative and cross-border impacts are highly likely. It was therefore essential to characterise the nature and scale of these impacts through the RESA study.

Emissions from the energy projects were estimated from different information sources. Those from energy projects in Botswana are significantly less than those in South Africa and are less than 20% of the combined totals. Although infrequent, there are easterly and westerly winds that blow along the axis of development of most of the major projects that would serve to combine emissions from all facilities in a manner not currently dealt with in the individual EIAs. EIAs for individual projects have indicated localised areas where defined air quality standards, and the World Health Organisation (WHO) guidelines in particular, are likely to be exceeded. With the proliferation of coal-fired activities in the Botswana-South Africa border areas, very high ambient pollution concentrations could occur.

The Botswana-South Africa border area is sparsely populated, suggesting that the exposure of people to air pollution will be limited. The largest urban settlements are Lephalale and Onverwacht in South Africa and Palapye, Mahalapye, Mochudi and Gaborone in Botswana. Other urban centres will likely develop (e.g. a town associated with the Mafutha project) as well as informal residential areas as work seekers move into the area. Exposure to relatively high pollutant concentrations in these areas is therefore likely.

3.4.2 DEA research seminar

Presentations at the DEA seminar included research initiatives and reports on current and proposed ambient air quality monitoring as well on AQMPs for municipalities. An overview of the research activities is provided here. AQMPs are reviewed in earlier sections of Section 3 and monitoring is discussed in Section 4.

The Spatial Distribution of Haze over the Bojanala District: Beverley Barnes

The objective of the research was to characterise the spatial and temporal distribution of the tropospheric aerosol burden over the Bojanala District in the North West Province of South Africa and to assess whether the optical properties of the aerosols could be used to quantify the relative importance of combustion and non-combustion sources to the aerosol load. Key findings of the research are that the atmospheric optical thickness (AOT), or the aerosol concentration in the atmospheric column, is highest during winter, AOT is highest during the morning, local sources impact heavily on the aerosol concentrations of various sites, combustion particles are becoming more important, and regional air masses have a significant impact on AOT.

Potential impacts of climate change on photochemistry and air quality in the Waterberg region: Francois Engelbrecht and Mogesh Naidoo

This research simulated annual temperature anomalies relative to the 1961-1990 climatological average 2071-2100 vs. 1961-1990. Under the IPCC A2 emission scenario, temperature is predicted to increase by more than 4 ºC in the Waterberg region with drastic increases in the number of very hot days per annum. The A2 emission scenario is characterised by independently operating, self-reliant nations, continuously increasing population and regionally oriented economic development. The drastic increases in surface temperatures result from stronger high-pressure systems and increased subsidence over the region. Reduced cloud cover will lead to stronger inversion layers at night and more solar radiation reaching the surface during the day, which in turn, is likely to affect local atmospheric chemistry, photochemistry and air quality. The photochemistry is the subject of on-going research.

Atmospheric corrosion monitoring study in the Lephalale area: Abel Moatshe et al

The objectives of the research were to measure the seasonal fluctuations in the corrosivity of the different sites in the Lephalale area, to determine the corrosion rates for different metals, to classify the corrosivity of the environments in terms of international standards, and to identify the key corrosion elements measured in the corrosion products. The key findings were that the corrosion index values were in the negligible range and showed an increase in spring-summer period due to the increase in moisture during the summer rainfall period. The highest atmospheric corrosion rates and indices were recorded at the Grootegeluk mine site, the adjacent Medupi construction site and Zaagput farm. Additionally, the lowest values were recorded for the Onverwacht site, which was located in an urban area. The overall conclusion was that the Lephalale area could be classified as a low corrosive environment.

Air quality and environmental health in South Africa – potential applications in the Waterberg area: Rebecca Garland

Baseline health assessments have been done on a larger scale that includes local municipalities in the WBPA. These provide the status quo of a population compiling available information and the focus not just on diseases or illness, but all factors that might impact health and well-being. The presentation detailed how the baseline assessments are important inputs to Human Health Risk Assessment or stand-alone studies in EIA.

Meteorological and Air Quality Modelling for the Waterberg Region: Maluta Mbedzi and Kristy Langerman

The research evaluated dispersion models and available meteorological data. The research concluded that meteorological data are scarce and prognostic meteorological models appear to offer a better and much more cost-effective alternative way to generate data for different modelling applications. In addition, it was found that CALPUFF performed the best of a number of dispersion models, both in terms of predicted zone of maximum influence and the magnitude of the predicted concentrations. It was also concluded that the use of Pasquill-Gifford (PG) or McElroy-Pooler (MP) dispersion coefficients versus coefficients calculated using micrometeorological variables needed to be assessed for the Waterberg region. In addition, the use of the probability density function used for dispersion under convective conditions needs to be assessed for the Waterberg region.

Toward a comprehensive criteria pollutants & GHG emissions inventory for the Waterberg and Bojanala-Platinum DM: Theo Fischer

The research proposed methodologies for the development of a comprehensive emission inventory for the WDM and BPDM for criteria pollutants, considering six sources types. It was concluded that emissions inventory development for a number of sources is complex and GIS methods are well suited for this, and a national emission data set had been developed using this methodology.

4 WBPA AIR QUALITY STATUS QUO

The air quality status quo examines available sources of data to determine the status quo for the year of interest for the baseline assessment, viz. 2012. It comprises data on emission sources, ambient air quality monitoring and dispersion modelling, as well as a capacity assessment. It is informed by the best available information across all sectors.

4.1 Emission sources

Emission sources are described with an updated emission inventory for WBPA, which was also used as an input for dispersion modelling for certain sectors. The emission inventory examines the major sectors in available detail and provides broader estimates and information for other smaller sectors. Listed activities, residential fuel burning, mining and trans-boundary sources are given detailed emission estimates. Motor vehicles, biomass burning and waste management are examined in an overarching manner at municipality level. Emission estimates are provided for SO_2, PM_{10} and NO_x.

4.2 Industrial emissions

4.2.1 Source description

There are several industries that operate Listed Activities in the WDM and BPDM. The key emission sources from their operations are combustion devices such as boilers, furnaces, gas turbines, gas engines, diesel engines, incinerators and flares. Combustion devices are emitters of the priority pollutants (SO_2, NO_x, CO, PM_{10} and benzene) and greenhouse gases (CO_2, CH_4, and N_2O).

A large number of industrial processes and facilities make use of industrial boilers for steam and electricity generation. Industrial boilers use a range of fuels depending on boiler size and design characteristics, and on the availability or proximity of fuel. In many cases, the fuel is a by-product or waste product from other processes. The volume and nature of the emissions from combustion differs depending on the fuel composition and consumption, boiler design and operation, and emission and pollution control devices in use.

When fuels burn, they produce various pollutants. The non-combustible portion of the fuel remains as solid waste. The coarser, heavier waste is called “bottom ash” and is extracted from the burner. The lighter, finer portion is “fly ash” and is usually emitted as particulates through the stack. Products of incomplete combustion include CO, SO_x, NO_x, acid gases and VOCs. Metals and their compounds may also be entrained (i.e. carried forward by a stream of gas or vapour of fine liquid droplets).

Process heaters such as furnaces are used extensively to supply the heat necessary to increase the temperature of feed materials to reaction or distillation level. The fuels burned may be refinery fuel gas, natural gas, residual fuel oils, or a combination thereof, depending on economic and operating conditions, and emission requirements. Process heaters may also use CO-rich regenerator flue gas as fuel.

In the WDM and BPDM, the most commonly used fuels are coal, followed by gas, diesel and heavy fuel oil (HFO). Data to estimate emissions is available for a total of 12 industrial Listed Activities in the WDM and 28 in the BPDM. Several of these industries have one or several combustion units. Common processes types amongst the districts' Listed Activities include power generation, gold and platinum processing, chemicals manufacturing and storage, brick manufacturing, and ferrochrome production.

Figure 4-1 shows the location of listed activities in the WBPA. There is a concentration of industrial sources in the BPDM between Rustenburg and Brits. This is associated with high levels of mineral processing, which take place at the mines. Minimal industrial sources are located in the WDM, with Listed Activities in Thabazimbi, Modimolle, Mokopane and Lephalale LMs. Most notable is the Matimba power station in Lephalale LM.

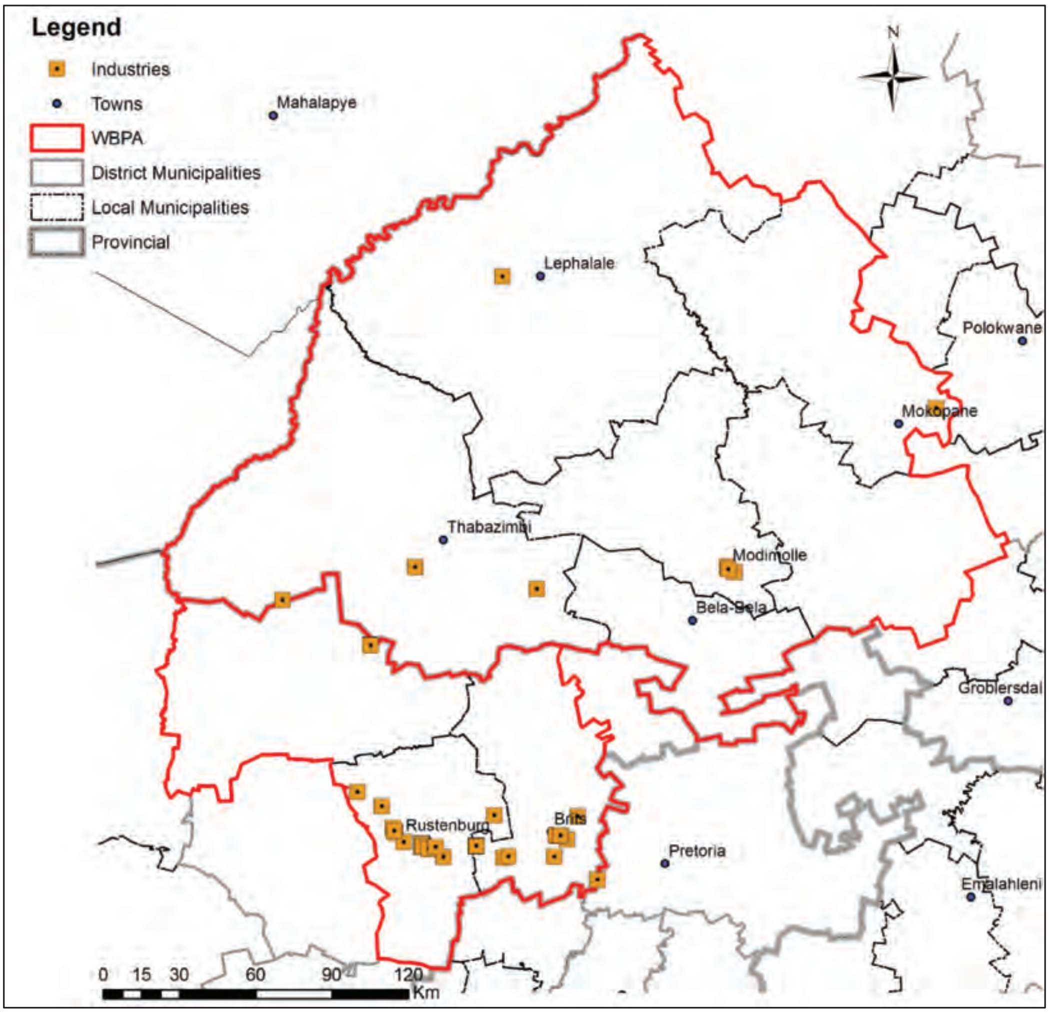


Figure 4-1: Relative location of industries in WBPA

4.2.2 Results of emission estimations

Waterberg DM

AEL applications and actual data were used to estimate emissions from industries in the WDM. Out of all the AEL applications in WDM, four of them lack adequate information. In addition, a petroleum storage depot in Mokopane is not a source of SO_2, NO_x or PM_{10} and is therefore not included in this assessment. Table 4-1 presents the emissions estimated for the industries in the WDM that emit SO_2, PM_{10} and NO_x.

Table 4-1: Emission distribution (in tpa) across industrial sectors in Waterberg DM

Industry Sector	SO_2	PM_{10}	NO_x
Cement production	8	222	1 797
Power generation	350 807	5 878	55 528
Mineral processing (including platinum ore processing)	214	259	29.6
Brick production	318	105	61
Animal feed production	3.6	1.2	0.7
Asphalt production	212	201	17
Meat production	0.3	0.04	0.8
Total	**351 563**	**6 666**	**57 434**

It is evident from Table 4-1 that the dominant industrial source sector in the WDM is power generation. It contributes >99% to the total SO_2 emission load from industries in the municipality, >62% to the total PM_{10} emission load and 99% to the total NO_x emission load. The SO_2 emissions of 350 807 tpa or 961 ton/day from the power generation sector was estimated by using emission factors and the fuel consumption data provided by industries. These relatively high emissions are partly due to the age of the power station and the lack of appropriate abatement technology.

Bojanala-Platinum DM

For the BPDM, a total of 30 AEL application forms were made available by the officials to extract information to estimate emissions from industries in the municipality. Of these, two applications lacked the information required to estimate emissions. Sources that do not emit any of the pollutants of concern for this assessment were not considered.

Table 4-2 presents the emissions estimated for the industries in the BPDM that emit SO_2, PM_{10} and NO_x.

Table 4-2: Emission distribution across industrial sectors in Bojanala-Platinum DM (in tpa)

Industry Sector	SO_2	PM_{10}	NO_X
Mineral processing (including platinum ore processing)	33 009	10 224	12 043
Motor vehicle manufacturing	0.0	15.1	0.0
Tyre manufacturing	1 448	212	773
Timber production	0.0	0.0	0.0
Petroleum industry	0.0	0.0	0.0
Ferro-alloy production	7 670	2 291	4 231
Asphalt production	22.2	14.4	2.4
Fluorochemical production	32.2	0.0	3.4
Non-ferrous metal production	1.1	0.1	130
Abattoirs	70	2.7	51
Agricultural industry	0.0	0.0	2.8
Total	**42 252**	**12 759**	**17 237**

Unlike the WDM, there is no single industrial source that contributes significantly to the total emission load in the BPDM. Whereas the total SO_2 emissions in the WDM exceed 353 905 tpa (969 ton/day), the figure for the BPDM was estimated at 42 252 tpa (116 ton/day), despite there being a significantly larger number of industrial sources in the BPDM. The key sources of SO_2 emissions in the BPDM is mineral processing, particularly of platinum ores, which in total emit more than 26 587 tpa or almost 63% of total industrial SO_2 emissions from the municipality.

Total PM_{10} emissions from industrial sources in the district were estimated at 12 759 tpa (36.1 ton/day). The most significant industrial sector, with a PM_{10} emission contribution of more than 77%, is platinum mining.

In terms of NO_x emissions, the district was estimated to emit a total of 17 237 tpa (47.2 ton/day) from its industrial sources (Table 4-3). Of these, the most significant industrial sector is also platinum mining, with a NO_x emission contribution of approximately 61% of total industrial NO_x emissions.

The priority pollutant estimated to be emitted in the greatest quantity is SO_2. This is primarily due to the combustion of high sulphur-containing fuels in the district municipality such as coal, coke, and heavy and light fuel oils.

Table 4-3: Emission distribution between the two WBPA districts (in tpa)

	SO_2	NO_x	CO	PM_{10}	VOCs
Waterberg DM	351 563	57 434	37 084	6 666	462
Bojanala-Platinum DM	42 252	17 237	2 225	12 759	290
WBPA	**393 815**	**74 671**	**39 309**	**19 425**	**753**

4.3 Residential fuel burning

Electricity usage in South Africa increased from 60% in 1995 to over 80% in 2010. However, many households are still reliant on paraffin, candles, wood and other sources of energy for domestic needs. The choice of fuel for household needs has an impact on both ambient and indoor air quality in the WBPA.

Electricity, paraffin, gas and candles are considered clean fuels with respect to air pollution. However, wood and coal burning are associated with human health impacts in indoor and ambient environments. Smoke resulting from incomplete combustion of wood and coal contains many harmful chemical substances, such as criteria pollutants, hazardous air pollutants (HAPs), fine particle pollution, volatile organic compounds (VOCs), NO_2 and SO_2.

The estimation of emissions from domestic burning in the WBPA was based on energy use data contained in the 2011 census (StatsSA, 2011), which delineates the number of households utilising fuels for domestic purposes (i.e. cooking, lighting, and space heating).

Electricity is the main fuel source in the priority area, but paraffin, wood and coal are used in cooking and space heating (Figure 4-2). The use of paraffin, coal and wood differs when comparing the WDM and BPDM. Wood use is higher in the Waterberg region for cooking, while households in Bojanala for cooking use paraffin more frequently. In both districts, wood use for space heating is high. Candles are most often used for lighting.

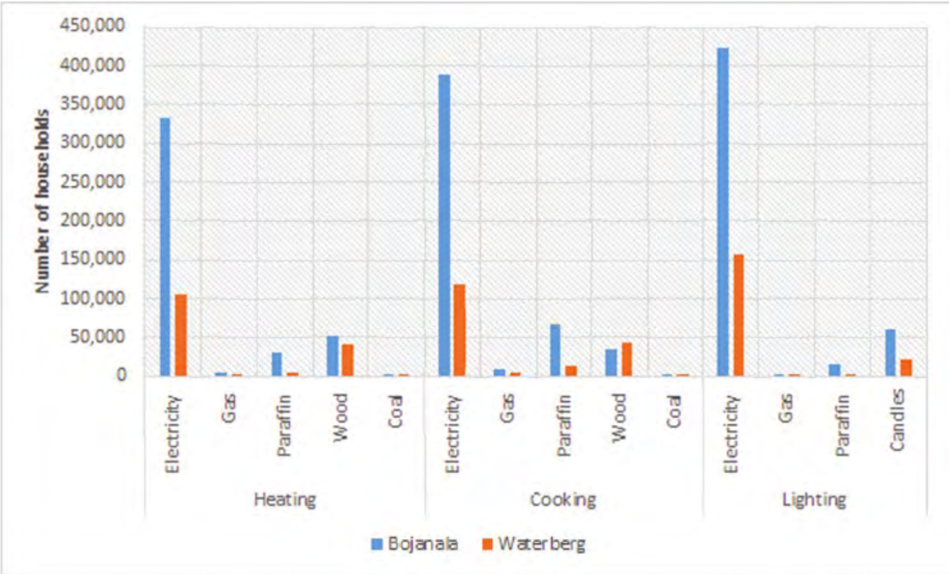


Figure 4-2: Fuel used by households for heating, cooking, and lighting in the WBPA

Based on total household fuel consumption, the use of wood is relatively higher than the use of other dirty fuels (Table 4-4). This is due to large quantities required in terms of energy generation, but also the predominant use of wood in the area as discussed previously. Wood has the highest emissions of criteria pollutants when compared to the other fuel types. Paraffin use is also high. The usage of coal is relatively low, but this could pose a threat to air quality in the future as coal becomes more available due to increased coal mining.

Table 4-4: Total household fuel consumption in local municipalities (in tpa) (FRIDGE, 2006)

	Cooking	Lighting	Heating
LPG	4.4	0.24	2.00
Paraffin	804	108	356
Wood	4452	0.00	4235
Coal	5.9	0.00	8.8

NO_x and PM_{10}, generated from domestic wood burning, produce the highest emissions of all fuel types considered (Table 4-5). This relates to the high level of emissions generated from this fuel type, and its predominant use in the WBPA. This highlights an area of focus for AQM interventions.

Emission distribution across WBPA local municipalities shows relatively high emissions of PM_{10} in Moses Kotane, Mogalakwena, and Rustenburg LMs (Figure 4-3, Table 4 6). Madibeng LM also had elevated PM_{10} emissions. The highest PM_{10} and NO_x emissions were estimated for

Moses Kotane LM, which also had the highest household wood and coal consumption in the priority area. High SO_2 levels in BPDM can be attributed to high paraffin usage.

Table 4-5: Emission distribution across fuel types (in tpa)

	SO_2	NO_X	PM_{10}
LPG	0.00	0.02	0.00
Paraffin	1.36	3.46	0.21
Wood	1.58	11.0	120
Coal	0.42	0.06	0.04
Total	3.35	14.6	121

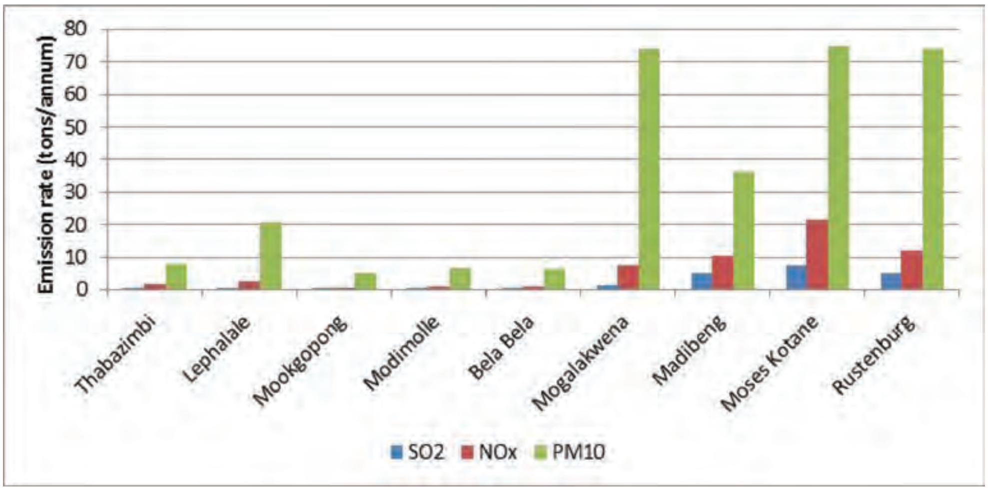


Figure 4-3: Residential fuel burning emission distribution across municipalities (in tpa)

Table 4-6: **Emission distribution across local municipalities for residential fuel burning (in tpa)**

	SO_2	NO_x	PM_{10}
Thabazimbi	0.66	1.99	8.04
Lephalale	0.58	2.57	20.8
Mookgopong	0.12	0.54	4.9
Modimolle	0.28	0.94	6.9
Bela- Bela	0.30	0.98	6.1
Mogalakwena	1.41	7.56	74.0
Madibeng	5.01	10.56	36.4
Moses Kotane	7.55	21.46	74.7
Rustenburg	4.92	12.02	74.0
Total	**20.8**	**58.6**	**305.9**

4.4 Motor vehicles

4.4.1 Previous emission estimates

Vehicle emissions were calculated for 2009 as part of the North West Province emission inventory. Figure 4-4 shows the spatial distribution of emissions across the province. Traffic emissions are notably high in the vicinity of Rustenburg and Brits. The report notes that "BPDM contains 16% of the major roadways, including a large section of the N4 and relatively high road traffic in the Brits-Rustenburg area, and is responsible for approximately 20% to 25% of the emissions from the province" (NWDACE, 2011). Annually, approximately 6 000 tons of NO_x and 120 tons of PM_{10} are attributed to vehicle emissions in the district.

Table 4-7: Vehicular emissions per pollutant for BPDM and the North West Province in tons per annum (extracted from NWDACE, 2011)

	BPDM	North West Province
Total roads (km)	808	4 823
NO_X	6 191	27 319
CO	17 806	71 512
SO_2	352	1 760
PM_{10}	119	626

The Waterberg-Bojanala Priority Area Air Quality Management Plan and Threat Assessment

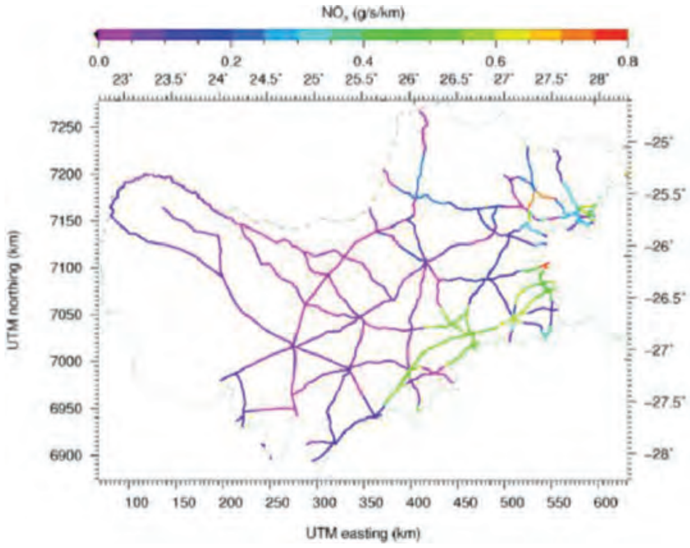


Figure 4-4: Traffic line source emissions for NO_X for 2009 in the North West Province (NWDACE, 2011)

Vehicle emission estimates were also prepared for WDM for 2009. The methodology used in preparing the emission estimates used generic travel distances and uniform emission factors across vehicle classes. The resulting emissions do not differentiate significantly across municipalities. The report shows high emissions in Mogalakwena, Thabazimbi and Modimolle (WDM, 2012). Mogalakwena LM is apportioned the largest emission contribution, of approximately 500 tons of NO_x and 34 tons of PM_{10} annually. SO_2 contributions are relatively small at 47 tons per annum.

Table 4-8: Vehicle emission estimates for Waterberg DM for 2009 (in tpa) (Waterberg DM, 2012)

	NO_x	SO_2	PM_{10}
Lephalale	226	21	15
Modimolle	285	26	19
Mogalakwena	510	47	34
Thabazimbi	291	27	19
Mookgopong	118	11	8
Bela-Bela	211	20	14
Waterberg DM	**1641**	**152**	**109**

4.4.2 Vehicle Emission estimates for 2012 WBPA inventory

Vehicle emissions were calculated for the WBPA for selected pollutants using the approach used in the development of the vehicle emission control strategy (DEA, 2013b). The methodology adopted is described further in Appendix 1. Significant emissions of NO_x are generated in the priority area for the year 2012, with over 11 000 tons per annum of NO_x (Table 4-9). These NO_x emissions are generated predominantly in the BPDM, with an apportionment of about two thirds of vehicle emissions across all pollutants. Rustenburg LM is the main driver for vehicle emissions generation. This is also consistent with the municipality's listing in the Top 20 emitting municipalities in the country by the Integrated Strategy for the Control of Motor Vehicle Emissions (DEA, 2013b). Mogalakwena LM has the highest emission in the Waterberg DM, followed by Thabazimbi and Modimolle LM's.

Table 4-9: Vehicle emission rates (in tpa) in 2012 for selected pollutants

Municipality	NO_x	SO_2	PM_{10}	CO_2
Madibeng	1 756	44	60	274 854
Moses Kotane	1 199	40	56	163 529
Rustenburg	4 501	113	154	703 623
Bojanala Platinum DM	7 456	197	270	1 142 006
Bela-Bela	466	11	15	76 146
Lephalale	530	14	18	84 301
Modimolle	862	26	36	130 568
Mogalakwena	1 399	40	55	214 716
Thabazimbi	896	29	41	131 145
Waterberg DM	4 152	120	165	560 730
Total	**11 608**	**317**	**435**	**1 778 882**

4.5 Biomass burning

Biomass burning is an important source of emissions. Agricultural burning, wildfires (uncontrolled burning of natural vegetation) and controlled burning of natural vegetation were all identified as the main types of biomass burning occurring in the WBPA. Fires emit large volumes of PM, ranging from coarse smut, which deposit on surfaces and are a nuisance, to fine inhalable particulate matter (PM_{10}). Gases emitted include CO, NO_x and VOC.

Biomass burning emissions were estimated using the total area burned annually, which was based on remote sensing data from the CSIR's Meraka Institute. The fuel load, which is linked to the varying abilities of different vegetation types to burn, was estimated using the vegetation map (SANBI, 2006). The combustion factor is the fraction of available fuel that burns. The emission factors were based on Safari 2000 data (Ito and Penner, 2004).

Biomes are geographically and climatically-similar areas, defined by factors such as plant structures (such as trees, shrubs, and grasses), leaf types (such as broadleaf and needle leaf), plant spacing (forest, woodland, savannah), and climate. The WBPA is therefore characterised as a largely Savannah biome, which is a mixture of trees, shrubs and grasses.

In Figure 4-5, the 2012 burn scar map for the WBPA indicates burnt areas in the WDM than the BPDM. The total burn area in the WDM was 16 125 ha compared with 15 772 ha in the BPDM. Moses Kotane LM recorded the greatest area burnt of 8 598 ha.

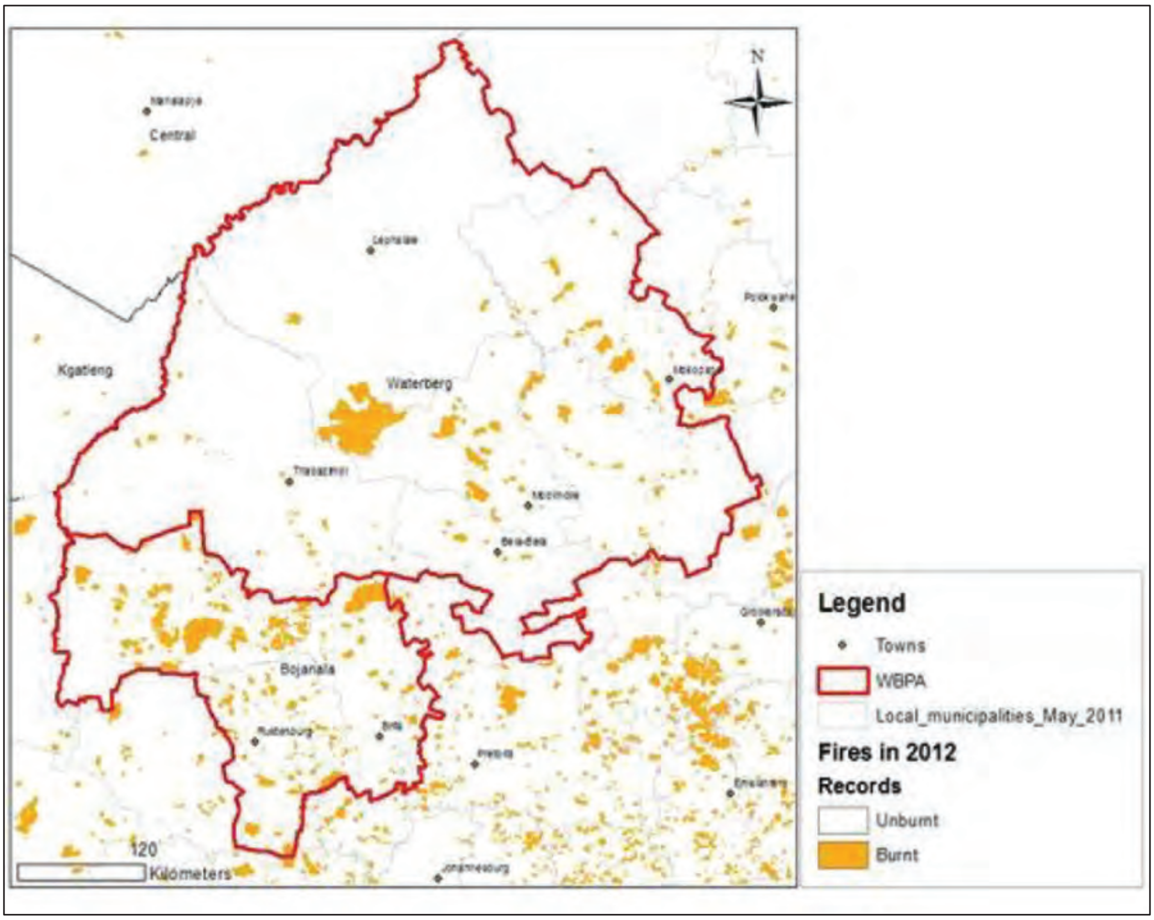


Figure 4-5: 2012 Burn Scar Map for the WBPA and the larger inflow domain

Biomass burning in the priority area results in the release of large quantities of a wide range of pollutants (Table 4-10). The pollutant emitted in the highest quantity is CO at 6 559.8 tpa. There are also significant quantities of VOCs and PM emitted at 1 211.0 tpa, and 544.9 tpa respectively. In line with the highest number of fires, the highest quantity of emissions as a result of biomass burning is emitted from Moses Kotane LM (Figure 4-6).

Table 4-10: Emission rates (tpa) from biomass burning per local municipality

Local Municipality	$PM_{2.5}$	CO	NO_x	VOC
Thabazimbi	27.3	328.8	10.1	60.7
Lephalale	62.9	757.3	23.3	139.8
Mookgopong	34.9	419.8	12.9	77.5
Modimolle	91.9	1106.4	34.0	204.3
Bela-Bela	9.5	114.0	3.5	21.0
Mogalakwena	49.0	589.8	18.2	108.9
Madibeng	67.8	815.8	25.1	150.6
Moses Kotane	147.0	1768.1	54.4	326.4
Rustenburg	54.8	659.7	20.3	121.8
Total	**545.0**	**6559.8**	**201.8**	**1211.0**

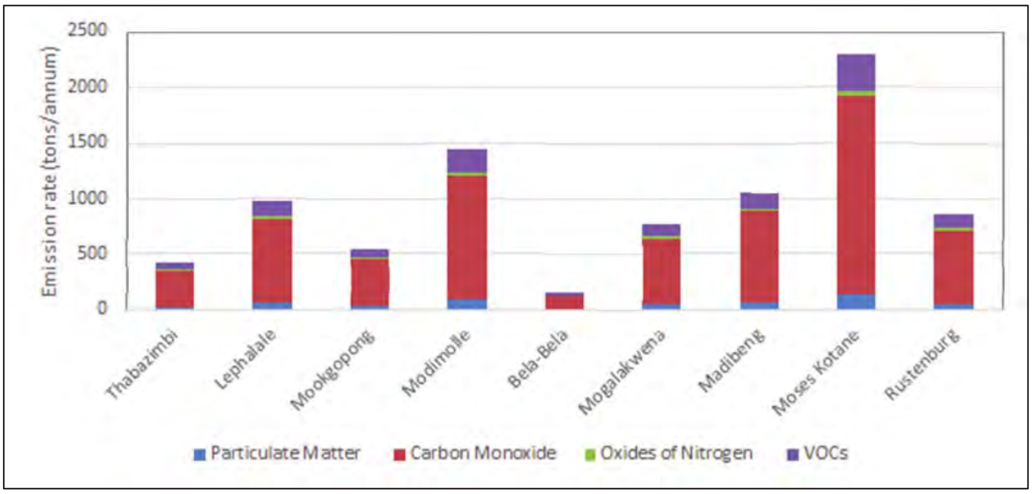


Figure 4-6: Emission rates from biomass burning per local municipality in tons per annum

Emission rates increased during the months of May to August, when the highest emissions were estimated (Figure 4-7). With the exception of SO_2, high emission rates were also experienced in September. This could be attributed to many factors, including higher incidence of wildfires during dry winter months, and controlled burning for grassland management and agricultural purposes, such as the clearing of grazing land.

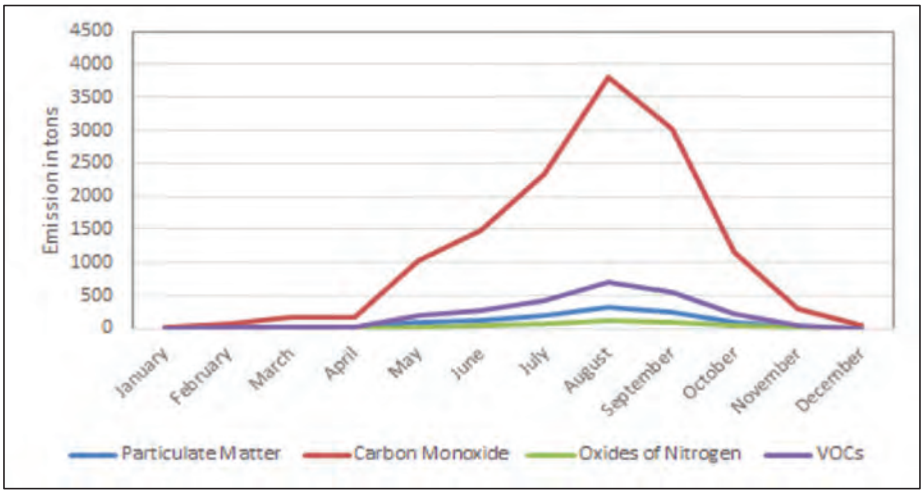


Figure 4-7: Monthly biomass burning emissions in tons

In summary, there are clear trends when considering biomass burning emission estimates for the WBPA.

- Moses Kotane LM, in the BPDM, has the highest number of fires and highest quantity of emissions as a result of biomass burning.
- The pollutant emitted in the highest quantities is CO, followed by VOC.
- A clear seasonal profile is evident, with emissions increasing in the winter

However, the data are representative of the 2012 calendar year. To identify further trends, a time series analysis is necessary, together with extensive ground truthing exercises, and an understanding of local burning practices and issues.

4.6 Mining

Emissions of PM_{10} from mining have been estimated as part of the NW AQMP using a combination of remote sensing data and GIS (NWDACE, 2011). The estimation included windblown dust from material stockpiles (including tailings disposal sites, slimes dams and significant material dumps), windblown dust from open mining activity (including surface mining, open pits, and entrances to inclined shaft) and fugitive dust of material transfer by road haulage. The total PM_{10} emissions from the assessment were estimated at 56 672 tons (Table 4-11).

The LDEDET Baseline Assessment and Emission Inventory Report (LDEDET, 2012) also provided estimated emissions of particulates from four opencast mines in the WDM with the estimated PM_{10} emissions from mining of 2 585 tons per annum.

Table 4-11: PM_{10} emissions from mining in BPDM (NWREAD, 2011) and WDM (LDEDET, 2012)

Municipality/Priority Area	**PM_{10} emission (tpa)**
Total for Bojanala-Platinum DM	56 672
Total for Waterberg DM	2 585
Total annual PM_{10} emission for the WBPA	**59 257**

The Council for Geosciences owns and maintains the South African Mineral Deposits Database (SAMINDABA), which contains, amongst others, information on active mines and quarries in South Africa. It is a computerised database continuously activated for data acquisition, data capturing and data updating for the whole of South Africa. Data were obtained from the SAMINDABA to identify and locate all mining activities in the WBPA, as well as the type and size of the mines. This information was used with the annual PM_{10} emissions to estimate generic PM_{10} emissions for mines of different size classes in the WBPA. The size classification refers to the size of a deposit and includes past production, and resources in tons metal or mineral content. Figure 4-8 shows the location of all mines in the SAMINDABA. Evident is the concentration of mining activity in the BPDM, clustered between Rustenburg and Brits. Mining also occurs in various areas across the WDM.

A total of 176 active mines were identified in the WBPA in the SAMINDABA, ranging in size class from zero (10^4 tons) to six (10^9) tons. A generic PM_{10} emission for each mine class was estimated using:

a) the number of mines in each class (obtained from SAMINDABA), and
b) the annual PM_{10} emission for the WBPA (59 257 tpa, as shown in Table 4-11: PM_{10} emissions from mining in BPDM (NWREAD, 2011) and WDM (LDEDET, 2012)).

The estimated PM_{10} emission for each mine class and the emission per mine are shown in (Table 4-12). See Appendix 1 for the methodology.

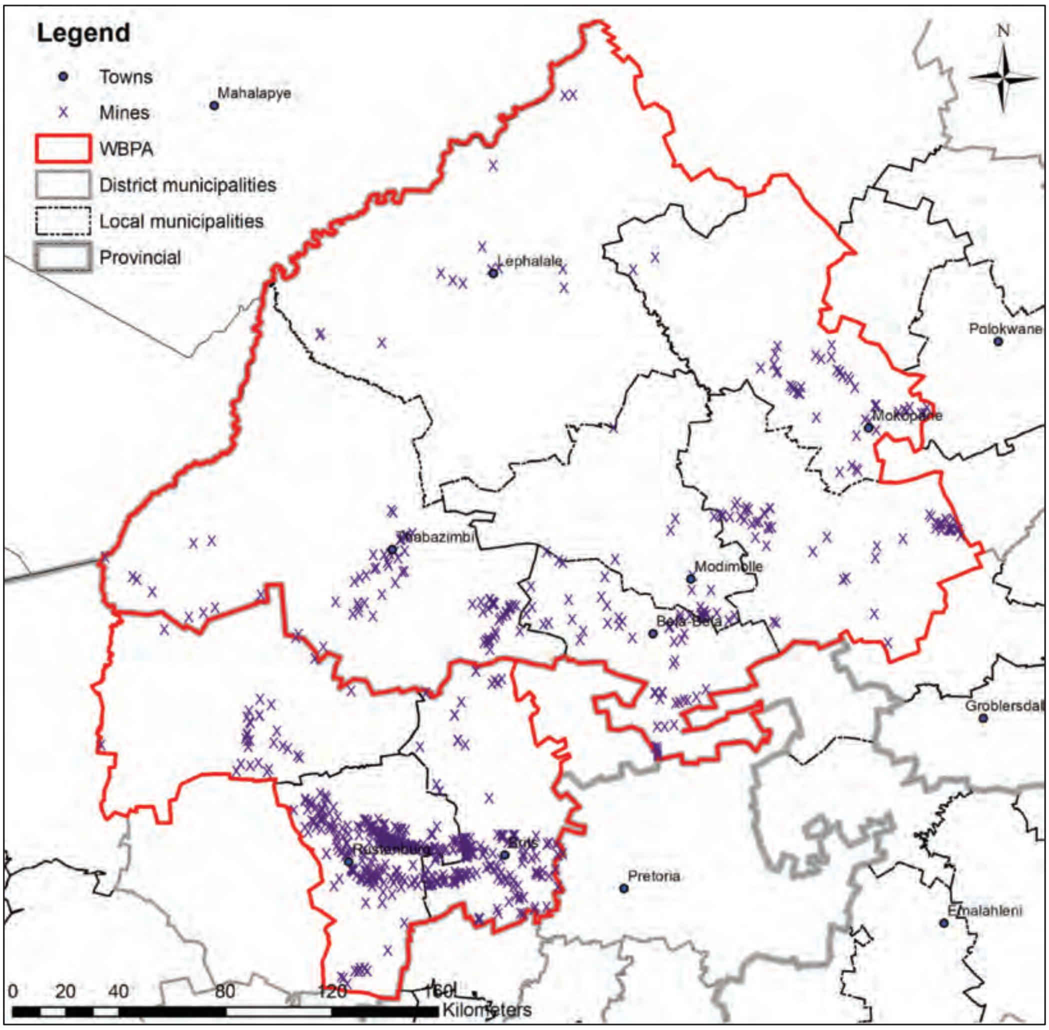


Figure 4-8: Relative location of mines in WBPA

Table 4-12: Estimated PM_{10} emission for the different mine size classes in WBPA

Mine size class	**Number of mines**	**Total PM_{10} emission (tpa) for the size class**	**PM_{10} emission (tpa) per mine**
0	62	2 080	34
1	24	1 611	67
2	24	3 221	134
3	21	5 637	268
4	27	14 495	537
5	6	6 442	1 074
6	12	25 770	2 147
All	**176**	**59 257**	-

4.7 Trans-boundary

Emissions from industrial activities, biomass burning and other agricultural activities in Botswana may affect air quality on a regional scale, with possible trans-boundary effects for the WBPA. Of these sources, the WBPA baseline assessment considers the potential trans-boundary effects of emissions from the energy sector, i.e. power generation.

The Morupule Power Station is located near Palapye in eastern Botswana and is currently the only source of SO_2, NO_X and PM_{10} that has the potential to affect air quality in the WBPA via long-range transport. It is a coal-fired power station operated by the Botswana Power Corporation (BPC) and comprises four steam turbines each with an installed capacity of 33 MW. Coal is supplied to the plant by conveyor belt from the Morupule Colliery and, depending on plant availability, between 560 000 and 630 000 tons of coal is used per annum. Electrostatic precipitators collect most of the fly ash in the boiler flue. Approximately 35 000 tons of fly ash are used annually in the local cement industry and the remainder is treated and pumped to the ash pond (Ecosurv, 2007).

There are currently no emission control measures in place at Morupule (BPC, 2012). Approximately 8 946 tons of SO_2, 2 853 tons of NO_2 and 183 tons of PM_{10} are emitted annually (DEA, 2012d) via two stacks. Emissions from mining, coal handling and storage at the Morupule Colliery will have local-scale effects on ambient air quality. Coal handling and storage, and power generation emissions at Morupule Power Station, as well as emissions from the Morupule Colliery will not result in trans-boundary effects on the WBPA and have not been quantified.

4.8 Other sectors

Other sectors were proposed for inclusion in the baseline assessment but they require extensive primary data collection to quantify emissions. These include controlled emitters, fugitive dust, and wastewater treatment works (WWTW) and waste management facilities. Some available information has been collated for these sectors as an indication of their contribution to baseline air quality. In both the WDM and BPDM, tyre burning and informal refuse burning are also emissions sources. Both activities contribute to ambient particulate concentrations (Bojanala-Platinum DM, 2013).

4.8.1 Waste management

Waterberg DM

There are approximately 13 licenced disposal sites in the WDM (SAWIC, 2014), but there are no licensed hazardous waste landfills in the municipality. Incinerators are located outside the municipality, with medical waste taken to Tshumisano Waste Management in Polokwane, for disposal (WDM, 2009).

There are two general and ten hazardous wastewater treatment plants in the WDM (SAWIC, 2014). The main pollutants from wastewater treatment are volatile organic compounds, including hydrogen sulphide, mercaptans, ammonia, formaldehyde, acetone, toluene, ethyl benzene, xylenes, perchloroethylene, butyric acid, propionic acid, valeric acid and acetic acid. The main impact of wastewater treatment is the generation of offensive odours.

Bojanala-Platinum DM

There are approximately eight general waste disposal landfill sites in the of Moses Kotane, Rustenburg and Madibeng local municipalities (SAWIC, 2014). Additional registered disposal sites under the BPDM include three general waste landfills. The waste types disposed of at these sites include residential, commercial, industrial and domestic waste (Bojanala-Platinum DM, 2013) (Table 4-13). As with WDM, the hazardous waste is also taken to Polokwane for disposal (Bojanala-Platinum DM, 2013). There are three hazardous wastewater treatment facilities within the local municipalities of Moses Kotane, Rustenburg and Madibeng and five in the BPDM.

Table 4-13: Waste treatment and management facilities

	Landfills		WWTW	
	General	**Hazardous**	**General**	**Hazardous**
Thabazimbi	3			
Modimolle	2			
Mogalakwena	4			
Bela-Bela	1		1	1
Mookophong				
Lephalale	2			1
Waterberg DM	1		1	8
Moses Kotane	1			
Rustenberg	3	1		2
Madibeng	4			1
Bojanala-Platinum DM	3	1		5
Total	**24**	**2**	**2**	**18**

4.9 Summary

The emission summary for the WBPA shows the dominant sectors with regard to the major pollutants considered in the baseline assessment (Table 4-14). SO_2 is primarily sourced from industry in the area, with 99.9% of total emissions generated by the sector. Minimal SO_2 contributions resulted from motor vehicles and residential sectors. Total SO_2 emissions for the priority area are estimated at almost 397 000 tons per annum. For NO_x, industrial contributions to the overall pollutant load are 87%, and the contribution from motor vehicles is 13%. Total WBPA NO_x emissions are estimated at approximately 87 000 tons per annum. For PM_{10}, mining contributes the greatest proportion of emissions, approximately 60 000 tons per annum, and over 70% of total emissions. Industry contributions are lower, but still significant at 27%. Total priority area PM_{10} emissions are estimated at approximately 83 000 tons per annum.

Table 4-14: Total emissions for WBPA (in tpa)

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

4.10 Ambient air quality

The status of ambient air quality is informed by data from monitoring stations and by the dispersion modelling. In the WBPA, there are several continuous ambient air quality monitoring stations operated by government and industry, as well as passive monitoring stations operated by government. Available SO_2, NO_x and PM_{10} data was used to describe the status of ambient air quality between 2010 and 2012. Monitoring data from stations located on industrial sites have not been used. The purpose of these monitoring stations is to monitor the ambient effects from the specific industrial sources and to monitor ambient compliance. The data collected by these facilities are therefore not always appropriate for describing the general status of ambient air quality.

The description of the air quality status is augmented with dispersion modelling using the baseline emission inventory of SO_2, NO_x and PM_{10} for Listed Activities, residential fuel burning and mining. As it is source-based, the model outputs are more suited than the ambient air quality monitoring data to identify areas where ambient concentrations exceed or are likely to exceed ambient air quality standards, i.e. air quality hotspots. Emissions from other sources, such as motor vehicles, biomass burning, waste management are not modelled.

4.10.1 Monitoring stations

There are ten continuous ambient air quality monitoring stations in the WBPA, operated by government and industry (Table 4-15). The longest monitoring record exists at Eskom's Marapong station, which has been in operation since 1 January 2006, while the DEA's WBPA stations have been in operation since 1 February 2013. Data collected at the ambient air quality monitoring stations are reported to the South African Air Quality Information System (SAAQIS) and have been made available for the WBPA baseline assessment.

Table 4-15: Ambient data monitoring stations in the WBPA

Location	Station Name	Owner	Station type	Data start data
Waterberg DM	Lephalale	DEA	Continuous	1 Feb 2013
	Mokopane	DEA	Continuous	1 Feb 2013
	Thabazimbi	DEA	Continuous	1 Feb 2013
	Marapong	Eskom	Continuous	1 Jan 2006
	Mafuta	Sasol	Continuous	Apr 2010 to May 2011
Bojanala-Platinum DM	Marikana	Rustenburg	Continuous	14 Jul 2010
	Thlabane	Rustenburg	Continuous	14 Jul 2010
	Boitekong	Rustenburg	Continuous	14 Jul 2010
	Damonsville	North-West	Continuous	Apr 2012 to Dec 2011
	Phokeng	North-West	Continuous	Apr 2010 to Sep 2011
	Marikana	DEA	Passive	Jun 2012 to Jul 2013
	Brits	DEA	Passive	Jun 2012 to Jul 2013
	RAS Dekroon	DEA	Passive	Jun 2012 to Jul 2013
	Mothulung	DEA	Passive	Jun 2012 to Jul 2013

In addition, Sasol conducted a continuous monitoring campaign at the proposed Mafuta site. These data have been made available for the baseline assessment. As part of the DEA's so-called Table 24 ground-truth project, passive monitoring was done at three sites in the BPDM (Table 4-15) (Figure 4-9). The siting rationale is presented in Table 4-16.

Ambient air quality monitoring, including continuous, passive and dust fallout is also undertaken by industries including Lonmin Platinum, Anglo Platinum and Impala Platinum. The monitoring stations are generally sited to monitor the direct impacts of the selected sources.

Anglo American Platinum operates seven ambient air quality-monitoring stations, measuring SO_2 and PM_{10} with meteorological parameters. Impala Platinum operates four monitoring stations also measuring these parameters. Lonmin Platinum operates two ambient air quality-monitoring stations, measuring SO_2 and PM_{10}, as well as an extensive SO_2 passive sampling network and an array of dust fallout buckets.

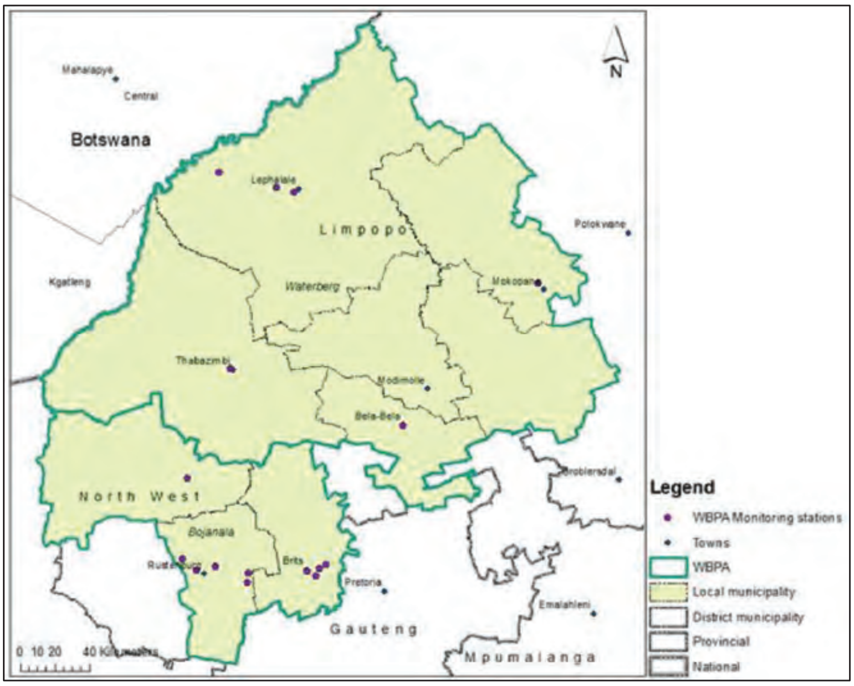


Figure 4-9: Location of the ambient air quality monitoring stations in the WBPA.

4.10.2 Data quality control

It is uncertain of the level of quality control that was performed on the hourly data received from the SAAQIS for the respective continuous monitoring stations. Certain datasets were open to high uncertainty and a standard set of quality control measures were therefore applied to all of the data. These included:

- Removal of all negative values;
- Removal of prolonged periods of zero concentration values;
- Removal of instantaneous concentration spikes in the data;
- Removal of short periods of concentration data between long periods of instrument down time; and
- Removal of prolonged periods of constant concentration values.

Noteworthy are the following at:

- Tlhabane: PM_{10} concentrations are questionable due to prolonged periods with concentrations stuck on constant values. The averages are likely to be unrealistically high.

- Marikana: PM_{10} and NO_2 concentrations are questionable due to prolonged periods with concentrations stuck on constant values and apparent zero drift. The averages are likely to be unrealistically high.
- Boitekong: PM_{10} and NO_2 concentrations are questionable due to prolong periods of no data and prolonged periods with concentrations stuck on constant values. The averages are likely to be unrealistically high.
- Phokeng: SO_2 and NO_2 data are not used due to considerable data gaps when the monitoring station was not functioning.
- Bakgatla: NO_2 and PM_{10} data are not used due to considerable data gaps when the monitoring station was not functioning.
- Mafuta: PM_{10} concentrations are questionable due to prolonged periods with concentrations stuck on constant values, and a clear shift in the instruments' zeros. These data have not been used.

Quality assurance and quality control measures applied in DEA's passive sampling campaign included field blanks and laboratory duplicates (DEA, 2013c).

Table 4-16: Station siting information extracted from the SAAQIS (SAAQIS, 2014)

Location	Station Name	Site location	Siting type[1]	Siting objective and sources
Waterberg DM	Lephalale	Lephalale Reservoir	Urban background/ traffic	Impact of mining and power generation 10-18 km W of station
	Mokopane	Mahwelereng Police Station	Residential	Impact of residential emissions and mining 17 km NNW of station
	Thabazimbi	Regorogile Gateway Clinic	Residential	Impact of residential emissions and mining 15-20 km S of station
	Marapong	Marapong	Urban background	Impact of mining and power generation on the local community
	Mafuta	Proposed Mafuta site	Background	Research station for background concentrations
BPDM	Marikana	Marikana Community Centre	Residential	Impact of domestic fuel burning, industry and mines
	Thlabane	Reatile Middle School	Residential	Impact of domestic fuel burning, industry and mines
	Boitekong	Boitekong Civic Centre	Residential	Impact of domestic fuel burning, industry and traffic
	Damonsville	Municipal offices	Residential	Background, some industrial influence
	Phokeng	Municipal water reservoir	Residential	Background, some influence from unpaved roads and denuded land
	Bakgatla	Municipal offices	Background	Determination of background concentrations
	Marikana (passive)	Marikana Clinic	Residential	Impact of residential fuel burning and motor vehicles
	Brits (passive)	Brits industrial area	Industrial	Impact of industry and motor vehicles
	RAS Dekroon (passive)	Municipal park	Residential	Impact of industry and motor vehicles
	Mothulung (passive)	Mothulung Clinic	Residential	Impact of residential fuel burning and motor vehicles

There are relatively few sources of SO_2 in the WDM as described in the emission source inventory, with the Matimba Power Station near Lephalale currently the largest industrial source and accounting for more than 95% of the total SO_2 emissions. The ambient concentrations of SO_2 in the WDM are therefore relatively low with the highest concentrations measured at Marapong, which is influenced by residential fuel burning and Matimba Power Station.

The annual average concentrations (Table 4-17) are well below the NAAQS. Hourly SO_2 concentrations (Figure 4-10) are also well below the limit value of the NAAQS at all monitoring stations besides Marapong, where occasional exceedances occur.

Table 4-17: **Annual average pollutant concentrations (in µg/m³) in the Waterberg DM**

	SO_2	NO_2	PM_{10}	$PM_{2.5}$
Mokopane	0.92	3.69	28.97	34.99
Thabazimbi	4.85	5.54	51.02	17.29
Marapong	9.79	12.46	88.73	37.27
Lephalale	1.0	8.8	25.25	7.55
Mafuta	0.36	*	*	*

* *Data is unreliable*

Hourly ambient SO_2 concentrations measured at Marapong comply with the NAAQS since fewer than the permitted 88 exceedances of the limit value occur. At Marapong, the SO_2 pollution rose (Figure 4-11) shows that more than 98% of all measured hourly SO_2 concentrations are <100 µg/m³. Furthermore, most SO_2 originates from sources in the sector east to south-southeast of the monitoring station. Matimba Power Station is 8 km to the south west of the Marapong monitoring station and 16 km to the west of the Lephalale station.

The diurnal variation of hourly SO_2 concentrations shows that the peak at 17:00 could be because of a contribution from residential fuel burning when fires are lit and continues through the evening. The peak at 13:00 coincides with daytime convection and stack emissions from Matimba Power Station affecting ground level concentrations. Like Marapong, the hourly SO_2 concentrations measured at the Lephalale monitoring site are mostly influenced by sources to the east of site under the influence of the prevailing easterly winds. The diurnal variation of hourly SO_2 concentrations at Lephalale shows an early afternoon peak, likely from local-scale transport and sustained higher concentrations at night from residential fuel burning.

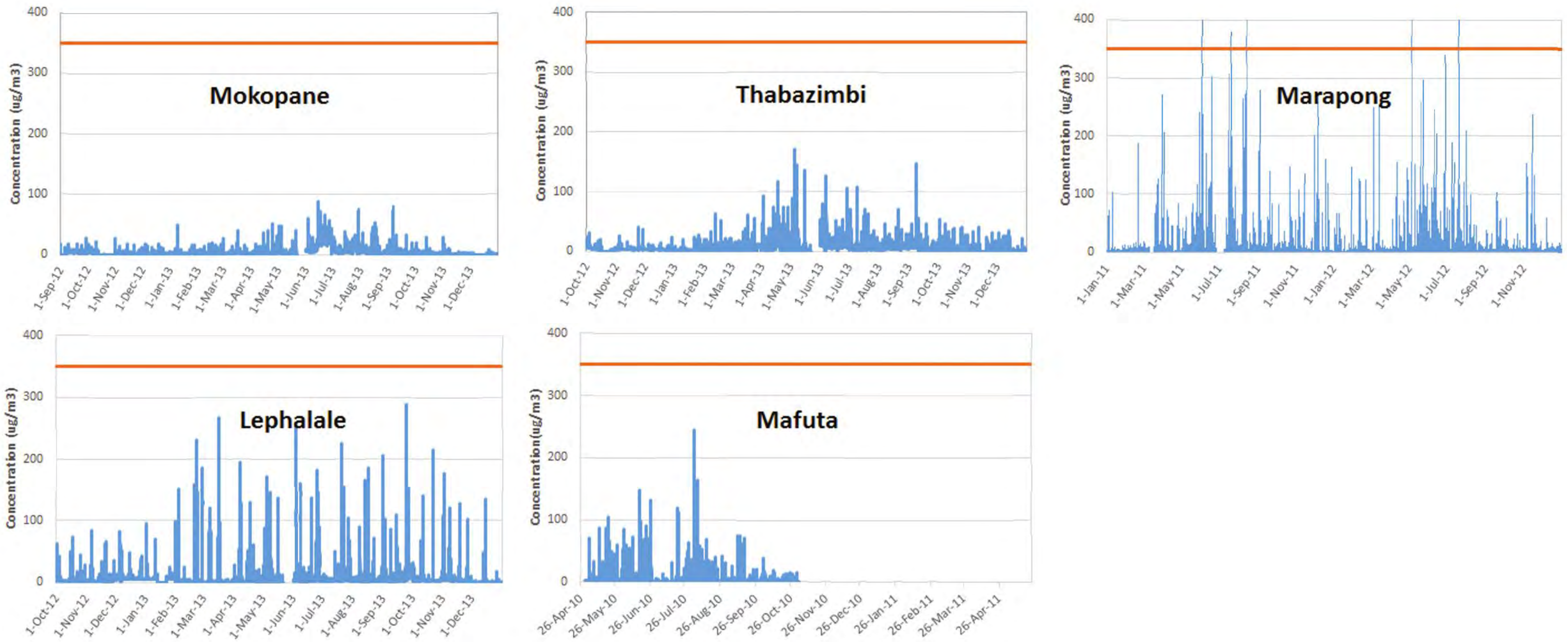


Figure 4-10: Hourly SO_2 concentrations ($\mu g/m^3$) in the Waterberg DM with the red line showing the NAAQS of 360 $\mu g/m^3$

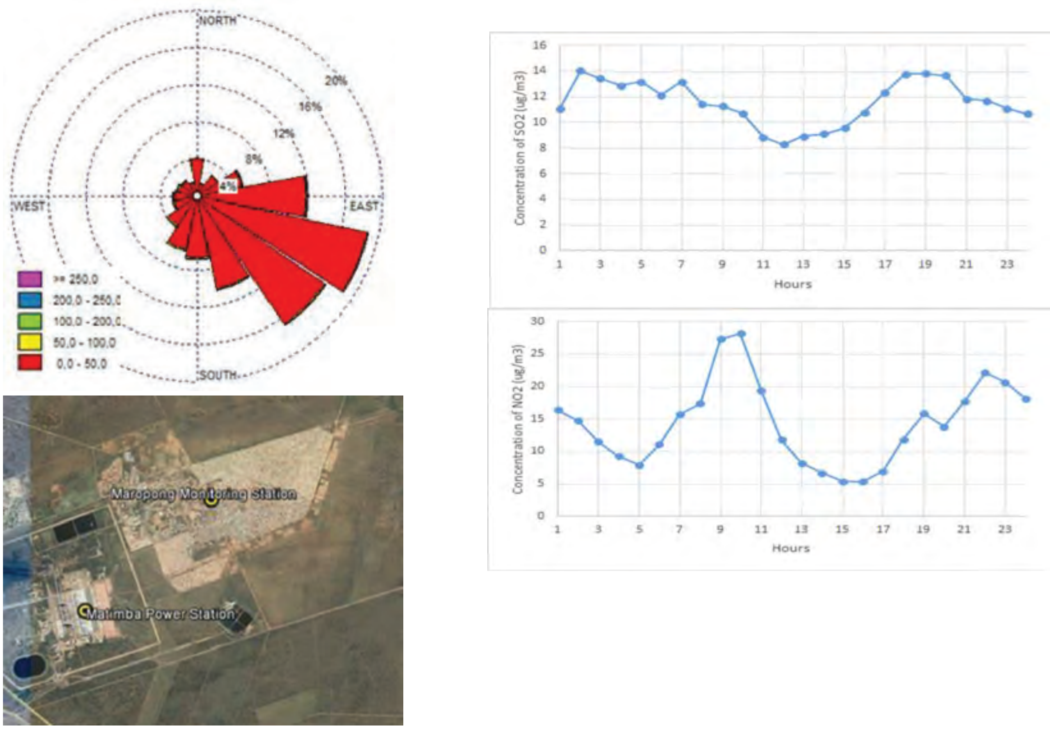


Figure 4-11: SO_2 rose at Marapong with concentrations in µg/m^3 (left) and the diurnal profile of hourly SO_2 concentrations (right top) and NO_2 concentrations (right bottom)

Hourly SO_2 concentrations measured at the Thabazimbi and Mokopane monitoring stations are relatively low and are influenced mostly by sources located in the sector north-northwest to north east, shown by the SO_2 pollution roses in Figure 4-12. This may be expected at Thabazimbi with the suburb of Regorogile located immediately to the north-northwest of the station where coal is commonly used as an energy source. The monitoring station at Mokopane is located to the south in Mahwelereng-A, where coal is also used.

Background SO_2 concentrations at Mafuta are low compared with the national ambient air quality standard (NAAQS), and result mostly from the east as a result of the prevailing winds. These background concentrations with an annual average of less than 1 µg/m^3 provide a reasonable indication of SO_2 concentrations without the direct influence of industrial sources and residential coal burning.

At all the stations, the ambient concentrations in winter are relatively higher than in summer as a result of generally more stable atmospheric conditions in winter and increased biomass fuel use in residential areas.

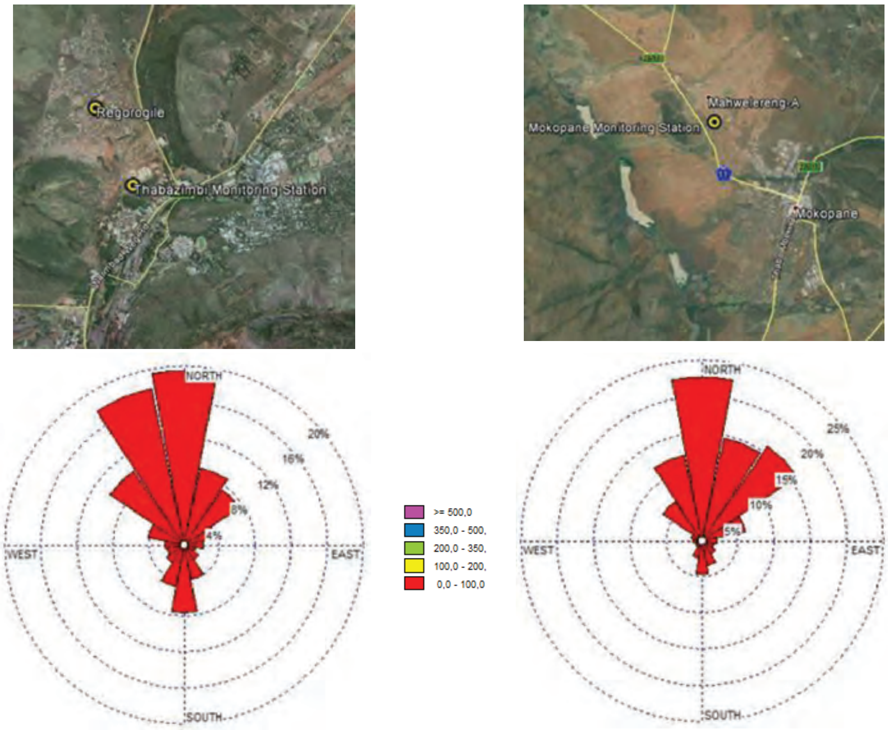


Figure 4-12: Relative location of the monitoring stations at Thabazimbi (top left) and Mokopane (top right) and the respective SO_2 roses with hourly concentrations in µg/m^3

Ambient NO_2 concentrations throughout the WDM are low (Figure 4-13) with no exceedances of the NAAQS limit value at any sites. Similar to SO_2, ambient NO_2 concentrations in winter are relatively higher than in summer; this could be attributed to generally more stable atmospheric conditions in winter and increased biomass fuel use in residential areas.

Like SO_2, most NO_2 monitored at Marapong originates from the east of the monitoring station. As might be expected, the ambient NO_2 concentrations are higher at Marapong than elsewhere as the monitoring station is in the immediate vicinity of residential coal burning. The diurnal variation of hourly NO_2 concentrations at Marapong clearly shows a contribution from residential coal burning with an evening peak, albeit at relatively low concentrations (Figure 4-11). The morning peak coincides with the morning traffic peak and the associated motor vehicle exhaust emissions.

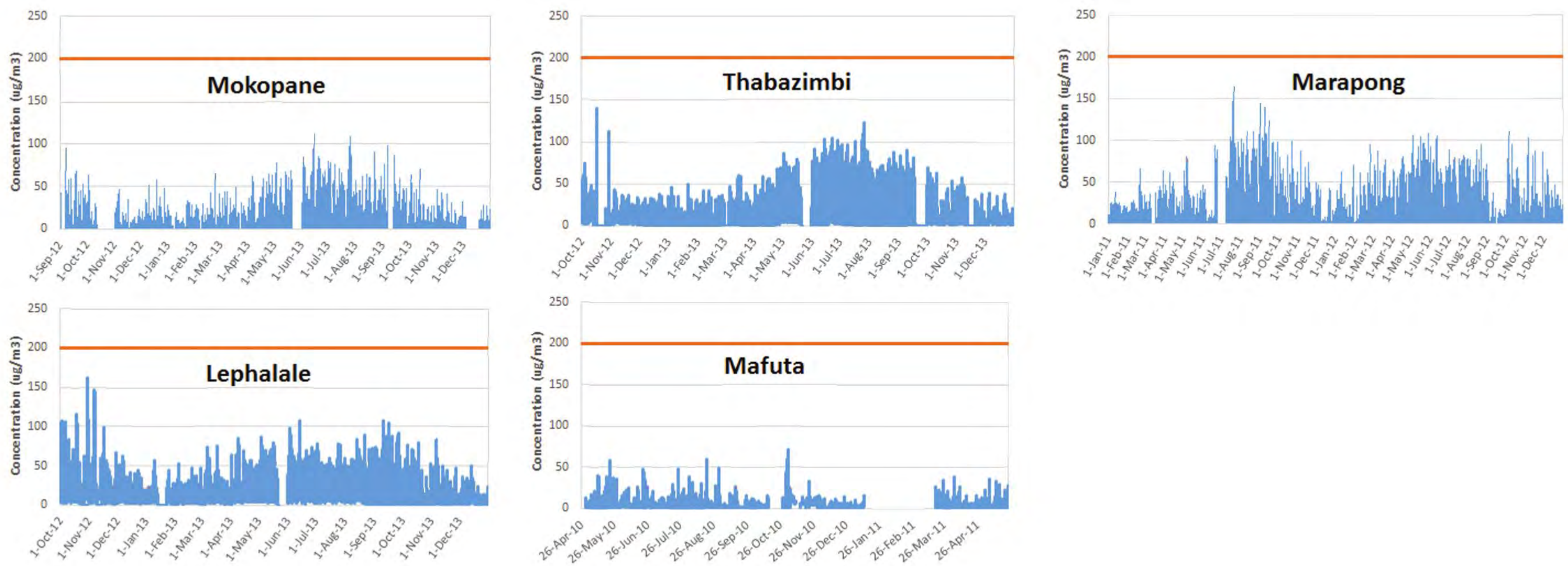


Figure 4-13: Available hourly NO_2 concentrations (µg/m³) in the Waterberg DM with the red line showing NAAQS of 200 µg/m³

Particulate matter

At Mokopane, the hourly PM_{10} concentrations are presented as a pollution rose in Figure 4-14, clearly showing the main sources to the north and north east of the monitoring station. At Lephalale, the main source of PM_{10} is from the east of the monitoring site. The diurnal variation of hourly PM_{10} concentrations at Mokopane has a distinct peak in the middle of the day and two smaller peaks at night. The diurnal variation of hourly PM_{10} concentrations at Lephalale has two distinct peaks. The first is at 08:00 in the morning, coinciding with residential burning and morning traffic, and there is a similar NO_2 peak. The second coincides with residential fuel burning, with the concentration increasing from 17:00 and peaking at 20:00.

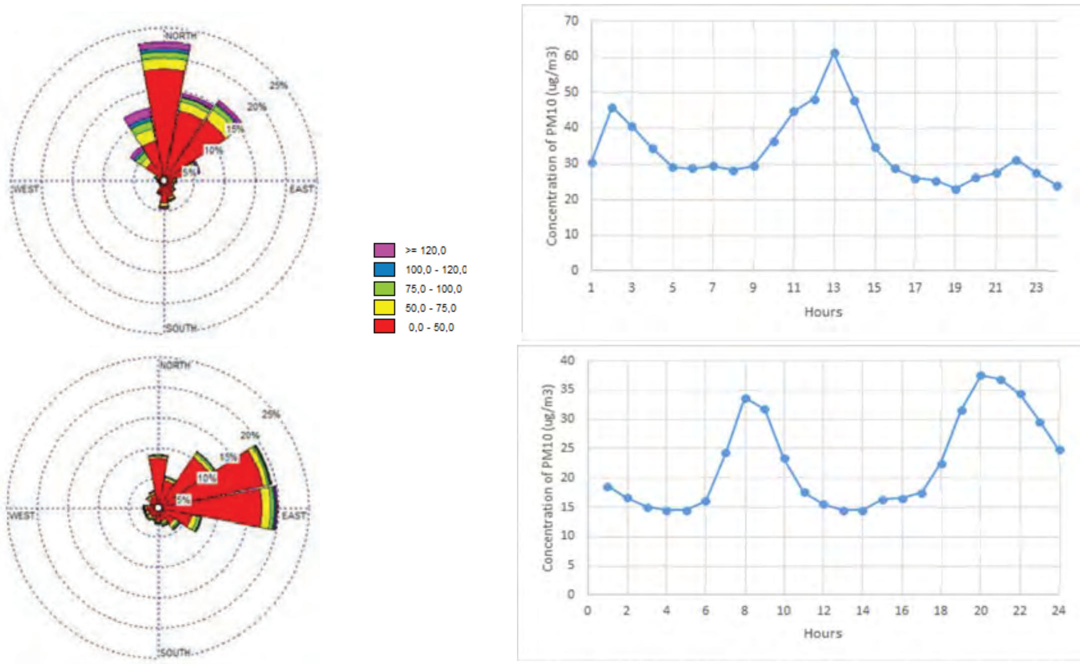


Figure 4-14: PM_{10} rose of hourly concentrations in µg/m³ and the diurnal variation of hourly PM_{10} concentrations at Mokopane (top) and Lephalale (bottom)

Hourly PM_{10} measured at Thabazimbi and Marapong monitoring stations are shown as pollution roses in Figure 4-15. At Thabazimbi, the highest hourly concentrations originate most frequently with winds from the sector north-north west to the north, with relatively low concentrations resulting when winds blow from the other sectors. As with the other pollutants, the main source area of PM_{10} is Regogogile.

The diurnal variation of hourly PM_{10} concentrations at Thabazimbi shows two peaks, in the middle of the day and again at night, with Regorogile the main source area as with other pollutants. The reason for the earlier peak is not clear, but possibly the result of increased wind flow by day and the transport of pollutants from sources further from the station.

At Marapong, high PM_{10} concentrations occur most frequently from the east to south-southeast. Two distinct diurnal peaks occur, in the late morning at 11:00 and at night at 22:00. The evening peak is associated with residential fuel burning at both sites. The earlier peak may be influenced at times when the Matimba Power Station plume is brought down by convection.

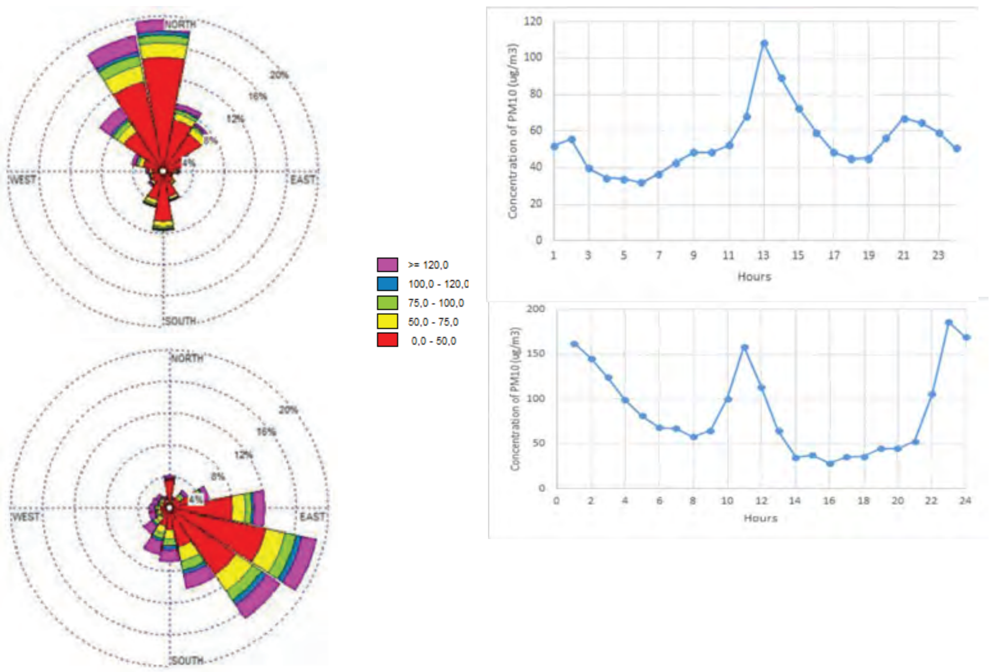


Figure 4-15: PM_{10} rose of hourly concentrations in µg/m^3 and the diurnal variation of hourly of PM_{10} concentrations at Thabazimbi (top) and Marapong (bottom)

Ambient PM_{10} concentrations measured at Mokopane and Lephalale are relatively low. Furthermore, the annual average concentration of PM_{10} is below the limit value of the NAAQS and the 24-hour average concentrations are below the current limit value of the NAAQS (Figure 4-16). However, exceedances of the 2015 PM_{10} NAAQS limit value occur more frequently at Mokopane. The annual average PM_{10} concentration at Thabazimbi and Marapong exceeds the NAAQS limit value, with Marapong being significantly higher. At these two stations, the average 24-hour concentrations routinely exceed the current NAAQS limit value, and are consistently above the 2015 limit value (Figure 4-16).

Annual average $PM_{2.5}$ concentrations at Lephalale comply with the current and future NAAQS. The NAAQS is, however, exceeded at Thabazimbi (future), Marapong and Mokopane (current and future) due to high daily concentrations in winter (Figure 4-17). At Lephalale and Thabazimbi, $PM_{2.5}$ concentrations are low relative to the NAAQS. At Marapong, the hourly average $PM_{2.5}$ concentrations are consistently high and exceed the NAAQS limit value on a daily basis. This is very likely attributed to residential fuel burning in the immediate vicinity of the monitoring station. At Mokopane, there are also numerous exceedances of the current NAAQS limit values, and these are more frequent in 2013. As may be expected at these two stations, ambient $PM_{2.5}$ concentrations do not comply with future limit values.

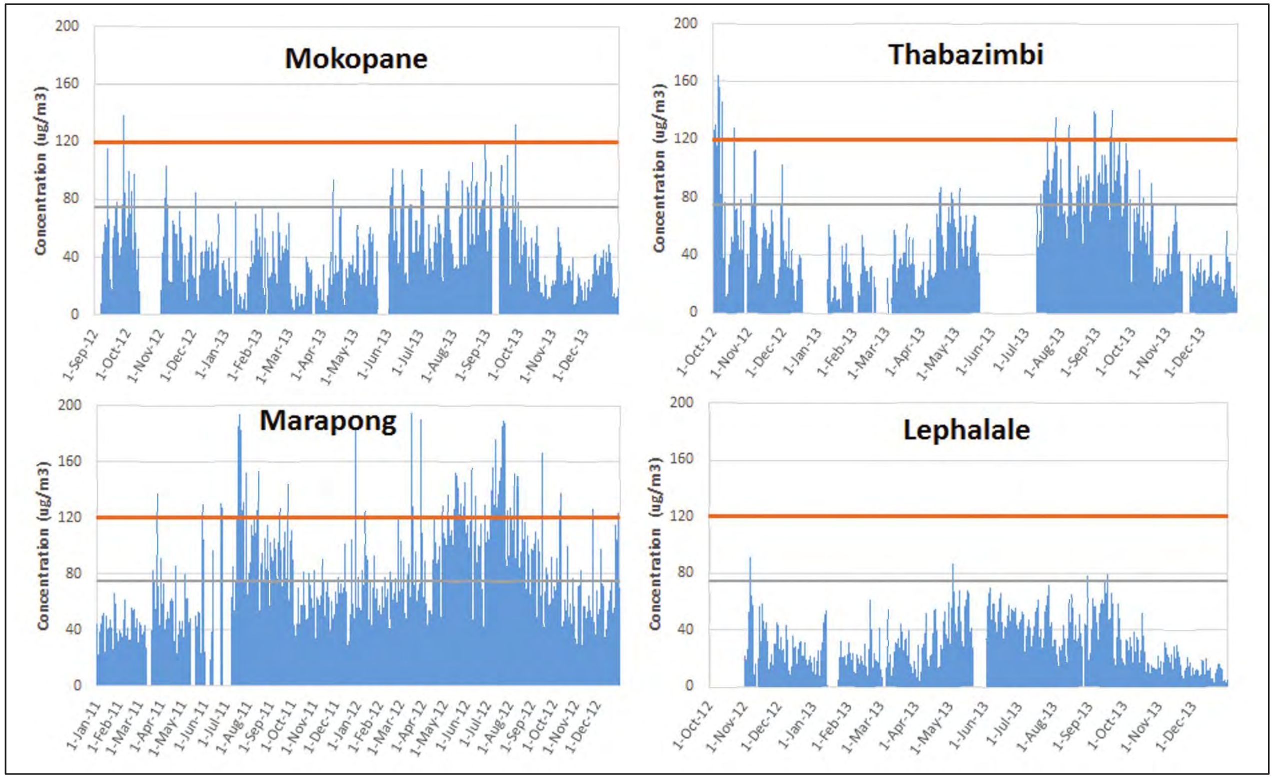
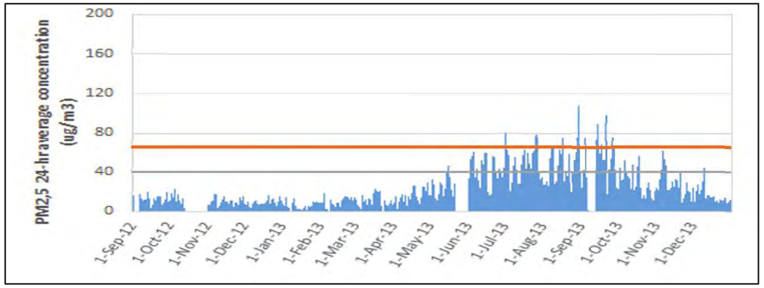
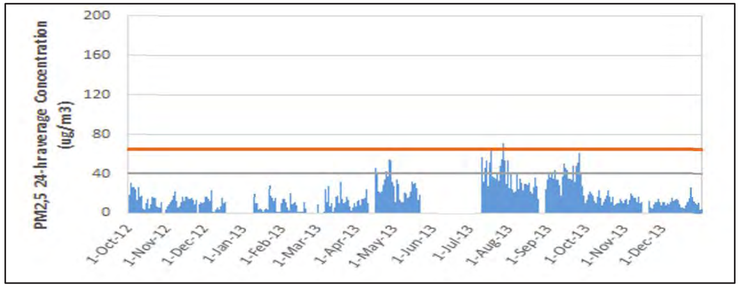


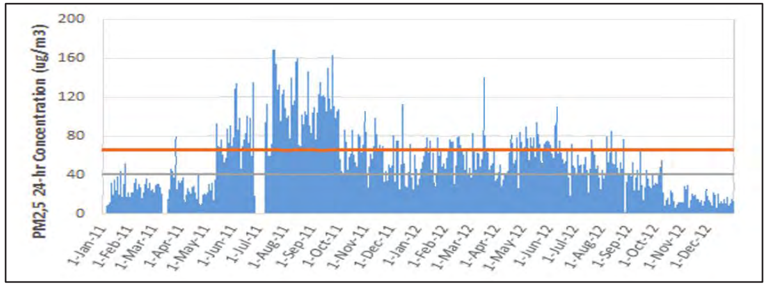
Figure 4-16: 24-hour PM_{10} concentrations ($\mu g/m^3$) in the Waterberg DM with the current NAAQS of 120 $\mu g/m^3$ (orange line) and the 2015 standard of 75 $\mu g/m^3$ (grey line).



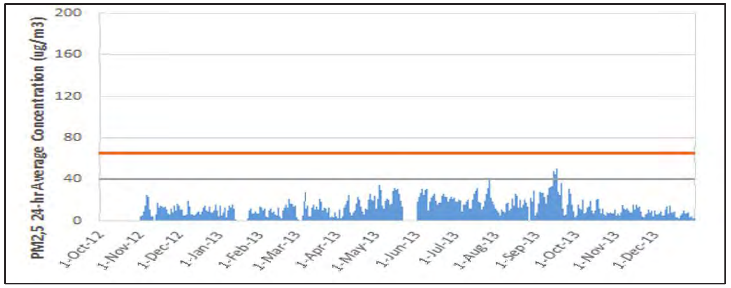
Mokopane



Thabazimbi



Marapong



Lephalale

Figure 4-17: 24-hour $PM_{2.5}$ concentrations ($\mu g/m^3$) in the Waterberg DM, with the current NAAQS limit value of 65 $\mu g/m^3$ (orange line)and 2015 value of 40 $\mu g/m^3$ (grey line).

Bojanala Platinum DM

Sulphur dioxide (SO_2)

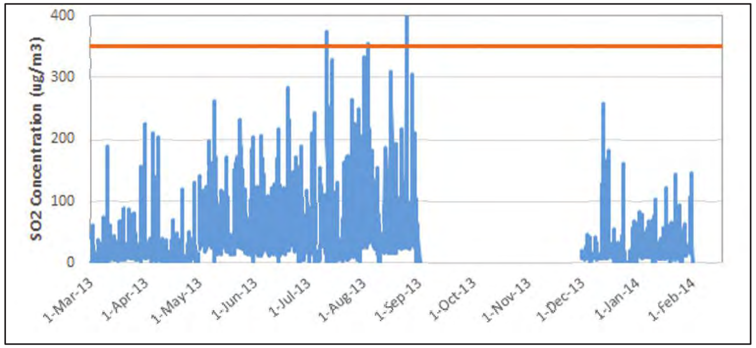
There is a concentration of mining and associated industrial processes in Rustenburg in the BPDM as described in the emission source inventory. Rustenburg LM is also more densely populated than elsewhere in the BPDM, with biomass fuel combustion in the high-density residential areas being a common form of energy. The ambient SO_2 concentrations in BPDM are relatively low with the highest concentrations measured at Boitekong and Thlabane; these concentrations may be mostly influenced by residential fuel burning. At Damonsville, near Brits, the ambient SO_2 concentrations are below the NAAQS limit value. The annual average of SO_2 concentrations measured at the three DEA passive sampling sites in Bojanala were low compared to the NAAQS limit value of 50 µg/m^3 (Table 4-18).

Table 4-18: Annual average concentrations in Bojanala-Platinum DM

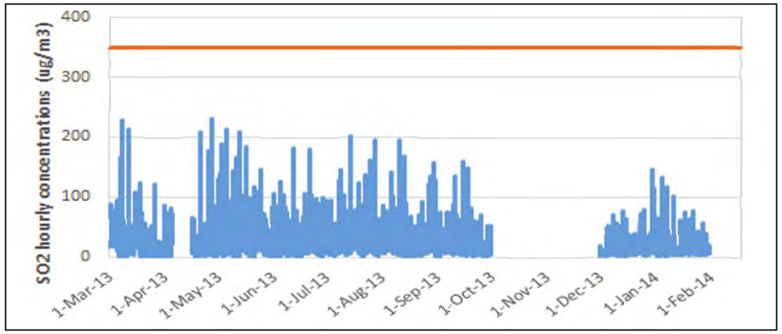
Station	**Annual average concentrations (in µg/m^3)**		
	SO_2	**NO_2**	**PM_{10}**
Boitekong	29.56	6.23	37.35
Tlhabane	21.55	*	*
Marikana	14.81	*	*
Damonsville	2.6	17.6	13.9
Phokeng	4.0	15.2	31.3
Bakgatla	4.7	-	-
Brits	21.1	18.0	-
RAS Dekroon	9.11	16.6	-
Mothulung	11.3	13.4	-
Marikana Clinic	15.6	13.7	-

* ***Data is unreliable*** - **No data**

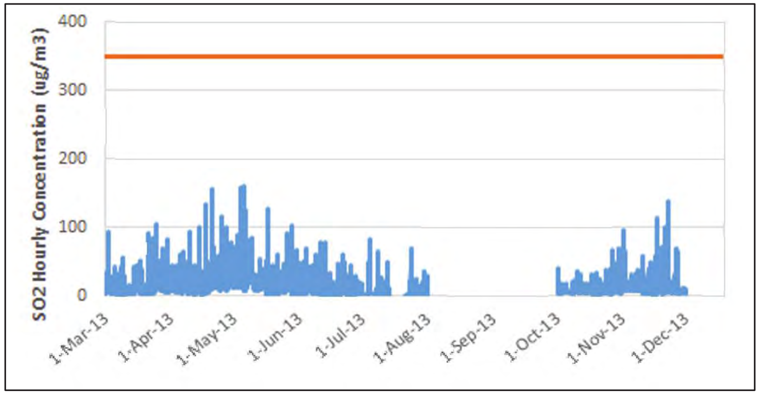
Hourly ambient SO_2 concentrations are relatively low at all the monitoring sites with occasional exceedances of the NAAQS limit value at Boitekong (**Figure 4-18**). The monthly average concentrations at the DEA monitoring sites (Figure 4-19) show that relatively higher ambient concentrations occur in winter than in summer, and this could be because poor dispersion of pollutants in winter and increased fuel use for residential energy provision.



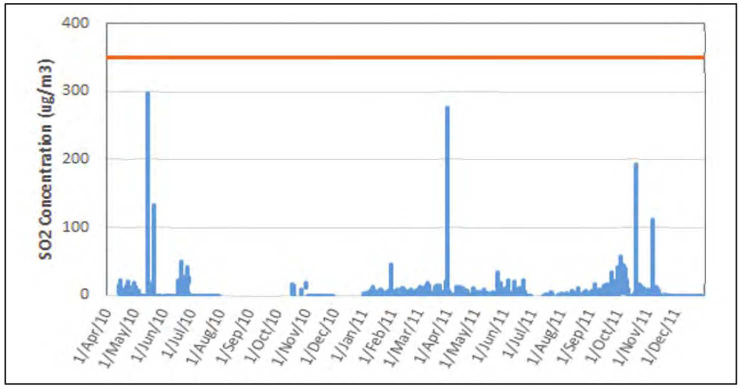
Boitekong



Tlhabane



Marikana



Damonsville

Figure 4-18: Hourly SO_2 concentrations ($\mu g/m^3$) in the Bojanala-Platinum DM with the NAAQS of 350 $\mu g/m^3$

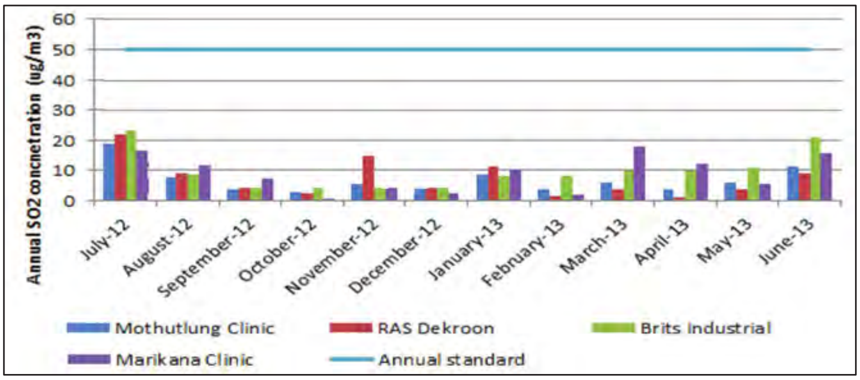


Figure 4-19: Annual average SO_2 concentrations at DEA Ground Truth sites

The SO_2 ambient concentration annual average measured at Anglo American Platinum monitoring stations was consistently below the NAAQS limit value of 50 µg/m^3 during the period 2010 to 2013 (Table 4-19). Occasional exceedances of limit values of the 10–minute, 1-hour and 24-hour standards are reported at some stations, most notable at Mfidikwe and Paardekraal. These however do not exceed that permitted tolerance for the respective exposure periods.

Table 4-19: Annual average SO_2 concentrations in µg/m^3 at Anglo Platinum sites (Anglo American, 2014)

	2010	2011	2012	2013
Bergsig	18.1			
Brakspruit	20.6	15.5	10.9	13.5
Hex River	15.0	12.5	11.8	18.1
Klipfontein	15.2	9.6	22.5	15.2
Mfidikwe	25.2	22.2	18.8	24.2
Paardekraal	30.9	31.4	22.8	23.9
Waterval			15.9	20.9
Wonderkop	19.9	14.5	16.7	

Lonmin Platinum has operated a passive monitoring network in the vicinity of the North West operations since 2004, increasing the number of monitoring stations over time. The SO_2 annual average concentrations at all monitoring stations is consistently below the NAAQS limit value of 50 µg/m^3 (Table 4-20).

Table 4-20: Annual average SO_2 concentrations at passive monitoring sites in µg/m³ (Pers. Comm, T Anderson, Lonmin, 2013)

	2010	2011	2012	2013	2014
Agisanang		8.39	9.78	8.56	4.58
Bapong	26.57	18.73	9.13	7.82	5.93
Karee	23.67	26.49	18.95	10.77	4.29
South of Mooinooi	31.15	16.85	9.99	16.49	4.58
Marikana	31.03	10.35	14.30	6.42	9.22
Mooinooi	20.91	15.04	9.65	9.36	5.58
Wonderkop N	22.85	11.64	11.24	10.21	4.00
Wonderkop C	18.95	12.11	15.88	9.39	5.62
Wonderkop S	36.39	18.17	13.41	10.07	2.86
Schaapkraal		11.92	9.06	10.06	5.90
Segwaelane	14.76	14.90	13.54	8.70	3.36
Sonop	11.23	11.60	9.77	5.46	2.86

Nitrogen dioxide (NO_2)

The annual average NO_2 concentrations at DEA Ground Truth sites are low compared with the NAAQS limit value of 40 µg/m³ (
Table 4-21). The average monthly ambient NO_2 concentrations in winter are relative higher than in summer (Figure 4-20).

Hourly NO_2 concentrations at Tlhabane and Damonsville are shown in Figure 4-21 and compared with the NAAQS limit value of 200 µg/m³. Data from other stations are not shown due to poor data recovery (See Section 4.10.2).

Table 4-21: Annual average NO_2 concentrations at DEA passive monitoring sites (DEA, 2013)

Station	**NO_2 concentration (in µg/m³)**
Mothutlung Clinic	13.38
RAS Dekroon	16.61
Brits Industrial	17.96
Marikana Clinic	13.66

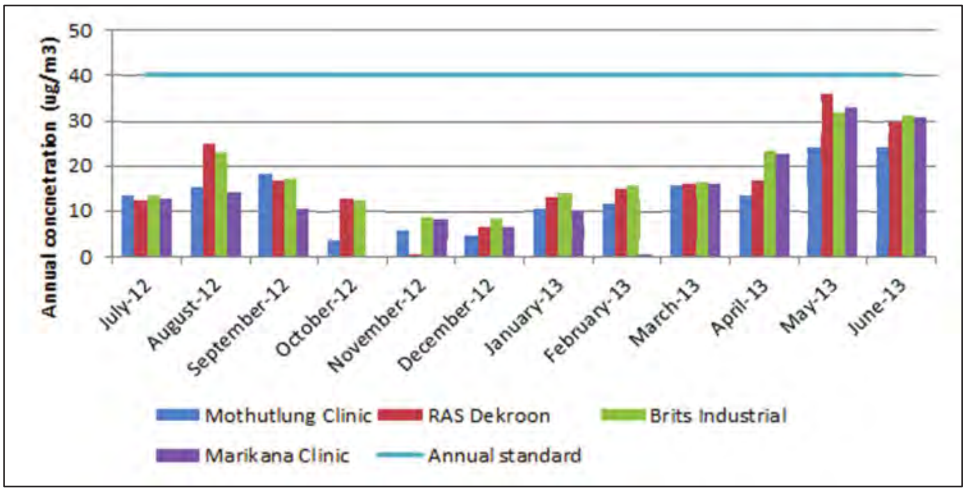
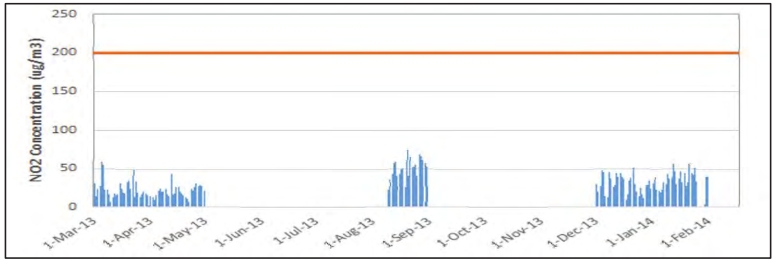
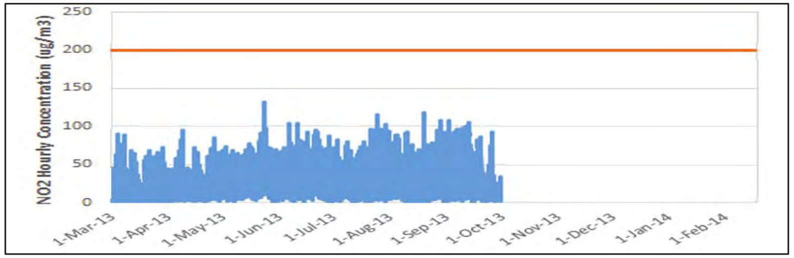


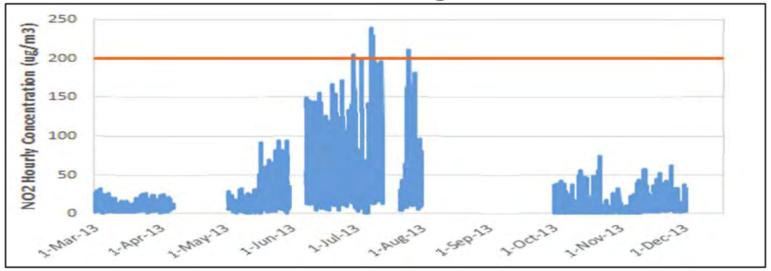
Figure 4-20: Monthly average NO_2 concentrations measured at DEA passive sampling sites



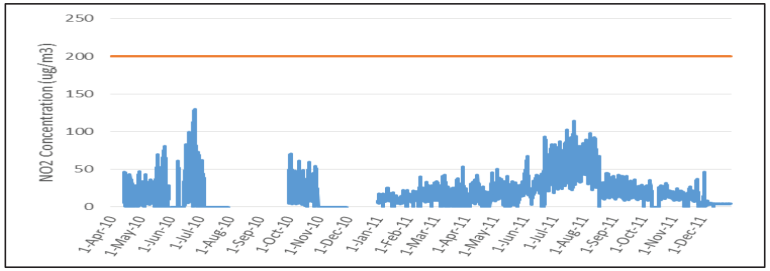
Boitekong



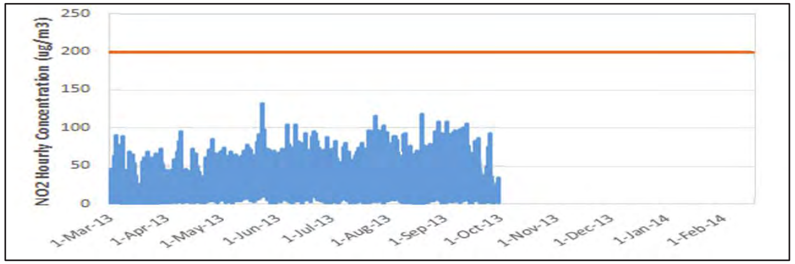
Tlhabane



Marikana



Damonsville



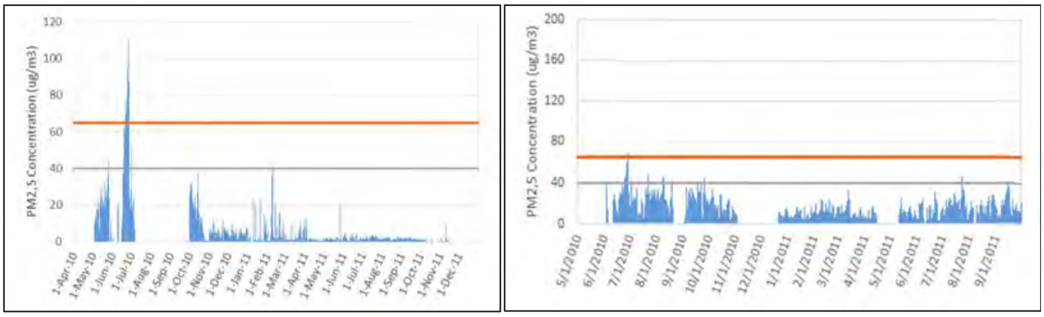
Thlabane

Figure 4-21: Hourly NO_2 concentrations in Bojanala-Platinum DM with the NAAQS of 200 µg/m^3 showing the NAAQS of 200 µg/m^3

Particulate matter

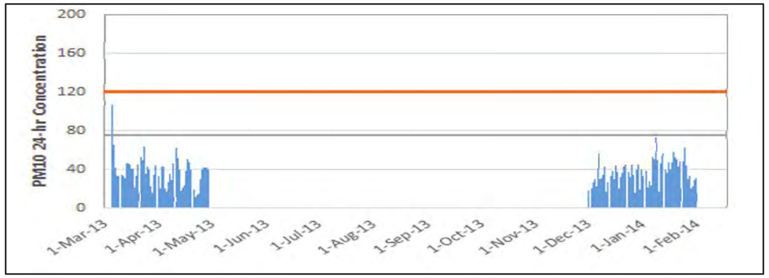
In BPDM, data recovery of PM_{10} and $PM_{2.5}$ was relatively poor with the only reasonable data at Pokeng and Damonsville. Despite this, available hourly data are shown in Figure 4-22 and Figure 4-23. At Marikana, Boitekong, Damonsville and Phokeng, hourly PM_{10} ambient concentrations are generally below the current limit value of the NAAQS, other than some exceedances of the limit value in winter. PM_{10} concentrations are higher at Marikana than other stations, where the 2015 limit value of the NAAQS is often exceeded. At Thlabane, the current and 2015 limit values of the NAAQS are frequently exceeded.

$PM_{2.5}$ ambient concentrations during the same period at Damonsville are relatively low besides a period of higher concentrations in July 2010. At Phokeng, the hourly $PM_{2.5}$ concentrations are well below the current limit value of the NAAQS, but often exceed the future limit value.

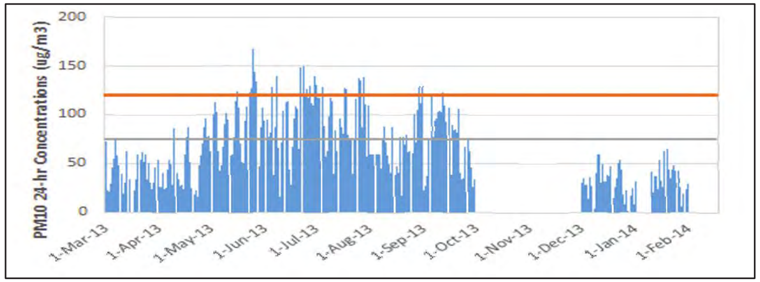


Damonsville **Pokeng**

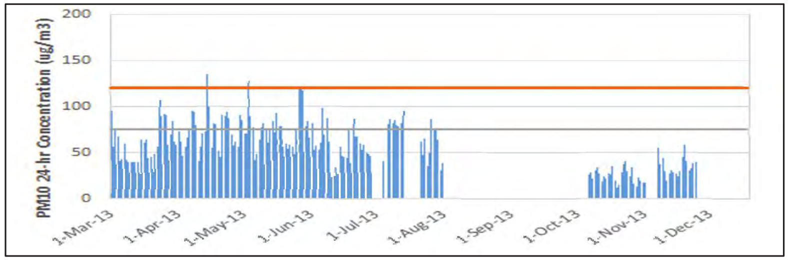
Figure 4-22: Hourly $PM_{2.5}$ concentrations ($\mu g/m^3$) at Damonsville and Pokeng with the current and future NAAQS limit value



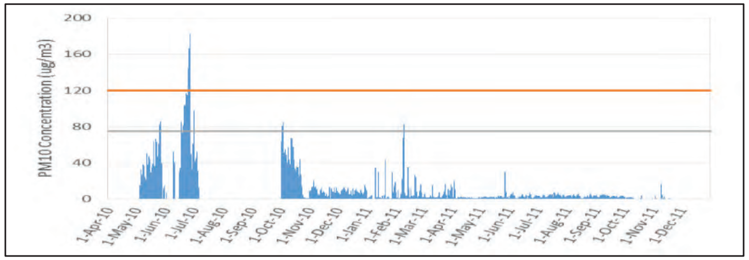
Boitekong



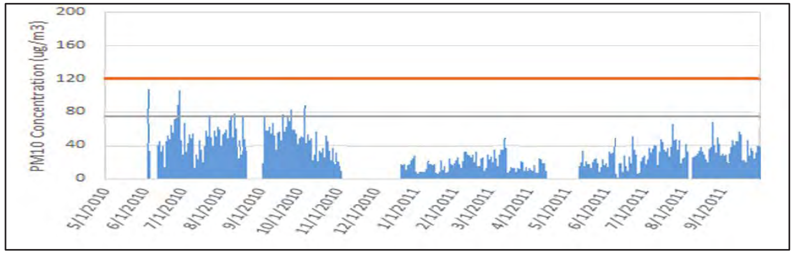
Thlabane



Marikana



Damonsville



Phokeng

Figure 4-23: Hourly PM_{10} concentrations (µg/m^3) in Bojanala-Platinum DM with the current NAAQS of 120 µg/m^3 and the 2015 value of 75 µg/m^3

High PM_{10} ambient concentrations at Damonsville coincide with winds from the north east (Figure 4-24). Residential fuel burning in Mothulung could be contributing to these higher concentrations.

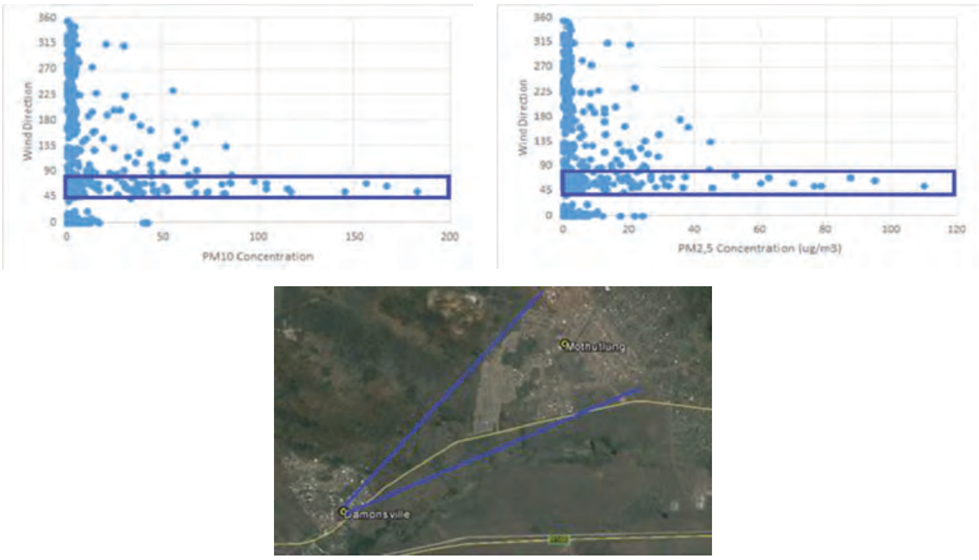


Figure 4-24: Hourly PM_{10} (left) and $PM_{2.5}$ (right) concentrations at Damonsville plotted against wind direction showing high values from Mothulung with northeastly winds

Anglo American Platinum operates seven monitoring stations in the vicinity of their operations in BPDM (Figure 4-25).

Figure 4-25: Relative location of Anglo Platinum ambient air quality monitoring stations

The annual average PM_{10} concentrations comply with the current NAAQS limit value of 120 µg/m³ at all stations (Table 4-22). However, in 2010, the overall 24-hour NAAQS limit value was exceeded at four stations, as the permitted frequency of exceedances observed were greater than four events (

Table 4-23). In 2011 and 2012, this reduced to an overall exceedance at one station in each year. In 2013, the 24-hour limit value was exceeded on ten occasions at Klipfontein in the south west of the works, and on seven occasions at Paardekraal in the North West.

Table 4-22: Annual average PM_{10} concentration (µg/m³) at Anglo Platinum

	2010	2011	2012	2013
Bergsig	34.6			
Brakspruit	98.4	30.2	31.4	29.4
Hex River	35.7	30.0	37.2	36.9
Klipfontein	74.9	59.5	46.2	53.8
Mfidikwe	59.8	49.3	55.8	53.4
Paardekraal	54.4	58.4	74.4	65.2
Waterval			43.9	40.9
Wonderkop	106.2	89.4		

Table 4-23: 24-hour limit value exceedances at Anglo Platinum

	2010	2011	2012	2013
Bergsig	0			
Brakspruit	**65**	3	0	0
Hex River	0	0	0	0
Klipfontein	**22**	2	2	**10**
Mfidikwe	3	1	0	1
Paardekraal	**5**	3	**7**	**7**
Waterval			0	0
Wonderkop	**85**	**33**		

NB. Bold type indicates overall 24-hour NAAQS exceedances, considering frequency of exceedance threshold

Other pollutants

Benzene was monitored at Marikana Clinic and Brits during the DEA's so-called Table 24 Ground Truthing campaign. The annual average concentrations at these two sites were 1 µg/m³ and 0.7 µg/m³, respectively, well below the 2015 NAAQS of 5 µg/m³.

Summary

Ambient air quality monitoring is relatively limited in the WBPA with only nine government-owned monitoring stations, some industry-specific monitoring and one short passive monitoring campaign. Due to higher levels of industrial and mining activity, ambient air quality monitoring is concentrated in the BPDM. The return of high-quality ambient air quality monitored data from the various networks is not consistent, and, unfortunately, considerable data have either not been captured or is of low quality. Nevertheless, available data provide some insights into the state of ambient air quality in the WBPA. These are:

- Ambient SO_2 concentrations in the WDM are very low compared to the NAAQS limit values, as there are few emission sources.
- Ambient SO_2 concentrations in the BPDM are low compared to the NAAQS limit values, as there are relatively few sources.
- Ambient NO_2 concentrations are low relative compared to the NAAQS limit values throughout the WBPA;
- Ambient PM_{10} concentrations in the WDM are relatively low compared to the NAAQS limit values.
- Ambient PM_{10} concentrations in the WDM are generally below the limit value of the NAAQS, but exceed the 2015 limit value often at Marapong and Mokopane.
- Ambient PM_{10} concentrations in the BPDM are generally below the limit value of the NAAQS, but will exceed the 2015 limit value often at most monitoring stations, particularly Marikana and Thlabane.
- Ambient PM_{10} concentrations, near industrial and mining sources, in the BPDM are relatively high with exceedances of the NAAQS limit values.
- Ambient benzene concentrations in the BPDM are well below the NAAQS.

4.10.3 Modelled data

The US-EPA-approved and DEA-recommended CALPUFF dispersion model was used to estimate ambient concentrations of SO_2, NO_2 and PM_{10} resulting from Listed Activities, residential fuel burning, mining, and trans-boundary sources in Botswana. A detailed description of the modelling approach is documented in the modelling plan of study (see Appendix 2). Modelling is done for a large domain covering the WBPA at a resolution of 5 km, and for two smaller domains, one centred on Lephalale in the WDM and the other centred on the Brits-Rustenburg area in the BPDM, both at a 1 km resolution. Hourly meteorological data from SAWS monitoring stations were used with the diagnostic meteorological model TAPM to create hourly meteorological input files for 2010-2012, for each modelling domain. Emissions from Listed Activities were modelled as point sources with some area sources. Residential fuel burning considered emissions from each municipal ward in the WBPA as an area source. For mining, each of the 176 mines in the WBPA was modelled as area source.

Morupule Power Station stacks in Botswana were the only trans-boundary source that was included in the modelling.

Emissions of SO_2, NO_x and PM_{10} from residential fuel burning were estimated for 180 municipal wards in the WBDM using energy use data from Census 2011 (StatsSA, 2011) and emission factors (See Section 4.3). The agreed dispersion modelling approach for residential fuel burning, documented in the modelling plan, was to treat the emissions for each ward as an area source, accounting for the municipal ward, considering AQM interventions are likely to be implemented at ward level.

In retrospect, this approach is unrealistic as emissions from residential fuel burning are localised, rather than distributed homogeneously throughout a ward. The approach served to significantly dilute the emissions spatially. The predicted annual average concentrations are therefore considerably lower than measured concentrations. Furthermore, the top-down emission estimation approach does not account for the morning and evening emissions peaks and seasonal variations. As a result, the measured diurnal and seasonal peaks are not captured in the dispersion modelling. This is because of the way in which the model has been parameterised with the available data, the model outputs for residential fuel burning provides an indication of the spatial variation in the WBPA, rather than estimations of the ambient concentrations. Fortunately, these variations in the data are provided by ambient air quality monitoring.

In the section that follows, the dispersion model results are presented on regional maps. The figures include three maps, one for the entire WBPA modelling domain in the left panel, and two zoomed maps for the Waterberg-Botswana sub-domain and the Rustenburg-Brits sub-domain in the panels on the right. Presented are the predicted annual average concentrations of SO_2, NO_2 and PM_{10} resulting from emissions from Listed Activities, mining, residential fuel burning and sources in Botswana and the 99th percentile of the predicted 24-hour and 1-hour concentrations. These are compared with the limit value of the respective NAAQS. The frequency of exceedances is compared with the permitted tolerance values, i.e. 12 for three years of 24-hour concentrations and 264 for 3 years of hourly concentrations.

Sulphur dioxide (SO_2)

Listed Activities

The predicted SO_2 concentrations resulting from emissions from Listed Activities are shown for the three domains in Figure 4-26 to Figure 4-30. These include predicted annual averages, the 99th percentile of the predicted 24-hour and 1-hour concentrations and the frequency of exceedance of the NAAQS limit values.

In the WDM, the predicted annual average SO_2 concentrations resulting from Listed Activities comply with the NAAQS limit value of 50 µg/m³. Similarly, the predicted 99th percentile of the 24-hour and 1-hour SO_2 concentrations comply with the limit values of the NAAQS throughout the WDM. In the BPDM, the predicted annual average SO_2 concentrations generally comply with the NAAQS, but exceedances are predicted in the area surrounding Rustenburg, extending approximately 20 km to the north, and north west of Mooinooi. Similarly, the predicted 99th percentile of the 24-hour and 1-hour SO_2 concentrations generally comply with the limit values of the NAAQS in the BPDM, but exceedances are predicted in an area centred on Rustenburg, north of Mooinooi and near Brits. In the three year modelling period, more than 12 exceedances (four per year) of the 24-hour limit value are predicted in these same areas. Likewise, more than 264 exceedances (88 per year) of the 1-hour limit value are predicted. Non-compliance with the NAAQS in the BPDM indicates that emissions of SO_2 from industrial sources and the potential impacts on health is an issue in the BPDM.

Interestingly, the predicted ambient SO_2 concentrations in the WDM are much lower than those in the BPDM, even though the SO_2 emission is significantly higher in the WDM than in the BPDM. More than 99% of all SO_2 emitted in the WDM is from a single source, i.e. the Matimba Power Station (Table 4-1). Because of the tall stacks, dispersion generally takes place above the surface temperature inversion at night preventing the plume reaching ground level. The predicted ambient SO_2 concentrations at ground level at Lephalale are therefore low relative to the NAAQS, with no predicted exceedances. In the BPDM, SO_2 is emitted from numerous sources with relatively low stacks, all located relatively close to one another. Pollutants are generally released into the stable layer close to ground level at night where dispersion is poor, resulting in the predicted exceedances of the NAAQS.

There seems to be general agreement between the predicted SO_2 concentrations and the monitored data throughout the WBPA. However, the predicted exceedances of the 24-hour and 1-hour SO_2 limit values in the BPDM are not seen as dramatically as in the monitored data. This may be because of the generally poor monitoring data records and because the monitoring stations are not located in the zone, where the highest SO_2 concentrations are predicted.

Residential Fuel Burning

The predicted annual average and maximum 24-hour and 1-hour SO_2 concentrations resulting from emissions from Residential Fuel Burning are shown in Figure 4-31 to Figure 4-33. Emissions of SO_2 from Residential Fuel Burning are relatively low and this is largely attributed to prevalent use of wood in the WBPA and the low sulphur content of wood. As a result, the ambient SO_2 concentrations resulting from Residential Fuel Burning in the WBPA are expected to be low.

This, together with the approach used in the modelling, where emissions are distributed across the respective municipal wards, accounts for very low predicted annual average SO_2 concentrations. Furthermore, by averaging emissions from Residential Fuel Burning, the predicted maximum 24-hour and 1-hour SO_2 concentrations are low compared to monitored data.

Despite the low predicted SO_2 concentrations, the model output provides a useful representation of the spatial distribution of ambient concentrations resulting from residential fuel burning. However, ambient air quality monitoring stations located in residential areas where wood and coal are used indicate that ambient SO_2 concentrations are low compared to the NAAQS. It appears, therefore that there are no issues relating to SO_2 from residential fuel burning.

Trans-boundary

For the baseline assessment, the only source of SO_2 considered in Botswana is the Morupule A Power Station. The predicted annual average and the 99^{th} percentile of the predicted 24-hour and 1-hour SO_2 concentrations resulting from Morupule A emissions are shown in Figure 4-34 to Figure 4-36. As may be expected with the relatively small source, the predicted annual average concentrations are low and comply with the NAAQS of 50 $\mu g/m^3$. Similarly, the predicted 99^{th} percentile of the 24-hour and 1-hour concentrations is low relative to the limit values of the NAAQS. Therefore, the spatial extent of the influence of Morupule A on ambient air quality is limited and currently it has no influence on ambient SO_2 concentrations in the WBPA.

By contrast, emissions of SO_2 from the Matimba Power Station have a considerably greater spatial impact and are predicted to affect ambient SO_2 concentrations in eastern Botswana. These emissions are predicted to increase the annual average SO_2 concentration by up to 2 $\mu g/m^{-3}$ at the border, and less further from the source (Figure 4-26). The predicted increase in the 99^{th} percentile of the 1-hour SO_2 concentrations is 50 $\mu g/m^{-3}$ at the border , decreasing further from the source (Figure 4-29).

All sources

The predicted annual average and 99^{th} percentile of the predicted 24-hour and 1-hour SO_2 concentrations are shown collectively for Listed Activities, Residential Fuel Burning, and trans-boundary emissions in Figure 4-37 to Figure 4-40 for the WBPA, the Waterberg-Botswana domain and the Rustenburg-Brits domain.

In the WDM, the predicted annual average SO_2 concentrations resulting from all sources comply with the NAAQS of 50 µg/m^3. Similarly, the predicted 99th percentile of the 24-hour and 1-hour SO_2 concentrations comply with the limit values of the NAAQS throughout the WDM. In the BPDM, the predicted annual average SO_2 concentrations generally comply with the NAAQS, but exceedances are predicted in the area surrounding Rustenburg, extending approximately 20 km to the north, and North West of Mooinooi. Similarly, the predicted 99th percentile of the 24-hour and 1-hour SO_2 concentrations generally comply with the limit values of the NAAQS in the BPDM, but exceedances are predicted in an area centred on Rustenburg, north of Mooinooi and near Brits. In the three year modelling period, more than 12 exceedances of the 24-hour limit value are predicted in these same areas. Likewise, more than 264 exceedances of the 1-hour limit value are predicted. Non-compliance with the NAAQS in the BPDM indicates that emissions of SO_2 from industrial sources and the potential impacts on health are an issue in the BPDM. It is clear that emissions from the Listed Activity source category dominate the resultant ambient concentrations.

There seems to be general agreement between the predicted SO_2 concentrations and the monitored data throughout the WBPA. However, the predicted exceedances of the 24-hour and 1-hour SO_2 limit values in the BPDM are not seen as dramatically as in the monitored data. This may be because of the generally poor monitoring data records and because the monitoring stations are not located in the zone, where the highest SO_2 concentrations are predicted.

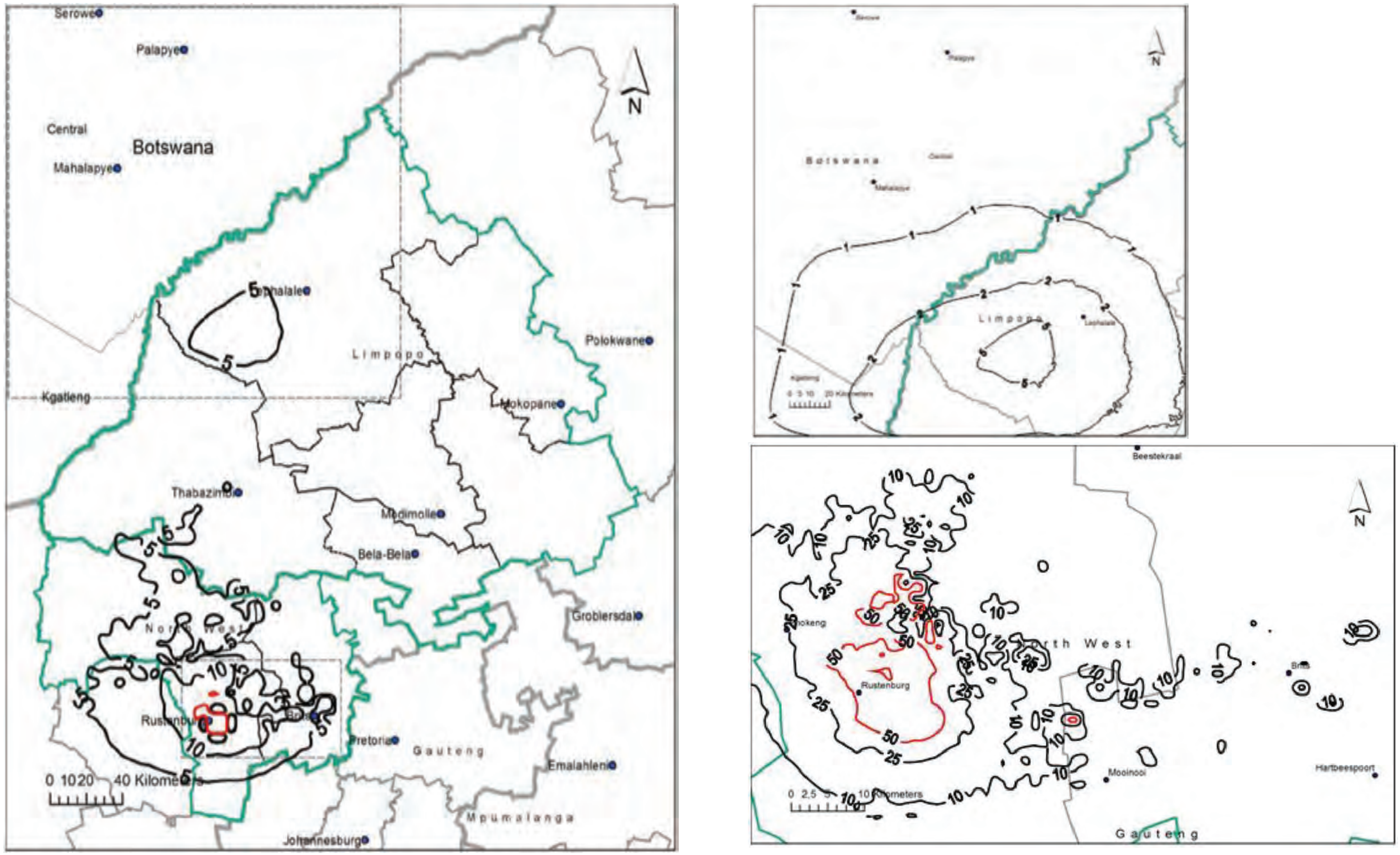


Figure 4-26: Predicted average annual concentrations of SO_2 resulting from Listed Activities in the WBPA (left), the Waterberg-Botswana domain (top right) and the Rustenburg-Brits domain (bottom right). Red isopleths indicate the NAAQS.

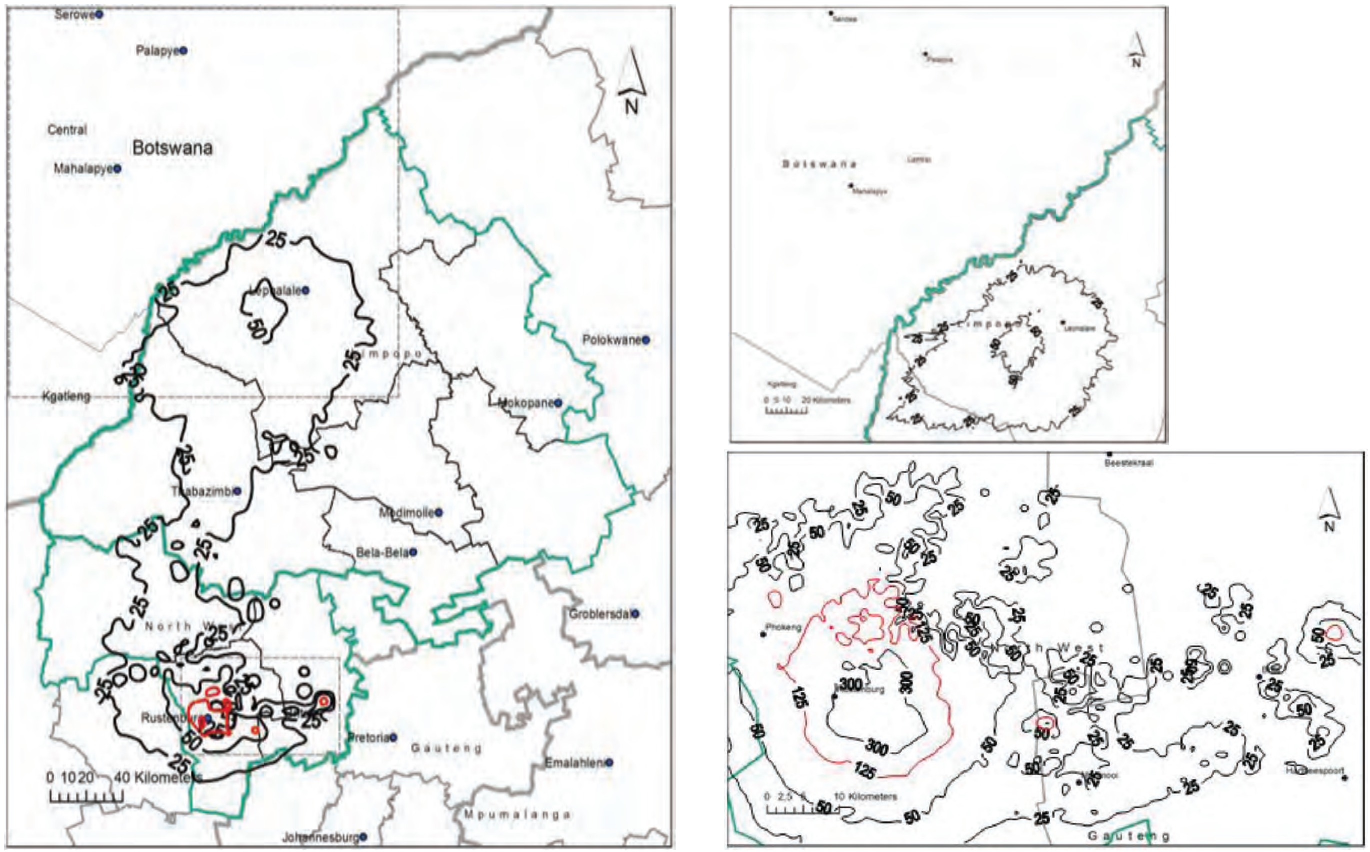


Figure 4-27: 99th percentile of the predicted 24-hour SO_2 concentrations resulting from Listed Activities in the WBPA (left), the Waterberg-Botswana domain (top right) and the Rustenburg-Brits domain (bottom right). Red isopleths indicate the NAAQS.

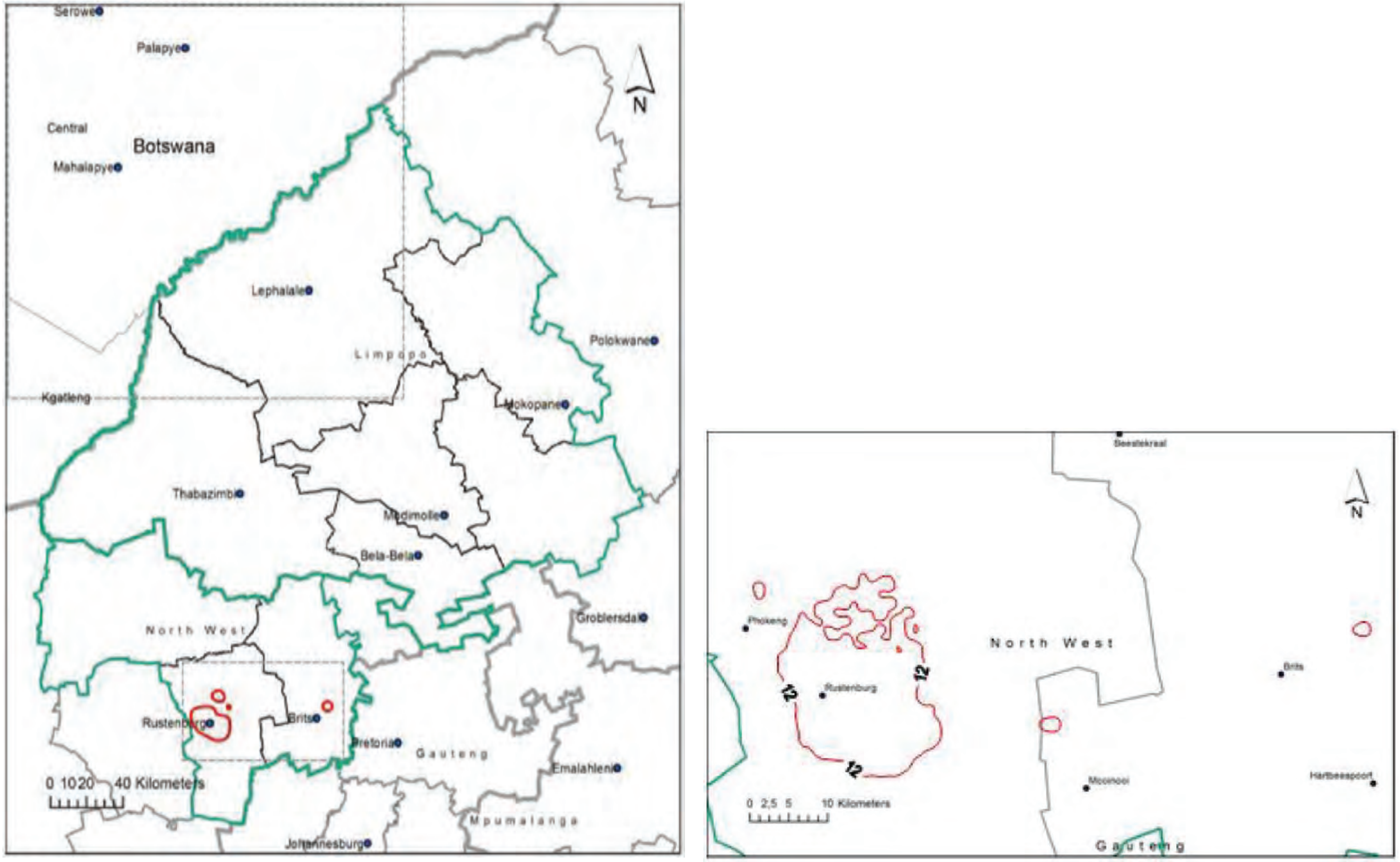


Figure 4-28: Frequency of exceedance of the limit value of the 24-hour limit value of the NAAQS for SO_2 resulting from Listed Activities in the WBPA (left), and the Rustenburg-Brits domain (bottom right). Red isopleths indicate the NAAQS.

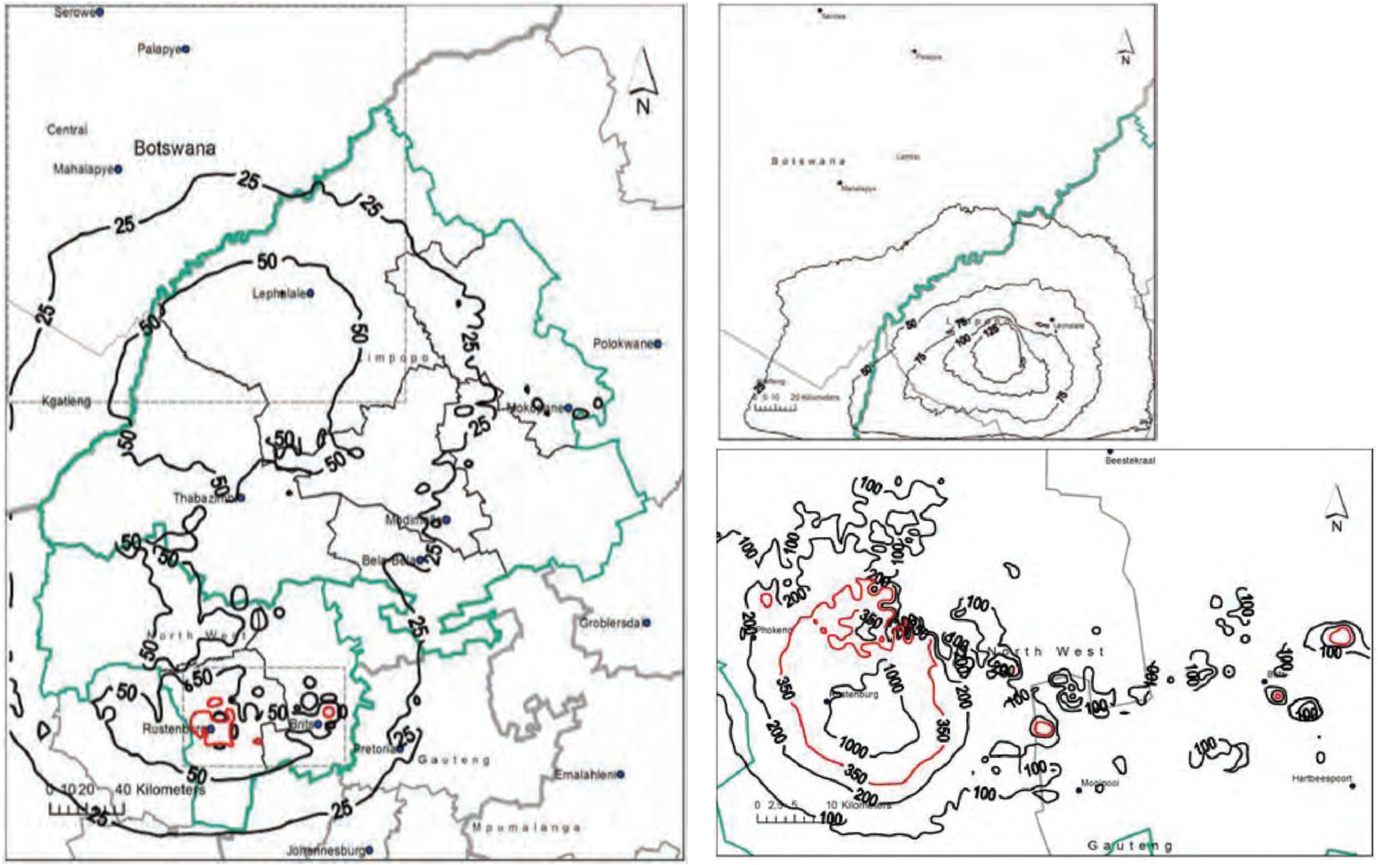


Figure 4-29: 99th percentile of the predicted 1-hour SO_2 concentrations resulting from Listed Activities in the WBPA (left), the Waterberg-Botswana domain (top right) and the Rustenburg-Brits domain (bottom right). Red isopleths indicate the NAAQS.

CONTINUES ON PAGE 130 - PART 2

Government Gazette
Staatskoerant

REPUBLIC OF SOUTH AFRICA
REPUBLIEK VAN SUID AFRIKA

Vol. 606 | 9 December / Desember 2015 | No. 39489

PART 2 OF 3

ISSN 1682-5843

39489

9 771682 584003

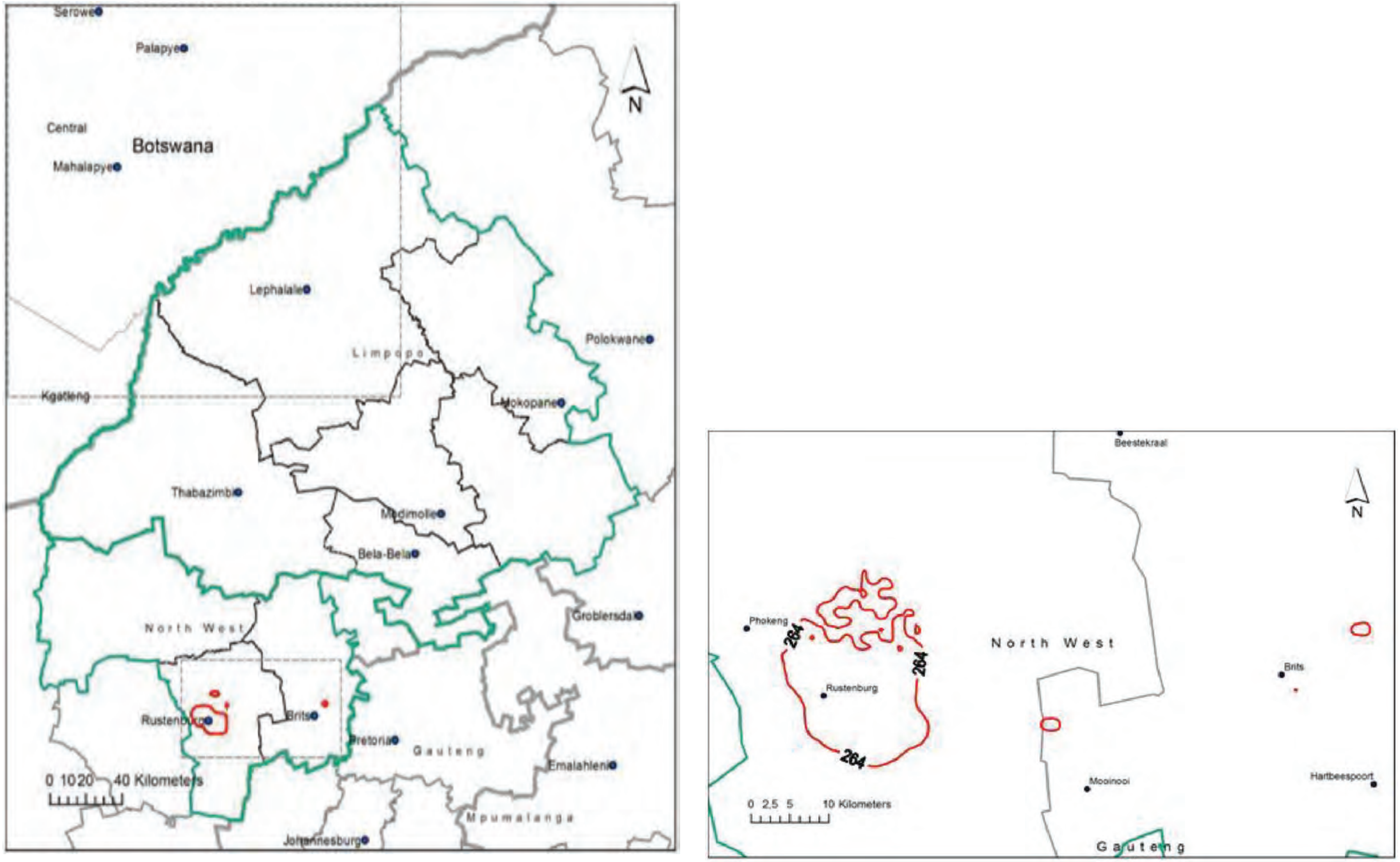


Figure 4-30: Frequency of exceedance of the limit value of the 1-hour limit value of the NAAQS for SO_2 resulting from Listed Activities in the WBPA (left), and the Rustenburg-Brits domain (bottom right). Red contours indicate the frequency of exceedance of the limit value.

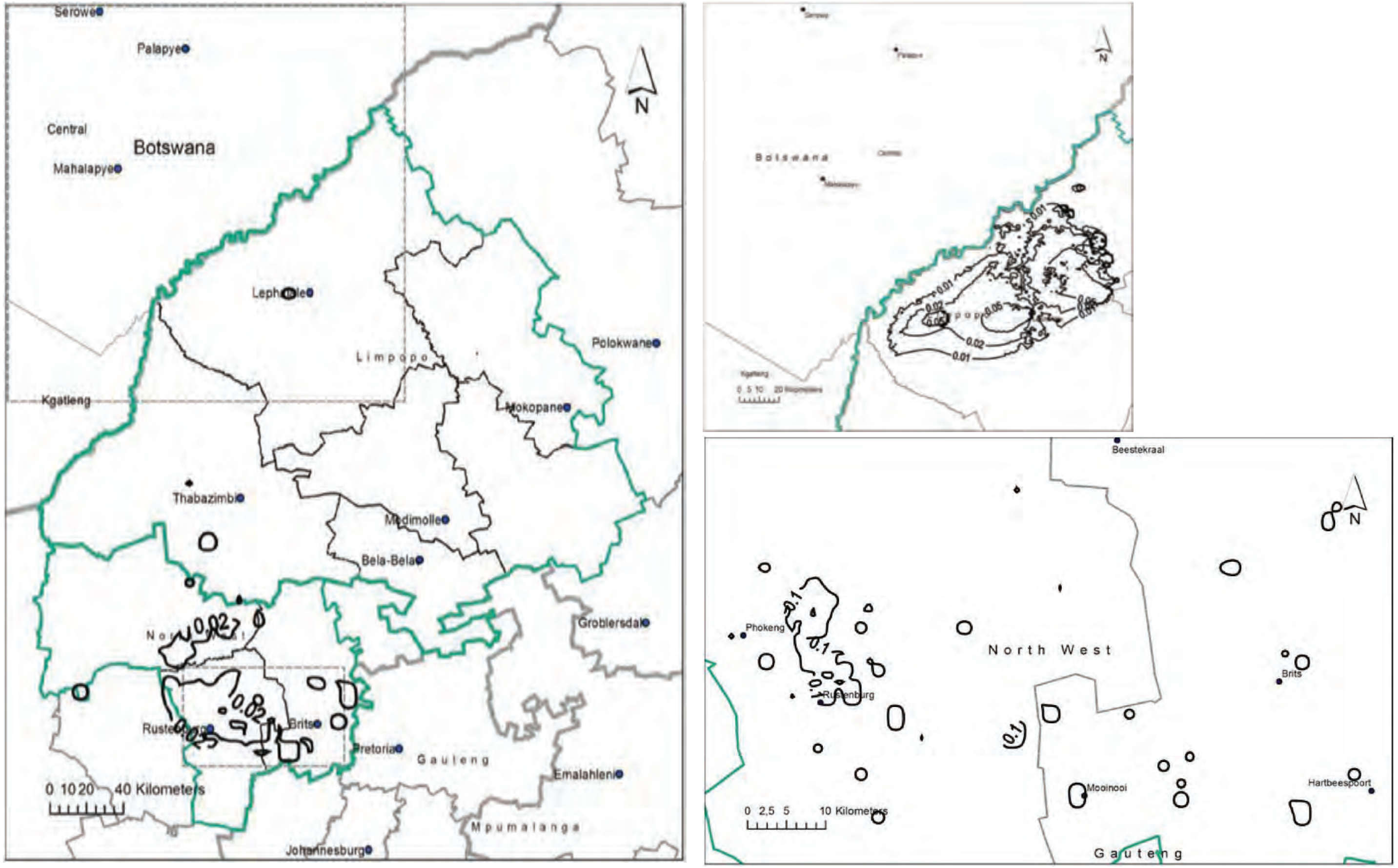


Figure 4-31: Predicted average annual concentrations of SO_2 resulting from Residential Fuel Burning in the WBPA (left), the Waterberg-Botswana domain (top right) and the Rustenburg-Brits domain (bottom right)

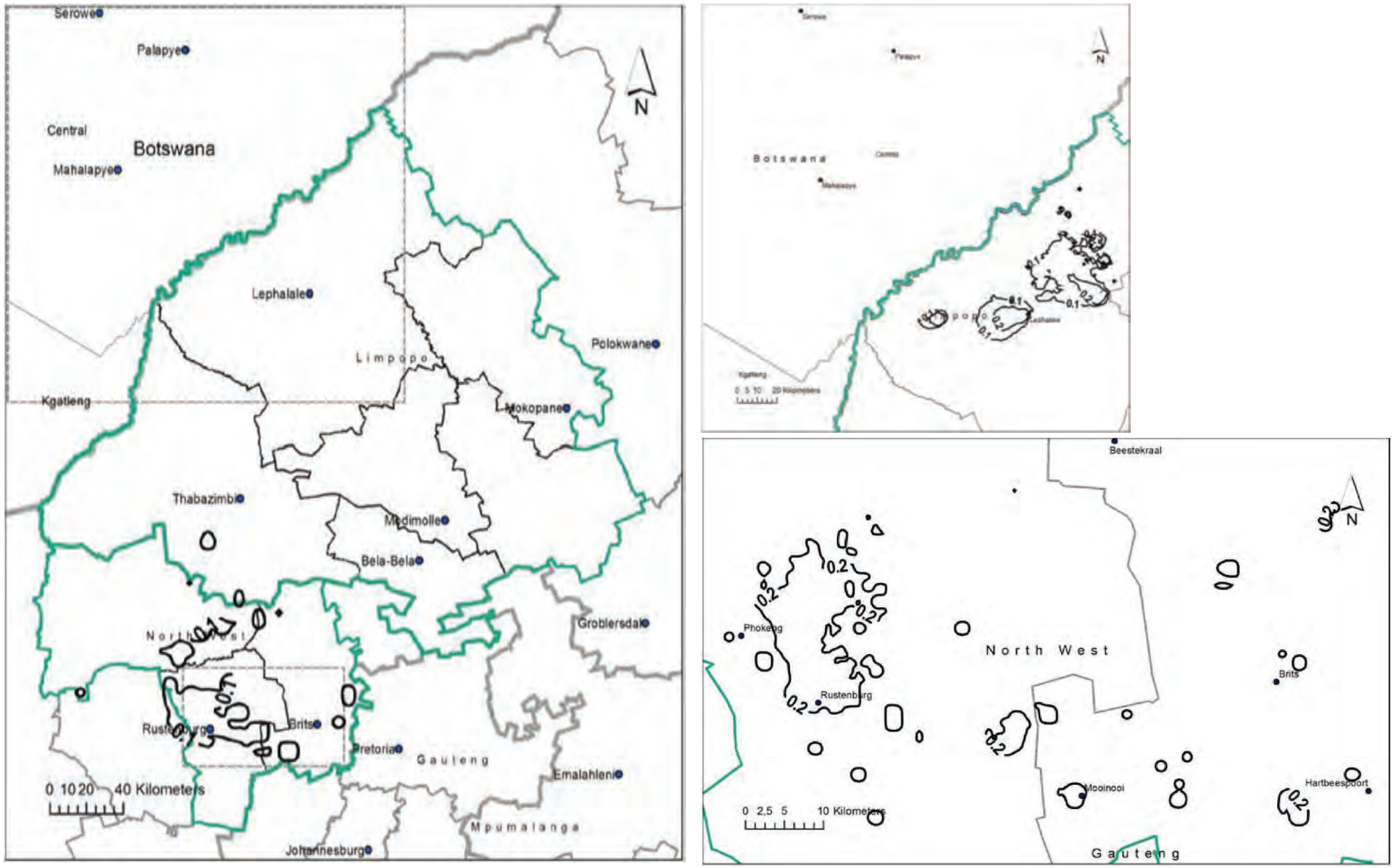


Figure 4-32: 99th percentile of the predicted 24-hour SO_2 concentrations resulting from Residential Fuel Burning in the WBPA (left), the Waterberg-Botswana domain (top right) and the Rustenburg-Brits domain (bottom right)

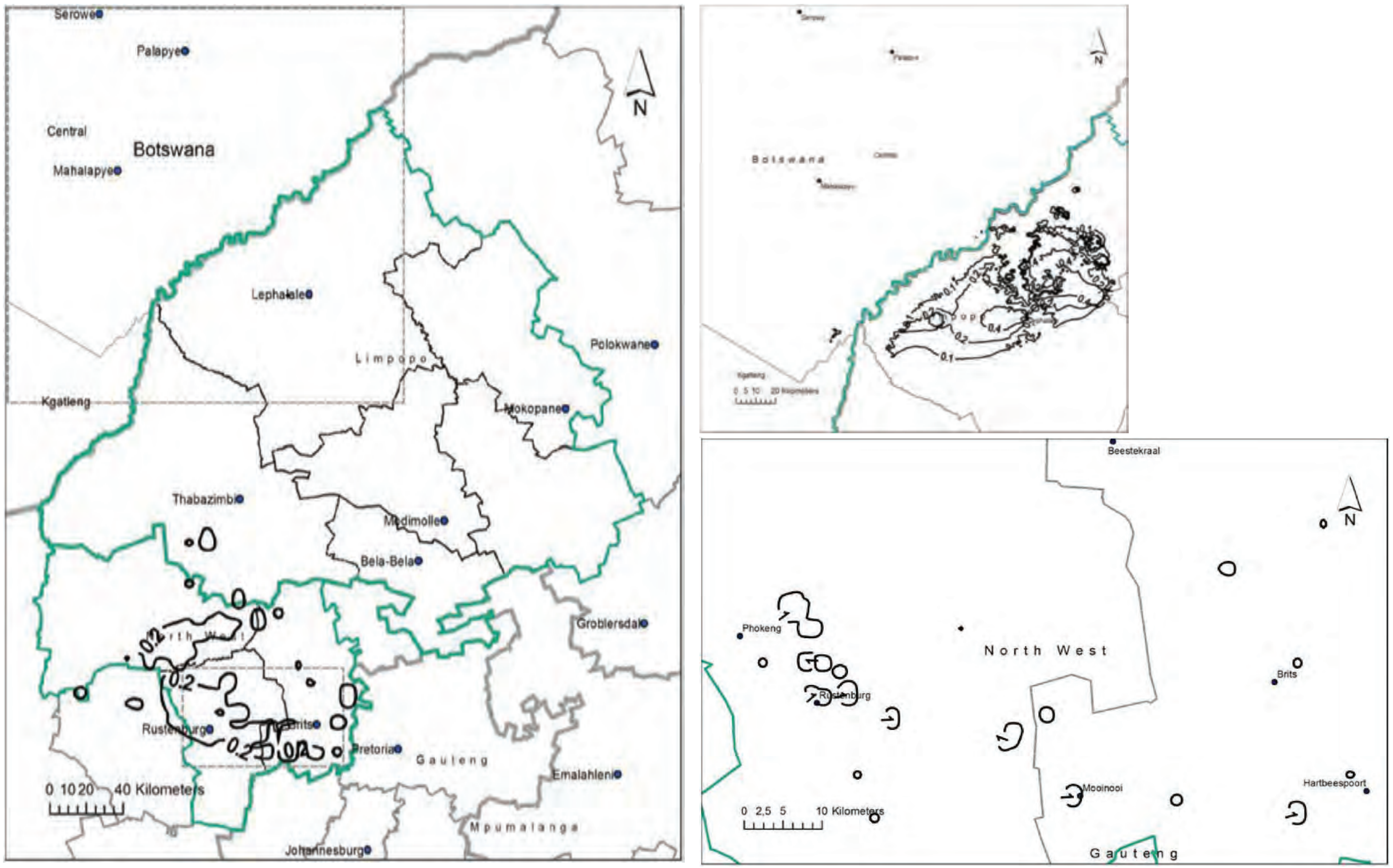


Figure 4-33: 99th percentile of the predicted 1-hour SO_2 concentrations resulting from Residential Fuel Burning in the WBPA (left), the Waterberg-Botswana domain (top right) and the Rustenburg-Brits domain (bottom right)

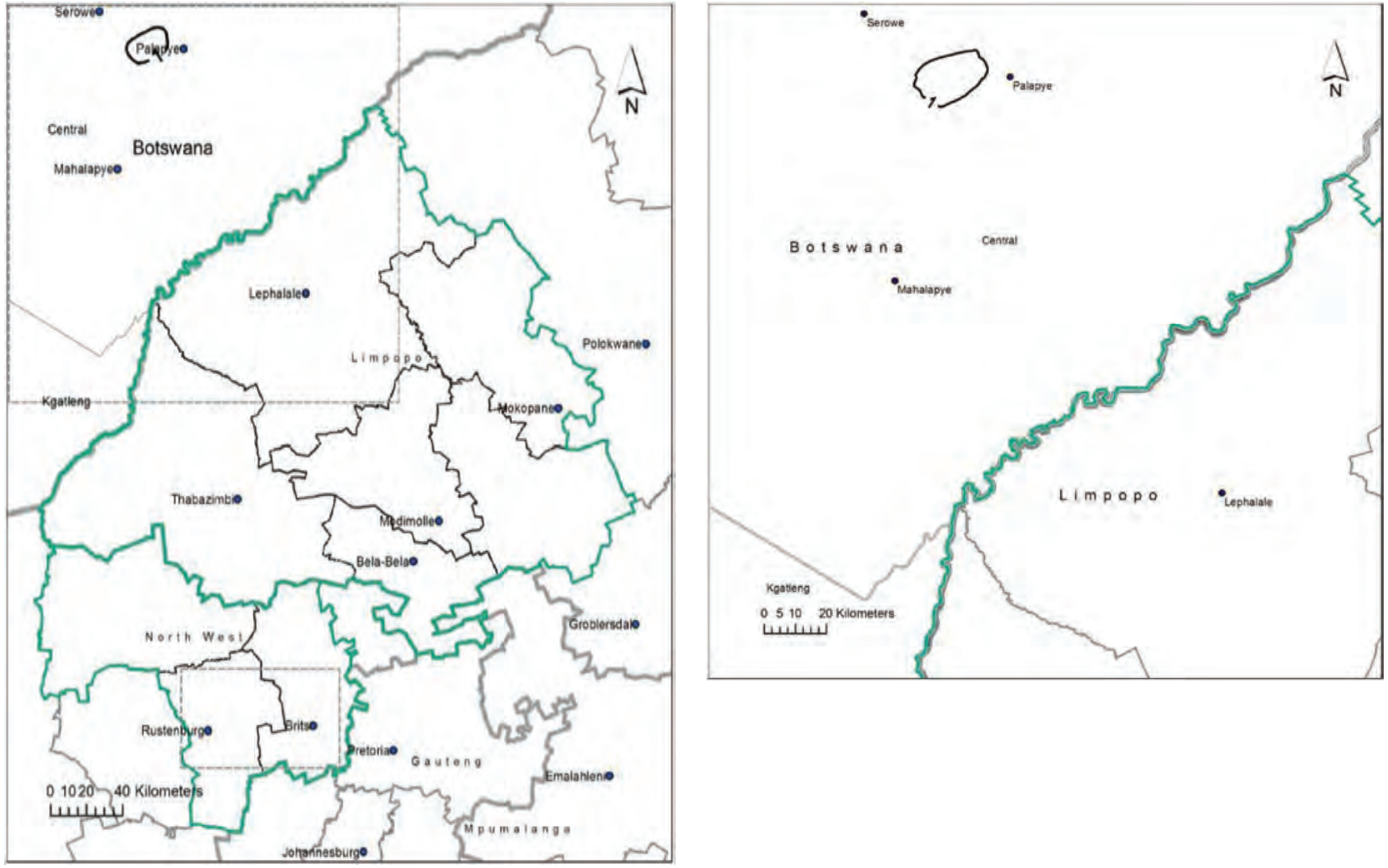


Figure 4-34: Predicted average annual concentrations of SO_2 resulting from trans-boundary emissions in the WBPA (left) and the Waterberg-Botswana domain (right)

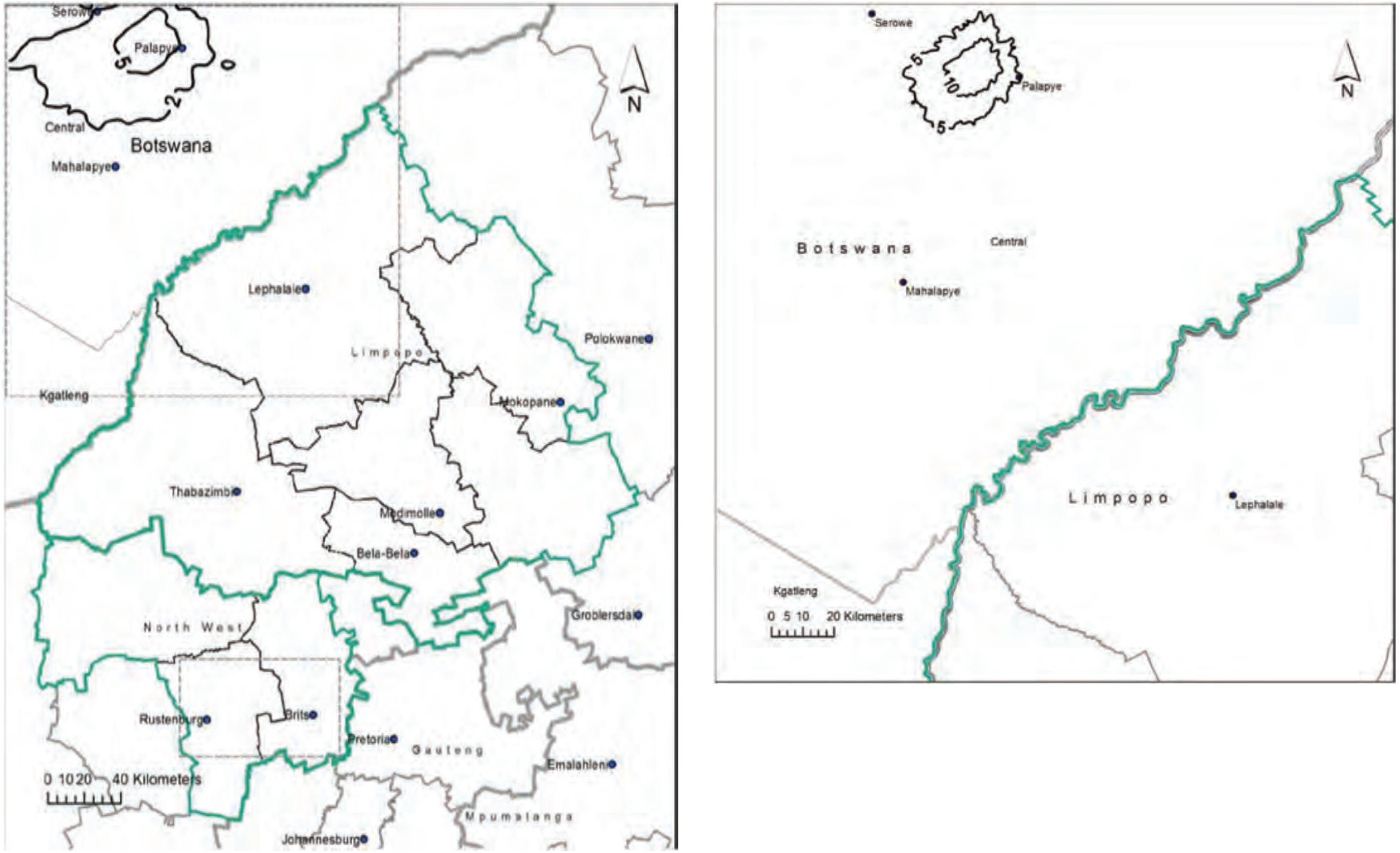


Figure 4-35: 99th percentile of the predicted 24-hour SO_2 concentrations resulting from trans-boundary emissions in the WBPA (left) and the Waterberg-Botswana domain (right)

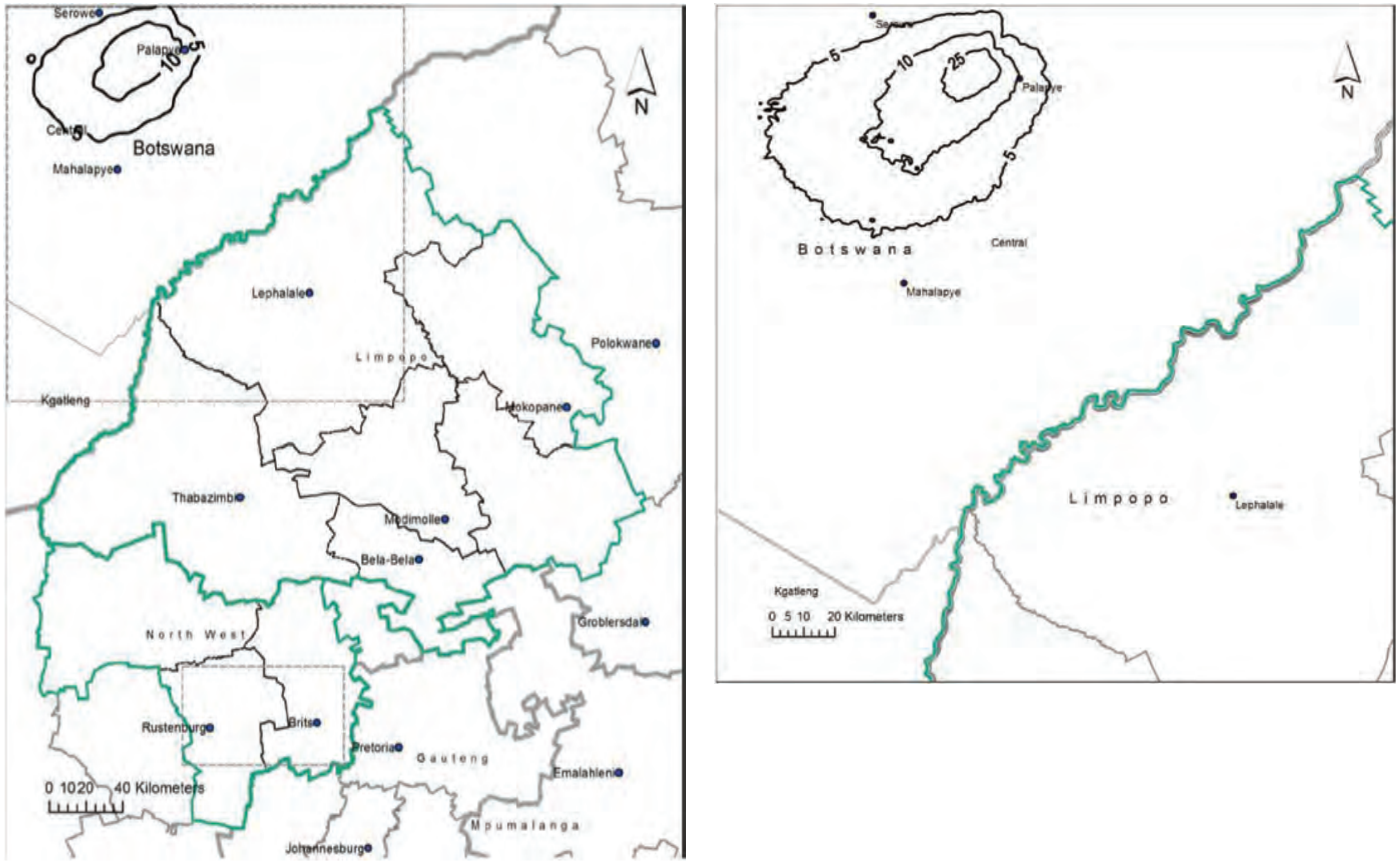


Figure 4-36: 99th percentile of the predicted 1-hour SO_2 concentrations resulting from trans-boundary emissions in the WBPA (left) and the Waterberg-Botswana domain (top right)

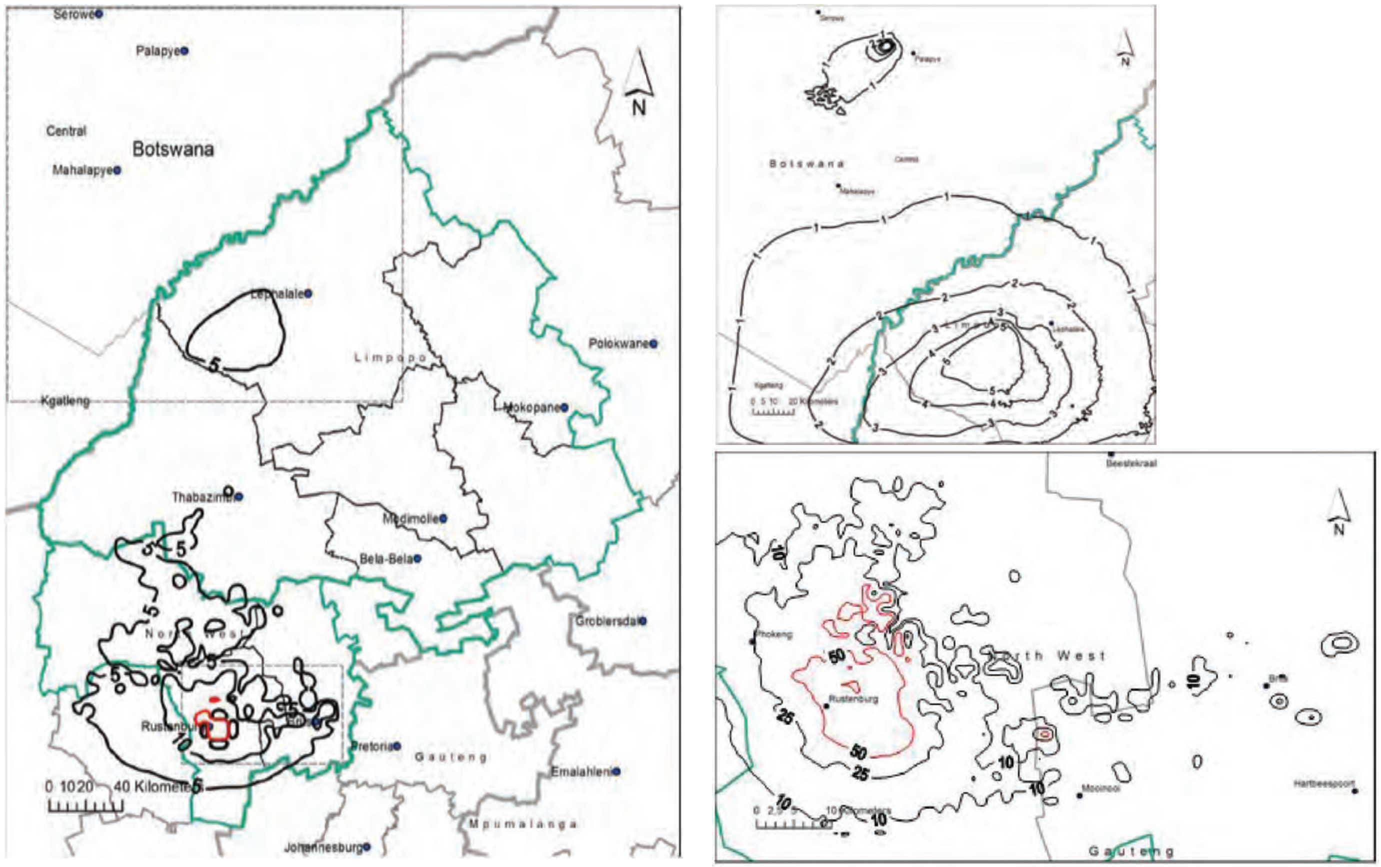


Figure 4-37: Predicted average annual concentrations of SO_2 resulting from Listed Activities, Residential Fuel Burning and trans-boundary emissions in the WBPA (left), the Waterberg-Botswana domain (top right) and the Rustenburg-Brits domain (bottom right). The red isopleth indicates the NAAQS.

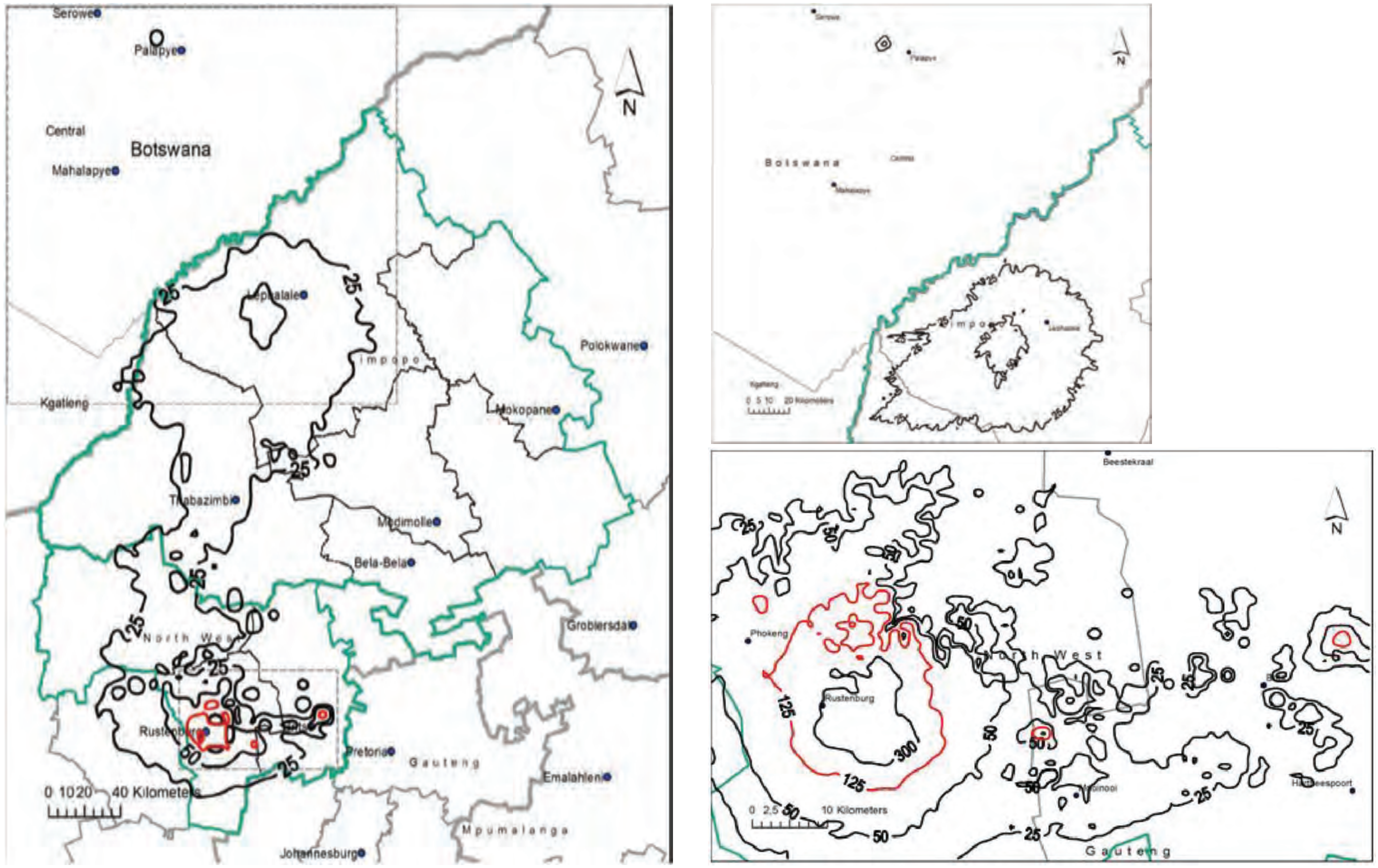


Figure 4-38: 99th percentile of the predicted 24-hour SO_2 concentrations resulting from Listed Activities, Residential Fuel Burning and trans-boundary emissions in the WBPA (left), the Waterberg-Botswana domain (top right) and the Rustenburg-Brits domain (bottom right). The red isopleth indicates the NAAQS.

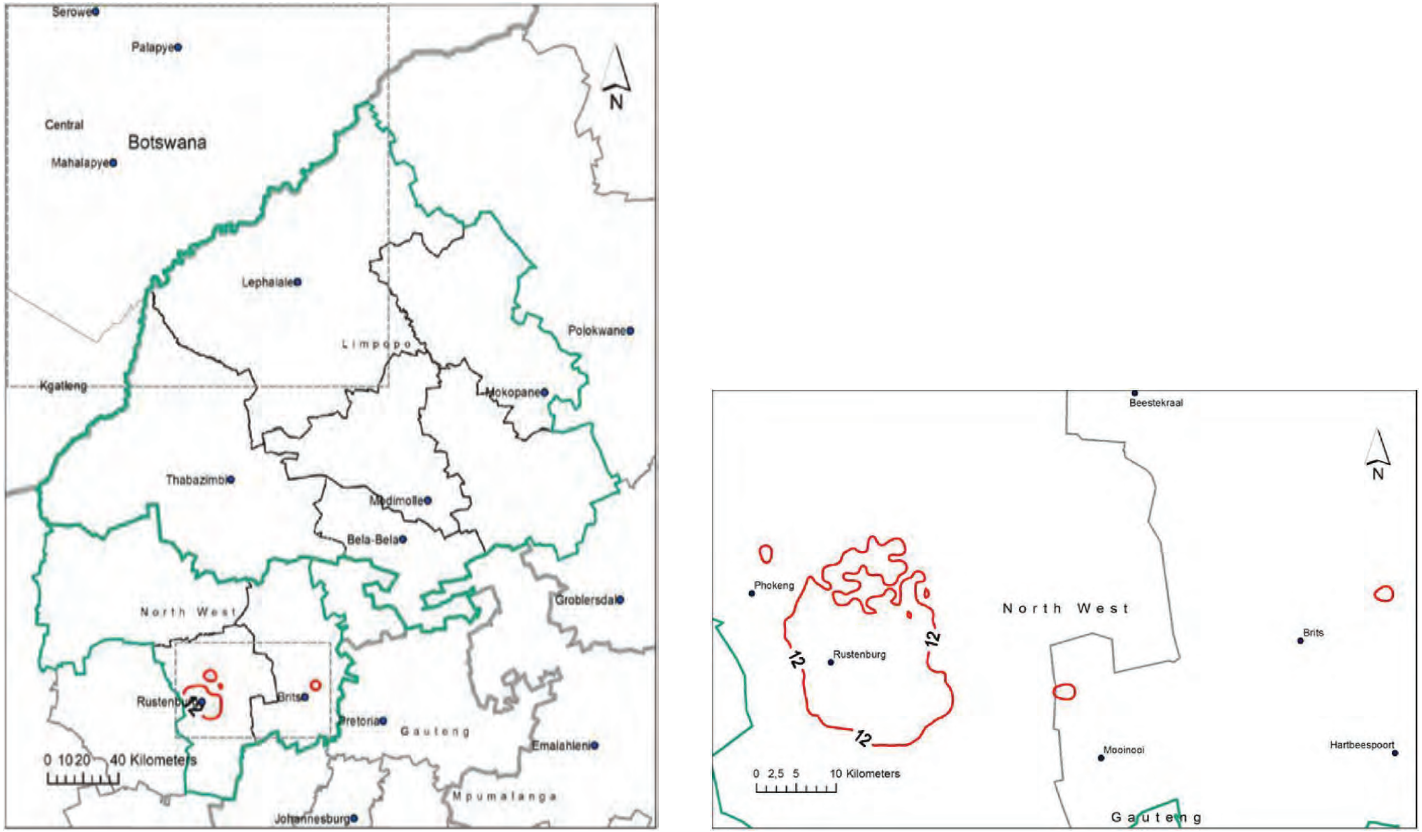


Figure 4-39: Frequency of exceedance of the limit value of the 24-hour limit value of the NAAQS for SO_2 resulting from Listed Activities, Residential Fuel Burning and trans-boundary emissions in the WBPA (left), and the Rustenburg-Brits domain (bottom right). The red contour indicates the frequency of exceedance of the limit value.

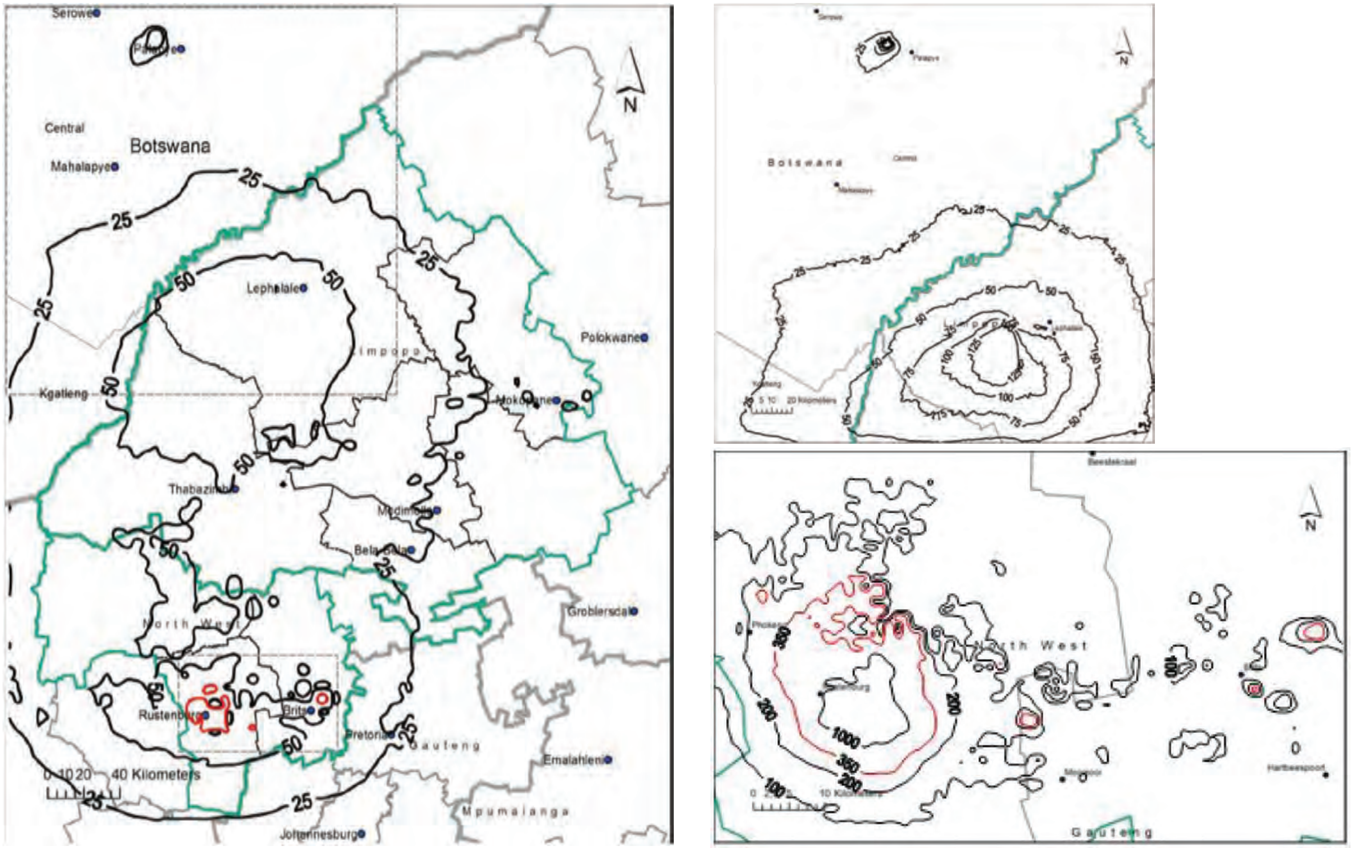


Figure 4-40: 99th percentile of the predicted 1-hour SO_2 concentrations resulting from Listed Activities, Residential Fuel Burning and trans-boundary emissions in the WBPA (left), the Waterberg-Botswana domain (top right) and the Rustenburg-Brits domain (bottom right). The red isopleth indicates the NAAQS.

Figure 4-41: Frequency of exceedances of the limit value of the 1-hour limit value of the NAAQS for SO_2 resulting from Listed Activities, Residential Fuel Burning and trans-boundary emissions in the WBPA (left), and the Rustenburg-Brits domain (bottom right). The red contour indicates the frequency of exceedance of the limit value.

Oxides of nitrogen (NO_X)

Listed Activities

The predicted NO_2 concentrations resulting from emissions from Listed Activities are shown for the three domains in Figure 4-42 to Figure 4-44. These include the predicted annual average and the 99th percentile of the predicted 1-hour concentrations.

The predicted annual average NO_2 concentrations resulting from emissions from Listed Activities comply with the NAAQS of 40 µg/m^3 throughout the WBPA. They are somewhat higher in BPDM than the WDM due to the differences in release height of the pollutant. The 99th percentile of the predicted 1-hour NO_2 concentrations complies with the limit value of the NAAQS (200 µg/m^3) throughout the WBPA, except in three small areas between Brits and Rustenburg. For the 3-year modelling period, the areas where more than 264 exceedances are predicted (88 per year) are localised close to the respective sources.

There seems to be general agreement between the predicted NO_2 concentrations and the monitored data throughout the WBPA. However, the predicted exceedances of the 1-hour NO_2 limit values in the BPDM are not seen in the monitored data. This is most likely because of station location, i.e. monitoring stations are not located in the zones where the highest NO_2 concentrations are predicted.

Residential Fuel Burning

The predicted annual average and 99th percentile of the 1-hour NO_2 concentrations resulting from Residential Fuel Burning emissions are shown in Figure 4-45 and Figure 4-46. Emission of NO_X from Residential Fuel Burning is relatively low and this is largely attributed to prevalent use of wood in the WBPA. As a result, the ambient NO_2 concentrations resulting from Residential Fuel Burning in the WBPA are expected to be low. This, and the approach used in the modelling of distributing emissions across the respective municipal wards, accounts for very low predicted annual average NO_2 concentrations. Furthermore, by averaging emissions from Residential Fuel Burning the predicted maximum 1-hour NO_2 concentrations are low compared to monitored data.

Despite the limited performance of the dispersion model with respect to NO_2, ambient air quality monitoring stations located in residential areas indicate that ambient NO_2 concentrations are low compared to the NAAQS. It appears therefore that there are no issues relating to NO_2 from residential fuel burning.

Trans-boundary

For the baseline assessment, the only source of NO_X considered in Botswana is the Morupule A Power Station. The predicted annual average and the 99th percentile of the 1-hour NO_2 concentrations resulting from Morupule A emissions are shown in Figure 4-47 to Figure 4-48. As may be expected with the relatively small source, the predicted annual average concentrations are low and comply with the NAAQS (40 µg/m^3). Similarly, the predicted 99th percentile of the 1-hour concentrations is low relative to the limit values of the NAAQS. The spatial extent of the influence of Morupule A on ambient air quality is limited and currently it has no influence on ambient NO_2 concentrations in the WBPA.

All sources

The predicted annual average and 99th percentile of the 1-hour NO_2 concentrations are shown collectively for Listed Activities and Residential Fuel Burning and Botswana emissions (Figure 4-49 to Figure 4-51) for the WBPA, the Waterberg-Botswana domain and the Rustenburg-Brits domain.

The predicted annual average NO_2 concentrations resulting from emissions from all sources comply with the NAAQS (40 µg/m^3) throughout the WBPA. They are somewhat higher in BPDM than the WDM as a result of the difference in release height of the pollutant. The 99th percentile of the predicted 1-hour NO_2 concentrations complies with the limit value of the NAAQS (200 µg/m^3) throughout the WBPA, except in three small areas between Brits and Rustenburg. For the 3-year modelling period, the areas where more than 264 exceedances are predicted (88 per year) are localised close to the respective sources. It is clear that emissions from the Listed Activities sources category dominate the resultant ambient concentrations.

There seems to be general agreement between the predicted NO_2 concentrations and the monitored data throughout the WBPA. However, the predicted exceedances of the 1-hour NO_2 limit values in the BPDM are not seen in the monitored data. This is most likely because of the station location, i.e. monitoring stations are not located in the zones where the highest NO_2 concentrations are predicted.

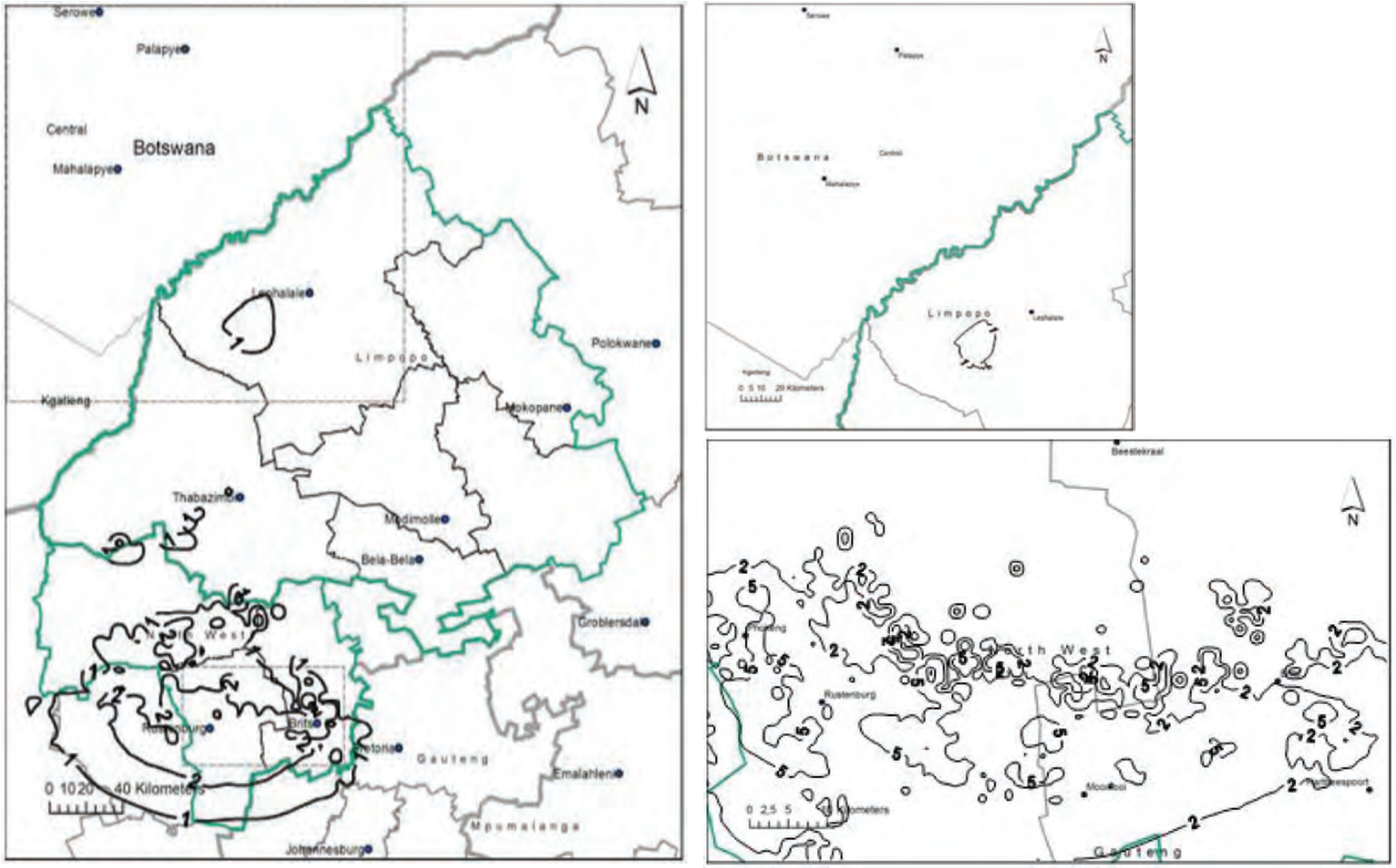


Figure 4-42: Predicted average annual concentrations of NO_2 resulting from Listed Activities in the WBPA (left), the Waterberg-Botswana domain (top right) and the Rustenburg-Brits domain (bottom right)

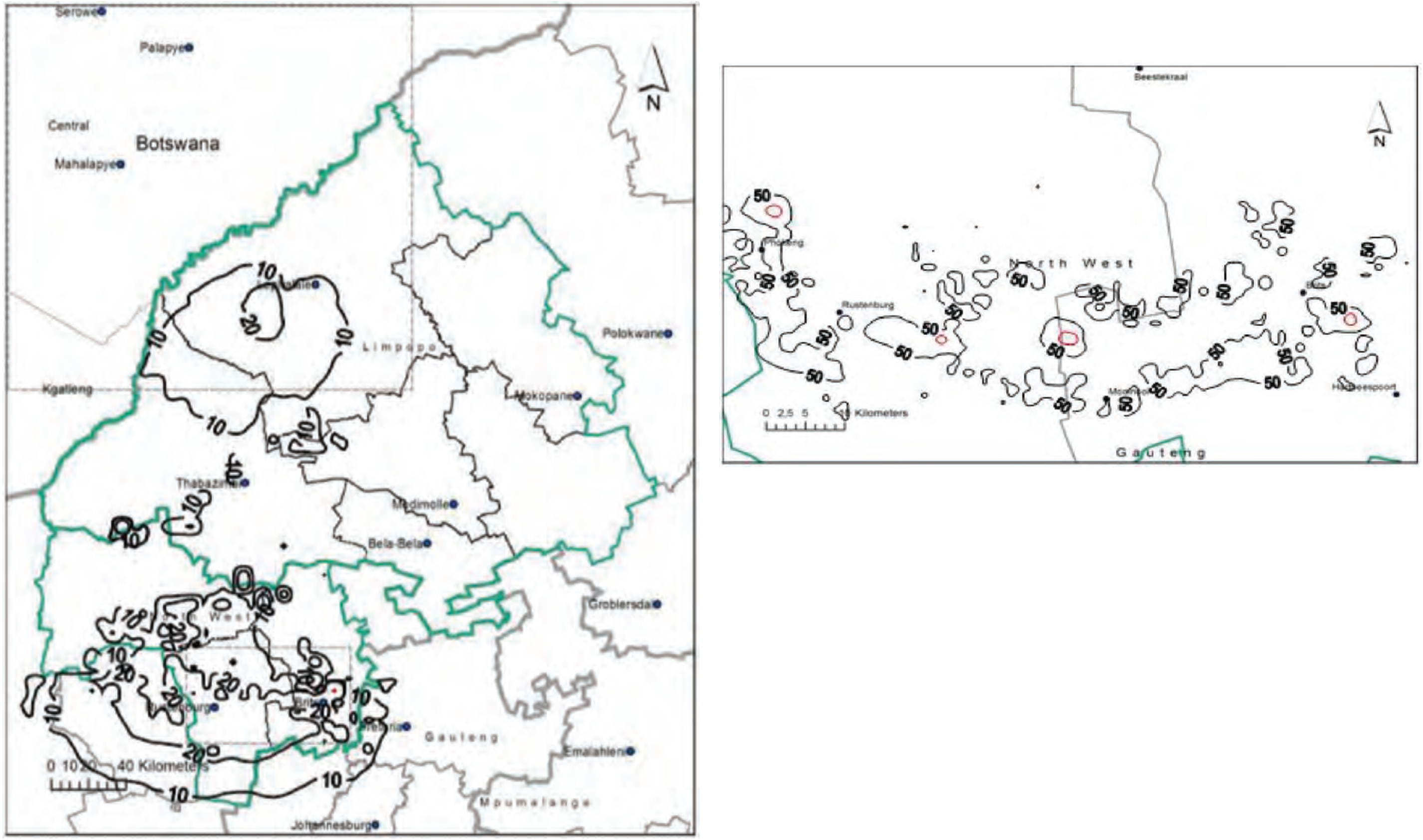


Figure 4-43: 99th percentile of the predicted 1-hour NO_2 concentrations resulting from Listed Activities in the WBPA (left), and the Rustenburg-Brits domain (bottom right). The red line is 200 µg/m³

Figure 4-44: Frequency of exceedance of the limit value of the 1-hour limit value of the NAAQS for NO_2 resulting for Listed Activities in the Rustenburg-Brits domain. The red lines indicating 264 exceedances

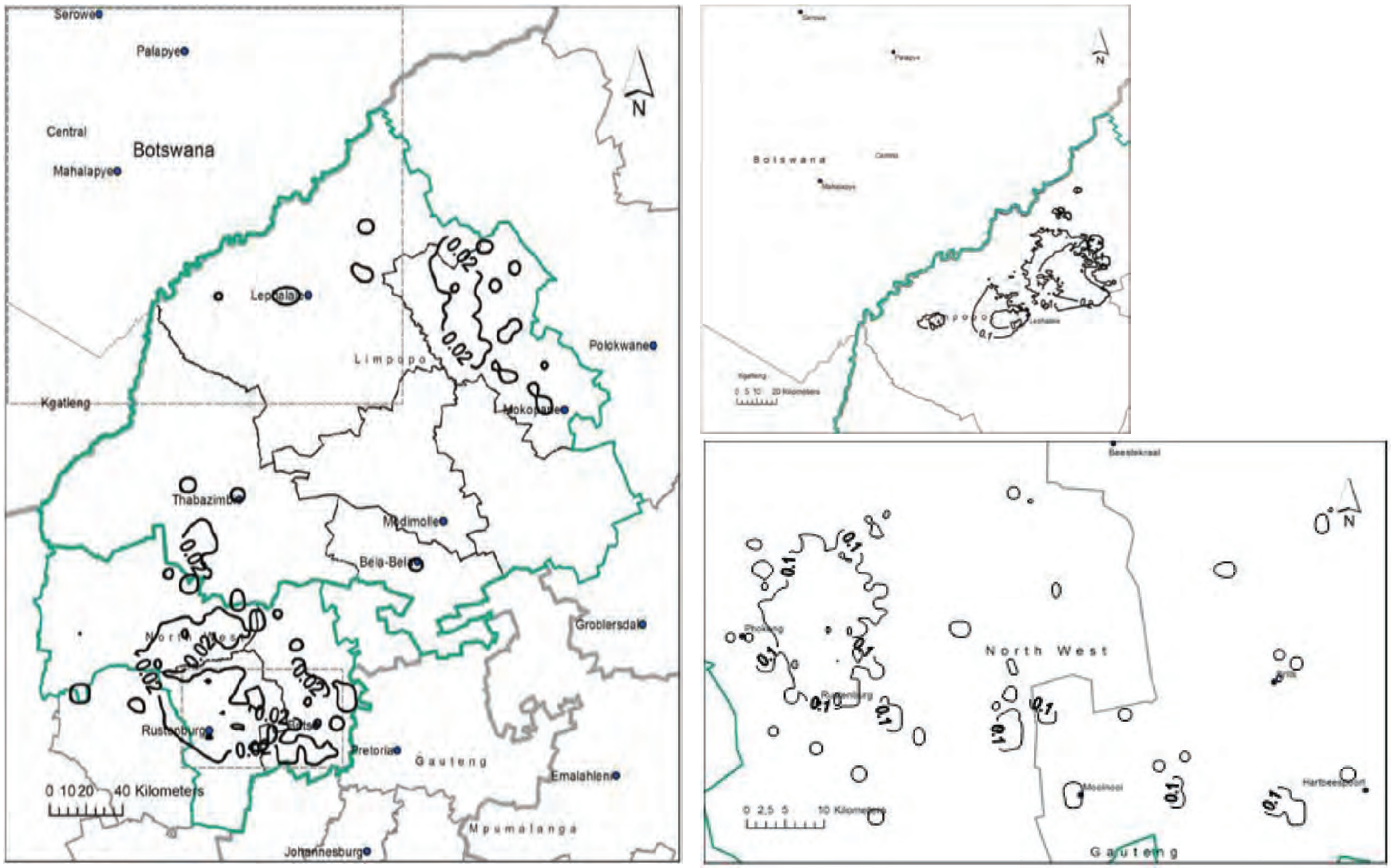


Figure 4-45: Predicted average annual concentrations of NO_2 resulting from Residential Fuel Burning in the WBPA (left), the Waterberg-Botswana domain (top right) and the Rustenburg-Brits domain (bottom right)

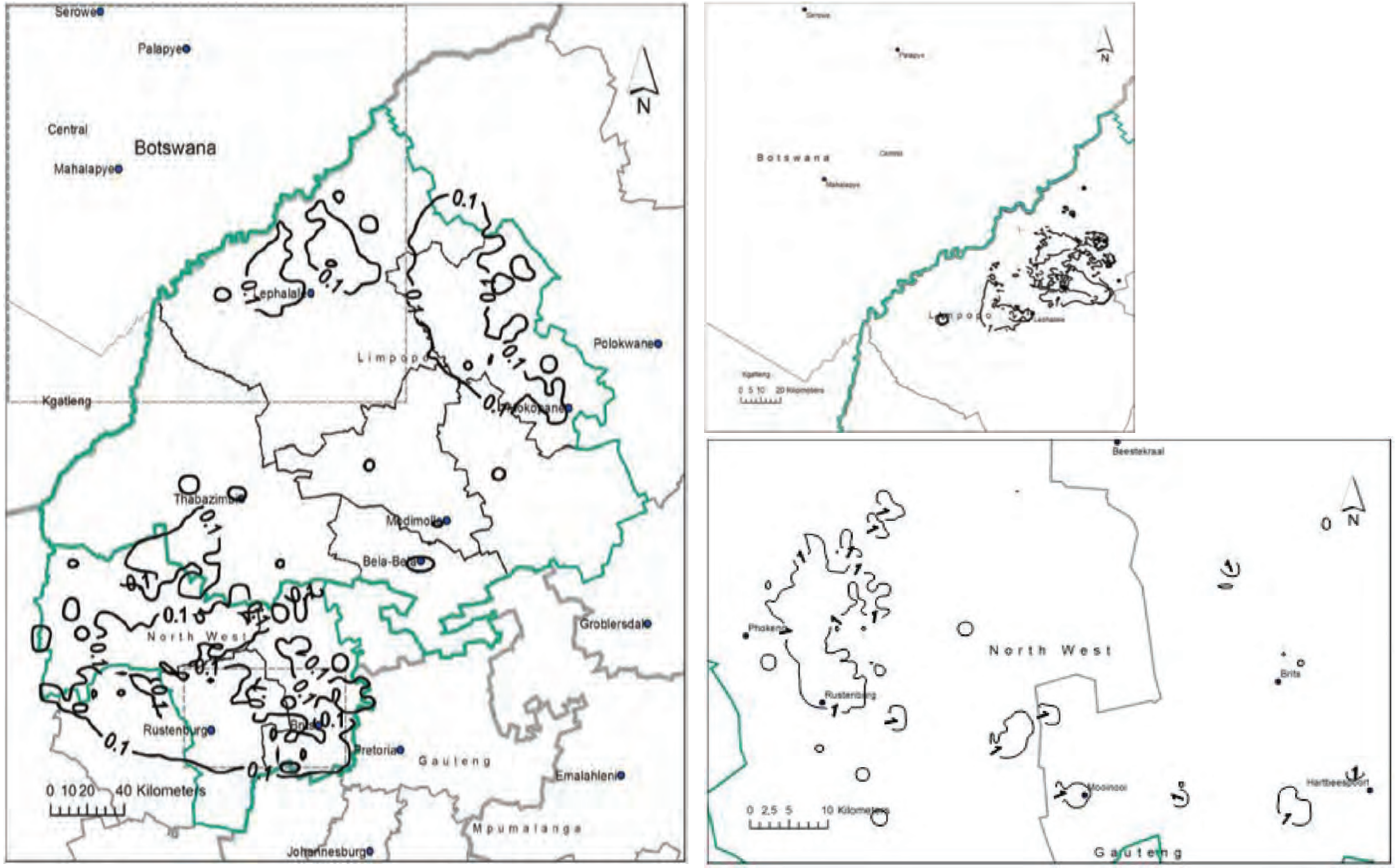


Figure 4-46: 99th percentile of the predicted 1-hour NO_2 concentrations resulting from Residential Fuel Burning in the WBPA (left), the Waterberg-Botswana domain (top right) and the Rustenburg-Brits domain (bottom right)

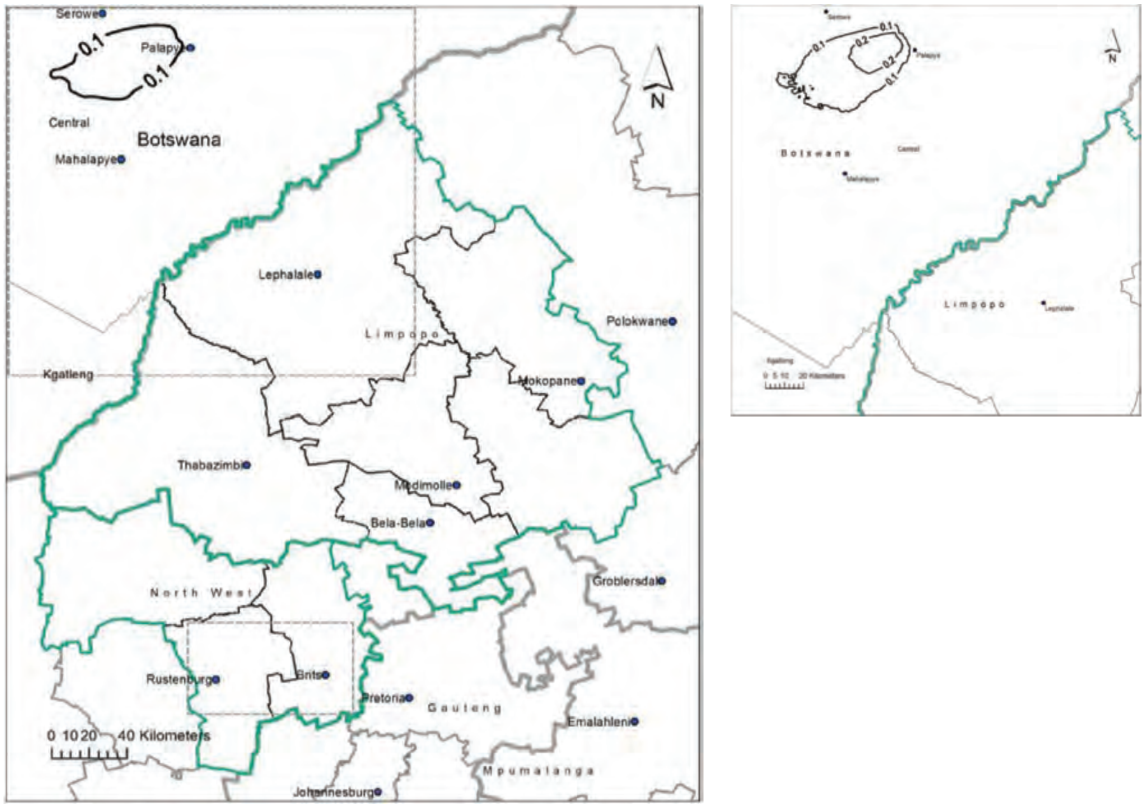


Figure 4-47: Predicted average annual concentrations of NO_2 resulting from trans-boundary emissions in the WBPA (left) and the Waterberg-Botswana domain (right)

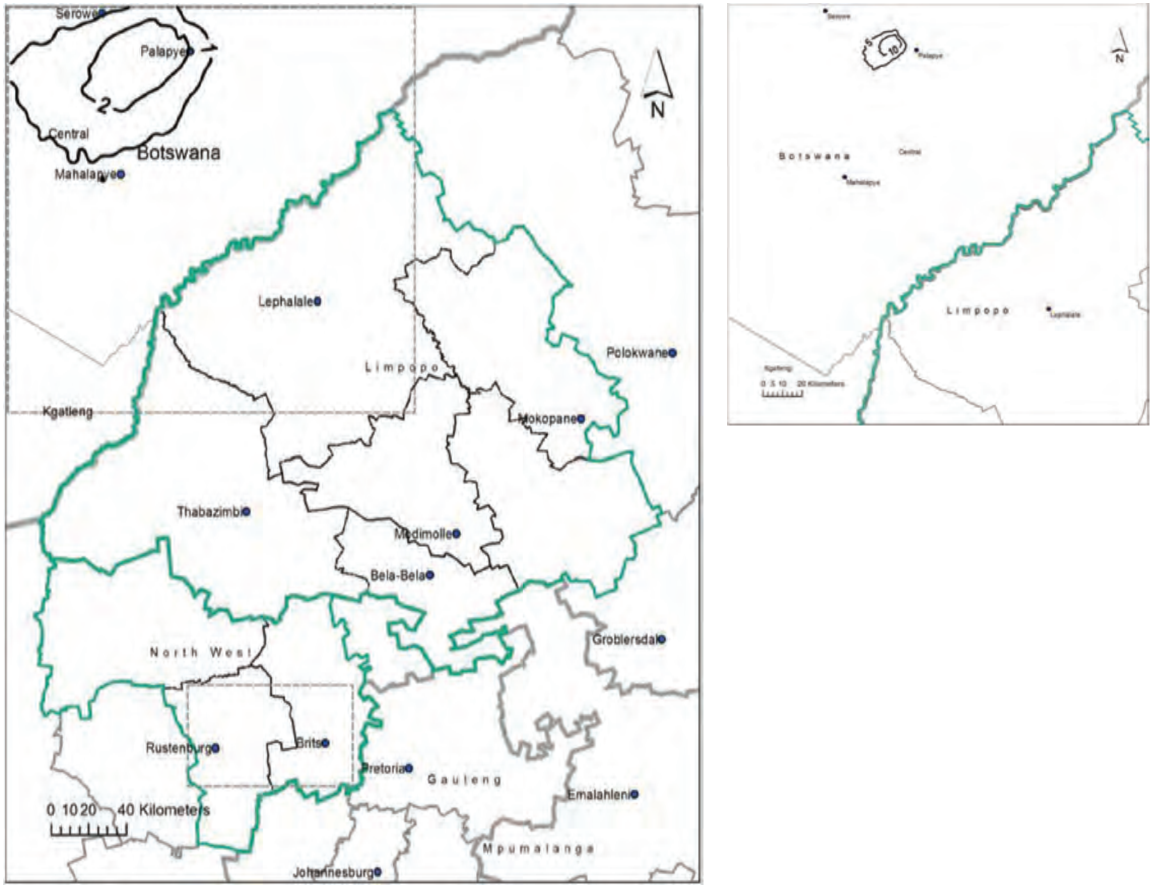


Figure 4-48: 99th percentile of the predicted 1-hour NO_2 concentrations resulting from trans-boundary emissions in the WBPA (left) and the Waterberg-Botswana domain (top right)

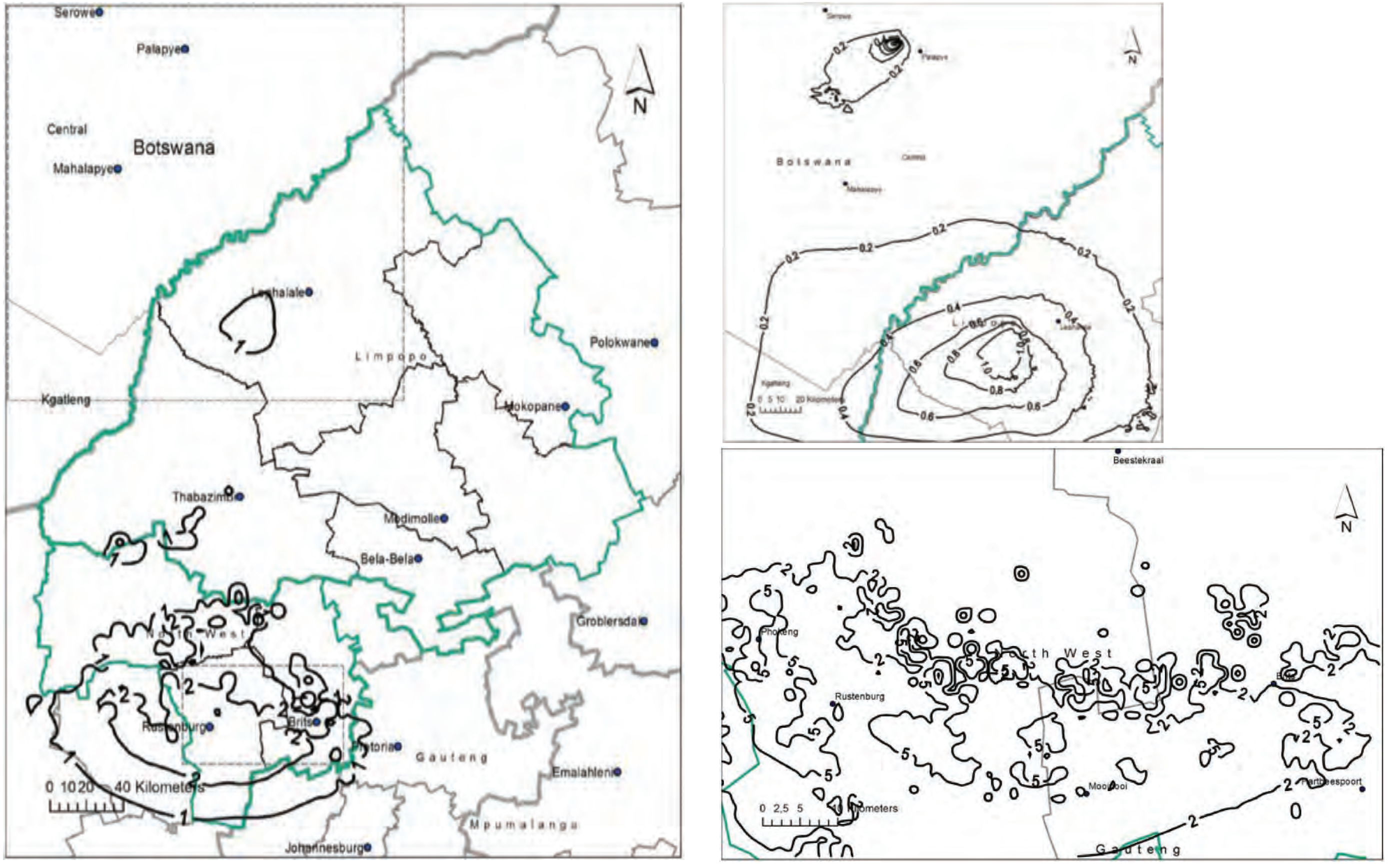


Figure 4-49: Predicted average annual concentrations of NO_2 resulting from Listed Activities, Residential Fuel Burning and trans-boundary emissions in the WBPA (left), the Waterberg-Botswana domain (top right) and the Rustenburg-Brits domain (bottom right)

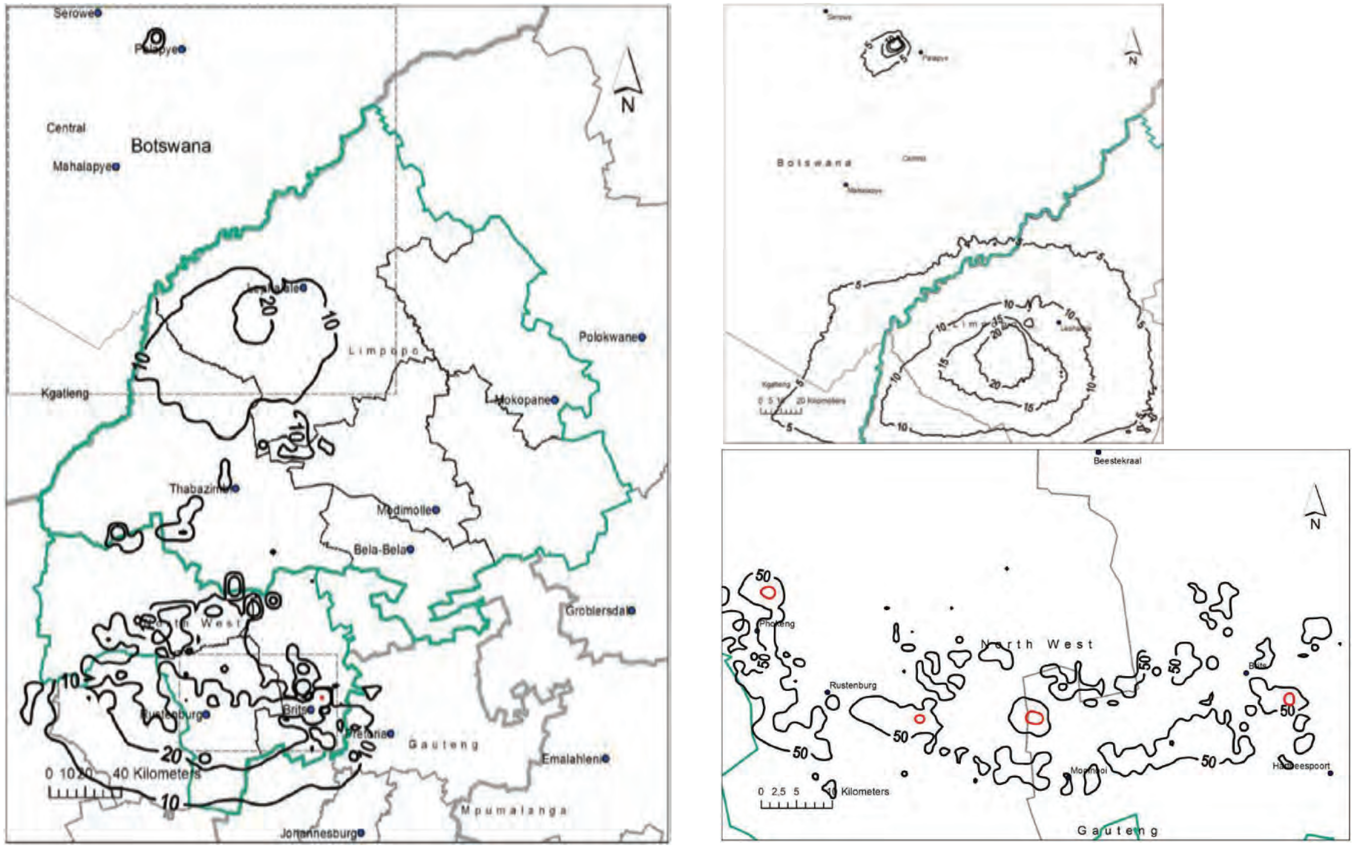


Figure 4-50: 99th percentile of the predicted 1-hour NO_2 concentrations resulting from Listed Activities, Residential Fuel Burning and trans-boundary emissions in the WBPA (left), the Waterberg-Botswana domain (top right) and the Rustenburg-Brits domain (bottom right). The red isopleth indicates the NAAQS.

Figure 4-51: Frequency of exceedance of the 1-hour limit value of the NAAQS for NO_2 resulting from Listed Activities, Residential Fuel Burning and Trans-boundary emissions in Rustenburg-Brits domain. The red lines indicate areas where the tolerance is exceeded

Respirable particulate matter (PM_{10})

Listed Activity

The predicted PM_{10} concentrations resulting from emissions from Listed Activities are shown for the three domains in Figure 4-52 to **Error! Reference source not found.**. These include annual average and the 99th percentile of the predicted 24-hour concentrations and the frequency of exceedance of the NAAQS limit value.

The predicted annual average PM_{10} concentrations comply with the NAAQS (50 µg/m^3) in the WBPA. The predicted 99th percentile of the 24-hour PM_{10} concentrations complies with the limit value of the NAAQS of 120 µg/m^3 throughout the WBPA, besides one small area southwest of Thabazimbi. In the 3-year modelling period, the areas where more than 12 exceedances are predicted (four per year) are localised around the source.

Unlike SO_2 and NO_X, where industry is the predominant source, mining and residential fuel burning contribute to PM_{10} emissions. Good agreement is therefore not expected between modelled PM_{10} concentrations for Listed Activities and the monitored data. This is particularly the case, considering the preferential location of monitoring stations to assess air quality in residential areas where wood and coal are burnt.

Residential Fuel Burning

While emissions of PM_{10} from Residential Fuel Burning are relatively low, the combustion process occurs in a relatively cold environment, particularly during winter; and pollutants are released at ground level. This results in smoky fires and the release of smoke into the cold, stable surface layer of air. Dispersion is poor and pollutants tend to accumulate until mid-morning. Ambient PM_{10} concentrations are expected to be high, as shown by the ambient air quality monitoring results.

The predicted annual average and maximum 24-hour PM_{10} concentrations resulting from emissions from Residential Fuel Burning (Figure 4-55 and Figure 4-56). The approach used in the modelling, where emissions from Residential Fuel Burning are distributed across the respective municipal wards, has resulted in very low predicted annual average PM_{10} concentrations, compared with monitoring data. The average emissions also result in low predicted 24-hour PM_{10} concentrations compared to monitored data.

Despite the low predicted PM_{10} concentrations, the model output provides a useful representation of the spatial distribution of ambient concentrations resulting from residential fuel burning. The settlements around Lephalale are highlighted as an area of potential concern, as well as the more densely populated areas around Rustenburg and extending to Brits. The ambient air quality monitoring stations located in residential areas record high concentrations relative to the NAAQS, with frequent exceedances of the limit value. Despite the limited model performance, it is clear from monitoring data that emissions from residential fuel burning impact on ambient air quality and potentially on human health in all areas in the WBPA where wood, coal and other biomass fuels are used are the primary energy source.

Mining

The predicted PM_{10} concentrations resulting from emissions from Mining are shown for the three domains (Figure 4-57 to Figure 4-59). These include the predicted annual average concentrations and the 99th percentile of the predicted 24-hour concentrations with the frequency of exceedance of the NAAQS limit values.

In the WDM, the predicted annual average PM_{10} concentrations resulting from Mining emissions generally comply with the NAAQS (50 $\mu g/m^3$). However, exceedances are predicted in the immediate vicinity of mining activities. Similarly, the predicted 99th percentile of the 24-hour PM_{10} concentration generally complies with the 24-hour limit value of 120 $\mu g/m^3$ except in the vicinity of mining activity. During the 3 year modelling period, more than 12 exceedances (four per year) are predicted to occur. Non-compliance with the NAAQS in the vicinity of the mines indicates that emissions of PM_{10} from mining and the potential impact on health is an issue in the WDM.

In the BPDM, the predicted annual average PM_{10} concentrations generally comply with the NAAQS (50 $\mu g/m^3$), but exceedances are predicted in between Brits and Rustenburg, extending towards the North West. Similarly, the predicted 99th percentile of the 24-hour concentration generally complies with the limit value of the NAAQS (120 $\mu g/m^3$) in the BPDM. However, exceedances are predicted in the area between Brits and Rustenburg due to the concentration of mining activities, but extending to the North West of the Moses Kotane LM. In the three year modelling period, more than 12 exceedances (four per year) of the 24-hour limit value are predicted throughout the same area. Non-compliance with the NAAQS in the BPDM indicates that emissions of PM_{10} from mining and potential impacts on human health are an issue.

PM_{10} is a ubiquitous pollutant that results from emissions from industry, mining and residential fuel burning, amongst others. With numerous contributing sources, good agreement is not expected between modelled PM_{10} concentrations from only Mining and monitored data. However, both methods confirm high PM_{10} concentrations in the mining areas of the WBPA. Additionally, there seems to be general agreement between the predicted and monitored PM_{10} concentrations in the WBPA.

Trans-boundary

For the baseline assessment, the only source of PM_{10} considered in Botswana is the Morupule A Power Station. The predicted annual average and the 99th percentile of the 24-hour PM_{10} concentrations resulting from Morupule A emissions are shown in Figure 4-60 to Figure 4-61. As may be expected with the relatively small emission source, the predicted annual average concentrations are low and comply with the NAAQS of 50 $\mu g/m^3$. Similarly, the predicted 99th percentile of the 24-hour concentrations is low relative to the limit value (120 $\mu g/m^3$) of the NAAQS. Therefore, the spatial extent of the influence of Morupule A on PM_{10} concentrations is limited and currently it has no influence on ambient PM_{10} concentrations in the WBPA.

All sources

The predicted annual average and 99th percentile of the predicted 24-hour PM_{10} concentrations are shown collectively for Listed Activities, Residential Fuel Burning, Mining and trans-boundary emissions in Figure 4-62 to Figure 4-64 for the WBPA, the Waterberg-Botswana domain and the Rustenburg-Brits domain.

In the WDM, the predicted annual average PM_{10} concentrations resulting from all sources generally comply with the NAAQS of 50 $\mu g/m^3$. However, exceedances are predicted in the immediate vicinity of mining activity. Similarly, the predicted 99th percentile of the 24-hour PM_{10} concentration generally complies with the 24-hour limit value of 120 $\mu g/m^3$ except in the vicinity of mining activity. In the 3 year modelling period, more than 12 exceedances (four per year) are predicted to occur. Non-compliance with the NAAQS in the vicinity of the mines indicates that emissions of PM_{10} from mining and the potential impacts on health are an issue in the WDM. It is clear that emissions from the Mining source category dominates the resultant ambient concentrations.

In the BPDM, the predicted annual average PM_{10} concentrations generally comply with the NAAQS (50 $\mu g/m^3$), but exceedances are predicted in between Brits and Rustenburg, extending towards the North West. Similarly, the predicted 99th percentile of the 24-hour concentration generally complies with the limit value of the NAAQS (120 $\mu g/m^3$) in the BPDM, but exceedances are predicted in the area between Brits and Rustenburg due to the concentration of mining activity, but extending to the North West of the Moses Kotane LM. During the three year modelling period, more than 12 exceedances (four per year) of the 24-hour limit value are predicted throughout the same area. Non-compliance with the NAAQS in the BPDM indicates that emissions of PM_{10} from mining and potential impacts on human health are an issue.

PM_{10} is a ubiquitous pollutant that results from emissions from industry, mining and residential fuel burning, amongst others. With numerous contributing sources, good agreement is not expected between modelled PM_{10} concentrations from only Mining and monitored data. However, both methods confirm high PM_{10} concentrations in the mining areas of the WBPA. There seems to be general agreement between the predicted and monitored PM_{10} concentrations in the WBPA.

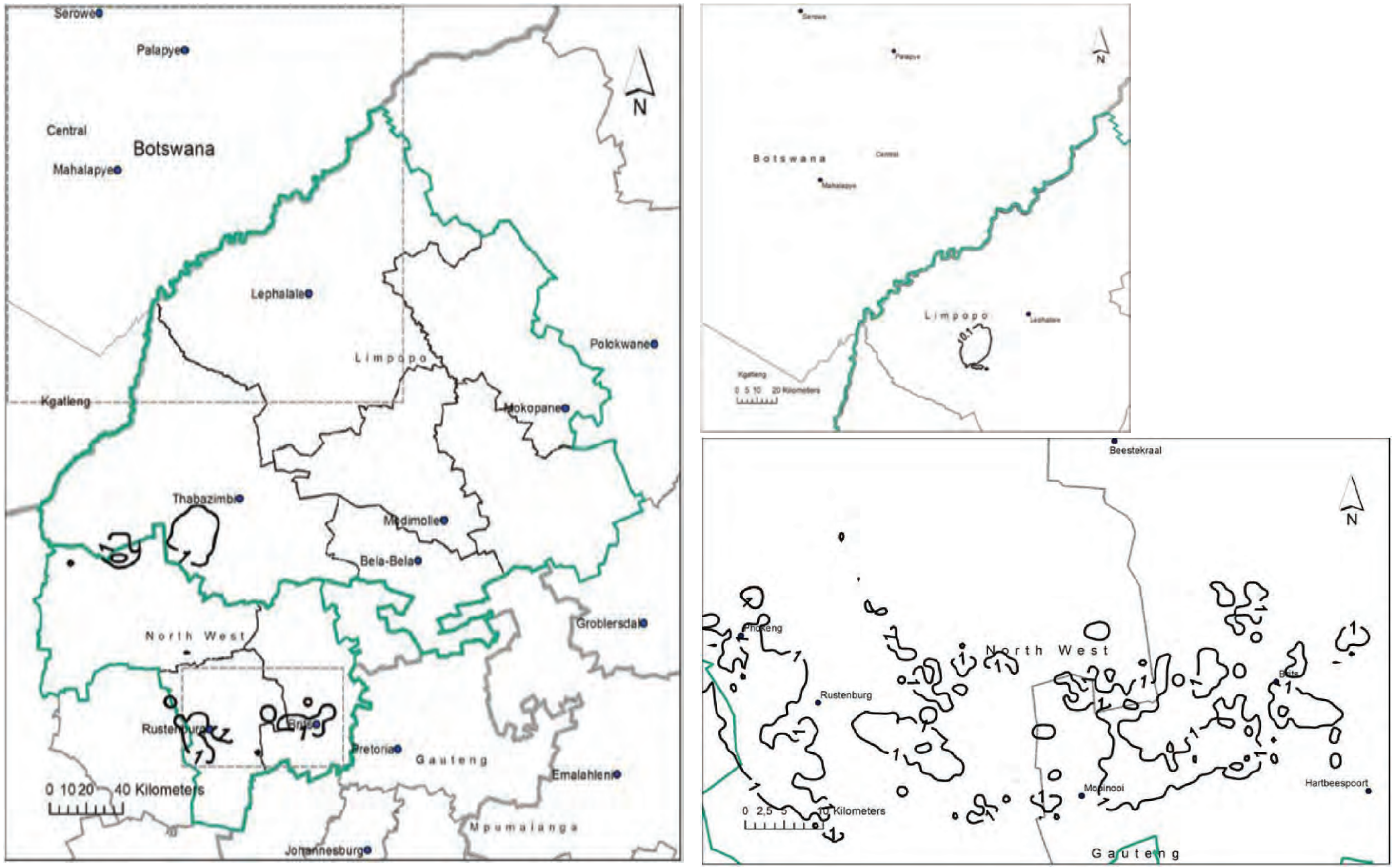


Figure 4-52: Predicted average annual concentrations of PM_{10} resulting from Listed Activities in the WBPA (left), the Waterberg-Botswana domain (top right) and the Rustenburg-Brits domain (bottom right)

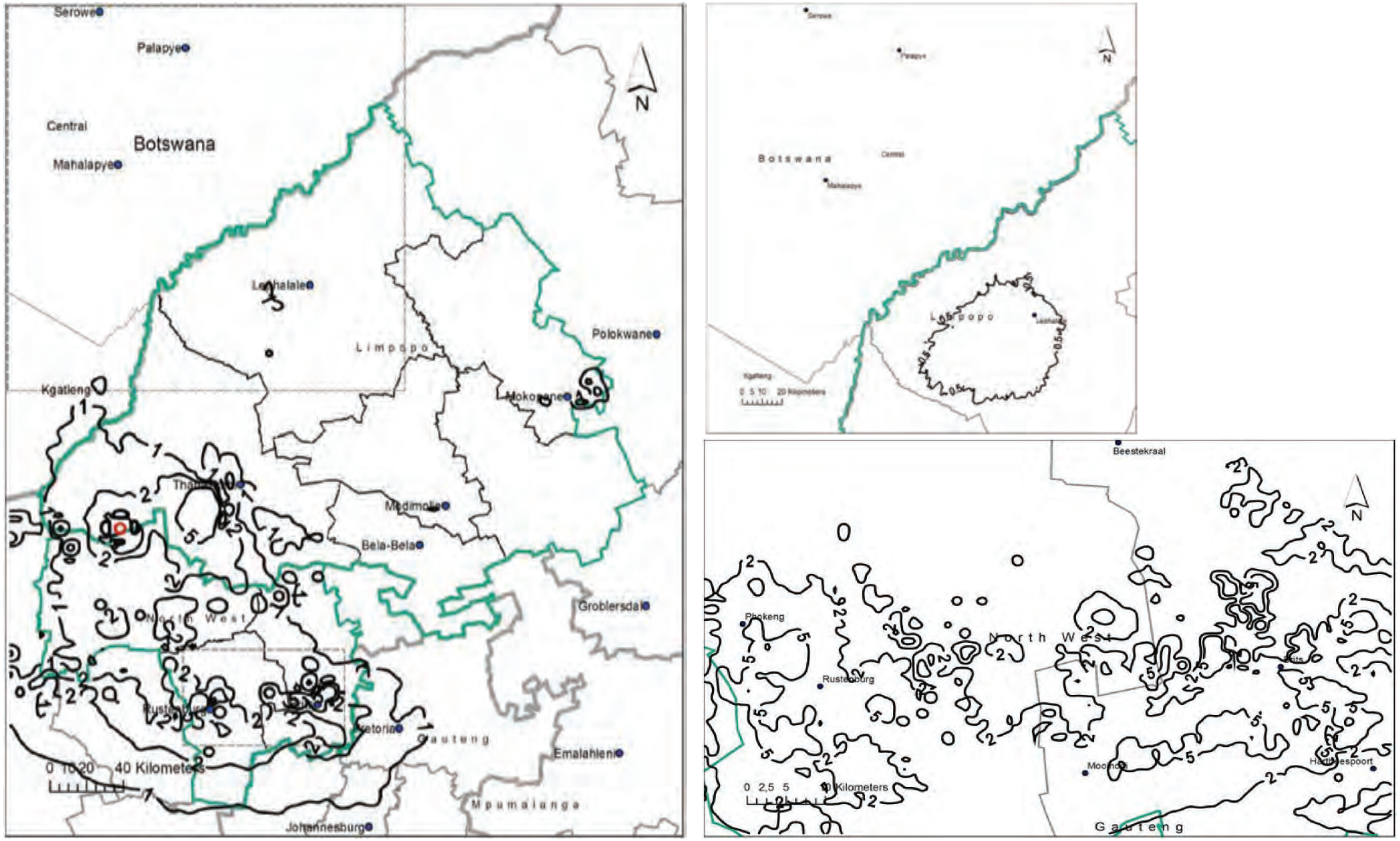


Figure 4-53: 99th percentile of the predicted 24-hour PM_{10} concentrations resulting from Listed Activities in the WBPA (left), the Waterberg-Botswana domain (top right) and the Rustenburg-Brits domain (bottom right)

Figure 4-54: Frequency of exceedance of the limit value of the 24-hour limit value of the NAAQS for PM_{10} resulting for Listed Activities in the WBPA where the red line is 12 exceedances

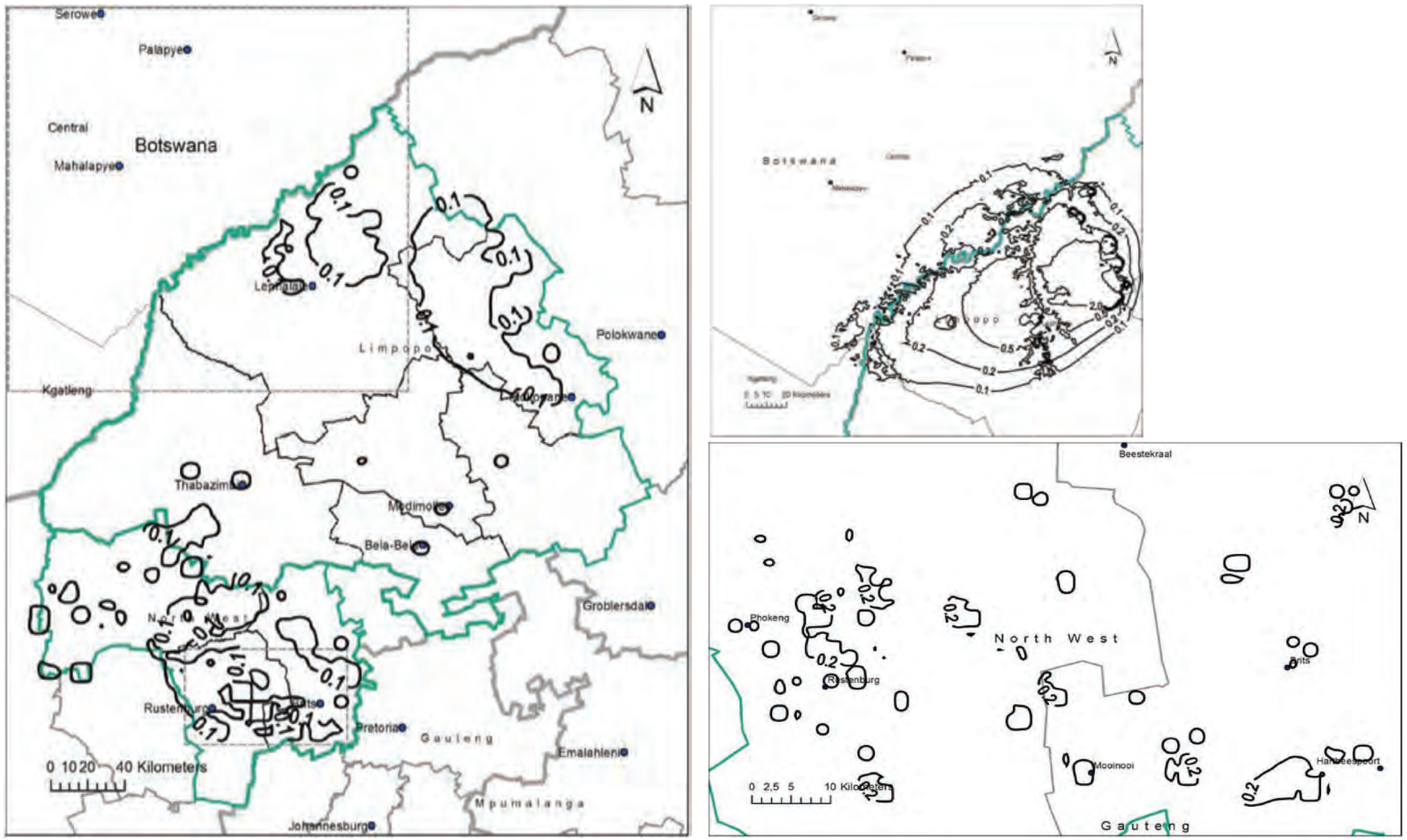


Figure 4-55: Predicted average annual concentrations of PM_{10} resulting from Residential Fuel Burning in the WBPA (left), the Waterberg-Botswana domain (top right) and the Rustenburg-Brits domain (bottom right)

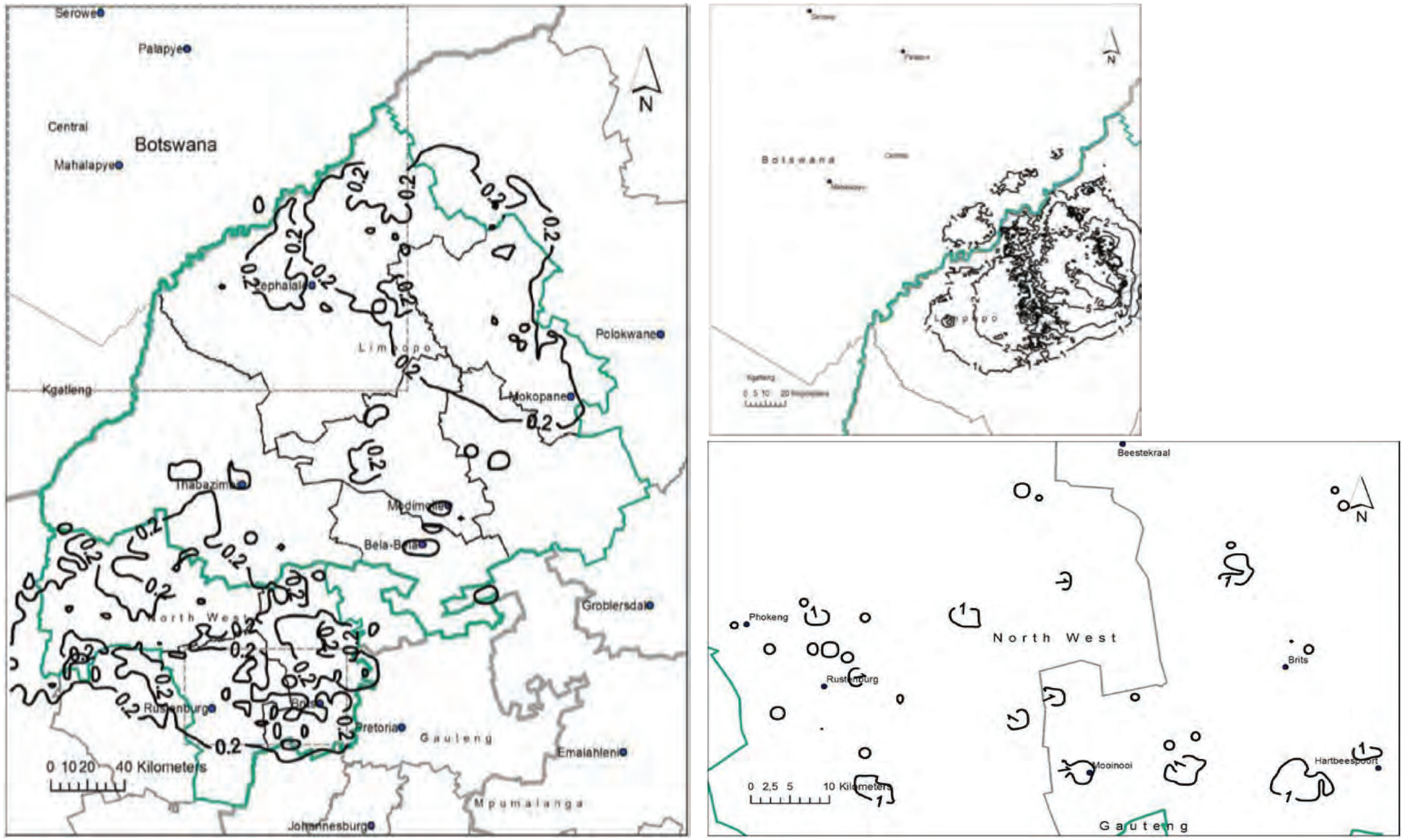


Figure 4-56: Maximum predicted 24-hour PM_{10} concentrations resulting from Residential Fuel Burning in the WBPA (left), the Waterberg-Botswana domain (top right) and the Rustenburg-Brits domain (bottom right)

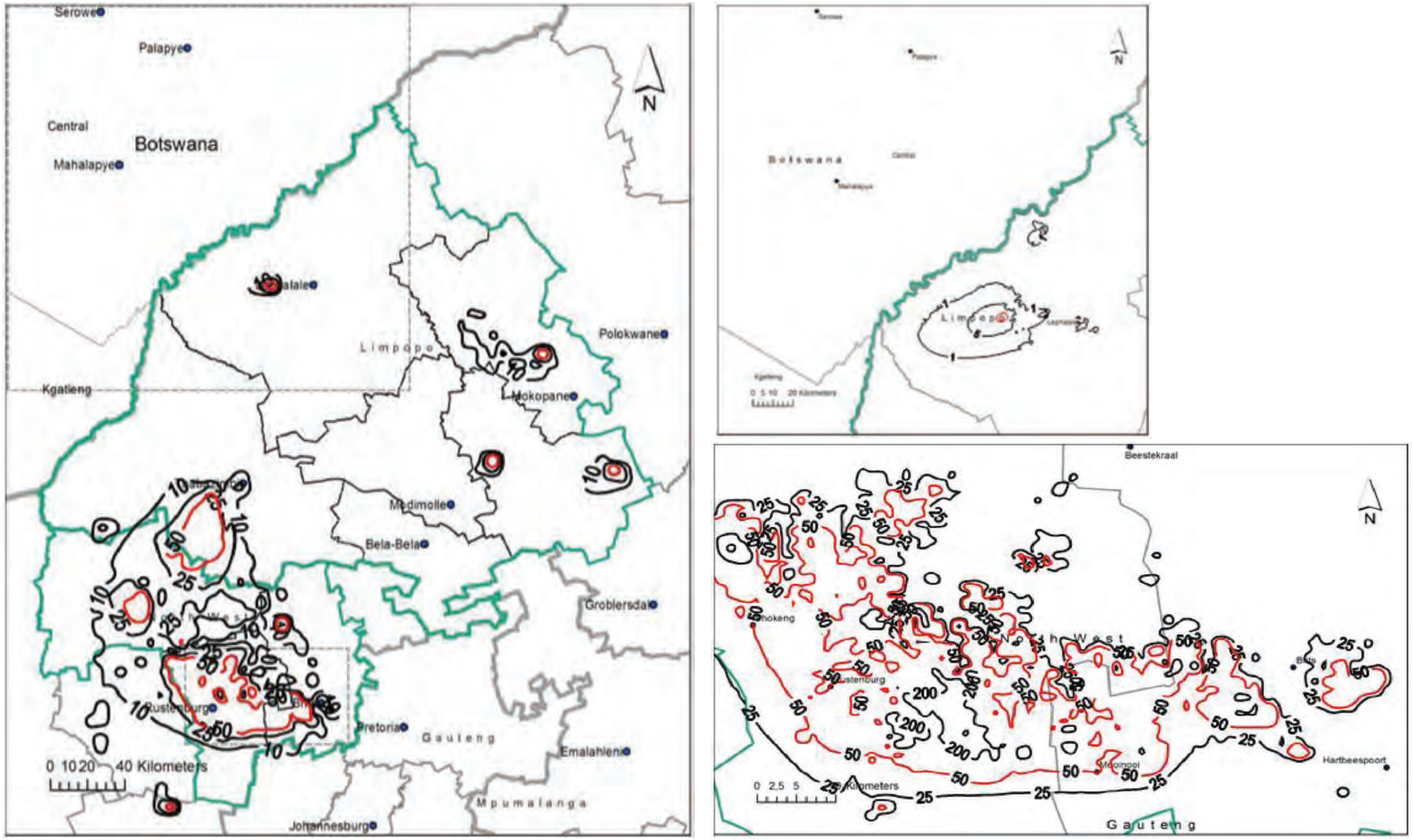


Figure 4-57: Predicted average annual concentrations of PM_{10} resulting from Mining in the WBPA (left), the Waterberg-Botswana domain (top right) and the Rustenburg-Brits domain (bottom right)

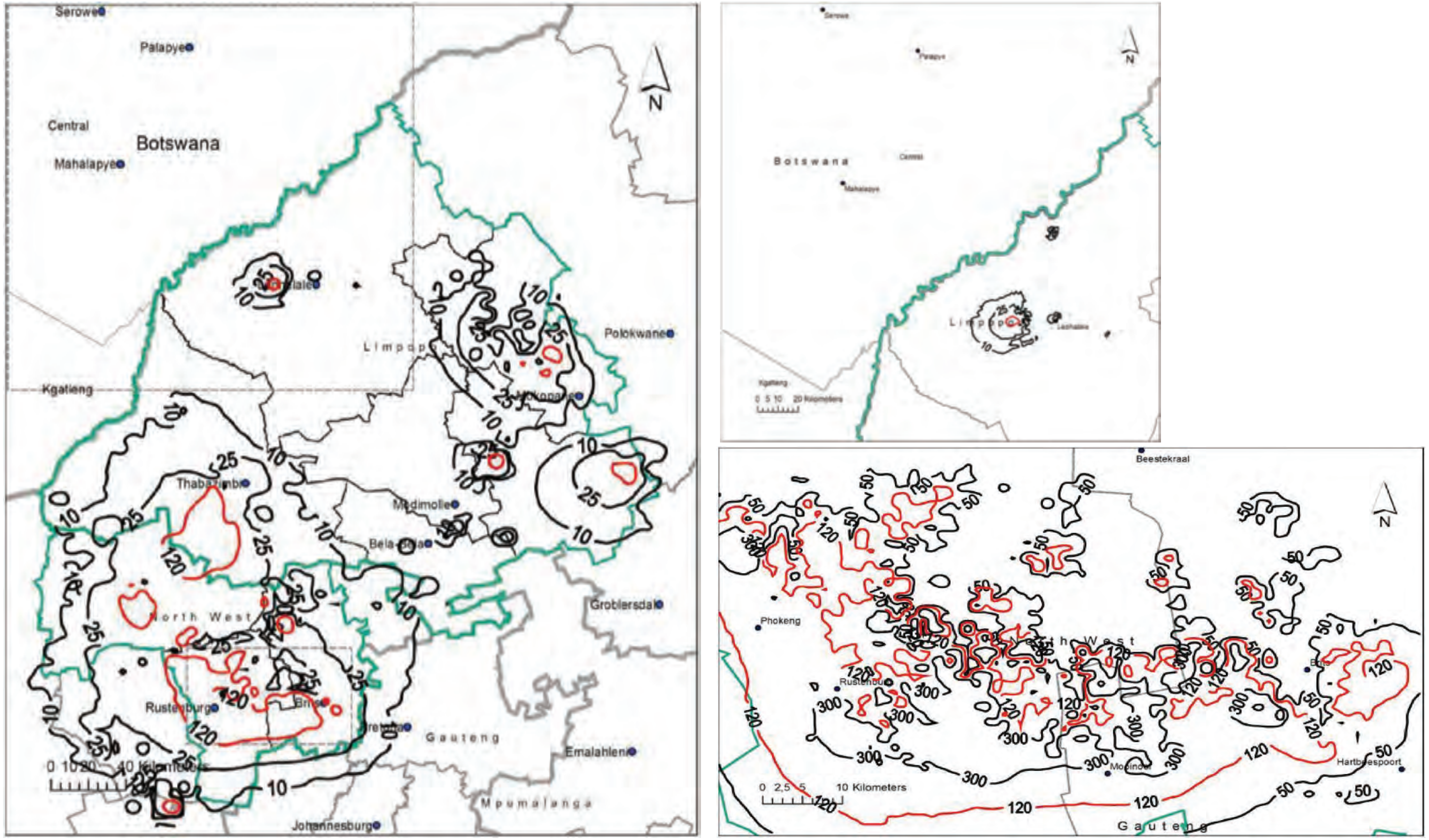


Figure 4-58: 99th percentile of the predicted 24-hour PM_{10} concentrations resulting from Mining in the WBPA (left), the Waterberg-Botswana domain (top right) and the Rustenburg-Brits domain (bottom right)

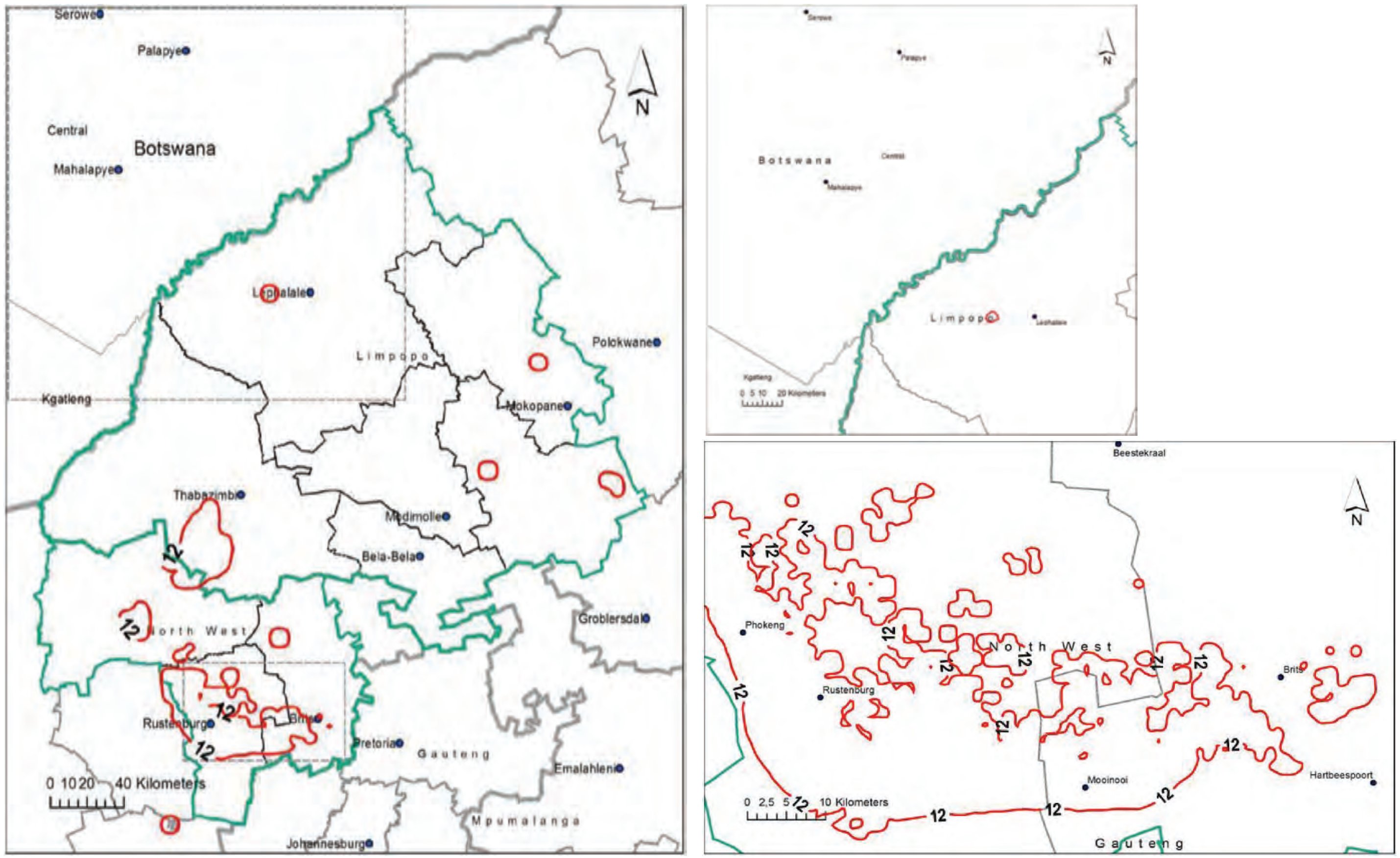


Figure 4-59: Frequency of exceedance of the limit value of the 24-hour limit value of the NAAQS for PM_{10} resulting for Mining in the WBPA (left), the Waterberg-Botswana domain (top right) and the Rustenburg-Brits domain (bottom right)

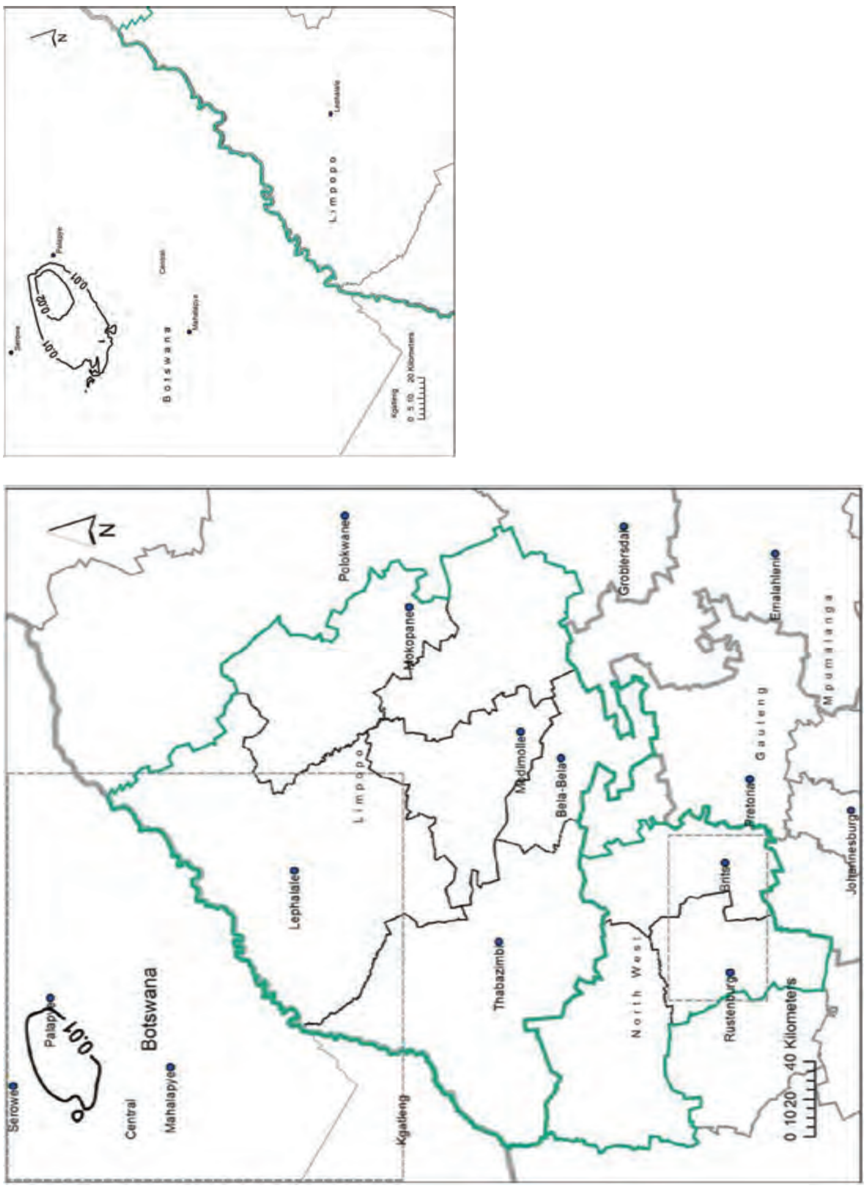


Figure 4-60: Predicted average annual concentrations of PM_{10} resulting from trans-boundary emissions in the WBPA (left) and the Waterberg-Botswana domain (right)

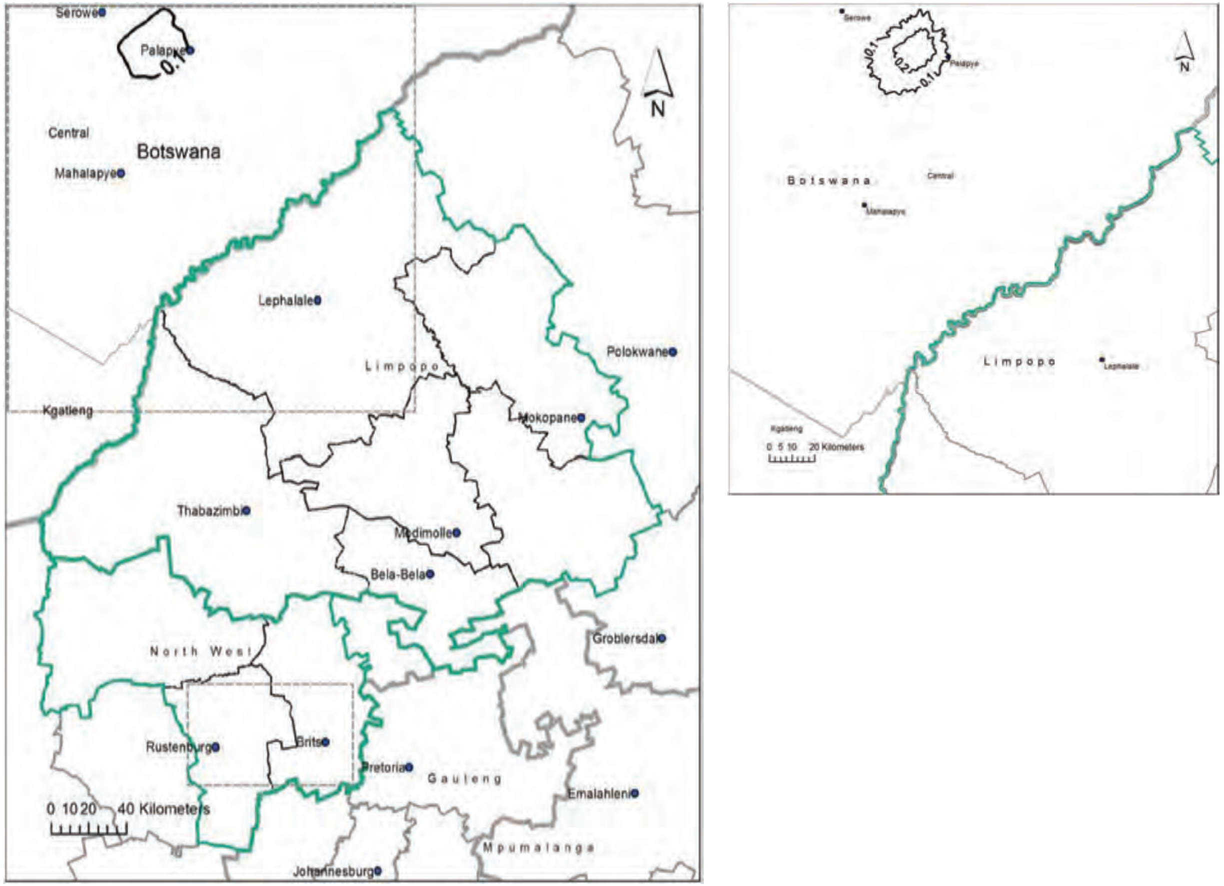


Figure 4-61: 99th percentile of the predicted 24-hour PM_{10} concentrations resulting from trans-boundary emissions in the WBPA (left) and the Waterberg-Botswana domain (top right)

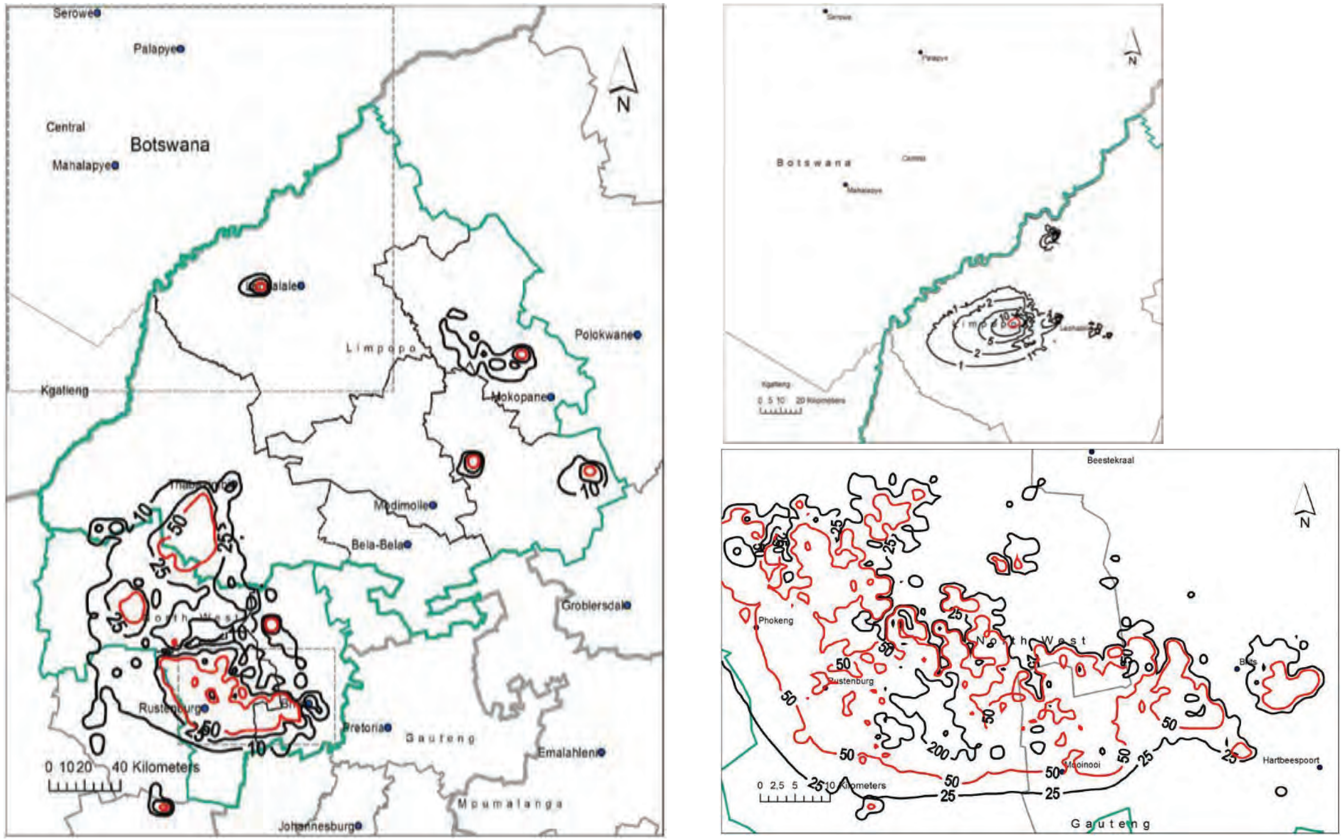


Figure 4-62: Predicted average annual concentrations of PM_{10} resulting from Listed Activities, Residential Fuel Burning, Mining and trans-boundary emissions in the WBPA (left), the Waterberg-Botswana domain (top right) and the Rustenburg-Brits domain (bottom right). The red isopleth indicates the NAAQS.

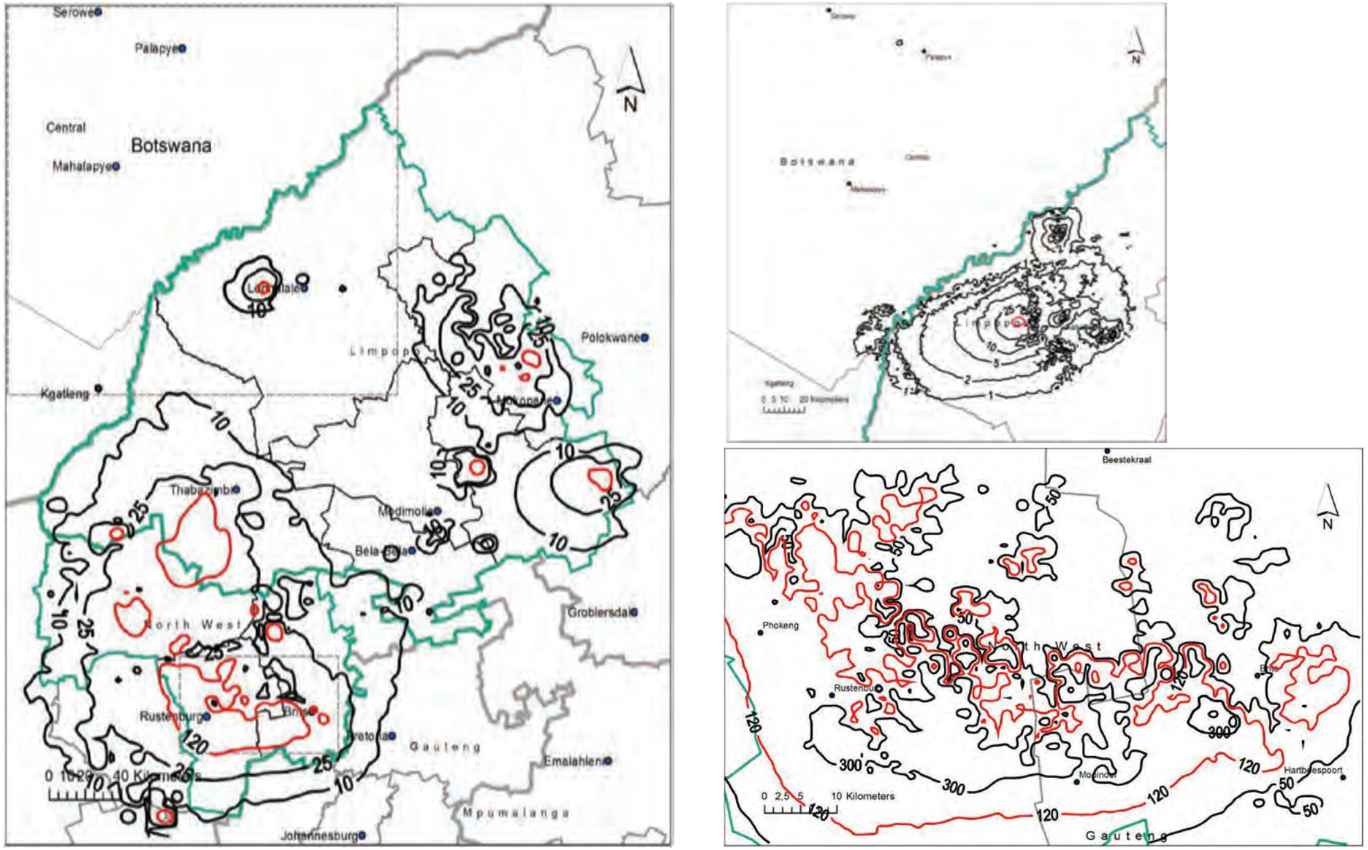


Figure 4-63: 99th percentile of the predicted 24-hour PM_{10} concentrations resulting from Listed Activities, Residential Fuel Burning, Mining and trans-boundary emissions in the WBPA (left), the Waterberg-Botswana domain (top right) and the Rustenburg-Brits domain (bottom right). The red isopleth indicates the NAAQS.

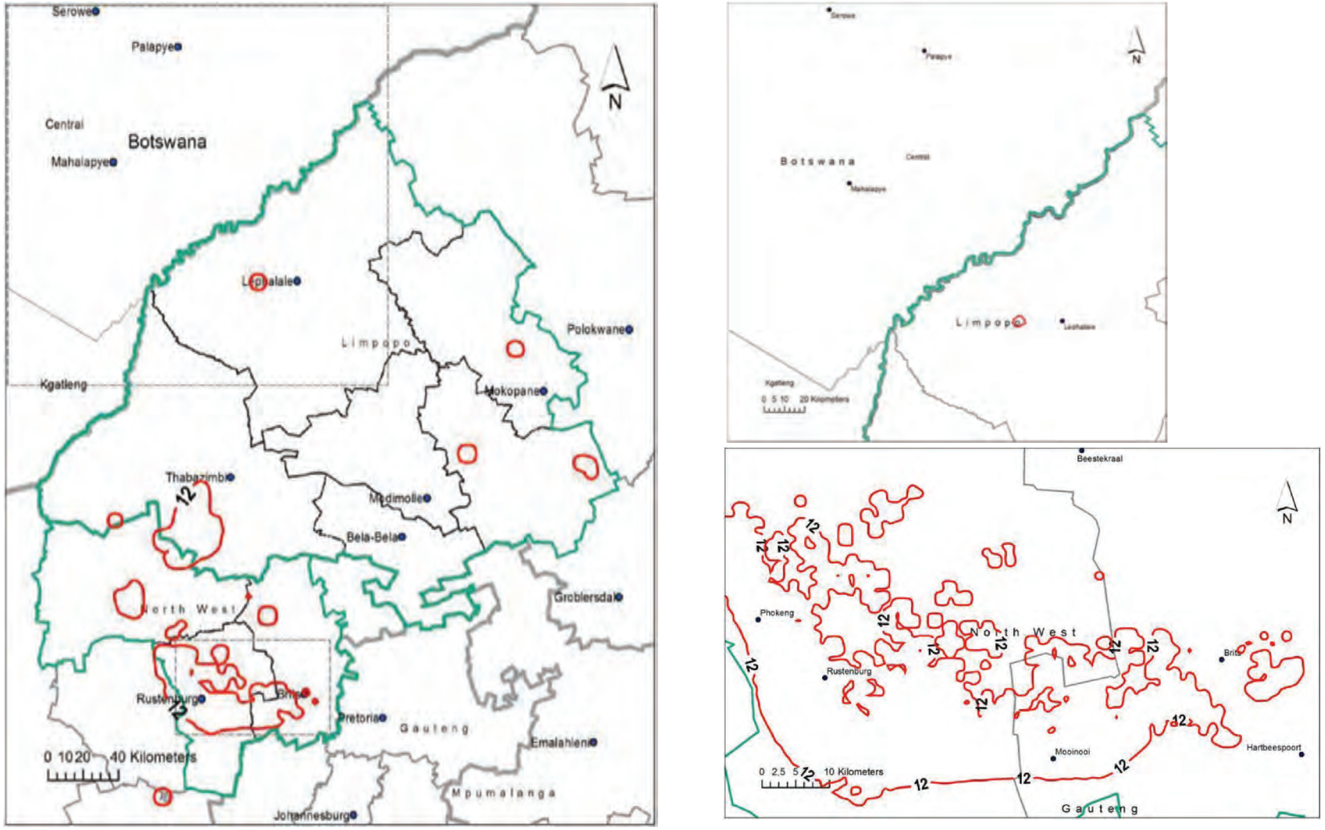


Figure 4-64: Frequency of exceedance of the 24-hour limit value of the NAAQS for PM_{10} resulting from Listed Activities, Residential Fuel Burning, Mining and trans-boundary emissions in the WBPA (left), the Waterberg-Botswana domain (top right) and the Rustenburg-Brits domain (bottom right). The red contour indicates the limit value of the NAAQS.

4.11 Capacity

The capacity assessment has been conducted for six essential components of capacity, viz. **S**tructure, **S**ystem, **S**kills, incentive**S**, Strategies and inter-relationship**S**. This is referred to as the '6S' model (T&B Consult, 2002). Each component is evaluated using a set of indicators relevant to the aspect being investigated and responses are presented from the authorities in the WBPA. Responses are included from both provinces, North West and Limpopo, the Waterberg DM, and Rustenburg LM. Bojanala Platinum DM did not provide any responses, and other LM's do not carry out AQM activities.

4.11.1 Structure

The structural component of capacity refers to the organisation itself and the broader arrangement of air quality staff. It refers to their roles and responsibilities within the department, and also to the lines of communication and command within the department. A well-defined structure forms the basis for establishing AQM within an organisation.

Legal requirement

The National Framework and the NEM: AQA do not strictly define the organisational structure for an AQM function or department. The AQMP often provides recommendations to the organisation on altering institutional arrangements to meet legal responsibilities. Each sphere of government is obligated to fulfil an AQM function according to NEM: AQA, including AQO designation and AQMP development.

Assessment

Table 4-24: Structural assessment of authorities

	LDEDET								NWREAD				
		WDM								BPDM			
			Lep	Thz	Mod	Mok	Mog	Bel			Rus	Mad	MK
AQM function	Y	Y	-	-	-	-	-	-	Y	Y	Y	-	-
AQM department	Y	N	-	-	-	-	-	-	Y	Y	N	-	-
Reporting line	Y	Y	-	-	-	-	-	-	Y	Y	Y	-	-
Communication line	U	N	-	-	-	-	-	-	Y	Y	Y	-	-

Y- Yes N- No U- Unsure L- Limited

LDEDET: Phumudzo Thivhafuni is the designated AQO for the Limpopo Province and the sub-directorate is under the department responsible for AQM in the province is Pollution and Waste Management, under the directorate of Environment, Trade and Protection. This is a full time occupation and she is supported by three permanent staff members. However, the organogram proposed in the provincial AQMP identifies the need for 13 full time AQM staff members.

NWREAD: Percy Matlapeng is the nominated AQO for the North West Province and is currently in the position Environmental Control Officer. The Department of Environmental Management is responsible for AQM sub-directorate. Ten staff members are involved in AQM on a full time basis, according to the proposed structure. The section consists of three primary areas: policy and AQM planning, licencing, and air quality monitoring. The functions of staff in these sections relate to their areas of responsibility. There are lines of communication to discuss AQM outside of the department, through the working committee.

Waterberg DM: The designated AQO for the WDM is Stanley Koenaite. The department of Social Development and Community Services is responsible for air quality. This is a full time position. There are two AQM staff members and while there is an organogram in place, it is not according to the AQMP and this could be attributed to budgeting issues.

There are measures in place to discuss AQM outside of the department, through municipal health services, but this is not an effective mechanism. There is a need for dedicated management-level AQM staff, who assist with motivations for AQM activities to the Council. Leadership on AQM matters is lacking at higher levels.

Bojanala-Platinum DM: Amanda Bubu is the designated AQO, and the function resides in the air quality and regulatory services department as a full time function. Challenges are experiences with the integration of air quality into related municipal departments and with governance. There are communications lines in place to discuss AQM through air quality forums. Regular provincial and national meetings are attended.

Rustenburg LM: Gift Zimba is the designated AQO for the Rustenburg LM. No additional staff members assist with AQM, and this function sits within the Department of Environmental Management. The AQO reports to the Environmental Manager. There are communication lines in place to discuss AQM outside of the department, with Council.

4.11.2 Systems

The system component of capacity refers to all the tools at the organisation's disposal to manage air quality. These include equipment and hardware, as well as 'soft' tools such as operational procedures and air quality information.

Legal requirement

The NEM: AQA includes requirements for certain AQM tools. These include:

- Ambient air quality standards
- Ambient air quality monitoring
- Emission standards
- Emission monitoring
- Air quality data management system

- Priority area management
- Controlled emitters
- Controlled fuels
- Atmospheric emission licensing

The National Framework provided some guidance, and regulation and norms and standards development thereafter has strengthened AQM systems in the country. Several manuals have published.

Assessment

Table 4-25: Systems assessment for authorities

	LDEDET								NWREAD				
		WDM								BPDM			
			Lep	Thz	Mod	Mok	Mog	Bel			Rus	Mad	MK
Defined approach	Y	Y	-	-	-	-	-	-	U	Y	Y	-	-
Performance indicators	U	N	-	-	-	-	-	-	U	U	U	-	-
Ambient air quality monitoring	Y	Y	-	-	-	-	-	-	Y	N	Y	-	-
Air quality data management system	Y	N	-	-	-	-	-	-	U	N	Y	-	-
Controlled emitters	N	L	-	-	-	-	-	-	L	L	L	-	-
Atmospheric emission licensing	Y	N	-	-	-	-	-	-	Y	Y	n/a	-	-

Y- Yes N- No U- Unsure L- Limited n/a Not applicable

LDEDET: The province has a dedicated data acquisition system and server for storing and accessing air quality data. Currently there are no processes in place to manage controlled emitters. AELs are processed and received by the compliance section.

NWREAD: Monitoring is done and there is a network of eight stations. Controlled emitters are documented in a register. AELs are processed and issued throughout the province.

Waterberg DM: Ambient air quality monitoring is done in hot spot areas and there is a system to store and access data, but it is not utilised currently; the SAAQIS is used to access air quality data. A qualitative account of controlled emitters is included in the emission inventory report done for the AQMP but emissions were not quantified. The AEL function has been delegated to province.

Bojanala-Platinum DM: The DM does not undertake ambient air quality monitoring, but rely on municipalities to provide information. There is of course no system to store and access data. There is an emission inventory, but it is incomplete. The AEL function has resided at the BPDM since 1 May 2013.

Rustenburg LM: The LM has three monitoring stations and vehicle emissions are also monitored. The following parameters are monitored: $PM_{2.5}$, PM_{10}, NO_x and O_3. The data is stored and accessed using the Opsis system and there is a dedicated server in the municipality for air quality data. The municipality is compiling a database of controlled emitters, which will be included in the AQMP revision. They also assist the District with AELs by providing reports and information on listed activities.

SAAQIS Phase 1 provides an air quality data management system across South Africa. However, authorities still require an in-house system for data generated within the authority's boundaries for institutional reference. Ambient air quality monitoring data is currently being logged in SAAQIS Phase 1 and can be processed online for air quality information graphs. Some quality control is carried out but the data still requires further processing.

4.11.3 Skills

Skills capacity refers to the ability of the available staff to perform their required functions.

Legal requirement

Skills in AQM are not defined in any legal document. Skills development is generally incorporated into the authority's AQMP, which is part of the IDP or other departmental planning document. This does not form a binding commitment.

Assessment

Table 4-26: Skills assessment for authorities

	LDEDET								NWREAD				
		WDM								BPDM			
			Lep	Thz	Mod	Mok	Mog	Bel			Rus	Mad	MK
Suitability of staff profiles	Y	L	-	-	-	-	-	-	Y	L	Y	-	-
Departmental learning processes	Y	Y	-	-	-	-	-	-	Y	Y	Y	-	-
Skill sharing	Y	Y	-	-	-	-	-	-	Y	Y	Y	-	-
Technical skills development	L	L	-	-	-	-	-	-	Y	Y	L	-	-
Management skills development	L	L	-	-	-	-	-	-	Y	U	Y	-	-

Y- Yes N- No U- Unsure L- Limited

LDEDET: Staff is confident in their abilities to implement the NEM: AQA but they require some capacity building and guidance. Staff has some training and the three permanent staff have attended various specialist AQM courses. Most of these staff members come from environmental science, environmental management and natural science backgrounds. Whilst there are opportunities for fostering learning, development of technical skills and management competencies, their realisation is limited because of a lack of funding. AQM is not generally given enough importance by the Human Resources department.

NWREAD: Staff is confident in their abilities to implement the NEM: AQA but they require capacity building. Competence areas where training is required include introductory training in AQM, training in specialist areas such as monitoring or dispersion modelling, and AQMP training. The staff background lies in Environmental Science and Chemical Engineering. Skill sharing, knowledge transfer and the development of specific technical skills do occur. There is a lot of guidance from senior officers.

Waterberg DM: Most of the staff has an environmental health background. Staff is confident but require extensive capacity building. Staffs have attended training courses for AEL development, AQMP implementation, and ambient air quality monitoring. The EMI training has not been done so notices cannot be issued. There are opportunities for training but it is crucial that this is motivated for with the council and the budget allocated. There is a need for specific motivations for AQM at the Council level. Skill sharing does occur but there is no specific training budget allocation. Specific technical skills are developed through the assistance of the DEA.

Bojanala-Platinum DM: Air quality management staff is confident to perform the AQM function, and has received training in AEL development, AQMP implementation, ambient monitoring and EMI training. They however feel that further training and guidance is required, particularly in ambient monitoring and dispersion modelling.

Rustenburg LM: The air quality staff members have a background in Environmental Science with a postgraduate qualification. There are departmental learning processes in place but there are budget constraints. Skill sharing occurs through workshops held by the District and the Province. However, there is a need for more practical training in specific technical skills such as dispersion modelling.

4.11.4 Incentives

Incentives examine the motivational policies at the individual level but also the broader collaboration motivation existing within the department and with other departments and stakeholders.

Legal requirement

Incentives as a motivational tool aimed at individuals is not legislatively mandated. Motivations for organisations to collaborate are also not mandated.

Assessment

Table 4-27: Incentives assessment for authorities

	LDEDET								NWREAD				
		WDM								BPDM			
			Lep	Thz	Mod	Mok	Mog	Bel			Rus	Mad	MK
Salary bonus opportunities	Y	N	-	-	-	-	-	-	U	U	L	-	-
Culture and work environment	Y	N	-	-	-	-	-	-	Y	Y	Y	-	-
Career growth/ flexibility	L	N	-	-	-	-	-	-	Y	U	Y	-	-
Partnerships	N	N	-	-	-	-	-	-	N	N	Y	-	-
External funding	N	N	-	-	-	-	-	-	N	N	Y	-	-

Y- Yes N- No U- Unsure L- Limited

LDEDET: There are salary and bonus opportunities in place but they are subject to the performance evaluation and the annual systems evaluation. There is the understanding that air quality is a specialised field and requires a specialised skills set. The culture and work ethic was described as suitable and accommodating for most people. It enabled AQM staff to fulfil their work objectives. There are limited opportunities for career growth and flexibility because there are no clear lines of work division. Each staff member is expected to be multi-functional in AQM competency areas. There are currently no financial partnerships within the organisation but the department is working on trying to establish forums to incorporate other stakeholders through identified programmes. There are no external funding sources.

NWREAD: A budget of more than R 5 million is allocated to AQM. The culture and work ethic is suitable and there is a lot of room for career growth and flexibility. AEL revenue is regarded as an additional funding source.

Waterberg DM: A budget of between R 500 000 – R 1 000 000 is allocated annually to AQM. There are no salary or bonus opportunities in place. There are limited opportunities for career growth and flexibility as motivation is required for additional resources. The Council has allocated funding but further motivations are needed to access these resources. There are no external funding sources at the district level.

Bojanala-Platinum DM: A budget of more than R 5 million is allocated to AQM. However, further funding for AQM function and activities is considered necessary.

Rustenburg LM: There are no financial incentives to achieve air quality targets outside of the routine performance reviews. The culture and work ethic is accommodating for most people and occasionally internships are offered to air quality professionals. There is a need for more staff as functions grow. There are opportunities for growth and flexibility because the AQO currently performs all functions, such as reporting, monitoring, IT, and documentation. There are financial partnerships within the organisation and a budget is assigned to AQM from Council; DEA also provides funding. For external funding, Rustenburg LM often looks to collaborate with the mining sector.

4.11.5 Strategy

Strategy as a component of capacity refers to the alignment of the department's structure, systems, skills and incentives to reach the air quality goals that have been set.

Legal requirement

The most important strategy document for each authority is the AQMP. This summarises all the necessary information relating to the authority and plans a way forward for implementation. This requirement is a mandated in the NEM: AQA for each authority.

Other supplementary strategy documents include AQMP's that may have been developed by higher authorities, as well as legislation. The NEM: AQA and National Framework are two overarching legal documents that guide all AQM activities in South Africa.

Assessment

Table 4-28: Strategy assessment for authorities

	LDEDET								NWREAD				
		WDM								BPDM			
			Lep	Thz	Mod	Mok	Mog	Bel			Rus	Mad	MK
AQMP development	Y	Y	-	-	-	-	-	-	Y	Y	Y	-	-
Level of AQMP implementation	L	L	-	-	-	-	-	-	Y	Y	L	-	-
Vision, mission internalisation	N	N	-	-	-	-	-	-	U	U	Y	-	-
Flexibility	U	N	-	-	-	-	-	-	U	U	Y	-	-
Plan ownership	L	N	-	-	-	-	-	-	Y	Y	Y	-	-
Plan monitoring, evaluation, review	N	L	-	-	-	-	-	-	N	L	L	-	-

Y- Yes N- No U- Unsure L- Limited

LDEDET: As the AQMP was compiled recently, there is little ownership of the AQMP and the department has not evaluated the efficacy of the plan. Short-term activities have been completed.

NWREAD: An AQMP is in place and has been incorporated into the Province's EIP, but it is due for review.

Waterberg DM: An AQMP has been developed and incorporated into the IDP, but the implementation has been delayed. The AQM structure and budget is not in place. AQM actions have not been implemented because of financial constraints. The aspects of the AQMP being currently addressed are emission inventory education, site visits and a focus on monitoring data. Reports are given to Provincial authorities to evaluate, review and monitor the plan; however, implementation is currently less than 50%. Capacity building and training are needed to implement the plan.

Bojanala-Platinum DM: An AQMP has been developed in 2011 and is incorporated into the IDP through reference to specific AQM projects. Review of the AQMP will be done in line with the objectives of the WBPA AQMP. Implementation has include the development of by-laws, executing the AEL function, and industry inspections.

Rustenburg LM: The first AQMP was developed in 2005, prior to the publication of the AQMP guidelines. The AQMP was currently in the process of being revised but there have been financial constraints. The initial AQMP has been internalised and incorporated into the LM's EMP, but it was implemented before the appointment of the current AQO. Some of the objectives have been achieved such as the passing of LM bylaws.

4.11.6 Inter-relationships

Inter-relationships deal with a critical element for implementation capacity, and examines the manner in which the AQM department relates to other departments within the authority and other stakeholders.

Legal requirement

Relationships between departments within an authority are not defined in legislation. Inter-governmental cooperation is subject to legislation. Departments are compelled to communicate in instances where conflict arises and resolve issues according to legislated steps. An inter-governmental forum is also a necessary tool to foster cooperation and improve relations.

Assessment

Table 4-29: Inter-relationships assessment of authorities

	LDEDET								NWREAD				
		WDM								BPDM			
			Lep	Thz	Mod	Mok	Mog	Bel			Rus	Mad	MK
Internal working partners	Y	N	-	-	-	-	-	-	L	L	L	-	-
External working partners	Y	Y	-	-	-	-	-	-	Y	Y	Y	-	-
Other organisations	Y	L	-	-	-	-	-	-	Y	L	Y	-	-

Y- Yes N- No U- Unsure L- Limited

LDEDET: There are internal working partners, viz. Roads and Minerals departments. The department's external working partners are DEA and SAWS. There are service level agreements in place between municipalities and the Province. Regular meetings are held between district and local municipal staff as well as between national and provincial staff. PAGOR is a forum held with mining and industry, with waste management invited.

NWREAD: There are currently SLAs that cover licencing between all municipalities except the Bojanala Platinum DM, which does its own licencing. Regular meetings are held between provincial and municipal staff at an air quality forum, where information is shared and reports are submitted. An established governmental forum is the North West Air Pollution Control Officers forum, which represents industries in the Bojanala district. There is also the Klerksdorp, Orkney, Stillfontein and Hartebeesfontein Forum (KOSH), representing industries outside of the BPDM, which meets on a quarterly basis to discuss air quality issues. The AQM unit also works with other departments within the province, and externally with the DEA, Department of Mineral Resources, and with the districts. Other working partners include the North-West University.

Waterberg DM: Service level agreements are in place. There are regular meetings held between provincial and municipal staff at the AQO's forum. Internal working partners of the district should be the strategic planning department but there is no engagement, and there is a need for representation. External working partners are DEA and Province. There are serious challenges with local municipalities. They need to play a role, as they currently refer all their responsibilities to the district. There are no focal points at the LMs with which to engage. Province and DEA are assisting with the LM engagement. There are provincial-municipal air quality forums. Other working partners include industries, where stakeholder engagements are sought.

Bojanala-Platinum DM: There are regular meetings held between provincial and municipal staff at the AQO's forum. Internal working partners of the district should be the strategic planning department but there is no engagement, and there is a need for representation. External working partners are DEA and Province. There are challenges with local municipalities other than Rustenburg LM (see below). Province and DEA are assisting with the LM engagement.

Rustenburg LM: Internal working partners include the planning department and external working partners include DEA and the district. Other working partners include the mining industry. Rustenburg LM often provides AQ information to North-West University and University of Johannesburg for academic purposes.

4.11.7 Summary

The following overarching issues are identified regarding capacity within the WBPA authorities:

- Structural assessments show provincial capacity to be strong with local authorities requiring greater attention to support effective AQM functioning. This could be linked to lags in AQMP implementation.
- Stemming from the AQMP implementation, a defined approach and indicators for systems capacity are needed. Ambient air quality monitoring is carried out to varying levels and requires a coordinated approach across the WBPA. SAAQIS needs to be strengthened to provide an effective framework for data management and quality control. Controlled emitters management requires further guidance. AEL functions need to be extended to Waterberg DM, when capacity development is undertaken.
- Skills capacity across the WBPA authorities is at a good level, with most authorities having a strong background for AQM activities and accessing training within the department and from outside parties. Technical and management skills development requires greater focus to bolster AQM activity implementation.
- Incentives are not applied in a uniform manner across the WBPA authorities. Certain authorities have access to salary incentives and a suitable work environment, whereas others are not able to access the same level of institutional capacity.
- AQMP development needs to be aligned with the DEA AQMP Planning Manual to ensure all critical elements are addressed. Implementation requires assistance from a cooperative process that draws in higher management as well. Plan ownership and flexibility could be improved by effective internalisation of the AQMP as a departmental planning tool, i.e. a 'living document'. Monitoring, evaluation and review processes require greater regulation and oversight activity by authorities.

- Inter-relationships could be strengthened within authorities and with related outside authorities. This includes planning departments in particular, but also transport, housing, and minerals development. Opportunities are available for work with academic institutions; however, civic associations, ward committees, and environmental NGO's could be explored further.

5 STRATEGIC DEVELOPMENT IN THE WBPA

The extensive coal and other mineral reserves in the WDM and in neighbouring Botswana, make it a favourable region for industrial development. Several strategic projects are planned for in and around the WBPA, both in South Africa and Botswana.

The Presidential Infrastructure Coordinating Commission in the National Infrastructure Plan has detailed eighteen Strategic Infrastructure Projects (SIPs). These SIPs comprise of a large number of specific infrastructure components and programmes to support economic development and address service delivery, particularly in South Africa's poorest provinces. Three SIP's focus directly on areas within the WBPA, viz. SIPs 1, 4 and 9 (Table 5-1).

Table 5-1: Specific SIP activities in WBPA

No.	SIP title	Activities
SIP 1:	Unlocking the northern mineral belt with Waterberg as the catalyst	• Unlock mineral resources • Rail, water pipelines, energy generation/ transmission • Infrastructure • Urban development in Waterberg
SIP 4:	Unlocking the economic opportunities in North West Province	• Facilitate development of mining, agricultural activities and tourism opportunities • Open up beneficiation opportunities in North West Province
SIP 9:	Electricity generation to support socio-economic development	• Accelerating the construction of new electricity generation capacity • Monitor the implementation of major projects such as new power stations, including Medupi

Several large-scale developments are planned for the Waterberg area and in areas of Botswana within the border region with the Limpopo and North West provinces. They are power and fuel generation projects, with varying timelines and project scales (Table 5-2).

Table 5-2: Proposed and existing energy projects (DEA, 2012d)

South Africa		Botswana	
Project	*Output (MW)*	*Project*	*Output (MW)*
Matimba	3990	Morupule A	118
Medupi	4800	Morupule B	1200
Mafutha	80 000 bpd	Mmamabula	2700
Coal 3	5400	Mmamantswe	2000
Coal 4	5400		
Total	19590	Total	6018
Overall projects total (South Africa and Botswana)		25608 MW	

A regional study is underway on the possible environmental impacts of these projects for both countries. The Regional Environmental and Social Assessment of Coal-Based Energy Projects along the Botswana – South Africa Border will examine in detail the cumulative environmental, social and economic impacts associated with development plans. The objectives of the RESA are described in the inception report (Mott MacDonald, 2014) which will build on and expand the preliminary assessment (DEA, 2012d).

Given the nature of expected future developments in the WBPA and surrounding areas, an in-depth analysis of the impacts of the proposed future developments is timely. This will be examined in detail in the threat assessment, which is the accompanying document to the baseline assessment.

6 GAPS AND ISSUES

As an outcome of the status quo assessment, key issues and gaps need to be identified in each major section to be taken forward into the AQMP development process. The issues and gaps are listed in Table 6-1.

Table 6-1: AQM gaps and issues in the WBPA

AQM aspect	Gaps	Issues
Governance	Capacity at Provincial Government is not sufficient to carry out all AQM functions	Incumbent resources are limited and lack competence for some functions
	Capacity at Local Government is not sufficient to carry out all AQM functions	Incumbent resources are limited and lack competence for some functions
	Co-operative governance through AQM spheres (National, Provincial, Local Government) does not function effectively	Weak co-operative governance inhibits effective AQM
	Insufficient financial resources are available for AQM at all spheres of government	AQM is not prioritised in at all spheres of government inhibiting effective function
	Roles and responsibilities for AQM are not well understood at Local Government level, i.e. between district and local municipalities	Lack of understanding of roles and responsibilities leads either to duplication of effort or functions not being performed
	Co-operative governance through departmental structures (e.g. departments with AQM responsibilities) is not optimal	Weak co-operative governance and communications inhibits effective AQM function
	AEL function is not fulfilled by District Municipalities in the WBPA	Provincial departments are acting as AELAs due to a lack of capacity and competence in District Municipalities
Tools	Emission inventories are incomplete and unreliable: i.e. Listed activities: Not all sources are captured, some data are questionable Controlled emitters: Limited number of sources are captured Mining: Top-down approach for WBPA project needs to be refined and kept current Domestic fuel burning: Top-down approach for WBPA project needs refining spatially and temporally, and kept current	Poor emission inventories inhibit effective AQM function

	Motor vehicles: Requires annual updating for effective planning	
	Maintenance of ambient air quality monitoring stations is generally inadequate	Ambient data are generally unreliable
	The monitoring network is relatively sparse	Baseline air quality characterisation in all areas is not possible, particularly in areas where development is planned, e.g. WDM-Botswana border
Impact management	There is no health baseline with respect to air pollution in the WBPA and ecological impacts are not understood, i.e. with modelling and monitoring, efforts focus on industry, mining and residential fuel burning. Emissions from small boilers, biomass burning, waste management and transport were excluded	Health impacts as a result of air pollution in the WBPA are not understood and therefore not prioritised
		Air pollution impacts on ecology in the WBPA is not understood and therefore not prioritised
		Ambient air quality monitoring indicates areas where the NAAQS for PM_{10} are exceeded, particularly as a result of domestic fuel burning
		Dispersion modelling indicates areas where the NAAQS for PM_{10} are exceeded, particularly in the Rustenburg-Brits corridor as a result of mining emissions
		Dispersion modelling indicates areas where the NAAQS for SO_2 are exceeded, particularly in the Rustenburg-Brits corridor as a result of industrial emissions
		Transport, controlled emitters, biomass burning, and waste management require more in-depth study
		Development in the WDM and Botswana has the potential to result in exceedances of the NAAQS
Planning	Earlier AQMP's (NW, WDM) out-of-date and do not comply with the DEA AQMP manual AQMP for Limpopo and WDM lacking implementation Monitoring and review of AQMP has not been done	AQM is not considered with the necessary attention in environmental planning and implementation, resulting in inadequate resource allocation and inadequate implementation
Awareness and communication	There is generally a poor understanding of air quality and potential impacts on human and ecological health	AQM activities and emission reduction initiatives are difficult to implement

7 DEVELOPMENT OF THE THREAT ASSESSMENT

The South African Government had adopted a National Infrastructure Plan intended to transform the economic landscape of South Africa, create a significant number of new jobs, strengthen the delivery of basic services to the people of South Africa, and support the integration of African economies. The Presidential Infrastructure Coordination Committee (PICC) was established following the Cabinet Lekgotla in July 2011. The State Owned Enterprise (SOE) Projects were clustered into 18 Strategic Infrastructure Projects (SIPs) covering transportation, telecommunication, energy, health, education, water, and sanitation in all nine provinces. Each SIP comprises of a number of specific infrastructure components and programmes. Four SIPs are relevant to the WDM and these, with the proposed development in eastern Botswana, pose a threat to ambient air quality on a regional scale with negative implications for human health and the environment. An overview of the SIPs and the proposed development in Botswana is included in the following sections.

7.1 SIP 1: Unlocking the Northern Mineral Belt with Waterberg as the Catalyst

The PICC (2012) summarises SIP 1 as an investment in rail, water pipelines, energy generation and transmission infrastructure that will catalyse the unlocking of rich mineral resources in Limpopo resulting in thousands of direct jobs. Urban development in the Waterberg will be the first major post-apartheid new urban centre and will be a "green" development project. Mining includes coal, platinum and other minerals for local use and export, hence the rail capacity is being extended to Mpumalanga power stations and for export principally via Richards Bay and in future Maputo. The additional rail capacity will shift coal from road to rail in Mpumalanga with positive environmental and social benefits. Supportive logistics corridors will help to strengthen Mpumalanga's economic development.

The implications of SIP 1 for air quality lies in the potential increase in emissions associated with new power generation by coal-fired power stations, new coal mines and their associated emissions, and an increase in emissions associated with development and urbanisation, i.e. motor vehicles, domestic fuel burning, etc. With an increase in emissions, there is the potential for baseline ambient concentrations to increase with an increase on a regional scale in the WDM with an increase in exposure and risk to human and environmental health.

7.2 SIP 8: Green energy in support of the South African economy

The PICC (2012) summarises SIP8 as sustainable green energy initiatives on a national scale through a diverse range of clean energy options as envisaged in the Integrated Resource Plan (IRP2010) and to support bio-fuel production facilities. The implications of SIP 8 for air quality lies in the potential increase in emissions on a local scale associated with the development and resulting urbanisation, i.e. motor vehicles, domestic fuel burning, etc. With an increase in emissions there, is the potential for baseline ambient concentrations in parts of the WDM to increase with an increase in exposure and risk to human and environmental health.

7.3 SIP 9: Electricity generation to support socio-economic development

The PICC (2012) summarises SIP 9 as accelerating the construction of new electricity generation capacity in accordance with the Integrated Resource Plan for Electricity (DoE, 2011) to meet the needs of the economy and address historical imbalances. Further, the SIP intends to monitor the implementation of major projects such as new power stations, including Medupi.

Relevant to the WDM is the operation of the existing Matimba Power Station, and the construction and operation of the Medupi Power Station near Lephalale. Emissions of SO_2, NO_X and particulate matter from Medupi will add to the current baseline concentrations on a regional scale. In addition, with an increase in emissions associated with the development and the inevitable urbanisation, i.e. motor vehicles and domestic fuel burning, there is a potential for exceedances of health-based ambient air quality standards to occur and a risk to human and environmental health.

7.4 SIP 10: Electricity transmission and distribution for all

The PICC (2012) summarises SIP 10 as expanding the transmission and distribution network to address historical imbalances, provide access to electricity for all and support economic development. It aligns the 10-year transmission plan, the services backlog, the national broadband rollout and the freight rail line development to leverage off regulatory approvals, supply chain and project development capacity.

SIP 10 relates to SIP 9 as the supporting transmission and distribution capacity for growing the generation capacity in the region. The implications of SIP 10 for air quality in the WDM lies in the potential increase in emissions on a local scale associated with development and resulting urbanisation, i.e. motor vehicles, domestic fuel burning, etc. With an increase in emissions, there is the potential for baseline ambient concentrations in parts of the WDM to increase with an increase in exposure and risk to human and environmental health.

7.5 Regional energy development

Nine coal-based energy projects along the Botswana-South Africa border are the focus of a Regional Environmental and Social Assessment (RESA) commissioned by the World Bank, in conjunction with the Governments of South Africa and Botswana, to inform policy decisions required to meet rising electricity demand. The objectives of the RESA are described in the inception report (Mott MacDonald, 2014) which expands on the preliminary assessment (DEA, 2012b).

Coal-based energy projects are associated with emissions of SO_2, NO_X and particulate matter, amongst other pollutants. Individually, such projects may result in exceedances of health-based ambient air quality standards. The concentration of such projects regionally will result in a cumulative effect and an increase in ambient concentrations of pollutants. A preliminary analysis of the cumulative impacts associated with new coal-fired power plants is provided in the RESA, identifying potential air quality hot spots in Botswana and South Africa, cumulative impacts, and the potential for cross border exchange of air pollutants (DEA, 2012b).

8. DEVELOPMENT SCENARIOS

For the Threat Assessment, feasible development scenarios concerning energy-based projects and mining are developed for the WDM and neighbouring Botswana for 2015, 2020, 2025 and 2030. The objective is then to develop qualitative future emission inventories for each scenario to facilitate the prediction of future ambient concentrations of SO_2, NO_2 and PM_{10} resulting from these emissions.

The development scenarios for the Threat Assessment initially considered the energy-based projects listed in the RESA feasibility study (DEA, 2012b). They were updated in recognition of the revised coal investment plans for South Africa and Botswana. They were further refined to ensure agreement between the Threat Assessment scenarios and those developed for the World Bank-funded RESA study (Mott McDonald, 2014) which used information provided by the Department of Energy (DoE) and the Botswana Department of Energy. Mott McDonald (2014) also used information from the DEA, Eskom and the BPC to describe five future scenarios for the energy projects. Building on this information, development scenarios for 2015, 2020, 2025 and 2030 have been developed for the Threat Assessment.

Important exclusions from the scenario development and hence the Threat Assessment are the potential increase in emissions from the concomitant growth in urban settlements, motor vehicle traffic, the beneficiation industry and related secondary industry.

The projects that are included in the 2015, 2020, 2025 and 2030 scenarios are listed in Table 8-1 and their relative locations in the WDM and Botswana are illustrated in Figure 8-1.

Table 8-1: Energy-based and mining projects for the Threat Assessment scenarios

2012 Baseline	2015	2020	2025	2030
Matimba Power Station Grootegeluk Coal Mine Morupule B Power Station Morupule Coal Mine	Matimba Power Station Grootegeluk Coal Mine Morupule B Power Station Morupule Coal Mine	Matimba Power Station Morupule B Power Station (Phase 1)	Matimba Power Station Morupule B Power Station (Phase 1)	Matimba Power Station Morupule B Power Station (Phase 1)
	Medupi Power Station **Grootegeluk Coal Mine expanded** **Morupule A Power Station (recommissioned) Morupule Coal Mine expanded**	Medupi Power Station (no FGD) Grootegeluk Coal Mine expanded Morupule A Power Station (recommissioned) Morupule Coal Mine expanded	Grootegeluk Coal Mine expanded Morupule A Power Station (recommissioned) Morupule Coal Mine expanded	Grootegeluk Coal Mine expanded Morupule A Power Station (recommissioned) Morupule Coal Mine expanded
		IPP: Thabametsi Power Station **Thabametsi Coal Mine** **Sekoko Coal Mine** **IPP: Boikarabelo Power Station (Phase 1)** **Boikarabelo Coal Mine** **IPP: Unknown IPP Power Station (Phase 1)** **Morupule B Power Station (Phase 2)** **Greenfields IPP Power Station** **Mookane Coal Mine**	IPP: Thabametsi Power Station Thabametsi Coal Mine Sekoko Coal Mine IPP: Boikarabelo Power Station (Phase 1) Boikarabelo Coal Mine IPP: Unknown IPP Power Station (Phase 1) Morupule B Power Station (Phase 2) Greenfields IPP Power Station Mookane Coal Mine	IPP: Thabametsi Power Station Thabametsi Coal Mine Sekoko Coal Mine IPP: Boikarabelo Power Station (Phase 1) Boikarabelo Coal Mine IPP: Unknown IPP Power Station (Phase 1) Morupule B Power Station (Phase 2) Greenfields IPP Power Station Mookane Coal Mine
			Medupi Power Station (with FGD) **IPP: Boikarabelo Power Station (Phase 2)** **Boikarabelo Coal Mine expanded** **IPP: Unknown IPP Power Station (Phase 2)** **Thabametsi Coal Mine expanded** **Mmamabula Power Station (Phase 1)** **Mmamabula Power Station (Phase 2)** **Mookane Coal Mine expanded**	Medupi Power Station (with FGD) IPP: Boikarabelo Power Station (Phase 2) Boikarabelo Coal Mine expanded IPP: Unknown IPP Power Station (Phase 2) Thabametsi Coal Mine expanded Mmamabula Power Station (Phase 1) Mmamabula Power Station (Phase 2) Mookane Coal Mine expanded
				Coal 3 Power Station **New Pulverised Fuel Power Station** **New CTL** **Mmamantswe Power Station** **Mmamantswe Coal Mine**

Figure 8-1: Relative locations of the proposed energy-based, mining and other projects in the WDM and Botswana, shown in blue, brown and purple, respectively

9. FUTURE EMISSIONS

Emissions data for the facilities in the 2012 baseline case have been adopted from the baseline characterisation of the WBPA (uMoya-NILU, 2014a). For the future scenarios, the following general rules have been applied:

i. For some proposed energy-based projects, emission information is available from air quality specialist reports for EIAs or from AIRs. In these cases, the available data are used.
ii. For South African energy-based projects, it is assumed that 2020 Minimum Emission Standards (DEA, 2013) are met.
iii. For projects in Botswana, it is assumed that power plants comply with the relevant International Finance Corporation emission standards (IFC, 1998).
iv. For mines, the SAMINDABA definitions of Size Class apply and the estimated emission rates determined in the WBPA baseline characterisation (DEA, 2014a) are used.

In developing the emissions for future scenarios, it was necessary to make assumptions, as primary data does not exist. The assumptions that were made for the South African energy-based project projects are:

- Matimba Power Station: It is assumed that Matimba will continue to be operational as currently for the entire Threat Assessment period, i.e. to 2030.
- Medupi Power Station: It is assumed that Medupi will be fully operational in 2015 (six units) without FGD in accordance with the 'worst case' philosophy. It is assumed FGD is installed by 2025.
- Small-scale fluidised bed combustion (FBC) development (IPPs): The 2012 Ministerial Determinations for new coal generation indicates that by 2020, the DoE would seek to procure 1500 MW of base-load coal generation, increasing to 2500 MW of new coal generation by 2024. For the purposes of the RESA and the Threat Assessment, which both aim to assess future scenarios in terms of coal-based energy development, the installed capacity of IPPs is assumed to be 2360 MW IPP, attributed to the following IPPs:
  - Boikarabelo power station (total 260 MW)
  - Thabametsi power station (total 1200 MW)
  - IPP 1 (total 300MW)
  - IPP 2 (total 600MW)
- Small-scale fluidised bed combustion (FBC) development (Coal 3): The 2013 IRP update describes the Coal 3 project as a new set of fluidised bed combustion coal generation power plants with a total of capacity of 1000 to 1500 MW, based on discard coal. For purposes of the realistic but worst case future required in the RESA and the Threat Assessment, it is assumed that Coal 3 has the full capacity of 1500 MW and comes online between 2024 and 2034. Five sites have been selected in proximity to other emission sources and close to

the coal reserves. . Each site is assumed to have two circulating fluidised bed combustion (*CFBC*) units of 150 MW with a total of 300MW per site.

- New large-scale pulverised fuel (PF) station: The South African Coal Roadmap indicates that at least one new large-scale pulverised fuel power station will be required with the assumed commissioning date of 2027. The Coal Roadmap table indicates that future PF plants would have a generation capacity of approximately 4500 MW. The new PF plant is therefore assumed to have the same configuration as the Medupi Power Station, comprising 6 x 800MW units and the Medupi total installed generation capacity of 4800MW. The location of the new PF plant is assumed to be within the area considered for the original Coal 3 and Coal 4 projects.
- CTL Plant: Sasol's Mafutha project in the Waterberg was suspended in 2010. However, 80 000 BPD coal-to-liquid plant in the Waterberg is consistent with the worst-case assessment philosophy of the Threat Assessment. A hypothetical CTL plant is located at the proposed Mafutha site. It is assumed to be operational in the 2030 scenario.
- Coal mining: An increase in coal mining is necessary to support the energy-based projects in the region. A systematic increase in coal mining activity is therefore introduced by initially expanding existing collieries such as Grootegeluk and Morupule, then introducing known proposed collieries like Sekoko and Thabametsi in later scenarios, and finally adding collieries at the new power stations.

For the Botswana energy-based projects, the assumptions made by Mott MacDonald (2014) are carried into the Threat Assessment. These are paraphrased here:

- Morupule A: After being re-commissioned and returning to operation in 2016, available information indicates that this plant will continue to be operational up to 2025. With no information on decommissioning, the realistic worst-case scenario of the RESA and the Threat Assessment assumes the plant continues to operate for the full period of the assessment. The plant's generating capacity will be restored to the design level of 116 MW.
- Mmamabula: Development of this plant is currently on hold but it is likely considered that this power station will be developed. The Mmamabula Energy Project EIA states that Phase 1 will comprise 4 x 150 MW units and Phase 2 will comprise 2 x 300 MW units. The RESA and Threat Assessment assume that Phase 1 and Phase 2 are fully operational by 2024.
- Mmamantswe: This plant is included in the final scenario of the RESA and the 2030 scenario of the Threat Assessment. The most likely configuration is for 3 x 350MW units and a total generation capacity of 1050 MW.
- Location of Greenfields IPP: Expressions of Interest have been submitted for the Greenfield development, but a decision has not been made or information released. For consistency with the RESA and with the focus on the worst case for the WBPA, these plants are included in the Threat Assessment. The locations are unknown, but to be consistent with the worst

case approach of the RESA and the Threat Assessment they are assumed to be within the border region between the proposed Mmamabula plant and the village of Mookane.

Specific assumptions are made at a project level with respect to emission estimations; these are listed in Table 9-1.

The details regarding source parameterisation and emission information that are used in the dispersion modelling are presented in Appendix 5. A summary of emissions for 2015, 2020, 2025 and 2030 are presented for comparison with the baseline in Table 9-2.

Table 9-1: Project specific assumptions with respect to emissions

Plant / Mine	Emission assumption
Matimba	Current stack and emissions data from the AIR for Eskom's postponement applications for Matimba Power Station (uMoya-NILU, 2013a)
Medupi	Stack and emission data from the AIR for Eskom's postponement applications for Medupi Power Station cumulative assessment (uMoya-NILU, 2013b)
Grootegeluk Colliery	The mine expands from a Size Class 4 to a Size Class 5 according to the SAMINDABA definitions
Morupule A	Current stack and emissions data from the air quality specialist study for the EIA for Morupule A Power Station (BPC, 2012).
Morupule Coal Mine	Morupule Coal Mine is a Size Class 2 mine
IPP: Thabametsi	Stack and emission data from the air quality specialist study for the EIA for Thabametsi Power Station (uMoya-NILU, 2013c)
Thabametsi Coal Mine	Thabametsi Coal Mine is a Size Class 2 Mine
Sekoko Coal Mine	Emission data from the air quality specialist study for the EIA for Sekoko Coal Mine are used (uMoya-NILU, 2013d)
IPP: Boikarabelo Phase 1	Minimum Emission apply
Boikarabelo Coal Mine	Boikarabelo Coal Mine is a size Class 2
IPP: Unknown IPP Phase 1	Minimum Emission apply
Morupule B (Phase 1)	IFC emission standards for new thermal power plants
Greenfields IPP	IFC emission standards for new thermal power plants
Mookane Coal Mine	Mookane Coal Mine is a size Class 2
Thabametsi Coal Mine expanded	Thabametsi Coal Mine expands to a Class 3 Mine
IPP: Boikarabelo Phase 2	Minimum Emission Standards apply
Boikarabelo Coal Mine expanded	Boikarabelo Coal Mine expands to a Size Class 3 Mine
IPP: Unknown IPP Phase 2	Minimum Emission Standards apply
Mmamabula (Phase 1)	IFC emission standards for new thermal power plants
Mmamabula (Phase 2)	IFC emission standards for new thermal power plants
Mookane Coal Mine expanded	Boikarabelo Coal Mine expands to a Class 3 Mine

Plant / Mine	Emission assumption
Coal 3	Minimum Emission Standards apply
New Pulverised Fuel (PF) power station	Minimum Emission Standards apply
New CTL Plant	Minimum Emission Standards apply
Mmamantswe Power Station	IFC emission standards for new thermal power plants
Mmamantswe Coal Mine	Mmamantswe Coal Mine is a size Class 2

Table 9-2: Baseline and projected emissions rates in tons per annum for the respective energy-based and mining projects

Scenario	Facility	Emission Rate (tons per annum)		
		SO_2	NO_X	Particulates
Baseline	Matimba (6 units: 3990 MW)	309 262	67 592	4 904
	Morupule B (Phase 1) 4 units: 600 MW)	16 670	9 446	926
	Grootegeluk Coal Mine			537
	Morupule Coal Mine			134
	TOTAL	**325 932**	**77 038**	**6 501**
2015	Medupi (6 units: 4800 MW no FGD)	490 872	92 038	6 136
	Morupule A (4 units: 132 MW)	9 191	2 925	187
	Grootegeluk Coal Mine expanded			1 074
	Morupule Coal Mine expanded			268
	TOTAL	**500 063**	**94 964**	**7 665**
2020	IPP: Thabametsi (4 units: 1200 MW)	215 116	103 784	649
	IPP: Boikarabelo Phase 1 (3 units: 45 MW)	3 337	5 005	334
	IPP: Unknown IPP Phase 1 (2 units: 300 MW)	3 337	5 005	334
	Morupule B (Phase 2) (2 units: 300 MW)	8 335	4 723	463
	Greenfields IPP (2 units: 300 MW)	6 006	3 404	334
	Boikarabelo Coal Mine			134
	Thabametsi Coal Mine			134
	Sekoko Coal Mine			134
	Mookane Coal Mine			134
	TOTAL	**236 131**	**121 921**	**2 649**
2025	Medupi (6 units: total 4800 MW, now with FGD)	61 359	92 038	6 136
	IPP: Boikarabelo Phase 2 (1 unit: 215 MW)	6 674	10 011	667
	Mmamabula (Phase 1) (4 units: 600 MW)	12 013	6 807	667
	Boikarabelo Coal Mine expanded			268
	Thabametsi coal Mine expanded			268
	Mookane Coal Mine expanded			268
	TOTAL	**80 046**	**108 856**	**8 274**
2030	Coal 3 (10 units: 1500MW)	16 684	25 026	1 668
	New Pulverised Fuel (PF) power station (6 units: 4500 MW)	490 872	92 038	6 136
	Mmamantswe (3 units: 1050MW)	6 006	3 404	334
	New CTL (80000 bpd)	70 042	105 064	7 004
	Mmamantswe Coal Mine			134
	TOTAL	**583 605**	**225 532**	**15 276**

In Table 9-3 the cumulative emissions resulting from industry and mining are shown, i.e. 2015 = baseline + 2015, 2020 = baseline + 2015 + 2020, and so on. The decrease in SO_2 emissions from 2020 to 2025 is a result of FGD implemented at Medupi. The cumulative emissions are depicted graphically in Figure 9-1 as a percentage of the baseline emission.

Table 9-3: Cumulative emission from energy-based sources and mining from the baseline to 2030 in tons per annum

Scenario	Energy-based projects			Mining
	SO_2	NO_x	Particulate	Particulate
Baseline	325 932	77 038	5 830	671
2015	825 995	172 002	14 166	1 342
2020	1 062 126	293 923	16 815	1 878
2025	651 299	310 741	18 954	2 280
2030	1 234 904	536 273	34 230	2 414

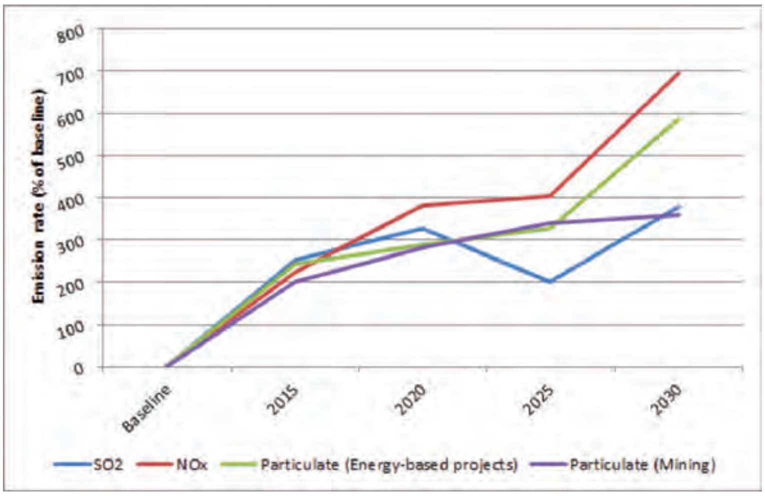


Figure 9-1: Change in emissions from 2015 to 2030 as a percentage of the baseline emission

10. PREDICTED AMBIENT AIR QUALITY

10.1 Methodology

The US-EPA-approved and DEA-recommended CALPUFF dispersion model was used to estimate ambient concentrations of SO_2, NO_2 and PM_{10} resulting from future energy-based projects and mining in the WDM and Botswana.

Modelling is done for a large domain covering the WDM and eastern parts of Botswana at a resolution of 3 km. Hourly meteorological data from SAWS monitoring stations were used with the diagnostic meteorological model TAPM to create hourly meteorological input files for 2010-2012. Emissions from energy-based projects were modelled as point sources and mines were modelled as area sources. A detailed description of the modelling approach is documented in the modelling plan of study (uMoya-NILU, 2014).

The locations of energy-based projects and mines in the Threat Assessment uses good judgement and the best available information, including information contained in EIA documents, Atmospheric Impact Reports (AIR), the initial RESA (DEA, 2012b) and information in technical notes produced by Mott MacDonald. The relative siting of the energy-based plants and mines from the base year through to 2030 is shown in Figure 10-1.

In the section that follows, the dispersion model results are presented on maps of the region. These results show the predicted annual average concentrations of SO_2, NO_2 and PM_{10} and the 99th percentile of the predicted 24-hour and 1-hour concentrations. These are compared with the limit value of the respective National Ambient Air Quality Standards (NAAQS) (Table 10-1). The frequency of exceedances of the limit value of the NAAQS was compared with the permitted tolerance values. These values include 12 for three years of 24-hour concentrations and 264 for three years of hourly concentrations. The change in ambient concentrations from the base year (2012) to 2015, 2020, 2025 and 2030 respectively, are also mapped.

It should be borne in mind that the Threat Assessment excludes the contribution of emissions from the potential increase in residential fuel burning and motor vehicles. The outputs of the Threat Assessment modelling most likely indicate a best case scenario without these two contributing source types. In other words, the future scenarios are likely to be under-predicted. Emissions from residential fuel burning are released close to ground level and have a relatively localised effect, albeit a potentially significant effect on ambient concentrations. The effect of motor vehicle emissions is also limited and resulting ambient concentrations are generally much lower.

Table 10-1: National Ambient Air Quality Standards for SO_2, NO_2 and PM_{10} (DEA, 2009)

Pollutants	Averaging period	Limit value ($\mu g/m^3$)	Number of permissible exceedances per annum
SO_2	1-hour	350	88
	24-hour	125	4
	Calendar Year	50	0
NO_2	1-hour	200	88
	Calendar Year	40	0
PM_{10}	24-hour	75	4
	Calendar year	40	0

10.2 Baseline case

The baseline case predicts ambient SO_2, NO_2 and PM_{10} concentrations resulting from emissions from the Matimba Power Station in the WDM and Morupule B Power Station in Botswana, as well as PM_{10} emissions from Grootegeluk and Morupule Coal Mines (Table 9-2).

10.2.1 Sulphur dioxide (SO_2)

The predicted ambient SO_2 concentrations of the baseline emissions are relatively low (Figure 10-1), with no predicted exceedances of the limit values of the NAAQS (Table 10-1). As it may be expected, the highest predicted concentrations occur in the vicinity of the Matimba and Morupule power stations being the only sources of SO_2 in the modelling domain.

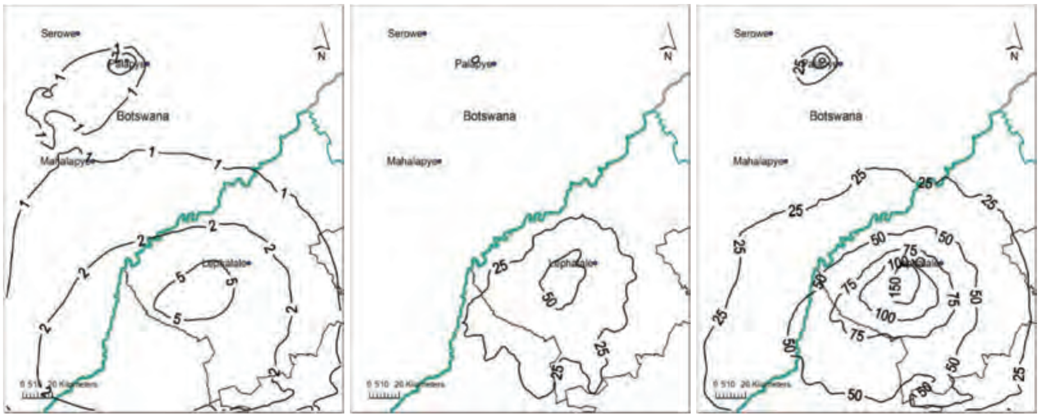


Figure 10-1: Predicted annual average SO_2 concentrations for the base case (left), the 99th percentile of the predicted 24-hour concentration (middle) and the 99th percentile of the predicted 1-hour concentration (right) in µg/m³

10.2.2 Nitrogen dioxide (NO_2)

The predicted ambient NO_2 concentrations of the baseline emissions are relatively low (Figure 10-2), with no predicted exceedances of the limit values of the NAAQS (Table 10-1). As it may be expected, the highest predicted concentrations occur in the vicinity of the Matimba and Morupule power stations, the only sources of NO_2 in the modelling domain.

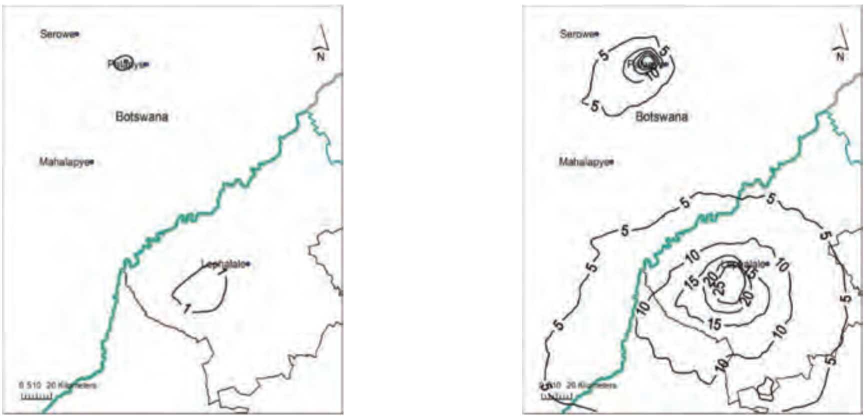


Figure 10-2: Predicted annual average NO_2 concentrations for the base case (left), and the 99th percentile of the predicted 1-hour concentration (right) in µg/m³

10.2.3 Respirable particulate matter (PM_{10})

The predicted ambient PM_{10} concentrations for the baseline emissions are relatively low (Figure 10-3), except in the immediate vicinity of the two power stations and the coal mines where there are predicted exceedance of the limit values of the NAAQS (Table 10-1). Four exceedances of the 24-hour limit value are permitted annually. More than 12 exceedances are predicted in the 3-year modelling period in a small area west of Lephalale and west of Palapye.

Figure 10-3: Predicted annual average PM_{10} concentrations for the base case (left), the 99th percentile of the predicted 24-hour concentration (middle) in µg/m³ and the predicted frequency of exceedance of the 24-hour limit value (right)

10.3 Predicted ambient concentrations for 2015

In 2015, the Medupi Power Station and Morupule A Power Station add to the emission loading of the area. The Grootegeluk and Morupule Coal Mines are currently being expanded in size; which result in an increase of emissions from the mining sector. The total SO_2 emissions increase by 500 063 t/a, while the NO_X emissions increase by almost 95 000 t/a and PM_{10} by more than 7 600 t/a.

10.3.1 Sulphur dioxide (SO_2)

The predicted ambient SO_2 concentrations in 2015 increase drastically with the addition of emissions from the new sources, particularly near Lephalale as a result of Medupi Power Station without FGD and Morupule A Power (near Palapye)Station (Figure 10-4). While the predicted annual concentrations are well below the NAAQS, the limit value of the 24-hour and 1-hour NAAQS (Table 10-1) are exceeded over a relatively large area southwest of Lephalale.

The frequency of exceedances of the 24-hour and 1-hour limit values is shown in Figure 10-5 for the 3-year modelling period. More than 12 exceedances of the 24-hour limit value occur over a relatively limited area southwest of Lephalale. More than 264 exceedances of the 1-hour limit value in the same area, albeit a somewhat smaller area.

The relative increase in predicted ambient SO_2 concentrations from the baseline case is shown in Figure 10-6. The predicted annual concentrations increase by 10% in the area of maximum predicted concentrations. The increase is more dramatic for the 24-hour and 1-hour concentrations. The predicted 24-hour concentrations increase by 80% in the area of maximum concentration southwest of Lephalale, with an increase of 20% and more up to 100 km from the main source area. The predicted 1-hour concentrations increase by more than 200% to the southwest of Lephalale, and by more than 50% up to 100 km from the main source area.

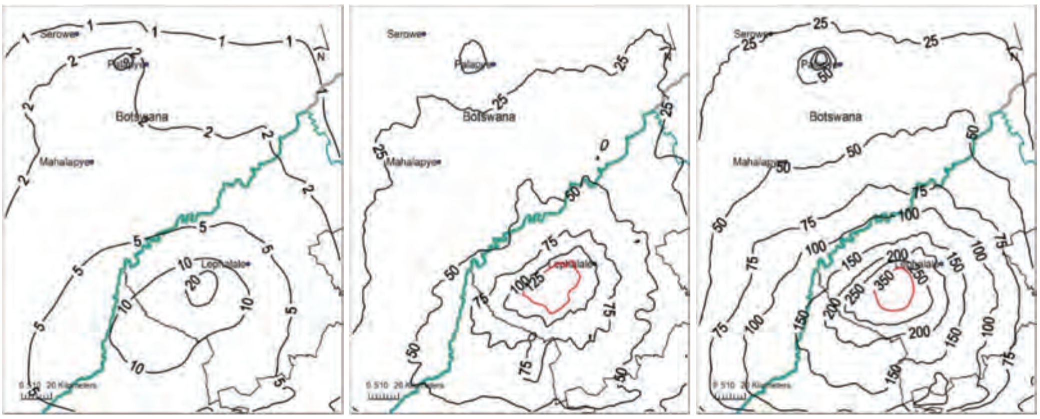


Figure 10-4: Predicted annual average SO_2 concentrations for 2015 (left), the 99th percentile of the predicted 24-hour concentration (middle) and the 99th percentile of the predicted 1-hour concentration (right) in µg/m^3. The limit values of the NAAQS are shown by the red isopleths

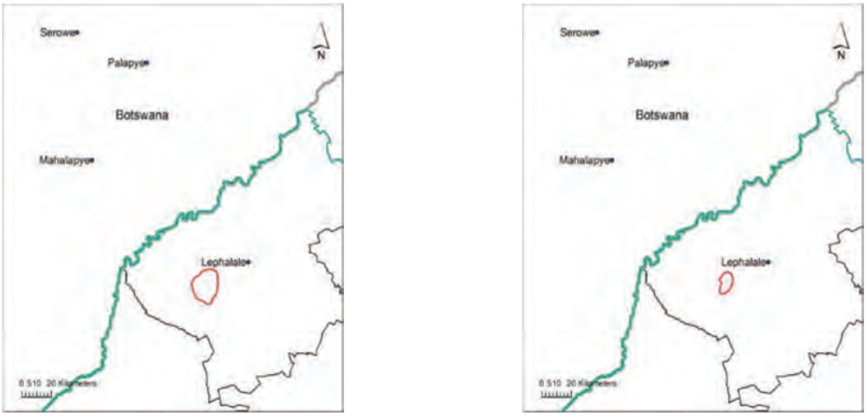


Figure 10-5: Predicted frequency of exceedance of the NAAQS limit value in 2015 for SO_2 for 24-hour (top) and 1-hour (bottom)

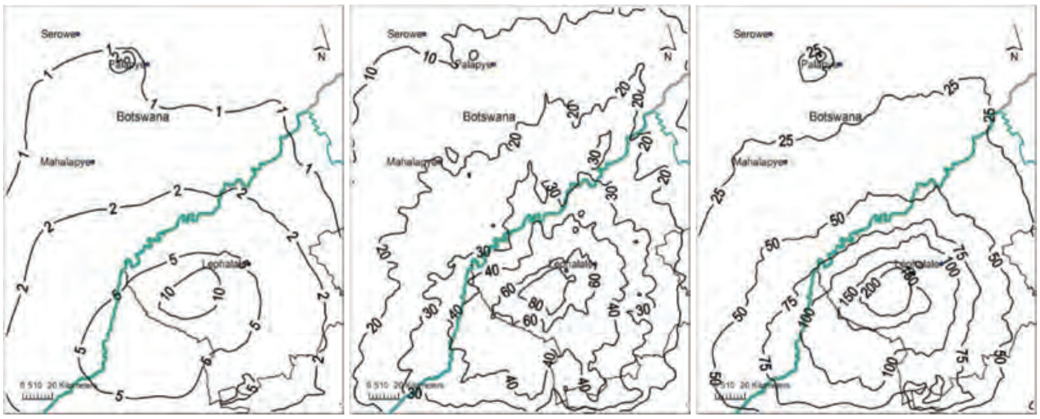


Figure 10-6: Difference in the predicted SO_2 concentrations in µg/m³ in 2015 from the base case for annual concentrations (left), the 99th percentile of the predicted 24-hour concentration (middle) and the 99th percentile of the predicted 1-hour concentration (right)

10.3.2 Nitrogen dioxide (NO_2)

The predicted ambient NO_2 concentrations in 2015 increase with the increase in emissions (Figure 10-7). The maximum concentrations are predicted to occur to the southwest of Lephalale and west of Palapye. The predicted annual concentrations are well below the NAAQS. Similarly, the 99th percentile of the predicted 1-hour concentrations is below the limit value of the 1-hour NAAQS (Table 10-1).

The relative increase in predicted ambient NO_2 concentrations from the baseline case is shown in Figure 10-8. The predicted annual concentrations increase by just 2% in the area of maximum predicted concentrations. The predicted 1-hour concentrations increase by up to 30% in the area of maximum predicted concentrations to the southwest of Lephalale.

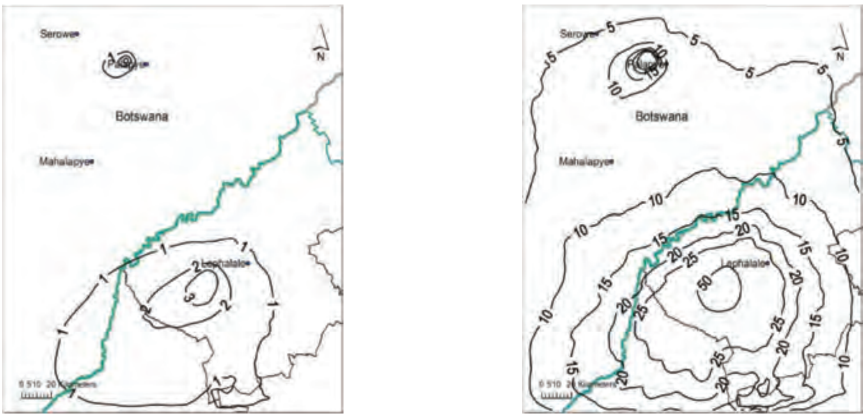


Figure 10-7: Predicted annual average NO_2 concentrations for 2015 (left) and the 99th percentile of the predicted 1-hour concentration (right) in µg/m^3

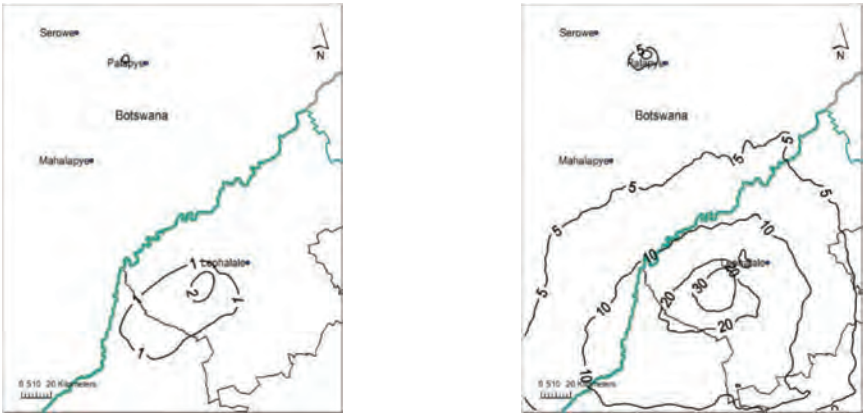


Figure 10-8: Percentage difference in the predicted NO_2 concentrations in 2015 from the base case for annual concentrations (top) and the 99th percentile of the predicted 1-hour concentration (bottom).

10.3.3 Respirable particulate matter (PM_{10})

The predicted ambient PM_{10} concentrations in 2015 increase with the addition of the power station emissions and as a result of expansion of the Grootegeluk and Morupule coal mines (Figure 10-9). The maximum concentrations are predicted to occur in the southwest of Lephalale and west of Palapye. The predicted annual concentrations are generally below the limit value of the NAAQS except in a small area west of Lephalale, coinciding with the Grootegeluk Colliery. Similarly, the 99^{th} percentile of the predicted 24-hour concentrations is below the limit value of the NAAQS other than the small area west of Lephalale.

The relative increase in predicted ambient PM_{10} concentrations from the baseline case is shown in Figure 10-10. The predicted annual concentrations increase by just 5% in the area of predicted maximum concentrations near Grootegeluk Colliery. The predicted 24-hour concentrations increase by up to 20% in the same area and by 10% west of Palapye.

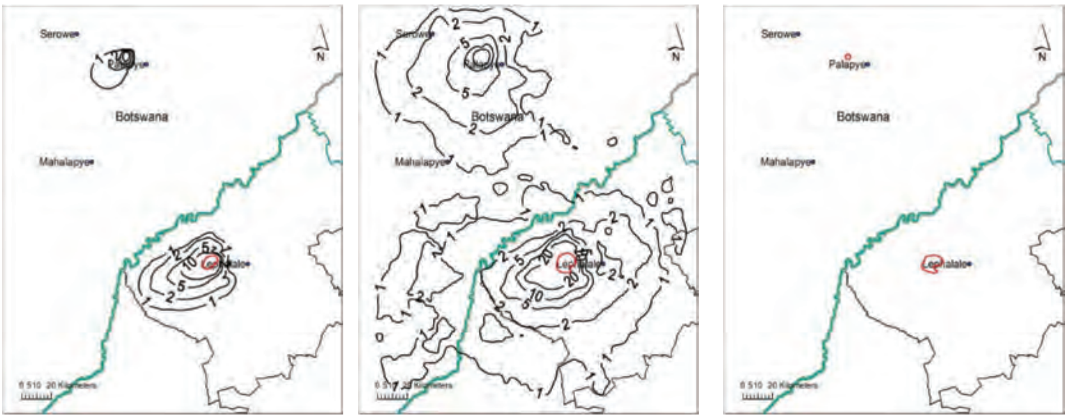


Figure 10-9: Predicted annual average PM_{10} concentrations for 2015 (left) and the 99^{th} percentile of the predicted 24-hour concentration (middle) in µg/m³ showing the limit values of the NAAQS, and the predicted frequency of exceedance of the 24-hour limit value of the NAAQS (right)

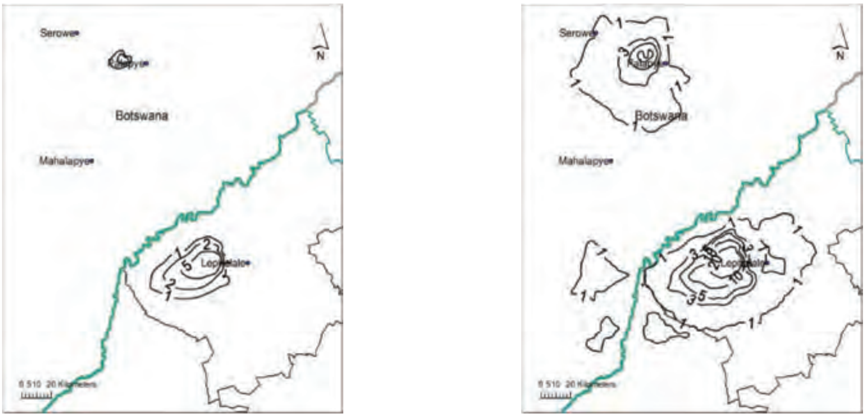


Figure 10-10: Difference in the predicted PM_{10} concentrations in 2015 from the base case for annual concentrations (left) and the 99th percentile of the predicted 24-hour concentration (right)

10.4 Predicted ambient concentrations for 2020

In 2020 the Thabametsi Power Station becomes operational with three new IPP power stations (Boikarabelo, Unknown IPP and Greenfields), supported by four new coal mines. The total SO_2 emissions increase from 2015 by 236 131 t/a, NO_X by nearly 122 000 t/a and PM_{10} by 2 649 t/a.

10.4.1 Sulphur dioxide (SO_2)

The predicted ambient SO_2 concentrations in 2020 increase somewhat from 2015 with the expansion and addition of the smaller IPP power plants, with a notable increase in the area of maximum predicted concentration in the vicinity of Lephalale and near Papapye (Figure 10-11). The predicted annual concentrations remain well below the NAAQS. However, the limit value of the 24-hour and 1-hour NAAQS (Table 10-1) are exceeded over a relatively large area west of Lephalale.

The frequency exceedances of the 24-hour and 1-hour limit values are presented in Figure 10-12 for the 3-year modelling period. More than 12 exceedances of the 24-hour limit value occur over a relatively large area west and southwest of Lephalale. More than 264 exceedances of the 1-hour limit value in the same area, albeit somewhat smaller.

The relative increase in predicted ambient SO_2 concentrations in 2020 from the baseline case is shown in Figure 10-13. The predicted annual concentrations increase by 20% in the area of maximum predicted concentrations. The increase is more dramatic for the 24-hour and 1-hour concentrations. The predicted 24-hour concentrations increase by more than 80% in the area of maximum concentration west and southwest of Lephalale, with an increase of 40% and more up to 100 km from the main source area. The predicted 1-hour concentrations increase by more than 200% in the west and southwest of Lephalale, and by more than 75% up to 100 km from the main source area.

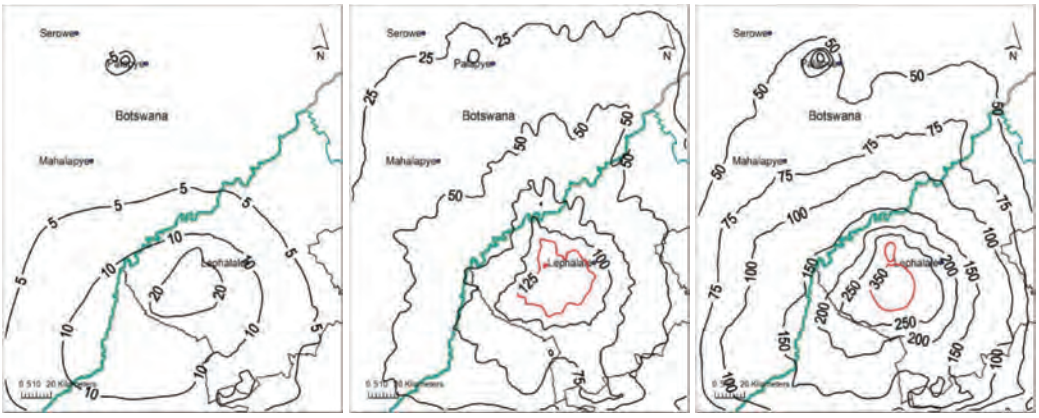


Figure 10-11: Predicted annual average SO_2 concentrations for 2020 (left), the 99th percentile of the predicted 24-hour concentration (middle) and the 99th percentile of the predicted 1-hour concentration (right) in μg/m³. The limit values of the NAAQS are shown by the red isopleths

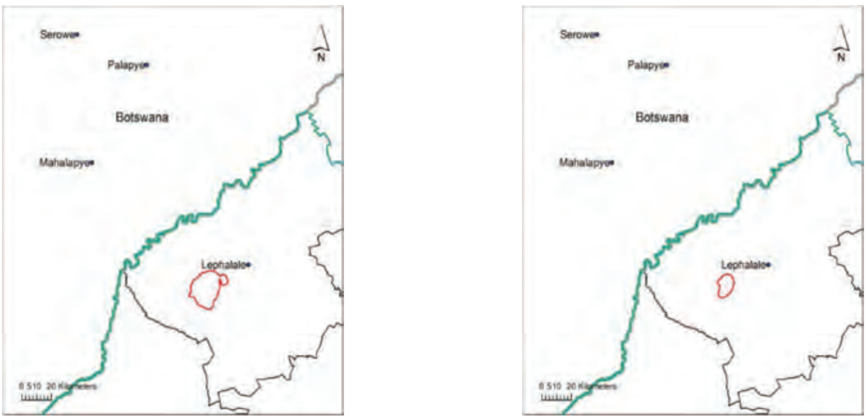


Figure 10-12: Predicted frequency of exceedance of the NAAQS limit value in 2020 for SO_2 for 24-hour (left) and 1-hour (right)

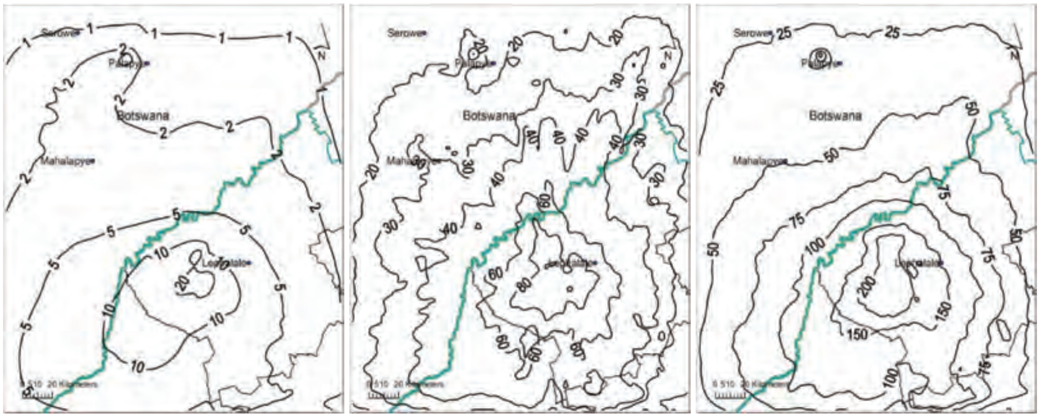


Figure 10-13: Difference in the predicted SO_2 concentrations in 2020 from the base case for annual concentrations (left), the 99th percentile of the predicted 24-hour concentration (middle) and the 99th percentile of the predicted 1-hour concentration (right)

10.4.2 Nitrogen dioxide (NO_2)

The predicted ambient NO_2 concentrations in 2020 increase with the added power generation capacity (Figure 10-14). The maximum concentrations are predicted to occur to the southwest of Lephalale and west of Palapye. The predicted annual concentrations remain well below the NAAQS (Table 10-1). Similarly, the 99th percentile of the predicted 1-hour concentrations remains below the limit value of the 1-hour NAAQS (Table 10-1).

The relative increase in predicted ambient NO_2 concentrations in 2020 from the baseline case is shown in Figure 10-15. The predicted annual concentrations increase by just 5% in the area of maximum predicted concentrations. The predicted 1-hour concentrations increase by up to 60% in the area of maximum predicted concentrations to the west and southwest of Lephalale, and by more than 20% west of Palapye.

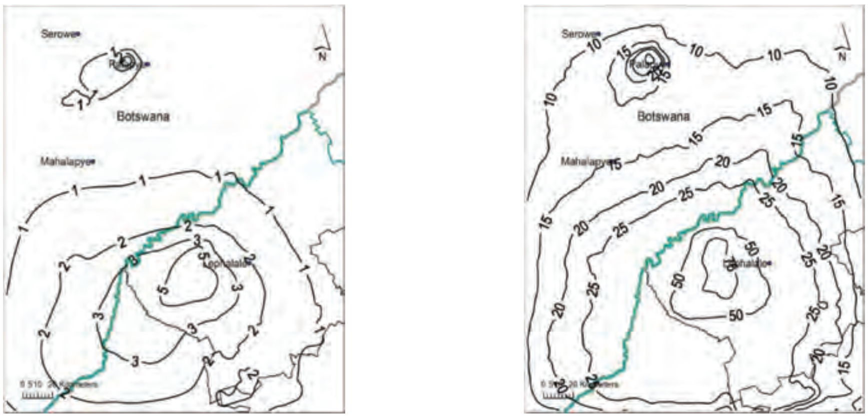


Figure 10-14: Predicted annual average NO_2 concentrations for 2020 (left) and the 99th percentile of the predicted 1-hour concentration (right) in µg/m³

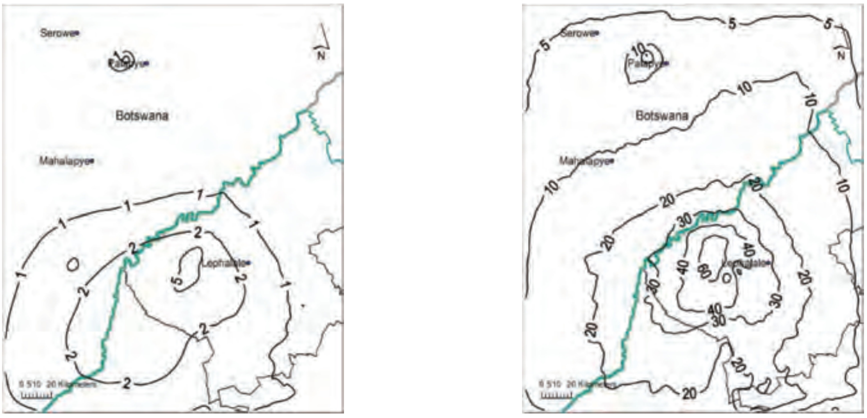


Figure 10-15: Percentage difference in the predicted NO_2 concentrations in 2020 from the base case for annual concentrations (left) and the 99th percentile of the predicted 1-hour concentration (right)

10.4.3 Respirable particulate matter (PM_{10})

The predicted ambient PM_{10} concentrations in 2020 increase with the addition of the generation capacity and four new coal mines in the WDM and Botswana (Figure 10-16). The maximum concentrations are predicted to occur west of Lephalale extending into Botswana and west of Palapye. The predicted annual concentrations are generally below the limit value of the NAAQS except in a small area west of Lephalale, coinciding with the Grootegeluk Colliery and the mines at Boikarabelo and Mookane. Similarly, the 99th percentile of the predicted 24-hour concentrations is below the limit value of the NAAQS other than the three small areas west of Lephalale. In these areas, the limit value is exceeded on more than 12 occasions in the 3-year modelling period.

The relative increase in predicted ambient PM_{10} concentrations in 2020 from the baseline case is shown in Figure 10-17. The predicted annual concentrations increase by just 5% in the area of maximum predicted concentrations west of Lephalale and towards Botswana. The predicted 24-hour concentrations increase by up to 20% west of Lephalale and by 10% further west into Botswana.

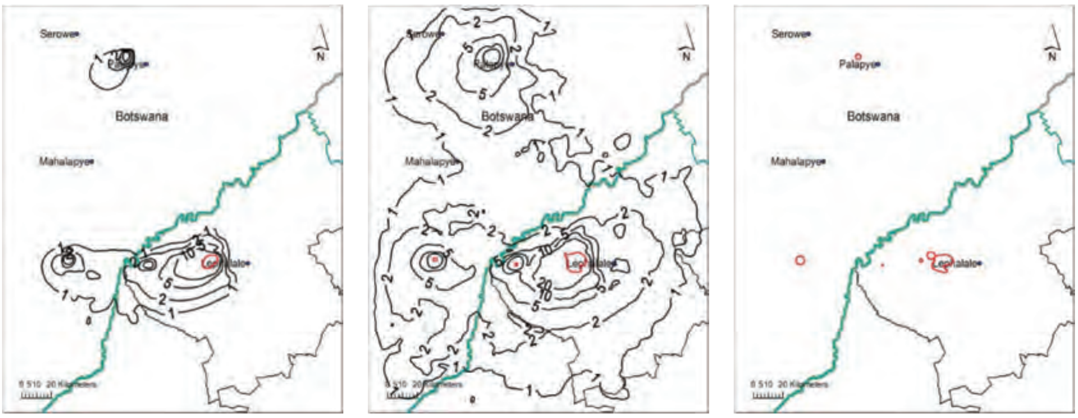


Figure 10-16: Predicted annual average PM_{10} concentrations for 2020 (left) and the 99th percentile of the predicted 24-hour concentration (middle) in µg/m³, the limit value of the NAAQS is shown by the red isopleths, and the frequency of exceedance of limit value of the 24-hour NAAQS (right)

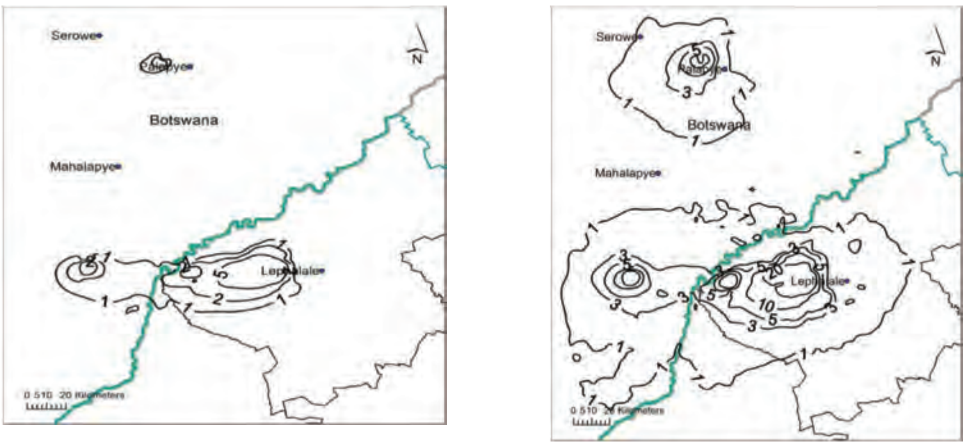


Figure 10-17: Percentage difference in the predicted PM_{10} concentrations in 2020 from the base case for annual concentrations (top) and the 99th percentile of the predicted 24-hour concentration (bottom).

10.5 Predicted ambient concentrations for 2025

New generation capacity in 2025 is brought by expansions at the Boikarabelo and Unknown IPP Power Stations, and commissioning of Phase 1 and 2 at the Mmamabula Power Station. The 2025 case also includes the expansion of three coal mines. The total SO_2 emission decreases substantially as FGD is operational at the Medupi Power Station (Table 9-2), but PM_{10} emission increase by a further 5 207 t/a.

10.5.1 Sulphur dioxide (SO_2)

The predicted ambient SO_2 concentrations in 2025 exhibit a marked decrease from 2020 despite the expansion of the Boikarabelo and Unknown IPP Power Stations, and commissioning of the Mmamabula Power Station. The decrease is attributed to a reduction in SO_2 emissions with the implementation of FGD at Medupi. The predicted annual concentrations remain well below the NAAQS (Figure 10-18). The limit value of the 24-hour and 1-hour NAAQS (Table 10-1) are exceeded over a small area west of Lephalale. The exceedances are predicted to occur on fewer occasions than permitted by the NAAQS, i.e. there is general compliance with the NAAQS for SO_2.

The relative increase in predicted ambient SO_2 concentrations in 2025 from the baseline case are shown in Figure 10-19. The predicted annual concentrations increase by 10% in the area of maximum predicted concentrations southwest of Lephalale. The increase is more exaggerated for the predicted 24-hour and 1-hour concentrations. The predicted 24-hour concentrations increase by more than 40% in the area of maximum concentration west of Lephalale, with an increase of 15% up to 100 km from the main source area. The predicted 1-hour concentrations increase by more than 100% to the west of Lephalale, and by more than 25% up to 100 km from the main source area.

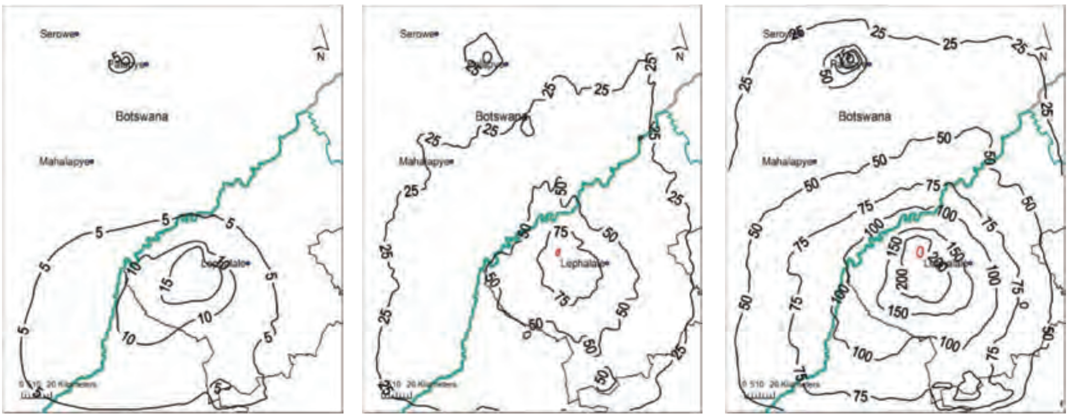


Figure 10-18: Predicted annual average SO_2 concentrations for 2025 (left), the 99th percentile of the predicted 24-hour concentration (middle) and the 99th percentile of the predicted 1-hour concentration (right) in $\mu g/m^3$. The limit values of the NAAQS is shown by the red isopleths

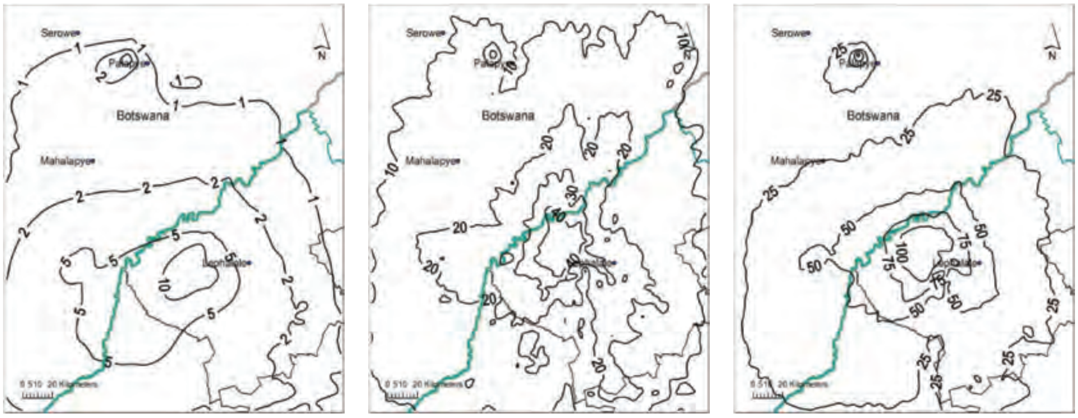


Figure 10-19: Percentage difference in the predicted SO_2 concentrations in 2025 from the base case for annual concentrations (left), the 99th percentile of the predicted 24-hour concentration (middle) and the 99th percentile of the predicted 1-hour concentration (right)

10.5.2 Nitrogen dioxide (NO_2)

The predicted annual concentrations remain well below the NAAQS (Figure 10-20). The limit value of the 1-hour NAAQS (Table 10-1) is exceeded over a small area west of Lephalale, but on fewer occasions than permitted by the NAAQS, i.e. there is general compliance with the NAAQS.

The relative increase in predicted ambient NO_2 concentrations in 2025 from the baseline case is shown in Figure 10-21. The predicted annual concentrations increase by 5% in the area of maximum predicted concentrations southwest of Lephalale. The increase is more exaggerated for the predicted 1-hour concentrations. The predicted 1-hour concentrations increase by more than 80% to the west of Lephalale, and by more than 20% up to 100 km from the main source area.

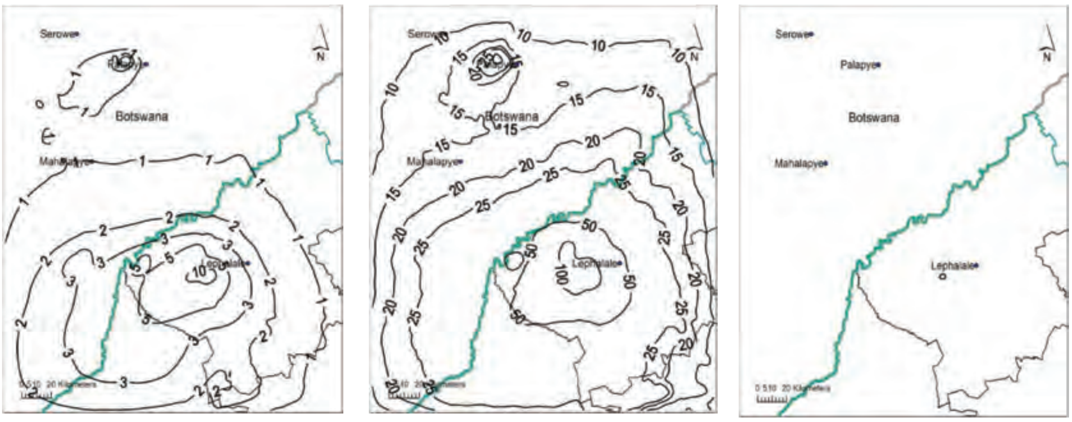


Figure 10-20: Predicted annual average NO_2 concentrations for 2025 (left) and the 99th percentile of the predicted 1-hour concentration (middle) in μg/m^3. The limit values of the NAAQS are shown by the red isopleths. The predicted frequency of exceedance is shown (right)

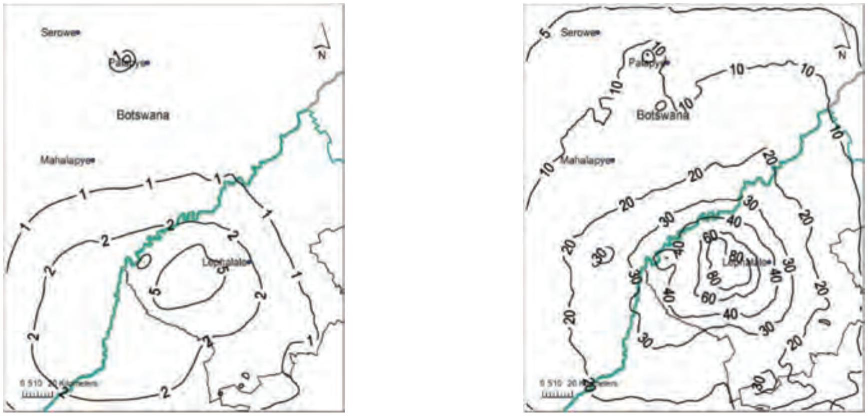


Figure 10-21: Percentage difference in the predicted NO_2 concentrations in 2025 from the base case for annual concentrations (top) and the 99th percentile of the predicted 1-hour concentration (bottom).

10.5.3 Respirable particulate matter (PM_{10})

The predicted ambient PM_{10} concentrations in 2025 increase with the addition of the generation capacity and as a result of the expansion at three coal mines in the WDM and Botswana (Figure 10-22). The maximum concentrations are predicted to occur west of Lephalale extending into Botswana and west of Palapye. The predicted annual concentration are generally below the limit value of the NAAQS other than small areas west of Lephalale, coinciding with the coal mines at Thabametsi, Boikarabelo and Mookane. The 99th percentile of the predicted 24-hour concentrations is also below the limit value of the NAAQS other than the three small areas west of Lephalale. In these areas, the limit value is exceeded on more than 12 occasions in the 3-year modelling period (Figure 10-22).

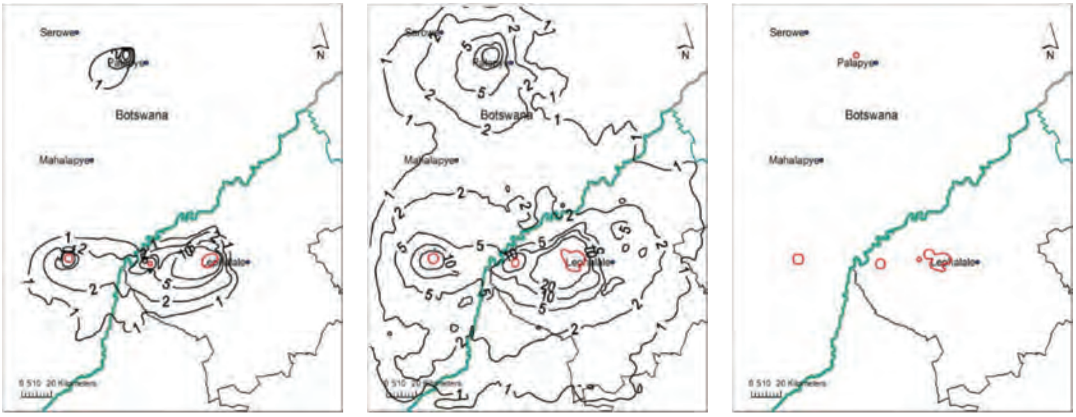


Figure 10-22: Predicted annual average PM_{10} concentrations for 2025 (left) and the 99th percentile of the predicted 24-hour concentration (middle) in µg/m³. The limit value of the NAAQS is shown by the red isopleth. The predicted frequency of exceedance is shown (right)

The relative increase in predicted ambient PM_{10} concentrations in 2025 from the baseline case is shown in Figure 10-23. The predicted annual concentrations increase by just 5% in the area of maximum predicted concentrations west of Lephalale and into Botswana. The predicted 24-hour concentrations increase by up to 20% west of Lephalale and by 10% further west into Botswana.

Figure 10-23: Difference in the predicted PM_{10} concentrations in 2025 from the base case for annual concentrations (left) and the 99th percentile of the predicted 24-hour concentration (right).

10.6 Predicted ambient concentrations for 2030

The 2030 scenario sees a significant increase in all emissions with SO_2 emissions increasing by 583 605 t/a, NO_2 by 225 532 t/a and PM_{10} by 15 276 t/a (Table 9-2). The increase is attributed to further expansion of the generation capacity by more than 7 000 MW and the operation of a new coal-to-liquid refinery.

10.6.1 Sulphur dioxide (SO_2)

The predicted ambient SO_2 concentrations in 2030 increase somewhat from 2025 (Figure 10-24). The predicted annual concentrations however remain well below the NAAQS. The limit value of the 24-hour and 1-hour NAAQS (Table 6-1) are exceeded over a relatively large area southwest and also northwest of Lephalale.

The frequency of exceedances of the 24-hour and 1-hour limit values is shown on Figure 10-25 for the 3-year modelling period. More than 12 exceedances of the 24-hour limit value occur over a relatively large area southwest of Lephalale and to the northwest. More than 264 exceedances of the 1-hour limit value in the same area, albeit somewhat smaller. There is non-compliance with the NAAQS in these areas.

The relative increase in predicted ambient SO_2 concentrations in 2020 from the baseline case is shown in Figure 10-26. The predicted annual concentrations increase by 20% in the area of maximum predicted concentrations. The increase is more dramatic for the 24-hour and 1-hour concentrations. The predicted 24-hour concentrations increase by more than 100% in the area of maximum concentration west and southwest of Lephalale, with increases of between 60% and 40% and more up to 100 km from the main source area. The predicted 1-hour concentrations increase by more than 200% to the west and southwest of Lephalale, and between 100% and 75% up to 100 km from the main source area.

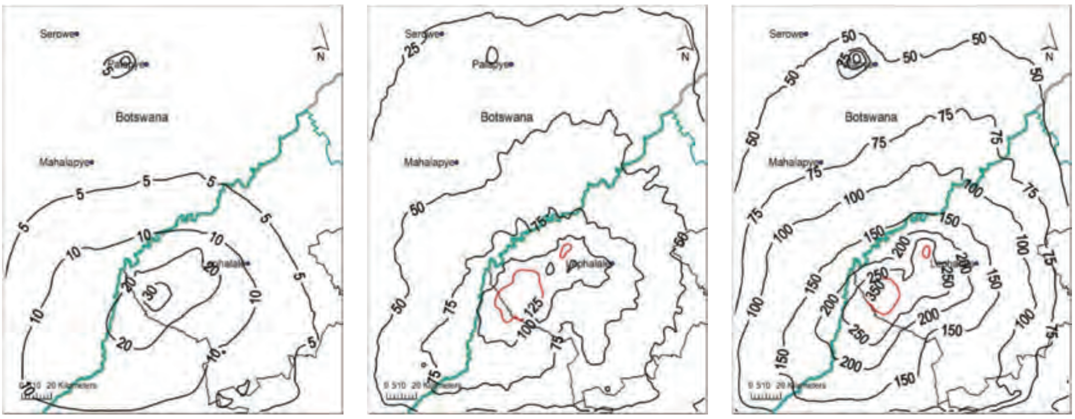


Figure 10-24: Predicted annual average SO_2 concentrations for 2030 (left), the 99th percentile of the predicted 24-hour concentration (middle) and the 99th percentile of the predicted 1-hour concentration (right) in µg/m^3. The limit values of the NAAQS is shown by the red isopleths

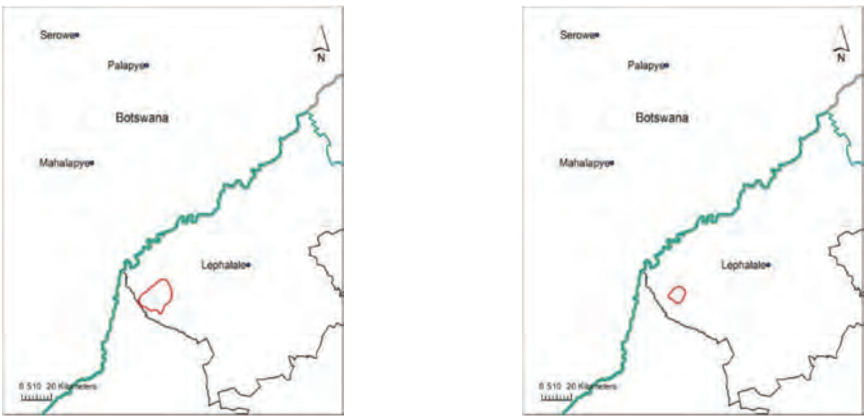


Figure 10-25: Predicted frequency of exceedance of the NAAQS limit value in 2030 for SO_2 for 24-hour (top) and 1-hour (bottom)

Figure 10-26: Percentage difference in the predicted SO_2 concentrations in 2030 from the base case for annual concentrations (left), the 99th percentile of the predicted 24-hour concentration (middle) and the 99th percentile of the predicted 1-hour concentration (right)

10.6.2 Nitrogen dioxide (NO_2)

The predicted ambient NO_2 concentrations in 2030 exhibit an increase in 2025, but despite substantial increase in emissions, the predicted annual concentrations remain well below the NAAQS (Figure 10-27). The limit value of the 1-hour NAAQS (Table 10-1) is exceeded over a small area west of Lephalale, but on fewer occasions than permitted by the NAAQS, i.e. there is general compliance with the NAAQS.

The relative increase in predicted ambient NO_2 concentrations in 2030 from the baseline case is shown in Figure 10-28. The predicted annual concentrations increase by just more than 10% in the area of maximum predicted concentrations southwest of Lephalale. The increase is more exaggerated for the predicted 1-hour concentrations. The predicted 1-hour concentrations increase by more than 80% to the west of Lephalale, and by more than 40% up to 100 km from the main source area.

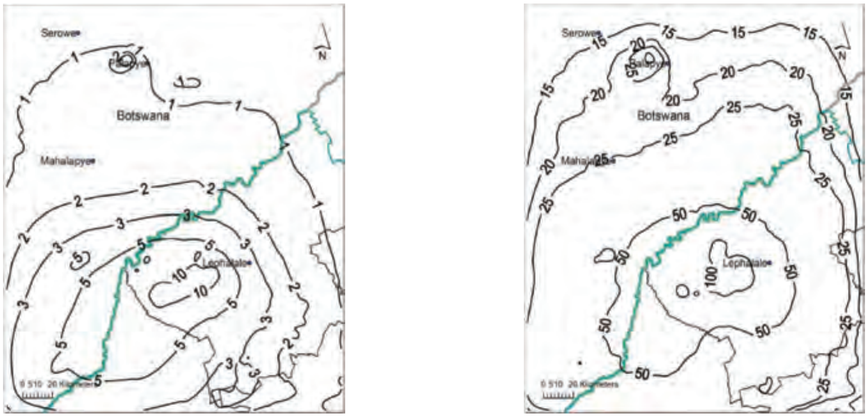


Figure 10-27: Predicted annual average NO_2 concentrations for 2030 (left) and the 99th percentile of the predicted 1-hour concentration (right) in µg/m³. The limit values of the NAAQS is shown by the red isopleths

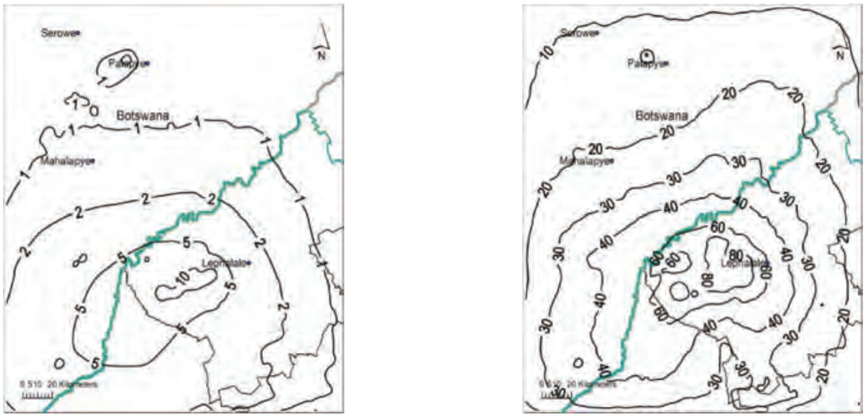


Figure 10-28: Percentage difference in the predicted NO_2 concentrations in 2030 from the base case for annual concentrations (left) and the 99th percentile of the predicted 1-hour concentration (right)

10.6.3 Respirable particulate matter (PM_{10})

The predicted ambient PM_{10} concentrations in 2030 increase with the addition of the generation capacity in the WDM and Botswana (Figure 10-29). The maximum concentrations are predicted to occur west of Lephalale extending into Botswana and just west of Palapye. The predicted annual concentrations are generally below the limit value of the NAAQS other than in the areas of maximum predicted concentrations. The 99th percentile of the predicted 24-hour concentrations is also below the limit value of the NAAQS other than the three small areas west of Lephalale. In these areas, the limit value is exceeded on more than 12 occasions in the 3-year modelling period (Figure 10-29) indicating areas of non-compliance with the NAAQS.

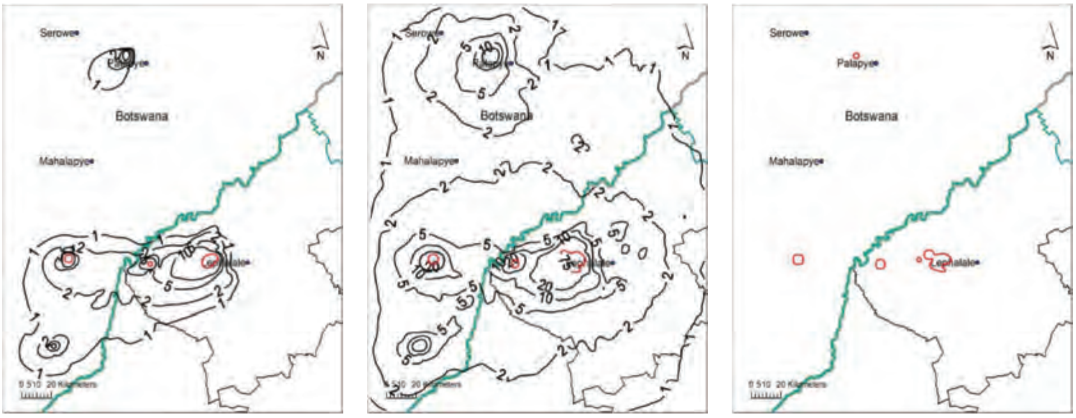


Figure 10-29: Predicted annual average PM_{10} concentrations for 2030 (left) and the 99th percentile of the predicted 24-hour concentration (middle) in µg/m³. The limit value of the NAAQS is shown by the red isopleth and the predicted frequency of exceedance of the NAAQS limit value in 2030 for PM_{10} for 24-hour (right)

The relative increase in the predicted ambient PM_{10} concentrations in 2030 from the baseline case is shown in Figure 10-30. The predicted annual concentrations increase by just 5% in the area of maximum predicted concentrations west of Lephalale and into Botswana. The predicted 24-hour concentrations increase by up to 20% west of Lephalale and by 10% further west into Botswana.

Figure 10-30: Percentage difference in the predicted PM_{10} concentrations in 2030 from the base case for annual concentrations (left) and the 99th percentile of the predicted 24-hour concentration (right)

11. THREAT ASSESSMENT SUMMARY AND CONCLUSION

The proposed expansion of energy-based projects and mining in the WDM and neighbouring Botswana are recognised as a potential threat to ambient air quality in the region. This lead to the declaration of the Waterberg-Bojanala Priority Area in June 2012. The potential increase in annual emissions from the current situation to 2030 for SO_2 of 370%, for NO_2 of 640% and for PM_{10} of 530% justifies the declaration of the priority area.

The threat to ambient air quality manifests in the associated increase in ambient concentrations of SO_2, NO_2 and PM_{10} and their potential impact on human health and the ecological environment. The increase in emissions from the base year (2012) to 2015 and from 2015 to 2020 results in a general increase in ambient concentrations on a regional scale. The largest increase occurs in the vicinity of the main sources near Lephalale and Palapye. Emissions from elevated power station stacks affect a large area, but dilution is effective and there is general compliance with the NAAQS, except close to the source areas where SO_2 and PM_{10} exceedances are predicted. Emissions from mines result in localised effects where exceedances of the NAAQS for PM_{10} are predicted. The potential increase in ambient concentrations in 2015 and 2020 in summarised in Table 11-1.

In 2025 marked reductions in SO_2 and emissions result when FGD is implemented at Medupi. PM_{10} emissions increase as a result of additional mining. The SO_2 emission reductions result in regional decreases in the predicted ambient concentrations and general compliance with

NAAQS for SO_2. Ambient PM_{10} concentrations increase in 2025, particularly in a band extending westward from Lephalale to the Botswana border with exceedances of the NAAQS.

Table 11-1: Summary of the threat to ambient air quality in the WDM

Scenario	SO_2	NO_2	PM_{10}
2015	• Increase in emission of more than 500 000 t/a • Regional scale increase in ambient concentrations • General compliance with annual NAAQS • General compliance with 24-hour and 1-hour NAAQS • Non-compliance with 24-hour and 1-hour NAAQS in a small area southwest of Lephalale	• Increase in emission of 94 964 t/a • Regional scale increase in ambient concentrations • General compliance with annual NAAQS • General compliance with 24-hour and 1-hour NAAQS	• Increase in emission of more than 7 600 t/a • Regional scale increase in ambient concentrations • General compliance with annual NAAQS • Non-compliance with annual NAAQS in an isolated area west of Lephalale • General compliance with 24-hour NAAQS • Non-compliance with 24-hour NAAQS in a small area west of Lephalale
2020	• Further increase in emission of 236 131 t/a • Further regional scale increase in ambient concentrations • General compliance with annual NAAQS • General compliance with 24-hour and 1-hour NAAQS • Non-compliance with 24-hour NAAQS in a large area including Lephalale • Non-compliance with 1-hour NAAQS in a smaller area west and southwest of Lephalale	• Further increase in emission of 121 921 t/a • Further regional scale increase in ambient concentrations • General compliance with annual NAAQS • General compliance with 24-hour and 1-hour NAAQS •	• Further increase in emissions of 3 185 t/a • Further regional scale increase in ambient concentrations • General compliance with annual NAAQS • Non-compliance with annual NAAQS in an isolated area west of Lephalale • General compliance with 24-hour NAAQS • Non-compliance with 24-hour NAAQS in a small but increased area west of Lephalale
2025	• Decrease in emissions of more than 440 000 t/a	• Decrease in emissions of more than 29 000 t/a • Notable decrease in ambient concentrations on a regional scale	• Decrease in emissions of more than 500 t/a • Small decrease in ambient concentrations on a regional scale

Scenario	SO_2	NO_2	PM_{10}
	• Marked decrease in ambient concentrations on a regional scale • General compliance with annual NAAQS • General compliance with 24-hour and 1-hour NAAQS • Non-compliance with 24-hour NAAQS in an isolated area west of Lephalale • Non-compliance with 1-hour NAAQS in a smaller isolated area west of Lephalale	• General compliance with annual NAAQS • General compliance with 24-hour and 1-hour NAAQS	• General compliance with annual NAAQS • Non-compliance with annual NAAQS in an isolated area west of Lephalale • General compliance with 24-hour NAAQS • Non-compliance with 24-hour NAAQS in a small but increased area west of Lephalale and near the Botswana border
2030	• Increase in emission of more than 530 000 t/a • Regional scale increase in ambient concentrations • General compliance with annual NAAQS • General compliance with 24-hour and 1-hour NAAQS • Non-compliance with 24-hour and 1-hour NAAQS in a small area southwest of Lephalale	• Increase in emission of more than 220 000 t/a • Regional scale increase in ambient concentrations • General compliance with annual NAAQS • General compliance with 24-hour and 1-hour NAAQS •	• Increase in emission of more than 15 000 t/a • Regional scale increase in ambient concentrations • General compliance with annual NAAQS • Non-compliance with annual NAAQS in an isolated area west of Lephalale • General compliance with 24-hour NAAQS • Non-compliance with 24-hour NAAQS in a small but increased area west of Lephalale and near the Botswana border

From the relatively low emissions base established in 2025 with the implementation of FGD, there is a significant increase in emissions to 2030. This results in a regional scale increase in ambient SO_2 and PM_{10} concentrations. The largest increase in ambient concentration is in the vicinity of the main sources near Lephalale and extending westward towards Botswana. The elevated emissions from the new power stations and the CTL plant affect a large area, but dilution is effective and there is general compliance with the NAAQS, except close to the source areas where SO_2 and PM_{10} exceedances are predicted. Emissions from mines result in localised effects where exceedances of the NAAQS for PM_{10} are predicted. The potential increase in ambient concentrations from 2025 to 2030 in summarised in Table 11-1.

It should be borne in mind that the Threat Assessment excludes the contribution of emissions from the potential increase in residential fuel burning and motor vehicles. The outputs of the Threat Assessment modelling most likely indicate a best case scenario without these two contributing source types. In other words, the future scenarios are likely to be under-predicted. Emissions from residential fuel burning are released close to ground level and have a relatively localised effect, albeit a potentially significant effect on ambient concentrations. The effect of motor vehicle emissions is also limited and resulting ambient concentrations are generally much lower.

Despite this limitation, the Threat Assessment has indicated a number of important points for air quality management in the region. These are:

- Development in the region will increase ambient concentrations of pollutants on a regional scale.
- The areas of greatest concern are where the NAAQS for SO_2 and PM_{10} are predicted to be exceeded, concentrated in the Lephalale area and extending towards Botswana.
- Tall stack emissions affect air quality on a more regional scale, but ground level concentrations are generally low compared to the NAAQS.
- Low level emissions from mining result in local scale effects, and ground level concentrations are relatively high compared to the NAAQS.
- FGD brings about significant reductions in SO_2 concentrations when implemented in 2025.
- The magnitude of the predicted threat to ambient air quality can be mitigated through well designed air quality management interventions and the application of appropriate technologies and emission control measures.
- The likelihood of impacts on ambient air quality in the WDM from sources in Botswana is very low. Rather sources in the WDM are likely to affect ambient concentrations in Botswana considering the prevailing easterly wind and proximity of these sources to the Botswana border.
- The current resources in all tiers of government responsible for AQM in the WBPA are not adequate to cope effectively with the imminent changes.

12 GOALS OF THE WBPA AQMP

Following the baseline characterisation, a Logical Framework Assessment (LFA) workshop was held in Rustenburg on 28 August 2014 and this was the first major milestone in the development of the WBPA AQMP. This workshop provided the opportunity for members of the MSRG to participate in the development of the overall objective of the WBPA AQMP, to formulate problem complexes, to construct outcomes-based objectives and to propose interventions to meet the objectives. Further input to the goals and draft interventions were received from community-based organisations at a workshop in Rustenburg on 30 September 2014 arranged by Groundwork. These processes allowed uMoya-NILU and members of the PSC to formulate the overall objective of the WBPA AQMP as well as the goals and objectives to address the problem complexes, and to develop the draft WBPA AQMP.

The overall objective of the WBPA AQMP recognises that the current ambient air quality does comply with NAAQS throughout the Priority Area, and proposed expansion of energy-based projects in the WDM and Botswana pose a risk to future air quality. The Overall Objective therefore states that:

Ambient air quality in the Waterberg Bojanala Priority Area is brought into full compliance with national ambient air quality standards by 2020 and the state is maintained as the region develops

The Overall Objective of the WBPA AQMP is to be realised through the attainment of five related goals. These are:

Goal 1

Cooperative governance in the WBPA promotes the implementation of the AQMP

This goal aims to address the shortcomings in cooperative governance by ensuring the appropriate structures and mechanisms are in place at the respective levels of governance for effective implementation of the AQMP

Goal 2

Air quality management in the WBPA is supported by effective systems and tools

This goal aims to improve the systems and tools required for effective air quality management in the WBPA, including emission inventories, ambient monitoring and modelling, and enforcement

Goal 3

Ambient concentrations of air pollutants comply with the NAAQS in the WBPA as a result of emission reductions

This goal focuses on emission control and reduction across in all sectors to ensure that there is compliance with the NAAQS in the WBPA

Goal 4

Air quality decision making in the WBPA is informed by sound research

This goal aims to ensure appropriate research establishes the health baseline, which improves the Threat Assessment and prioritises emission reduction interventions to inform air quality management and planning in the WBPA

Goal 5

Knowledge and the understanding of air quality amongst stakeholders in the WBPA is enhanced

This goal aims to improve communication and current levels of knowledge of air quality amongst stakeholders in the WBPA

13. IMPLEMENTATION PLAN

For the implementation of the WBPA AQMP, a number of outcomes-based objectives are set for each of the goals. Activities are then defined, which upon their completion, will ensure that the objectives are realised, and in turn, the goal is realised. These are listed for the respective goals in Tables 13-1 to 13-5. Mandatory and participatory assigns responsibility to different role players of executing the work required in each activity (see Tables 13-1 to 13-5). The main role players are:

The NAQO	Ultimately responsible for the implementation the WBPA AQMP, reports to the Minister on implementation
The WBPA PSC	Project Steering Committee consists of DEA officials
The WBPA Authority forum	Air Quality Officials from DEA, WDM, BPDM, Provinces (LDEDET & NWREAD), and Local Municipalities in the WBPA
MSRG	Multi-Stakeholder Reference Group consists of all stakeholders with the role of reviewing the progress of implementation of the WBPA AQMP
Implementation Task Teams	ITTs responsible for the implementation of the AQMP will be constituted accordingly and will report to the MSRG
LDEDET and NWREAD AQOs and Municipal AQO	Air Quality Officers for Limpopo and North West Province and the district and local municipalities in the WBPA
Government departments	National, provincial and municipal departments represented by appropriate personnel in the implementation of the WBPA AQMP
Industry ECO	Emission Control Officers at respective industries
Industry representatives	Official mandated to agree on emission control and reduction initiatives
Mine representatives	Official mandated to agree on dust control and reduction initiatives
Community representatives	Community members mandated to represent communities in the implementation of the WBPA AQMP
Specialists	Specialist in their respective fields, e.g. health scientists, ecologists, economists, etc.

The implementation of the WBPA commences when the AQMP has been accepted by the Minster and has been published in the Government Gazette. The implementation of the WBPA AQMP recognises the existing provincial and municipal AQMPs, their implementation and the current roles and responsibilities of the incumbent officials. The periods for implementation in Tables

13-1 to 13-5 then take effect. The timeframes provide for a phased implementation of the WBPA AQMP, accounting for priority activities and those with longer lead times.

Indicators are easily interpreted and focus on outcomes and offer a meaningful method of communicating progress with implementation.

Table 13-1: Goal 1 - Cooperative governance in the WBPA promotes the implementation of the AQMP

Goal 1: Cooperative governance in the WBPA promotes the implementation of the AQMP					
OBJECTIVES	**Activities**	**MANDATORY RESPONSIBILITY**	**PARTICIPATORY RESPONSIBILITY**	**TIMEFRAMES**	**INDICATORS**
1.1 Development planning recognises the goals and objectives of the WBPA AQMP	1.1.1 Participate in relevant national planning to ensure the goals and objectives WBPA AQMP are taken into account in development projects	**NAQO**	**Delegated members of LDEDET, NWDACE, Municipalities**	**On-going**	**Number of National development plans that consider cumulative air quality implications**
	1.1.2 Participate in relevant provincial planning to ensure the goals and objectives WBPA AQMP are taken into account in development projects	**LDEDET AQO, NWDACE AQO**, WDM AQO, BPDM AQO	**Delegated members of LDEDET, NWDACE and other relevant Provincial Departments e.g. Housing, Transport**	**On-going**	**Number of provincial development plans that consider cumulative air quality implications**
	1.1.3 Participate in municipal planning to ensure the Municipal spatial development plans consider the goals and objectives of the WBPA AQMP	**WDM AQO, BPDM AQO, Local Municipality AQOs**	**Delegated municipality members**	**On-going**	**Number of municipal plans that consider cumulative air quality implications**
1.2 Provincial and Municipal AQMPs recognise the goal and objectives of the WBPA AQMP	1.2.1 Integrate the goals and objectives of the WBPA AQMP into the Limpopo and NWP provincial AQMPs and EMPs	**LDEDET AQO, NWDACE AQO**	**DEA, Provincial departments**	**Coordinate with EMP revision cycle**	**Limpopo and North West Province EMPs and AQMP include relevant goals and objectives from the WBPA AQMP**
	1.2.2 Integrate the goals and objectives of the WBPA AQMP into the Waterberg and Bojanala DM AQMPs and IDPs	**WDM AQO, BPDM AQO**	**Provincial and Municipal departments**	**Coordinate with IDP revision cycle**	**Waterberg DM and Bojanala DM AQMPs and IDPs include relevant goals and objectives from the WBPA AQMP**

Goal 1: Cooperative governance in the WBPA promotes the implementation of the AQMP					
OBJECTIVES	**Activities**	**MANDATORY RESPONSIBILITY**	**PARTICIPATORY RESPONSIBILITY**	**TIMEFRAMES**	**INDICATORS**
1.3 Municipalities are adequately resourced for effective implementation of the WBPA AQMP	1.3.1 Prioritise the deployment of resources to municipalities in the WBPA where currently required and in the future	**WDM AQO, BPDM AQO, Local municipalities**	**NAQO, LDEDET AQO, NWDACE AQO**	**First 12 months, then on-going**	**Number of AQ officials appointed Budget allocated for AQMP implementation**
1.4 Progress with the implementation of the WBPA AQMP is continually monitored	1.4.1 Ensure the mandate of the MSRG includes the monitoring of progress with the implementation of the WBPA AQMP	**NAQO**	**WBPA Authorities**	**Continuous**	**ToR for WBPA MSRG developed with clear mandate**
	1.4.2 Report on progress to the MSRG with the implementation of WBPA AQMP	**NAQO ITT's**	**WBPA Authorities**	**Quarterly**	**MSRG meetings report Annual implementation report**
	1.4.3 Ensure the membership of the MSRG includes representation from all stakeholder groups	**NAQO**	**WBPA MSRG**	**On-going**	**ToR for WBPA MSRG developed MSRG stakeholder database is current**
1.5 Co-operative governance with Botswana addresses trans-boundary air pollution in the WBPA	1.5.1 Identify existing forum(s) through which working relationship with Botswana air pollution authorities can be fostered.	**NAQO**		**Year 1**	**A forum through which AQ matters will be discussed between Botswana and South Africa is Identified**
	1.5.2 Participate in air pollution bi-lateral discussions and planning	**NAQO**		**On-going**	**Minutes indicating South Africa and Botswana's discussions on AQ**

Table 13-2: Goal 2 - Air quality management in the WBPA is supported by effective systems and tools

Goal 2: Air quality management in the WBPA is supported by effective systems and tools					
OBJECTIVES	**Activities**	**MANDATORY RESPONSIBILITY**	**PARTICIPATORY RESPONSIBILITY**	**TIMEFRAMES**	**INDICATORS**
2.1 The emission inventory for the WBPA is comprehensive, accurate and current	2.1.1 Update and maintain the emission inventory for **Listed Activities** in the WBPA	**Licensing authority**	**LDEDET AQO, NWDACE AQO, WDM AQO, BPDM AQO, industry ECO**	**1-12 months, and then annually**	**Up-to Date WBPA emission inventory report/database for Listed Activities (NAEIS)**
	2.1.2 Develop and maintain an emission inventory for **Controlled Emitters** in the WBPA	**WDM AQO, BPDM AQO, local authorities**	**NAQO, LDEDET AQO, NWDACE AQO, Local business chambers Chamber of mines, DMR, industries operating controlled emitters**	**1-12 months, and then annually**	**Number of Authorities with current emission database for controlled emitters and entered in the NAEIS**
	2.1.3 Develop and maintain an emission inventory for **fuel burning devices (<10 MW)**	**WDM AQO, BPDM AQO, Local Municipalities**	**Local business chambers Chamber of mines, DMR**	**1-12 months, and then annually**	**Number of Authorities with updated emission database for smaller fuel burning devices and entered in the NAEIS**
	2.1.4 Improve the inventory for **mining emissions** in the WBPA	**NAQO, Chamber of mines, DMR and the licensing authority**	**LDEDET AQO, NWDACE AQO, WDM AQO, BPDM AQO, mine representatives**	**1-12 months, and then annually**	**Comprehensive, accurate and current emission inventory for mining in WBPA and entered in the NAEIS**
	2.1.5 Improve the inventory for **residential emissions for the WBPA** by incorporating local variability, e.g. fuel use	**Local Authorities**	**WDM AQO,**	**1-12 months, and then annually**	**Number of Authorities with updated emission database for**

Goal 2: Air quality management in the WBPA is supported by effective systems and tools					
OBJECTIVES	**Activities**	**MANDATORY RESPONSIBILITY**	**PARTICIPATORY RESPONSIBILITY**	**TIMEFRAMES**	**INDICATORS**
		Research Institutions and NGOs	**BPDM AQO, NGOs, research institutions**		**residential emission and entered in the NAEIS**
	2.1.6 NAQO to develop template for emission inventory compilation for motor vehicles, dust generated on unpaved roads, waste management and biomass burning	**NAQO**	**LDEDET AQO, NWDACE AQO**	**1-12 months**	**Templates developed**
	2.1.6 Improve the spatial and temporal aspects of the emissions inventory for **motor vehicle emissions in the WBPA**	**WDM, BPDM, Local Municipalities**	**WDM AQO, BPDM AQO, Dept. of Energy, Dept. of Transport, LDEDET AQO, NWDACE AQO**	**1-24 months, and then annually**	**Number of Authorities with updated emission database for motor vehicle emissions and entered in the NAEIS**
	2.1.7 Develop and maintain an emission inventory for **dust generated on unpaved roads in urbanised areas in the WBPA**	**WDM, BPDM, Local Municipalities**	**WDM AQO, BPDM AQO, Municipal Dept. of Transport**	**In Year 2 and 3 then on-going**	**Number of Authorities with updated emission database of dust generated from unpaved roads**
	2.1.8 Develop and maintain an emission inventory for **waste management in the WBPA,** i.e. landfill and waste water treatment plants	**Local Municipalities, industry,**	**WDM AQO, BPDM AQO, Provincial and Municipal Waste Management Departments**	**1-24 months, and then annually**	**Number of Authorities with updated emission database** waste **management facilities and entered in the NAEIS**
	2.1.9 Maintain the emission inventory for **biomass burning** in the WBPA	**Local Municipalities. WDM, BPDM**	**WDM AQO, BPDM AQO, CSIR Meraka Inst.**	**1-24 months, and then annually**	**WBPA emission inventory for biomass burning is comprehensive, accurate and current and entered in the NAEIS**

Goal 2: Air quality management in the WBPA is supported by effective systems and tools					
OBJECTIVES	**Activities**	**MANDATORY RESPONSIBILITY**	**PARTICIPATORY RESPONSIBILITY**	**TIMEFRAMES**	**INDICATORS**
	2.1.10 Maintain and update the emission inventory to address the changing emissions profile and report to the MSRG	**NAQO**	**Economic Development departments, NPC, industrial ECOs**	**Annually**	**Updated emissions included in the annual report**
2.2 Ambient air quality monitoring in the WBPA is comprehensive and the data is accurate and reliable and readily available	2.2.1 Repair existing ambient monitoring stations and upgrade telemetry to ensure uninterrupted transmission of data and ensure on-going maintenance	**DEA, LDEDET AQO, NWDACE AQO, WDM AQO, BPDM AQO, Rustenburg LM, SAWS**		**1 to 12 months and then on-going**	**Number of monitoring stations with more than 80% data recovery** **Number of networks with monitoring plans**
	2.2.2 Extend the ambient monitoring network in the WBPA to address identified gaps and areas of concern, e.g. WDM-Botswana border area	**DEA**	**LDEDET AQO, NWDACE AQO, WDM AQO, BPDM AQO, Local Municipality AQO**	**1 to 24 months**	**Monitoring network is extended to all areas of concern in the WBPA**
	2.2.3 Implement established quality control and quality assurance measures at real-time ambient monitoring stations in the WBPA	**DEA, LDEDET AQO, NWDACE AQO, WDM AQO, BPDM AQO, Local Municipality AQOs**	**SAWS**	**Year 2 to 3**	**Number of networks working towards SANAS accreditation**
	2.2.4 Publish ambient data on the SAAQIS in real time	**DEA, LDEDET AQO, NWDACE AQO, WDM AQO, BPDM AQO, Local Municipality AQOs**	**SAWS**	**1 to 12 months and then on-going**	**Number of networks reporting to SAAQIS in real time**
2.3 Dispersion modelling in the WBPA supports and informs AQM *	2.3.1 Establish a dispersion modelling capability for the WBPA using data from	**DEA**	**WBPA PSC**	**1 to 12 months**	**Number of officials actively using dispersion modelling**

Goal 2: Air quality management in the WBPA is supported by effective systems and tools					
OBJECTIVES	**Activities**	**MANDATORY RESPONSIBILITY**	**PARTICIPATORY RESPONSIBILITY**	**TIMEFRAMES**	**INDICATORS**
	the baseline assessment and threat assessment modelling				
	2.3.2 Improve the methodology for modelling dispersion from residential fuel burning in the WBPA	**DEA Research institutions**	**WBPA PSC**	**1 to 24 months**	**Tested methodology for modelling dispersion from residential fuel burning**
	2.3.3 Based on the updated emission inventory for the WBPA, utilise the modelling capability to inform development and planning decision making, e.g. evaluation of impacts of new projects, proactively assess cumulative effects of development using the Threat Assessment methodology	**NAQO**	**WBPA PSC, LDEDET AQO, NWDACE AQO, WDM AQO, BPDM AQO**	**Annually, and as the need requires**	**Annual reports includes modelling outcomes based on new projects (if any)**
2.4 Compliance monitoring is consistent and effective in the WBPA	2.4.1 Train Provincial and DM AQOs within WBPA as EMI's and designate them	**NAQO**	**WBPA PSC, LDEDET AQO, NWDACE AQO, WDM AQO, BPDM AQO**	**1 to 12 months**	**Number of EMI trained and designated**
	2.4.2 EMI's conduct compliance inspections of all listed activities	**EMIs**	**LDEDET AQO, NWDACE AQO, WDM AQO, BPDM AQO, local Municipal AQOs**	**Quarterly, Within 24-hours for complaints**	**Number of Inspections conducted**
2.5 The contribution of different source types to ambient concentrations in the WBPA is quantified *	2.5.1 Develop the terms of reference for a comprehensive source apportionment study in the WBPA	**NAQO**	**WBPA PSC**	**Year 2**	**Terms of reference for source apportionment study**
	2.5.2 Conduct source apportionment study in the WBPA to understand the relative contribution of different source types to ambient air quality in the WBPA	**NAQO**	**LDEDET AQO, NWDACE AQO, WDM AQO, BPDM AQO, local Municipal AQOs**	**Year 2 to 4**	**Source apportionment study report**

Goal 2: Air quality management in the WBPA is supported by effective systems and tools					
OBJECTIVES	**Activities**	**MANDATORY RESPONSIBILITY**	**PARTICIPATORY RESPONSIBILITY**	**TIMEFRAMES**	**INDICATORS**
			Industry, mining, NGOs, specialists		
	2.5.3 Review the source apportionment study to assess the changes in source apportionment profile as a result of increasing development and the implementation of emission reduction measures	**NAQO**	**LDEDET AQO, NWDACE AQO, WDM AQO, BPDM AQO, local Municipal AQOs**	**Every 5 years**	**Revised source apportionment reports**
*** Objective specifically designed to address air quality threats**					

Table 13-3: Goal 3 - Ambient concentrations of air pollutants comply with the NAAQS in the WBPA as a result of emission reductions

Goal 3: Ambient concentrations of air pollutants comply with the NAAQS in the WBPA as a result of emission reductions					
OBJECTIVES	ACTIVITIES	MANDATORY RESPONSIBILITY	PARTICIPATORY RESPONSIBILITY	TIMEFRAMES	INDICATORS
3.1 Emission from **Listed Activities** are reduced in the WBPA	3.1.1 All Listed Activities in the WBPA are regulated and comply with the MES and reporting requirements	**EMIs, LDEDET AQO, NWDACE AQO, WDM AQO, BPDM AQO, Industry representatives**	**Local Municipal AQOs**	**1 to 12 month then on-going**	**Number of listed activities Complying to MES**
	3.1.2. Develop plans for emission reductions in areas of the WBPA where there is non-compliance with NAAQS	**Industry representatives, WDM AQO, BPDM AQO**	**LDEDET AQO, NWDACE AQO,**	**Following the sources apportionment study (2.5.2)**	**Number of facilities with Emission reduction plans**
	3.1.3 Assess the cumulative impact for new Listed Activities to ensure the NAAQS are not exceeded as a result of these developments *	**Industry representatives, Licensing Authorities**	**LDEDET AQO, NWDACE AQO, WDM AQO, BPDM AQO**	**On-going**	**AQIAs include cumulative assessments**
	3.1.4 Develop emission reduction plans for new Listed Activities that ensure the NAAQS are not exceeded as a result of these developments *	**Industry representatives, Licensing Authorities**	**LDEDET AQO, NWDACE AQO, WDM AQO, BPDM AQO**	**On-going**	**AQIAs include assessment of emission reduction plans**
	3.1.5 Evaluate the inclusion of offsets as a condition for AELs particularly where cumulative impacts are envisaged and there is no BAT for further emission reduction beyond minimum emission standards *	**Licensing Authorities**	**Local Municipal AQOs**	**On-going**	**Number of AELs evaluated for possible inclusion of offset activities**
3.2 Emission from **Controlled Emitters** are reduced in the WBPA	3.2.1 Register all controlled emitters in the WBPA	**LDEDET AQO, NWREAD AQO, WDM AQO, BPDM AQO**	**Local Municipal AQOs**	**On-going**	**Controlled emitters registers**

Goal 3: Ambient concentrations of air pollutants comply with the NAAQS in the WBPA as a result of emission reductions					
OBJECTIVES	**ACTIVITIES**	**MANDATORY RESPONSIBILITY**	**PARTICIPATORY RESPONSIBILITY**	**TIMEFRAMES**	**INDICATORS**
	3.2.2 Regulate all Controlled Emitters in the WBPA and assess compliance with emission standards for controlled emitters	**EMIs, LDEDET AQO, NWDACE AQO, WDM AQO, BPDM AQO**	**Municipal AQOs**	**On-going**	**Number of Inspections conducted**
3.3 Particulate emissions from **mining** in WBPA are reduced	3.3.1 Implement approved dust management plans at all mines in the WBPA and incorporate these in EMPs.	**Mine managers**	**LDEDET AQO, NWDACE AQO, WDM AQO, BPDM AQO,**	**1 to 12 month then on-going**	**Number of mines with dust management plans**
	3.3.2 Monitoring implementation of dust management plans at all mines in the WBPA	**EMIs, LDEDET AQO, NWDACE AQO, WDM AQO, BPDM AQO**	**LDEDET AQO, NWDACE AQO, WDM AQO, BPDM AQO**	**On-going**	**Number of site Inspection conducted**
	3.3.3 In areas of the WBPA where there is non-compliance with NAAQS as a result of emissions from mining, investigate, implement and regulate more effective dust control measures	**Mine representatives**	**DMR, LDEDET AQO, NWDACE AQO, WDM AQO, BPDM AQO**	**1 to 12 month then on-going**	**Amended dust emission reduction plans**
3.4 Particulate emissions from **abandoned mines** in the WBPA are reduced	3.4.1 Allocate responsibility for the matters regarding abandoned mines??	**DMR**		**1 to 3 months**	**Responsibility for dust management at abandoned mines is allocated**
	3.4.2 Identify abandoned mines in the WBPA and prioritise where dust management should be implemented	**NAQO, DMR**	**WBPA PSC**	**1 to 12 month**	**Priority list of abandoned mines**
	3.4.3 Develop and implement approved dust management plans at all prioritised mines	**DMR**	**NAQO**	**Year 2 and on-going**	**Report on dust control at abandoned mines**
	3.4.4 Assess the efficacy of dust management plans at individual mines through appropriate ambient monitoring	**DMR Air Quality Officers**		**Year 2 then on-going**	**Reporting of monitoring results**

Goal 3: Ambient concentrations of air pollutants comply with the NAAQS in the WBPA as a result of emission reductions					
OBJECTIVES	**ACTIVITIES**	**MANDATORY RESPONSIBILITY**	**PARTICIPATORY RESPONSIBILITY**	**TIMEFRAMES**	**INDICATORS**
3.5 Emissions resulting from activities in **residential areas** are reduced and managed	3.5.1 Research appropriate clean energy alternatives, including electricity, solar, natural gas, etc. applicable to communities in the WBPA	**Research Institutions, DoE, DEA**	**Community representatives, Department of Energy, CEF, Sanedi, Treasury**	**1 to 12 months**	**Report on clean technology options for residential areas**
	3.5.2 On approval, adopt the *Strategy On Air Quality In Low Income Settlements* to prioritise the implementation of clean energy technologies in residential areas in the WBPA	**NAQO, DoE**	**Community representatives**	Defined following the approval of the strategy	***To be defined once Strategy On Air Quality In Low Income Settlements* is finalised**
	3.5.3 Implement *Strategy On Air Quality In Low Income Settlements* in the WBPA	**DoE, DHS**	**Community representatives**	**18 months onwards**	**Annual report on implementation progress**
	3.5.4 Improve service delivery with respect to waste collection and disposal in the WBPA to reduce emissions from waste burning	**Municipal waste management services**	**Community representatives**	**1 to 12 months, then on-going for new residential areas**	**Report on waste collection services in WBPA municipalities**
	3.5.5 Promote separation of waste and establish mechanisms to sell waste for recycling	**Municipal waste management services**	**Private institutions**	**1 year and on-going**	**Report on improved waste collection services in the WBPA municipalities**
	3.5.6 Develop an infrastructure improvement plan that prioritises the paving of roads in residential areas in the WBPA to reduce dust	**Municipal transport department, AQOs**	**Community representatives**	**1 to 12 months**	**Infrastructure improvement plans developed and incorporate air quality issues**
	3.5.7 Implement the plan for paving of roads in residential areas in the WBPA	**Municipal transport department**	**Community representatives**	**Year 2, then on-going for new residential areas**	**Annual report on implementation progress**

Goal 3: Ambient concentrations of air pollutants comply with the NAAQS in the WBPA as a result of emission reductions					
OBJECTIVES	**ACTIVITIES**	**MANDATORY RESPONSIBILITY**	**PARTICIPATORY RESPONSIBILITY**	**TIMEFRAMES**	**INDICATORS**
3.6 Emissions resulting from **waste management** in the WBPA are reduced	3.6.1 Develop and promulgate a municipal by-law that regulates open burning of waste, including tyres	**WDM AQO, BPDM AQO**	**LDEDET AQO, NWDACE AQO**	**1 to 24 months**	**By-laws developed and adopted**
	3.6.2 Enforce a municipal by-law that regulates open burning of waste, including tyres	**EMIs**	**LDEDET AQO, NWDACE AQO, WDM AQO, BPDM AQO, Local Municipality AQOs**	**Year 3 and onwards**	**Record of enforcement of waste bylaws**
	3.6.3 Encourage waste separation and recycling of waste at source	**Municipal waste management services**	**Private institutions**	**1 year and on-going**	**Report on improved waste collection services in the WBPA municipalities**
3.7 Emissions from **biomass burning** in the WBPA are reduced	3.7.1 Develop a protocol for the management of burning for agricultural purposes and land management in the WBPA focused on ambient air quality	**Provincial and Municipalities,**	**Department of Agriculture Farmers**	**1 to 12 months**	**Protocol developed and adopted**
	3.7.2 Implement the protocol in the WBPA and enforce its requirements	**Provincial and municipal, Dept. of Agriculture Farmers**	**LDEDET AQO, NWDACE AQO, WDM AQO, BPDM AQO, Local Municipality AQOs**	**Year 2 and onwards**	**Annual report on implementation progress**
3.8 Emission from **illegally operating industry and mines** in the WBPA are reduced	3.8.1 Identify illegally operating industries and mines	**WDM AQO, BPDM AQO, Local Municipality AQOs DMR**		**1 to 24 months**	**Register of illegal operations**
	3.8.2 Enforce relevant regulations and by-laws to bring operations into compliance	**EMIs**	**WDM AQO, BPDM AQO, Local Municipality AQOs**	**On-going**	**Number of industry and mining operations that comply with AQ regulations**

Goal 3: Ambient concentrations of air pollutants comply with the NAAQS in the WBPA as a result of emission reductions					
OBJECTIVES	ACTIVITIES	MANDATORY RESPONSIBILITY	PARTICIPATORY RESPONSIBILITY	TIMEFRAMES	INDICATORS
3.9 Emissions from **heavy duty vehicles** are reduced	3.9.1 Establish a motor vehicle emission testing unit in the WBPA	**WDM AQO, BPDM AQO**	**LDEDET AQO, NWDACE AQO**	**1 to 24 months**	**Vehicle emissions testing unit**
	3.9.2 Develop and promulgate a municipal by-law that regulates emissions from heavy duty vehicles *	**WDM AQO, BPDM AQO**	**LDEDET AQO, NWDACE AQO**	**Year 2**	**Number of municipalities with By-law for vehicle emission testing developed and adopted**
	3.9.3 Conduct emission testing on heavy duty vehicles operating in the WBPA as part of the annual vehicle license renewal process	**Local and District Municipalities**	**LDEDET AQO, NWDACE AQO, WDM AQO, BPDM AQO, Local Municipality AQOs**	**Year 3 and onwards**	**Record of enforcement**
***Activities specifically designed to address air quality threats**					

Table 13-4: Goal 4 - Air quality management in the WBPA is informed by sound research

GOAL 4: Air quality management in the WBPA is informed by sound research					
OBJECTIVES	**ACTIVITIES**	**MANDATORY RESPONSIBILITY**	**PARTICIPATORY RESPONSIBILITY**	**TIMEFRAMES**	**INDICATORS**
4.1 The impacts of emissions from urbanisation in the WBPA as a result of energy-based development is understood *	4.1.1 Expand the scope of the Threat to include the effects of urbanisation in the WBPA as a result of the defined development scenarios	**WDM AQO, BPDM AQO**	**DoH, Health scientists, Department of Human Settlements, Department of Transport , Town and Regional Planners**	**Year 3**	**Revised Threat Assessment includes emissions from human settlements**
	4.1.2 Ensure that the Threat Assessment is updated and revised as new and relevant information of development becomes available or is confirmed	**NAQO, LDEDET NWREAD WDM AQO, BPDM AQO,**	**DoH, Health scientists, Department of Human Settlements, Department of Transport , Town and Regional Planners**	**After Year 3**	**Updated Threat Assessment**
	4.1.3 Communicate the findings of the Threat Assessment to relevant stakeholders, particularly spatial planning	**NAQO**	**Goal 4 Task Team**	**On-going**	**Threat Assessment findings communicated at planning forums and MSRG**
4.2 The health impacts of emissions from current and future energy-based development in the WBPA is understood	4.2.1 The scope of the Threat Assessment is expanded to include Human Health Risk Assessment for the defined development scenarios	**NOQO**	**LDEDET AQO, NWDACE AQO, WDM AQO, BPDM AQO, DoH, MRC, Health scientists**	**After Year 3**	**ToR HHRA study developed and adopted**
4.3 The implementation of emission reduction interventions are prioritised based on a holistic assessment including cost-benefit analysis	4.3.1 Conduct a holistic assessment of the emission reductions interventions in the WBPA, including costs and benefits	**NAQO**	**DEA, WDM AQO, BPDM AQO, Domain specialists**	**Following the sources apportionment study (2.5.2)**	**Emission reduction interventions are prioritised based on the findings of a holistic assessment**

GOAL 4: Air quality management in the WBPA is informed by sound research					
OBJECTIVES	**ACTIVITIES**	**MANDATORY RESPONSIBILITY**	**PARTICIPATORY RESPONSIBILITY**	**TIMEFRAMES**	**INDICATORS**
4.4 The human health baseline with respect to air pollution in the WBPA is established and tracked over time	4.4.1 Develop the terms of reference for a study to establish the health baseline in the WBPA, focusing on exposure to air pollutants	**NAQO**	**DEA, WDM AQO, BPDM AQO, DoH, health scientists**	**Year 1**	**ToR developed and adopted**
	4.4.2 Conduct a comprehensive health study to establish the health baseline in the WBPA focusing on exposure to air pollutants	**NAQO Research Institutions**	**Goal 4 Task Team DoH, health scientists**	**Year 2 to year 3**	**Health study report**
	4.4.3 Communicate the findings of the health baseline to relevant stakeholders	**NAQO**	**LDEDET AQO, NWDACE AQO, WDM AQO, BPDM AQO, DoH, health scientists**	**Year 3**	**Health study communicated to relevant stakeholders**
	4.4.4 Repeat the study to assess the changes in the health baseline as a result of increasing development and the changing emissions profile emissions profile	**NAQO**	**DoH, health scientists**	**5 years after initial study**	**Health study reports for respective years**
4.5 The ecological baseline with respect to air pollution in the WBPA is understood	4.5.1 Consolidated all available information of air pollution and ecological impacts and thresholds in the WBPA	**Research Institutions**	**DEA, LDEDET AQO, NWDACE AQO, WDM AQO, BPDM AQO, NGOs, ecological scientists**	**Year 3 to 4**	**Inventory of existing information**
	4.5.2 Ensure that air pollution impacts on ecological systems and services in the WBPA are addressed in the biodiversity strategy	**NAQO**	**DEA, ecological scientists, SANBI**	**3 to 4**	**ToR developed and adopted**
	4.5.3 Conduct a study to determine the impact of air pollution on ecological systems and services in the WBPA and the thresholds of these systems	**Research Institutions**	**Research institutions, ecological scientists, SANBI**	**Year 5**	**Ecological study communicated to relevant stakeholders**

GOAL 4: Air quality management in the WBPA is informed by sound research					
OBJECTIVES	**ACTIVITIES**	**MANDATORY RESPONSIBILITY**	**PARTICIPATORY RESPONSIBILITY**	**TIMEFRAMES**	**INDICATORS**
	4.5.4 Communicate the findings of the ecological systems and services assessment to relevant stakeholder	**Research Institutions**	**Research institutions, ecological scientists, SANBI**	**Year 5**	**Ecological study report**
	4.5.5 Conduct a study to monitor changes in ecosystem health as a result of changes in the emissions profile	**Research Institutions**	**Research institutions,**	**2020, 2025, 2030**	**Ecological study reports**
***Objective specifically designed to address air quality threats**					

Table 13-5: Goal 5 - Knowledge and the understanding of air quality amongst stakeholders in the WBPA is enhanced

GOAL 5: Knowledge and the understanding of air quality amongst stakeholders in the WBPA is enhanced					
OBJECTIVES	**ACTIVITIES**	**MANDATORY RESPONSIBILITY**	**PARTICIPATORY RESPONSIBILITY**	**TIMEFRAMES**	**INDICATORS**
5.1 Communication of air quality in the WBPA is effective and sustained	5.1.1 Identify key stakeholders to assist with the development of an awareness/communication strategy to improve the understanding of air pollution	**NAQO LDEDET NWREAD**	**DEA, LDEDET AQO, NWDACE AQO industry, mining , Community representatives, health department and MHRC**	**1 to 3 months**	**Team members identified**
	5.1.2 Assess the current state of knowledge regarding air quality and its impacts	**NAQO**	**DEA, LDEDET AQO, NWDACE AQO Community representatives**	**1 to 3 months**	**Knowledge baseline report**
	5.1.3 Develop an awareness strategy to improve the understanding of air quality and its impacts and address the gaps identified in the baseline, including communication mechanisms, language of communication, technical level, etc.	**NAQO**	**DEA, LDEDET, NWREAD, industry, mining , Community representatives, BPDM, WDM, Local Municipalities**	**1 to 6 months**	**Awareness/communication strategy is adopted**
	5.1.4 Develop educational material in accordance with the requirements of the awareness strategy	**NAQO LDEDET NWREAD**	**DEA, industry, mining , Community representatives**	**6 to 18 months**	**Education material available for roll-out**
	5.1.5 Implement the awareness strategy	**NGOs All Air Quality Officers**	**DEA, industry, mining , Community representatives**	**After 18 months and then annually**	**Record of events (training event, radio inserts , campaigns etc.**

GOAL 5: Knowledge and the understanding of air quality amongst stakeholders in the WBPA is enhanced					
OBJECTIVES	**ACTIVITIES**	**MANDATORY RESPONSIBILITY**	**PARTICIPATORY RESPONSIBILITY**	**TIMEFRAMES**	**INDICATORS**
	5.1.5 Assess the impact and effect of the awareness strategy	**DEA, LDEDET, NWREAD**	**Industry, mining , Community representatives**	**5 Year**	**Record of awareness training events and training material**
5.2 Air quality information is available to all stakeholders in the WBPA	5.2.2 Establish and implement mechanisms to ensure that ambient air quality monitoring data is accessible and pro-actively communicated to stakeholders	**DEA**	**DEA, LDEDET, NWREAD, industry, mining , Community representatives, all municipalities**	**Year 1 to 2**	**Agreed mechanisms are implemented**
5.3 The AQM function in the WBPA is clearly understood by all stakeholders	5.3.1 Publish the updated contact details of AQOs on SAAQIS including call centre number	**AQM officials**		**Following the SAAQIS upgrade**	**Publication record for data**
5.4 Stakeholders in the WBPA are fully aware of the progress with the implementation of the AQMP and the effectiveness of its interventions	5.4.1 Update the existing stakeholder communication database to include all stakeholders	**NAQO**	**MSRG**	**On-going**	**Comprehensive database**
	5.4.2 Inform stakeholders about AQMP implementation progress	**NAQO**		**Quarterly**	**Publication of implementation report on SAAQIS**

14. MONITORING, EVALUATION AND REVIEW

14.1 Monitoring

The monitoring of progress with implementation of the WBPA AQMP is an on-going process that assesses all aspects of the plan. Monitoring allows for issues to be addressed timeously so that implementation is not hindered and aspects do not lag. Monitoring should be performed by the WBPA PSC with reporting to the NAQO, and in turn to the Minister. Progress with the implementation is also reported to the WBPA MSRG.

14.2 Evaluation

Evaluation aims to measure the success of the WBPA AQMP implementation. AQMP evaluation consists of two sections, an internal evaluation of the final AQMP and an on-going evaluation, which addresses implementation outcomes.

WBPA PSC should conduct the first evaluation. It is recommended that a comprehensive evaluation checklist that is provided in the DEA's AQMP Manual (DEA, 2012b) be used. The checklist includes details on the general document and process, as well as specific information on the performance of interventions. Annual evaluation of the WBPA AQMP is suggested using the indicators provided in the Implementation Plan. The annual evaluation coincides with the NAQO State of Air Report to the Minister. The results of the evaluation should also be reported to the WBPA MSRG.

14.3 Review

AQMP review comprises of an internal and external review. It addresses advancements in the science and management of air quality. A review period of five years is recommended for air quality management plans in the Manual for Air Quality Management (DEA, 2012b). However, considering the potential for rapid change in the WBPA, a midterm review of the WBPA AQMP is recommended after 2 years. This will not override the purpose of monitoring and evaluation, but allows for an effective assessment of the performance of the AQMP and examines the successes and failures of implementation.

Following a comprehensive evaluation, the goals and objectives may be amended as needed and activities updated. The internal revision should be communicated to stakeholders through the WBPA MSRG, followed by a further iteration and publication.

REFERENCES

Anglo American Platinum, 2014. Regional Ambient air quality monitoring Data Report 2010 to 2013, 28 May 2014.

Bojanala Platinum District Municipality, 2005. Growth and Development Strategy 2005.

Bojanala Platinum District Municipality, 2010. 2009/2010 Reviewed Integrated Development Plan.

Bojanala Platinum District Municipality, 2011. Draft Air Quality Management Plan for Bojanala Platinum District Municipality.

Botswana Power Corporation (BPC), 2012. Coal Road Map Pitso, presentation on operational Readiness by G. Kelesitse. http://www.mmewr.gov.bw/pitso/energy/download.php?file=BPC%20PRESENTATION%20COAL%20PITSO%201.pdf

BPC, 2012. Coal Road Map Pitso, presentation on operational Readiness by G. Kelesitse. http://www.mmewr.gov.bw/pitso/energy/download.php?file=BPC%20PRESENTATION%20COAL%20PITSO%201.pdf.

DEA, 2012a. Declaration of the Waterberg Priority Area, Notice 494 of 2012, 15 June 2012, Government Gazette, 35435.

DEA, 2012b. The 2012 National Framework for Air Quality Management in the Republic Of South Africa.

DEA, 2012c. Manual for Air Quality Management Planning, April 2012.

DEA, 2012d. Regional Environmental and Social Assessment of Coal Based Energy Projects along the Botswana – South Africa Border: Phase 1 – Preliminary Analysis of Cumulative Impacts and terms of Reference for a Detailed Study. https://www.environment.gov.za/sites/default/files/docs/regionalenvironmental_socialassessment_coalbased_energyprojects.pdf.

DEA, 2013a. Waterberg Airshed Priority Area Air Quality Monitoring Network Monthly Activity Report: April 2013.

DEA, 2013b. Integrated Strategy for the Control of Motor Vehicle Emissions. September 2013.

DEA, 2013c. DEA Table 24 Ground Truthing Annual Report, report prepared by uMoya-NILU Consulting (Pty) Ltd.

DEDECT, 2011. Emission Inventory Report: Development of an Air Emission Inventory for the North West Province. March 2011.

DoE, 2011: Department of Energy: Integrated Resource Plan for Electricity 2010-2030, Rev 2, Final Report, 25 March 2011, http://www.energy.gov.za/IRP/irp%20files/IRP2010_2030_Final_Report_20110325.pdf

Ecosurv, 2007. ESIA for the Morupule B Power Station Project, Section 4: Development Plan Description, Ecosurv in association with GIBB Botswana for Botswana Power Corporation, http://www.bpc.bw/Pages/generation_projects.aspx.

Fund for Research into Industrial Development, Growth and Equity (FRIDGE), 2004: Study to Examine the Potential Socio-Economic Impact of Measures to Reduce Air Pollution from Combustion, Final Report 2004, report by Bentley West Management Consultants (Pty) Ltd for the Trade and Industry Chamber, PA 1970 FINAL REPORT v26 20-2-04

Freiman, M.T., and Piketh, S.J., 2003. Air Transport Into and Out of the Industrial Highveld Region of South Africa, Applied Meteorology, **42**, 994–1002, doi: http://dx.doi.org/10.1175/1520-0450(2003)042<0994:ATIAOO>2.0.CO;2.

Ito, A., and Penner, J. E., 2004. SAFARI 2000 1-Degree Estimates of Burned Biomass, Area, and Emissions, 2000. Data set. from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A. doi: 10.3334/ORNLDAAC/754.

Garstang, M., Tyson, P. D., Swap, R. J., Edwards, M., Kållberg, P., and Lindsay, J. A., 1996. Horizontal and Vertical Transport of Air Over Southern Africa, Journal of Geophysical Research, **101**, 23 721-23 736.

LDEDET, 2012. Limpopo Department of Economic Development, Environment and Tourism: Provincial Air Quality Management Plan Baseline Assessment and Emissions Inventory, Report Project No. APP/11/LDEDET01, October 2012.

LDEDET, 2013. Limpopo Department of Economic Development, Environment and Tourism Provincial Air Quality Management Plan, Final Plan Rev 0, March 2013.

Mott McDonald, 2014. Regional Environmental and Social Assessment of Coal-Based Energy Projects, Inception Report to the World Bank, 325330/TRD/EFR/1/A, 11 April 2014.

National Planning Commission, (2012): National Development Plan 2030, available at http://www.gov.za/issues/national-development-plan/

NWDACE, 2009. Provincial Air Quality Management Plan. Final draft. February 2009.

NWDACE, 2011. Emission Inventory Report: Development of an Air Emission Inventory for the North West Province. March 2011.

PICC, 2012. Presidential Infrastructure Coordinating Committee, A Summary of the Infrastructure Plan, Provincial and Local Government Conference, 13 February 2012.

SAAQIS, 2014. Ambient air quality monitoring datasets. www.saaqis.org.za.

SANBI, 2006. Vegetation Map, SANBI, BGIS. www.bgis.sanbi.org

SAWIC, 2014. South African Waste Information Centre. http://sawic.environment.gov.za/.

SAWS, 1998. South African Weather Service, Climate of South Africa, Climate Statistics up to 1984.

StatsSA, 2014. SuperWeb application. http://interactive.statssa.gov.za/superweb/login.do. Accessed on 27 March 2014.

T&B Consult, 2002. Capacity Assessment of the Danish Centre for Human Rights. Final Report.

Tyson, P. D., Garstang, M., Swap, R. J., Kållberg, P., and Edwards, M., 1996. Air Transport Climatology for Subtropical Southern Africa, International Journal of Climate, **16,** 265-291.

uMoya-NILU, 2013. Atmospheric Impact Report in support of Lonmin North West Province Operations AEL Renewal and Variation Application, Report No. uMN010-2013, March 2013.

uMoya-NILU (2013a): Atmospheric Impact Report in support of Eskom's application for exemption from the minimum emission standards and/or extension of the minimum emission standards compliance timeframes for the Matimba Power Station, Report No. uMN040-2013, October 2013

uMoya-NILU (2013b): Atmospheric Impact Report in support of Eskom's application for exemption from the minimum emission standards and/or extension of the minimum emission standards compliance timeframes for the Medupi Power Station, Report No. uMN040-2013, October 2013

uMoya-NILU (2013c): Air quality and health risk specialist study for the EIA for the Proposed Thabametsi Coal-Fired Power Station near Lephalale, Limpopo Province, Report No. uMN059-2013, November 2013.

uMoya-NILU (2013d): Air Quality Study for the EIA for the Proposed Sekoko Waterberg Colliery, Limpopo Province, Report for Savannah Environmental (Pty) Ltd, uMoya-NILU Consulting (Pty) Ltd, Report No. uMN018-2013.

DEA (2014): Dispersion Modelling Plan of Study Report for the Development of the Air Quality Management Plan and Threat Assessment for the Waterberg-Bojanala Priority Area.

Waterberg District Municipality, 2009. Air Quality Management Plan.

Waterberg District Municipality, 2010. Environmental Management Framework for the Waterberg District.

Waterberg District Municipality, 2012. Emission inventory Report for the Waterberg District Municipality. January 2012.

Waterberg District Municipality, 2012. Waterberg District Municipality 2013/14 IDP. http://www.waterberg.gov.za/docs/plans/FINAL%20IDP%20201314.pdf

APPENDIX 1: Emission estimation techniques

Industrial

a. Source testing

Atmospheric Emission License (AEL) application forms serve as the principle information source for activity data for estimating emissions from industrial sources. Industries that operate Listed Activities must undertake emission testing to demonstrate compliance with emission limits. The main outputs of emission testing are emission concentrations in units of mg/Nm^3. These emission concentrations were converted to emission rates by utilising the measured gas flow rate (also measured as part of an emission testing campaign) through the stacks and the following equation:

$$Emission\ rate\ \left(\frac{kg}{hr}\right) = Emission\ concentration\ \left(\frac{mg}{m^3}\right) \times Flowrate\ \left(\frac{m^3}{hr}\right) \div 10^6 \qquad (1)$$

Emission testing is generally considered to be the most accurate method for estimating emissions, as it entails the direct measurement of pollutant concentrations. However, emission testing companies in South Africa are not accredited. The results of emission testing must therefore be used with caution.

b. Emission factors

Several industries did not submit emission testing data with their AEL applications. It was therefore not possible to estimate emissions using the source testing method. The alternate method was to use fuel consumption data and apply appropriate emission factors to estimate emissions.

Sulphur dioxide

The quantity of SO_2 emitted from combustion processes depends on the mass fraction of sulphur in the fuel burnt. According to CONCAWE, the following equation can be used to estimate SO_2 emissions from combustion processes (Concawe, 2009):

$$Emission\ rate\ \left(\frac{kg}{year}\right) = 2000 \times A \times MFS \qquad (2)$$

Where,

A = mass of fuel consumed (ton/year)

MFS = mass fraction of sulphur in fuel

This equation assumes complete combustion of sulphur to SO_2. The composition of sulphur in coal generally varies between 0.5 and 1.3%. A conservative estimate of 1% (or mass fraction of 0.01) was however used in cases where the sulphur content was not provided.

The composition of sulphur in HFO is generally high as 3.5% or 0.035 (m/m). Sasol gas has the lowest sulphur content of 0.001875%. This value was estimated from information provided by Sasol that the sulphur content of its gas is < 15 mg/m^3. The composition of sulphur in diesel is 500 ppm (m/m), which is commercially available from most suppliers, including the oil companies. In terms of mass fraction, this equates to a value of 0.0005.

Nitrogen oxides

According to Environment Australia (2008), the following equation can be used to estimate emissions from combustion processes using emission factors:

$$Emission\ rate\ (\frac{kg}{year}) = A \times EF \times CE \qquad (3)$$

Where,

A = mass of fuel consumed (ton/year)

EF = uncontrolled emission factor (kg pollutant/ton fuel burnt)

CE = control efficiency of the emission from the use of a control device

The NO_x emission factor for the uncontrolled combustion of coal is 3.8 kg/ton. The NO_x emission factor for the uncontrolled combustion of natural gas (similar to Sasol gas) from boilers of <30 MW is 2.16 kg/ton. The relevant emission factor for the uncontrolled combustion of residual oil (similar to HFO) is 7.32 kg/ton and for diesel, it is 2.72 kg/ton. As with SO_2, emissions of NO_x are the highest when residual oil is burnt.

Carbon monoxide

Equation (3) above is also used for the estimation of CO emissions from combustion processes. The CO emission factor for uncontrolled combustion of coal in boilers is 2.5 kg/ton. For residual oil combustion, a CO emission factor 0.67 kg/ton is specified by Environment Australia. This value is almost three times higher for gas combustion at 1.82 kg/ton. The CO emission factor drops to 0.68 kg/ton for diesel, a value similar to that of residual oil.

Particulate matter

The US-EPA (2005) provides emission factors of 33 kg/ton for PM and 6.6 kg/ton for PM_{10} for coal combustion from boilers with a spreader stoker feed configuration. For natural gas, Environment Australia provides an emission factor of 0.16 kg/ton for boilers rated < 30 MW. For residual oil, the emission factor for PM_{10} is even less at 0.0542 kg/ton, while it is 0.14 kg/ton for diesel.

Volatile organic compounds

VOCs emissions by definition include all emissions of volatile organics with the exception of methane. Emissions of VOCs from combustion processes are estimated by using the emission factor method and equation (3), as presented by Environment Australia. In line with the US-

EPA, Environment Australia provides an emission factor of 0.03 kg/ton of VOC emissions from the uncontrolled combustion of coal.
With respect to natural gas, the VOCs emission factor increases to 0.119 kg/ton. For residual oil and boilers rated < 30 MW, the VOCs emission factor is low at 0.04 kg/ton, and decreases further to 0.0272 kg/ton for diesel.

Residential fuel burning

The estimation of emissions from domestic burning in the WBPA was based on energy use data contained in the 2011 census (StatsSA, 2011), which delineates the number of households utilising fuels for domestic purposes (cooking, lighting, space heating). To determine the average quantity of fuels consumed per household, data on the quantities of fuels consumed in specific geographical areas of South Africa were sourced from the FRIDGE (Fund for Research into Industrial Development, Growth and Equity, 2006) report. The estimation of domestic fuel burning emissions is challenging given that the amount of fuel consumed is not known with certainty. The quantity of fuel consumed varies with geographical areas due to climate (more fuels are consumed in colder areas) and the extent of development (more fuels are consumed in rural areas). The FRIDGE report does not specify fuel consumption data for the WBPA. Household fuel consumption data for residential areas in eThekwini Municipality were chosen to represent the residential fuel use in the WBPA.

The total fuel consumption was based on household level fuel consumption for wood, paraffin and LPG. The quantity of wood consumption was estimated to be 0.1008 ton/year/household, and paraffin 0.0638 ton/year/household and 0.0010 ton/year/household for LPG. Emission factors for the criteria pollutants from domestic burning were also sourced from the FRIDGE report. The Table A presents these emission factors.

Table A: Emission factors identified for the estimation of household fuel combustion emissions

Fuel	Units	Emission Factors					
		SO_2	NO_x	VOCs	PM_{10}	CO	Benzene
Wood	g/kg	0.18	5	22	15.7	114.6	0.9
Paraffin	g/l	8.5	1.5	0.09	0.2	44.9	0
LPG	g/kg	0.01	1.4	0.5	0.07	13.6	0

Mining

Emissions of particulates result from most mining activities, i.e. from the initial removal of topsoil and overburden, to drilling and blasting, loading, hauling, crushing and the storage of ore and waste material. The amount of particulates emitted by any activity depends mostly on the nature and amount of material moved or handled and the nature and extent of the dust control measures, influenced also by rainfall and wind. Emissions may be estimated using emission factors and details of the activities. As this may be a protracted process, especially in the absence of activity data, emissions were not estimated for the 176 active mines in the WBPA that were identified in the Council for Geosciences owns and maintains the South African Mineral Deposits Database (SAMINDABA).

Emissions for mining were rather estimated using the total annual emissions for the WBPA reported in the Limpopo (LDEDET, 2012), North West (EScience, 2011) provincial emission inventories, and production data from the SAMINDABA. The SAMINDABA ranks mine size according to the size of a deposit which includes past production plus resources in tons of metal or mineral contained, ranging from 0 (10^4 tons) to 6 (10^9 tons). A simple scaling algorithm apportioned the total annual emission according to the mine size where size '0' mines half the size of size '1' mines, and so on to size '6' mines with a scaling factor of 1. In so doing, a generic emission is estimated for each mine size from 0 to 6.

Table B: Mine size classifications and the applied emission in tons per annum

Production (tons/annum)	Code	Mine area (km^2)	Emission (tons/annum)
10^4 tons per annum	0	0.25	33.69
10^5 tons per annum	1	0.64	67.37
10^6 tons per annum	2	1	134.74
10^7 tons per annum	3	4	269.49
10^8 tons per annum	4	9	538.98
10^9 tons per annum	5	16	1077.96
10^4 tons per annum	6	25	2155.92

Motor vehicles

For the top-down approach, fuel sales data for 2012 was sourced from the Department of Energy (DoE). The data are arranged in accordance with the defunct demarcation system of magisterial districts. This necessitated the linking of magisterial districts to local and metropolitan municipalities. Table C presents the Tier 1 emission factors developed by the European Environmental Agency (EEA), which were used in the top-down approach, for combustion.

Table C: Emission factors for motor vehicle combustion

Category	Fuel	Emission Factor (g/kg Fuel)			
		NO_x	SO_2	PM_{10}	CO_2 [1]
Motorcycles	Gasoline	9.50	-	2.7	69 300
Passenger cars	Gasoline	14.5	-	0.037	69 300
	Diesel 50	11	0.1	1.7	74 100
Light-duty vehicles	Gasoline	24	-	0.03	69 300
	Diesel 500	11	1	1.7	74 100
Heavy-duty vehicles and buses	Diesel 500	37	1	1.2	74 100

Notes: CO_2 emission factor unit is kg/TJ (IPCC, 2006)

The following equation was used to estimate motor vehicle emissions (with the exception of SO_2 emissions from combustion and PM_{10} emissions from tyre and brake wear and road surface wear) using the Tier 1 (or top-down) approach:

$$E_i = \Sigma_j (\Sigma_m (FC_{j,m} \times EF_{i,j,m})) \qquad (1)$$

Where,

E_i = emission of pollutant i (g),

$FC_{j,m}$ = fuel consumption of vehicle category j using fuel m (kg),

$EF_{i,j,m}$ = fuel consumption-specific emission factor of pollutant i for vehicle category j and fuel m (g/kg).

Since emissions of SO_2 are dependent on the sulphur content of the fuel burnt, the EEA proposes the following equation to estimate SO_2 emissions:

$$E_{SO2,m} = 2 \times k_{S,m} \times FC_m \qquad (2)$$

Where,

$E_{SO2,m}$ = emissions of SO_2 per fuel m (g),

$k_{S,m}$ = weight related sulphur content in fuel of type m (g/g fuel),

FC_m = fuel consumption of fuel m (g).

The $k_{S,m}$ for diesel 50 is 0.00005 and for diesel 500, it is 0.0005. This implies that the SO_2 emission factor for diesel 50 is 0.0001 and for diesel 500, it is 0.001.

The vehicle composition for the priority area was determined using provincial vehicle registration information obtained from eNatis. The breakdown of used and new vehicles according to specific categories is as follows:

- Motorcycles
- Passenger cars
- Light-duty vehicles
- Heavy-duty vehicles and buses

This breakdown is consistent with the emission factors developed by the EEA and allows for direct use of the factors without further conversions or assumptions.

Having determined the vehicle composition per province, it was then necessary to correct these figures for fuel type. The relevance of this is related to the use of certain types of fuels by certain types of vehicle categories. For instance, HDVs do not use gasoline and motorcycles do not use diesel. To simplify the task, certain assumptions were also necessary. Included amongst these were:

- Diesel 50 is used exclusively by passenger cars;
- Diesel 500 is not used by passenger cars;
- Gasoline is not used by HDVs and buses;

- The proportion of fuel consumed by a certain class of vehicle is equal to the composition of that class of vehicle in the province. The inherent assumption is that the fuel economy rates are equal for motorcycles, passenger cars and LDVs using gasoline and for LDVs and HDVs using diesel 500. This assumption is not necessary for diesel 50 as only passenger cars use diesel 50.

Using the steps described above, motor vehicles emissions were estimated using the top-down approach to estimate emissions from motor vehicles for municipalities in the WBPA. The emissions were reported in units of ton/year.

Biomass burning

Emissions from biomass burning are estimated by using the following equations:

$$M_{ijt} = \sum \left([A]_{ijt} \times [B]_{ijt} \times [CF]_{ijt} \right) \qquad (1)$$

Where

M is the total amount of burned biomass

A is the annually (t) burned area (m^2)

B is the fuel load (kg/m^2) expressed on a dry mass CDM basis

CF is the fraction of available fuel, which burns (the combustion factor)

The total emissions of gaseous pollutants and particulate matter are calculated using the following equation:

$$Q(x) = M_{ijt} \times EF(x)$$

Where

Q(x) Total emissions of gaseous pollutants and particulate matter

χ is the chemical species

EF is the emission factor in gram species per kilogram of dry matter burned

Area Burned:

The determination of the annual burned area was based on remote sensing techniques and procedures. Data were sourced from the Meraka Institute at CSIR. The Remote Sensing Research Unit (RSRU) conducts activities related to remote sensing and earth observation application development. Earth surface properties, such as fires, are observed from satellites. One of their main areas of focus is tracking of fires, namely, active fires, burnt area mapping and fire danger modelling.

Notes:

1) A count of 463m x 463m pixels in a given year, for a given LM, that are flagged as "Burned" by one or other of two algorithms for detecting burned areas from MODIS data.

2) An aggregation of the area of all the "Burned" pixels that are counted in a given year, for a given LM. Unit of measure is m^2. To convert to hectares divide by 10 000.

3) The count may include the same areas more than once – this is possible, as a fire can partially burn the area of a pixel observation more than once in a year. In addition, each burned area is not necessarily 463m x 463m; rather, what the algorithm says is that enough of a pixel has burned to flag the whole pixel as Burned

Fuel Loading:

Fuel load data, specifically related to South Africa, were acquired from a study conducted in the Kruger National Park (Govender et al., 2006). The fuel load characteristics for mostly Savannah vegetation, similar to the WBPA, were established (Govender et al., 2006). The fuel load B is a function of the vegetation cover. This was determined using the 'Vegetation Map of South Africa, Swaziland and Lesotho compiled by the South African National Biodiversity Institute (SANBI). The combustion factor (CF) is the function of biomass exposed to fire that actually burned. The CF determined by fuel type, fuel spatial arrangement and fuel moisture content. The WBPA vegetation is characterised mostly as a Savannah biome, i.e. a mixture of trees, shrubs and grasses. The emission factors used were sourced from SAFARI 2000 (S2K) Project, an International Science initiative that studied the linkages between land and atmospheric processes in the Southern African region. In addition, SAFARI 2000 examined the relationship of biogenic, pyrogenic, and anthropogenic emissions and the consequences of their deposition to the functioning of the bio-geophysical and biogeochemical systems.

APPENDIX 2: Dispersion modelling plan

1. INTRODUCTION

1.1 Project background

The Minister of Water and Environmental Affairs declared the Waterberg Bojanala Priority Area (WBPA) on 15 June 2012 (Government Notice 495 of 2012). The WBPA includes the Waterberg (DM) in the Limpopo Province and the Bojanala Platinum DM in the North West Province (Figure A2-1). The Waterberg DM includes six Local Municipalities (Thabazimbi, Modimolle, Mogalakwena, Bela-Bela, Mookgopong and Lephalale) while three of the five local municipalities in the Bojanala Platinum DM (Moses Kotane, Rustenburg and Madibeng) are included.

Figure A2-1: Location of the Waterberg-Bojanala Priority Area, and Local Municipalities within the Waterberg DM and the Bojanala Platinum DM

The Minister stated that the area required specific national air quality management action on the basis that ambient air quality within the Waterberg (DM) may exceed NAAQS in the near future, which may cause a significant negative impact on air quality in both areas. The Minister also

CONTINUES ON PAGE 258 - PART 3

Government Gazette
Staatskoerant

REPUBLIC OF SOUTH AFRICA
REPUBLIEK VAN SUID AFRIKA

Vol. 606 | 9 December / Desember 2015 | No. 39489

PART 3 OF 3

N.B. The Government Printing Works will not be held responsible for the quality of "Hard Copies" or "Electronic Files" submitted for publication purposes

ISSN 1682-5843

39489

9 771682 584003

highlighted the possibility of trans-boundary air pollution impacts between South Africa and its neighbouring countries, Botswana in particular.

As the area overlaps provincial boundaries, the Department of Environmental Affairs (DEA) functions as the lead agent in the management of the priority area and is required in terms of Section 19(1) of the National Environmental Management: Air Quality Act (Act 39 of 2004) (NEM: AQA) to develop an Air Quality Management Plan (AQMP) for the priority area. To meet this requirement, the DEA appointed uMoya-NILU Consulting (Pty) to develop an Air Quality Management Plan (AQMP).

A baseline assessment is the first step in the development of an AQMP and includes the assessment of the status of the air quality management tools and systems, including dispersion modelling. Dispersion modelling is a fundamentally important tool for decision making in air quality management. It can also be used to identify source contributions to air quality problems and in assisting the design of strategies to reduce harmful air pollutants. It also be used during the environmental permitting process to verify that a new source will not exceed ambient air quality standards or to determine appropriate additional control requirements. On a larger scale, air quality models may be used in planning, such as industrial zoning, transport management, and in the identification on delineation of the priority areas.

The focus of this report is the dispersion modelling plan for the WBPA, according to the requirements of the Guideline for Air Dispersion Modelling for Air Quality Management in South Africa (DEA, 2012a). This report details the modelling approach to be undertaken for the baseline and threat assessments.

1.2 Project location

The WBPA is located in the Republic of South Africa and includes the Waterberg DM in the Limpopo Province and the Bojanala Platinum DM in the North West Province, (Figure A2-1).

1.3 Land use determination in modelling domain

The regulation regarding dispersion modelling in South Africa (DEA, 2014) 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 specified in the US EPA guideline on air dispersion models (US EPA, 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 the area falls into one of the use types in Table A2-1.

Table A2-1: Land types, use and structures and vegetation cover

Urban Land Use		
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 %

Based on the above assessment, it is clear that more than 35% of the study area is covered by vegetation. The study area is therefore classified as rural.

1.4 Elevation data (DEM) and resolution

The topographical and land use for the respective modelling domains were obtained from the dataset accompanying the CSIRO's The Air Pollution Model (TAPM) modelling package. 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 and Earth Resources Observation Systems (EROS) Data Center Distributed Active Archive Center (EDC DAAC).

2. EMISSIONS CHARACTERISATION

A comprehensive inventory of emission sources is the foundation on which an AQMP is based. It is critically important to understanding, amongst others, individual sources and their relative contribution to the emission loading, the spatial distribution of sources, and pollutants being emitted.

2.1 Baseline Assessment Scenarios (Objective 2: Problem Analysis)

Emissions from six source categories, namely industry (listed activities), residential fuel burning, motor vehicles, biomass burning, mining, and trans-boundary transport were estimated for the baseline assessment. These are discussed in the following sections. The individual sector inventories were then collated into a complete emission inventory for the WBPA. Emissions from controlled emitters, waste management and fugitive dust will not be included in the baseline assessment.

- Listed activities

DEA has collected AELs from the Waterberg and Bojanala Platinum District Municipalities, which vary in their completeness. A verification of sources and emissions was conducted by DEA together with authorities in the WBPA to ensure the data are complete. Thereafter, uMoya-NILU compiled an emission inventory for all pollutants such as SO_2, NO_X, PM_{10}, CO, benzene and lead for the baseline assessment, but only SO_2, NO_X and PM_{10} were included in the dispersion modelling.

- Residential fuel burning

Energy use data at a municipal ward level from the 2011 StatsSA Census dataset were basis for the emission calculations. Default emission factors from the NAEIS will be used to estimate annual average SO_2, NO_X, PM_{10} and CO emissions.

- Motor vehicles

The methodology used for the Motor Vehicle Emissions Reduction Strategy was used for the WBPA AQMP. The emissions generated for the year 2009 in the strategy document was updated using 2012 fuel sales data from the Department of Energy. Annual average emissions for each local municipality were estimated for different vehicle classes.

- Biomass burning

Biomass burning emissions were estimated from burnt area data and emission factors for the burnt vegetation. Monthly average emissions at a local municipality scale were estimated using burnt area data provided by the Meraka Institute at CSIR.

- Mining

The register of mines prepared by DEA was reviewed to determine the number of mines and the types of mining undertaken in the area. Suitable proxy mines were selected from the list and activity data sourced from the respective mines. US-EPA methodologies were utilized to estimate particulate emissions from the respective mines. The mines were regarded as area sources. Following emission calculations for the representative mines, the emissions were scaled for other mines in the WBPA.

- Trans-boundary sources

Due to the closeness of the national border with Botswana, trans-boundary sources were assessed using information from the 2012 Regional Environment and Social Assessment (RESA) study. However, the emphasis was in industrial sources.

2.2 Threat Assessment and Scenario Building (Objective 3)

The threat assessment for the WBPA refers to the assessment of future developments that could impact negatively on ambient air quality in the area. The cumulative impacts of several large-scale developments planned for the WBPA, as well as trans-boundary impacts of development in Botswana has the potential to recreate air quality hotspots as experienced in the Vaal Triangle and Highveld priority areas. The threat assessment evaluated the pollution causing potential of the various planned developments, determined the new baseline air quality under various development scenarios, and proposed means to improve air quality management in the area through management interventions.

The Threat Assessment considered a 20-year period, with 5-year intervals, commencing in 2015. Emission estimates for the future scenarios were qualitative and based on best available information in the respective Strategic Implementation Plans. They included industrial and associated residential emissions.

2.3 Strategy Analysis and Intervention Description (Objective 4)

Using the baseline and threat assessments as an input and together with stakeholders in the WBPA, strategies and implementable interventions were sought to improve and maintain air quality in the area. The emissions reduction potential of each of the strategic interventions was quantified. This required estimating the effect of each strategic intervention on the emission inventory. This analysis therefore developed alternative scenarios to those developed in the baseline and threat assessments.

3. METEOROLOGICAL DATA

The South African Weather Service (SAWS) is the main source of reliable observed surface meteorological data in South Africa as it has been collected in accordance with the requirements established by the World Meteorological Organisation (WMO). While there is a good network of SAWS observation stations across the country, the coverage is not always adequate to meet the requirements for robust dispersion modelling. The DEA, Eskom, mines and municipalities operate meteorological monitoring stations at different locations within the study area. Data from these stations were however not considered in the modelling as they are located relatively close to the SAWS stations; or there are large gaps in the data (either because of instrument failure or the stations have been only recently installed). The SAWS stations that were used in this study include Pilanesburg, Lephalale, Mokopane, Polokwane, Rustenburg, Warmbad Towoomba and Irene. It is important to note that data from SAWS stations at Thabazimbi, Marken, Alldays, and Doornlaagte were considered for the modelling, but are no longer available as the stations have been decommissioned.

To address the challenges relating to data scarcity in the area of interest, TAPM meteorological data were used to supplement the meteorology in the modelling domain. Mesoscale models such as TAPM use gridded meteorological data and sophisticated physics algorithms to produce meteorological fields at defined horizontal grid resolutions and in multiple vertical levels over a large domain. They therefore offer an alternative to meteorological measurements as input for advanced dispersion models. Providing actual surface observations to mesoscale meteorological model simulations produce more accurate meteorological fields as the actual observations are used to “nudge” the model in its solutions.

During meteorological data selection, there are instances where meteorological stations are located very close together. For example, a cluster of SAWS meteorological stations between Pretoria and Johannesburg (in the south east of the modelling domain) is located within a 4-11 km radius. Due to the close proximity of the stations, only one station can be used to nudge meteorological fields in TAPM.

TAPM will be used to model spatially and temporally continuous surface meteorological fields for the modelling domain. The Waterberg-Bojanala Priority Area extends approximately 410 km in a north to south direction and 305 km in a west to east direction. In order to accommodate a 10 km buffer from the boundary of the WBPA, TAPM is required to cover an area greater than 430 km (north to south) by 335 km (west to east). TAPM is configured with a domain that is 500 km (north to south) by 400 km (west to east) at a 10 km grid resolution. This is a relatively fine resolution for a regional scale modelling exercise. Such a configuration ensures that topographical effects on meteorology are captured and that the modelled meteorology is well resolved and characterised across the boundaries of the inner domain, i.e. the CALPUFF dispersion modelling domain.

Three years (2010, 2011 and 2012) of hourly observed meteorological data from SAWS meteorological stations (Figure A2-2) were input to TAPM to ‘nudge’ the modelled meteorology towards the observations and to create a continuous meteorological input file for the domain.

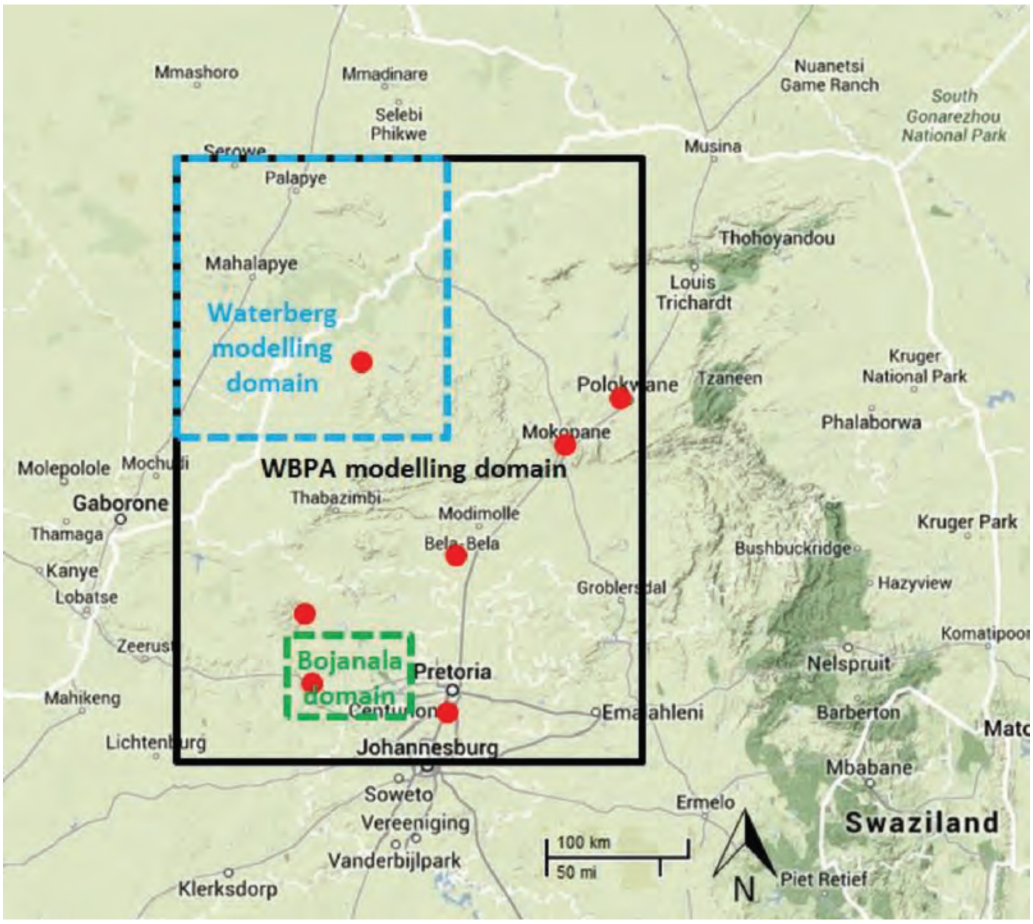


Figure A2-2: Relative location of the three modelling domains that will be used for the CALMET and CALPUFF model runs. SAWS stations are represented by red dots

The model outputs include 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 subset of the entire TAPM model output in the form of pre-processed gridded surface meteorological data fields will be input into CALMET. This approach negates the potential issues associated with missing observational data.

Upper air data are included in the pre-processed TAPM meteorological fields. The upper air data are spatially and temporally continuous, and includes data at 27 vertical levels between 10 m - 5 km above ground level. There are more levels close to the surface and decreasing with increasing altitude up to the last level.

4. AMBIENT IMPACT ANALYSIS AND AMBIENT LEVELS

4.1 Standards levels

Annual average modelled ambient concentrations and the 99th percentile concentration of daily and hourly predictions were assessed against National Ambient Air Quality Standards for SO_2, NO_2 and PM_{10} (DEA, 2009), in Tables A2-2.

Table A2-2: Ambient standards for SO_2, NO_2 and PM_{10} (DEA, 2009)

	Exposure period	Limit value (µg/m³)	Number of permissible exceedances per annum
SO_2	Hourly	350	88
	Daily	125	4
	Annual	50	0
NO_2	Hourly	200	88
	Annual	40	0
PM_{10}	Daily	120	4
		75 (2016 standard)	4
	Annual	50	0
		40 (2016 standard)	0

4.2 Background concentrations and other sources

A background concentration is the portion of the ambient concentration of a pollutant due to sources, both natural and anthropogenic, other than the source being assessed. Where appropriate, background concentrations were obtained from ambient measurements of SO_2, NO_2 and PM_{10} at monitoring stations within the modelling domain (Table A2-3). The most suitable upwind monitoring station was selected and hourly measured data for the period of 2010-2012 were analysed to develop an understanding of the characteristics of the background concentrations, including seasonal and diurnal variation.

Table A2-3: **Ambient data monitoring stations**

Network area	Network Owner	Station Name	Parameters
Waterberg Priority Area	DEA	Lephalale	NO, NO_2, NO_X,SO_2, PM_{10}, $PM_{2.5}$
		Mokopane	NO, NO_2, NO_X,SO_2, PM_{10}, $PM_{2.5}$
		Thabazimbi	NO, NO_2, NO_X,SO_2, PM_{10}, $PM_{2.5}$
		Marapong	NO, NO_2, NO_X,SO_2, PM_{10}, $PM_{2.5}$
		Mafutha	NO, NO_2, NO_X,SO_2, PM_{10}, $PM_{2.5}$, H_2S, NH_3, CO, O_3, Benzene, Toluene, e-Benzene,p-Xylene, m-Xylene, o-Xylene, Methane, THC, NMH, Mercury
Rustenburg	Rustenburg Local Municipality	Boitekong	NO, NO_2, NO_X,SO_2, PM_{10}, $PM_{2.5}$
		Marikana	NO, NO_2, NO_X,SO_2, PM_{10}, $PM_{2.5}$
		Thlabane	NO, NO_2, NO_X,SO_2, PM_{10}, $PM_{2.5}$

5. MODELLING PROCEDURES

5.1 Proposed model

A Level 3 air quality assessment is 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, 2012b). 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 environmental consequences. Under these circumstances, this study clearly demonstrates the need for a Level 3 assessment.

CALPUFF is a US-EPA approved air dispersion model (http://www.src.com/calpuff/calpuff1.htm) and is recommended by the DEA for Level 3 assessments (DEA, 2012a). It 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. This model can be applied on scales of tens to hundreds of kilometres. It includes algorithms for sub-grid scale effects (such as terrain impingement), as well as longer-range effects (such as pollutant removal due to wet scavenging and dry deposition, chemical transformation, and visibility effects of particulate matter concentrations). It is considered to be an appropriate air dispersion model for the purpose of this assessment as it is well suited to simulate dispersion in the WBPA.

5.2 Grid receptors

Three modelling domains (Figure A2-2) will be used for the CALMET and CALPUFF model runs.

WBPA (Modelling domain 1)

A CALPUFF modelling domain of 144 050 km^2 which covers the entire WBPA, where the domain extends 430 km (north-south) by 335 km (west-east). It consists of a uniformly spaced receptor grid with 5 km spacing, giving 5762 grid cells (86 x 67 grid cells). The WBPA modelling domain is set at a coarse resolution to provide a holistic view of impacts in the WBPA. The WBPA modelling domain is represented by the black square in Figure A2-2.

Waterberg (Modelling domain 2)

A CALPUFF modelling domain of 40 000 km^2 covers the main industrial sources in Lephalale and Botswana as well as future sources in the Waterberg DM, where the domain extends 200 km (north-south) by 200 km (west-east). It comprises of a uniformly spaced receptor grid with 1 km spacing, giving 40 000 grid cells (200 x 200 grid cells). The Waterberg modelling domain is informed by the density of sources in the area and is set at a high resolution. The Waterberg modelling domain is represented by the blue square in Figure A2-2.

Bojanala (Modelling domain 3)

A CALPUFF modelling domain of 4000 km^2 which covers the main industrial sources in the Bojanala Platinum DM, where the domain extends 50 km (north-south) by 80 km (west-east consist of a uniformly spaced receptor grid with 1 km spacing, giving 4000 grid cells (50 x 80 grid cells). The Bojanala modelling domain is also informed by the density of sources and is set at a high resolution. The Bojanala modelling domain is represented by the green square in Figure A2-2.

5.3 Emissions scenarios to be modelled

Three main scenarios (as discussed in Section 2) will be modelled to assess the ambient air quality in the WBPA. These include:

Scenario 1: Baseline Assessment Scenarios
Scenario 2: Threat Assessment and Scenario Building
Scenario 3: Strategy Analysis and Intervention Description

5.4 Model settings

The parameterisation of key variables that are applied in CALMET and CALPUFF are indicated in Table A2-4 and Table A2-5 respectively.

Table A2-4: 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)	No used as continuous surface data field is applied

Table A2-5: 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

5.5 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 the 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, 2012a) 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.

REFERENCES

DEA, (2009): National Ambient Air Quality Standards, Government Gazette, 32861, Vol. 1210, 24 December 2009.

DEA, (2012a): Guideline to Air Dispersion Modelling for Air Quality Management in South Africa, draft regulation.

DEA, (2012b): National Ambient Air Quality Standard for Particulate Matter of Aerodynamic Diameter less than 2.5 micrometres, Notice 486, 29 June 2012, Government Gazette, 35463.

DEA (2014): Waterberg-Bojanala Priority Area: Draft Process Plan for the Development of the Air Quality Management Plan, March 2014.

US EPA: (2005). Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions; Final Rule. US EPA.

APPENDIX 3: Legislative background

Introduction

The Bill of Rights contained in the Constitution of the Republic of South Africa enshrines the rights of all people in the country and affirms the democratic values of human dignity, equality and freedom. The state must respect, protect, promote and fulfil the requirements in the Bill of Rights. Section 24 of the Constitution states that everyone has the right:

a) To an environment that is not harmful to their health or well-being; and
b) To have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that -
    i. Prevent pollution and ecological degradation;
    ii. Promote conservation; and
    iii. Secure ecologically sustainable development and the use of natural resources while promoting justifiable economic and social development

In order to give effect to this right in the context of air quality, it is necessary to ensure that levels of air pollution are not harmful to human health or well-being. It follows that the setting of ambient air quality standards is necessary, as well as mechanisms to ensure that ambient air quality standards are achieved and maintained. Hence, the National Environmental Management: Air Quality Act (Act No. 39 of 2004) (the NEM: AQA) provides an objective-based approach to the management of air quality at different governance and operational levels and is the legislative means to ensuring that the rights described above are upheld. An overview of some legislative tools that enable authorities to managing air quality is provided here:

Priority Areas

Section 18 of the NEM: AQA provides for the Minister of Water and Environmental Affairs to declare an area a priority area if ambient air quality are or may be exceeded, or a situation exists where negative impacts on air quality may occur and the area requires specific air quality management to rectify the situation. The declaration provides for situations of national interest, where impacts may affect neighbouring counties, or if the situation extends beyond provincial borders.

The declaration of a Priority Area triggers the requirement for the development of a Priority Area AQMP (Section 19(1) (a)). The AQMP, in turn, provides authorities with a means to address the ambient air quality situation. Section 19(6) specifies that the AQMP must (a) be aimed at co-ordinating air quality management in the area, (b) must address the issues relating to air quality in the area, and (c) must provide for the implementation of the plan by a committee representing relevant role-players. Further to this, Section 20 of the NEM: AQA provides for the development of regulations for the implementation and enforcement of the AQMP.

National ambient air quality standards

Health based ambient air quality standards have been established for criteria pollutants and one toxic air pollutant in South Africa (DEA, 2009 and 2012). The national ambient air quality standard consists of a *limit value* and a *tolerance* or permitted frequency of exceedances. The limit value is the fixed concentration level aimed at reducing the harmful effects of a pollutant. The permitted frequency of exceedances is the 99^{th} percentile and represents the tolerated exceedances of the limit value. It accounts for high concentrations due to emissions and meteorological variations. Compliance with the ambient standard therefore implies the frequency of exceedances does not exceed the permitted tolerance.

Table A3-1: Ambient air quality standards for SO_2, NO_2, PM_{10}, O_3, benzene, ozone and lead (DEA, 2009) and $PM_{2.5}$ (2012)

Pollutant	Averaging Period	Limit value (μg/m^3)	Number of exceedances per annum
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	65 40[1] 25[2]	0 0 0
	1 year	25 20[1] 15[2]	0 0 0
O_3	8 hours	120	11
Benzene	1year	5	0
Pb	1 year	5	0
CO	1 hour 8 hours	30 10	88 11

1: Effective date is 1 January 2016
2: Effective date is 1 January 2030

Minimum Emission Standards

On 31 March 2010, the Minister of Water and Environmental Affairs published Notice No. 537 in the Government Gazette terms of Section 21 of the NEM: AQA, declaring Listed Activities and related Minimum Emission Standards. These were subsequently revised and published in Notice No. 893 in Government Gazette 37054 on 22 November 2011 for 10 Listed Activity categories and a total of 64 sub-categories. For each sub-category, emission standards are specified as concentrations for relevant pollutants, as well as the requirements for emissions measurements, compliance periods, reporting and the methods for emission sampling and analysis.

Facilities that operate Listed Activities must be in the possession of an Atmospheric Emission License (AEL) in terms of Section 22 of the NEM: AQA. The AEL Authority through the conditions of the AEL enforces compliance with Minimum Emission Standards.

Controlled Emitters

Controlled emitters are a source category defined in Section 23 of the NEM: AQA, and caters for appliances or activities that are not Listed Activities, but result in atmospheric emissions that present a threat to health or the environment. On 1 November 2014, the Minister of Water and Environmental Affairs declared boilers of less than 50 MW heat input, the first Controlled Emitter through the publication of Notice No. 831 in Government Gazette 36973.

This declaration provides municipal regulators with a means of managing emissions from smaller facilities by enforcing the requirements of the regulations. This applies to limiting black visible smoke, enforcing emission standards specified in the regulation, enforcing emission measurements and reporting. On 28 March 2014, the Minister published her intention to declare temporary asphalt plants controlled emitter through the publication of Notice No. 201 in Government Gazette 37461.

National dust control regulation

On 1 November 2013, the Minister of Water and Environmental Affairs published the National Dust Control Regulations in terms of Section 53(o) of the NEM: AQA, prescribing general measures for the control of dust in all areas. The regulation provides standards for acceptable dust fall for residential and non-residential areas, as well as the requirements and method of monitoring and reporting. The Air Quality Officer enforces the regulations.

Policy for the thermal treatment of general and hazardous waste

The Minister of Water and Environmental Affairs published the National Policy on Thermal Treatment of General and Hazardous Waste on 24 July 2009 in Notice No. 777 in Government Gazette 32439.

Schedule 1 of the policy provided interim emission standards for waste incineration as the Minimum Emissions were being developed. The interim emission standards in Schedule 1 were superseded by the Minimum Emission Standards in Category 8 of Notice No. 537 of 31 March 2010, and then later in Notice No. 893 of 22 November 2013. Waste incineration is a listed activity and minimum emission standards are enforced through the AEL.

Similarly, Schedule 2 of the policy provided interim emission standards for the use of Alternative Fuels and Resources (AFR) co-processing. The interim emission standards in Schedule 2 were superseded by the Minimum Emission Standards in Sub-Category 5.4 of Notice No. 537 of 31 March 2010, and then later in Notice No. 893 of 22 November 2013. Schedule 4 of the policy specifies the conditions for environmental authorisation for AFR co-processing, specifying conditions for operational management and air quality management. The minimum emission standards and conditions for AFR co-processing are enforced through the AEL.

References:

DEA, 2009. National Ambient Air Quality Standards, Government Gazette, 32861, Vol. 1210, 24 December 2009.

DEA, 2010. Listed Activities and Associated Minimum Emission Standards identified in terms of Section 21 of the Air Quality Act, Act no. 39 of 2004, Government Gazette, 33064.

DEA, 2012. National Ambient Air Quality Standard for Particulate Matter of Aerodynamic Diameter less than 2.5 micrometres, Notice 486, 29 June 2012, Government Gazette, 35463.

DEA, 2013a. Listed Activities and Associated Minimum Emission Standards identified in terms of Section 21 of the Air Quality Act, Act no. 39 of 2004, Government Gazette, 33064.

DEA, 2013b. National Dust Control Regulations in terms of the National Environmental of the Air Quality Act, Act No. 39 of 2004, Government Gazette, 36974, No. R. 827.

DEA, 2014. Regulation regarding Dispersion Modelling, Notice R.533, Government Gazette, 37804, 11 July 2014.

APPENDIX 4: Air pollutants and risks to human health

The route of exposure to air pollutants is mostly inhalation. Different groups of people are affected differently to exposure to air pollutants, depending on their level of sensitivity with the elderly, young children and the health impaired being more susceptible. The factor that links an air pollutant to an observed health effect is the level of the concentration and the duration of the exposure to that particular air pollutant, known as the dose. The effects may be with short-term (acute) effects or long-term (chronic).

Short-term effects include irritation to the eyes, nose and throat and the upper respiratory system, headaches, nausea and allergic reactions. Short-term exposure can aggravate existing health problems such as asthma and emphysema. Long-term effects include chronic respiratory disease, lung cancer, heart disease and damage to the nervous and renal systems.

The three pollutants of concern in the WBPA are sulphur dioxide (SO_2), oxides of nitrogen (NO_X = NO + NO_2) and particulate matter. An overview of these pollutants is provided in the following text.

Sulphur dioxide (SO_2)

The dominant sources of SO_2 include fossil fuel combustion from industry and power plants. SO_2 is emitted when coal is burnt for energy. The combustion of oil also results in high SO_2 emissions. Domestic coal or kerosene burning can thus also result in the release of SO_2. Motor vehicles also emit SO_2, in particular diesel vehicles due to the high sulphur content of diesel fuel. Mining processes where smelting of mineral ores occurs can also result in the production of SO_2 as metals usually exist as sulphides within the ore.

On inhalation, most SO_2 only penetrates as far as the nose and throat, with minimal amounts reaching the lungs, unless the person is breathing heavily, breathing only through the mouth, or if the concentration of SO_2 is high (CCINFO, 1998). The acute response to SO_2 is rapid, within 10 minutes in asthmatics (WHO, 2005). Effects such as a reduction in lung function, an increase in airway resistance, wheezing and shortness of breath, are enhanced by exercise that increases the volume of inspired air, as it allows SO_2 to penetrate further into the respiratory tract (WHO, 1999).

SO_2 reacts with cell moisture in the respiratory system to form sulphuric acid. This can lead to impaired cell function and effects such as coughing, broncho-constriction, exacerbation of asthma and reduced lung function.

SO_2 has the potential to form sulphurous acid or slowly form sulphuric acid in the atmosphere via oxidation by the hydroxyl radical. The sulphuric acid may then dissolve in water droplets and fall as precipitation. This may decrease the pH of rain water, altering any balance within ecosystems and can be damaging to man-made structures.

Nitrogen dioxide (NO_2)

Nitrogen dioxide (NO_2) and nitric oxide (NO) are formed simultaneously in combustion processes and other high temperature operations such as metallurgical furnaces, blast furnaces, plasma furnaces, kilns and internal combustion engines. NO_X is a term commonly used to refer to the combination of NO and NO_2. NO_X can also be released from nitric acid plants and other types of industrial processes involving the generation and/or use of nitric acid. NO_X also forms naturally by denitrification by anaerobic bacteria in soils and plants. Lightning is a source of NO_X during the discharge and the rapid cooling of air after the electric discharge.

The route of exposure to NO_2 is inhalation and the seriousness of the effects depends more on the concentration than the length of exposure. The site of deposition for NO_2 is the distal lung where NO_2 reacts with moisture in the fluids of the respiratory tract to form nitrous and nitric acids (WHO, 1997). About 80 to 90% of inhaled nitrogen dioxide is absorbed through the lungs (CCINFO, 1998). Nitrogen dioxide (present in the blood as the nitrite ion) oxidises unsaturated membrane lipids and proteins, which then results in the loss of control of cell permeability. Nitrogen dioxide caused decrements in lung function, particularly increased airway resistance. People with chronic respiratory problems and people who work or exercise outside will be more at risk to NO_2 exposure (EAE, 2006). People with a vitamin C deficiency may be more at risk, as vitamin C inhibits the oxidation reactions of NO_2 in the body (WHO, 1997).

NO_x also reacts with water in the atmosphere and can contribute to the formation acid rain. It is an important pre-cursor in the formation of ozone. NO_x is a key ingredient in atmospheric photochemistry and the formation of secondary pollutants such as ozone and smog.

Particulates

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

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

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

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

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

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

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

Coarse particles (PM_{10} to $PM_{2.5}$) can accumulate in the respiratory system and aggravate health problems such as asthma. $PM_{2.5}$ which can penetrate deeply into the lungs, are more likely to contribute to the health effects (e.g. premature mortality and hospital admissions) than coarse (WHO, 2003).

People with existing health conditions such as cardiovascular disease and asthmatics, as well as the elderly and children, are more at risk to the inhalation of particulates than normal healthy people (Pope, 2000; Zanobetti *et al*., 2000).

APPENDIX 5: Emissions parameterisation used in the CALPUFF dispersion modelling

Table A5-1: Emissions Inventory – location and base elevation of power stations

	Facility	Source name	Location		
			UTMx (km)	UTMy (km)	Base elevation (m)
Baseline	Matimba Power Station (6 units: 3990 MW)	Stack 1	562.333	7382.183	870
		Stack 2	562.278	7382.430	870
	Morupule B Power Station - Phase I (4 units: 600 MW)	Stack 1	504.904	7509.375	945
		Stack 2	504.904	7509.250	945
2015	Medupi Power Station (6 units: 4800 MW, no FGD)	Stack 1	557.140	7378.399	897
		Stack 2	557.308	7378.108	897
	Morupule A Power Station (4 units: 132 MW)	Stack 1	503.778	7509.710	953
		Stack 2	503.865	7509.758	953
2020	IPP: Thabametsi Power Station (4 units: 1200 MW)	Stack 1	549.778	7391.089	937
		Stack 2	549.836	7391.005	937
		Stack 3	549.890	7390.923	937
		Stack 4	549.946	7390.839	937
	IPP: Boikarabelo Power Station - Phase I (3 units: 45 MW)	Stack 1	515.500	7385.481	871
	IPP: Unknown IPP Power Station - Phase I (2 units: 300 MW)	Stack 1	545.100	7377.725	933
	Morupule B Power Station - Phase II (2 units: 300 MW)	Stack 1	504.904	7509.500	945
	Greenfields IPP Power Station (2 units: 300 MW)	Stack 1	472.000	7384.263	929
2025	Medupi Power Station (6 units: 4800 MW, with FGD)	Stack 1	557.140	7378.399	897
		Stack 2	557.308	7378.108	897
	IPP: Boikarabelo Power Station - Phase 2 (1 unit: 215 MW)	Stack 1	515.700	7385.481	871
	IPP: Unknown IPP Power Station - Phase 2 (4 units: 600 MW)	Stack 1	545.300	7377.725	933
	Mmamabula Power Station - Phase 1 (4 units: 600 MW)	Stack 1	478.200	7388.701	914
	Mmamabula Power Station - Phase 2 (2 units: 600 MW)	Stack 1	478.400	7388.701	914
2030	Coal 3 Power Station - Site 1 (2 units: 300MW)	Stack 1	509.2500	7379.875	870
	Coal 3 Power Station - Site 2 (2 units: 300MW)	Stack 1	516.9000	7374.784	906
	Coal 3 Power Station - Site 3 (2 units: 300MW)	Stack 1	534.7000	7365.586	981
	Coal 3 Power Station - Site 4 (2 units: 300MW)	Stack 1	547.4000	7370.367	923
	Coal 3 Power Station - Site 5 (2 units: 300MW)	Stack 1	520.6500	7391.397	852
	Pulverised Fuel Power Station (6 units: 4500MW)	Stack 1	527.1200	7370.297	966
		Stack 2	527.3200	7370.297	966
	Mmamantswe (3 units: 1050MW)	Stack 1	461.7000	7322.146	932
	CTL	Stack 1	533.9400	7393.160	865
		Stack 2	534.1400	7393.160	865

Table A5-2: Emissions Inventory – stack parameters for power stations

	Facility	Source name	Stack Height (m)	Stack Temp (degree)	Stack Temp (k)	Stack Diameter (m)	Stack Area (m^2)	Stack Velocity (m/sec)	Average pressure (hPa)	Stack Flowrate (Am^3/s)	Stack Flowrate (Nm^3/s)
Baseline	Matimba Power Station (6 units: 3990 MW)	Stack 1	250	132	405	12.82	129.08	27.9	920	3601	2205
		Stack 2	250	132	405	12.82	129.08	27.9	920	3601	2205
	Morupule B Power Station - Phase I (4 units: 600 MW)	Stack 1	150	130	403	5.2	21.24	21.1	980	448	294
		Stack 2	150	130	403	5.2	21.24	21.1	980	448	294
2015	Medupi Power Station (6 units: 4800 MW, no FGD)	Stack 1	220	140	413	15.4	186.26	17.4	920	3241	1946
		Stack 2	220	140	413	15.4	186.26	17.4	920	3241	1946
	Morupule A Power Station (4 units: 132 MW)	Stack 1	150	127	400	2	3.14	18	no data	no data	no data
		Stack 2	150	127	400	2	3.14	18	no data	no data	no data
2020	IPP: Thabametsi Power Station (4 units: 1200 MW)	Stack 1	150	145.6	418.6	11.5	103.87	18.29	no data	no data	no data
		Stack 2	150	145.6	418.6	11.5	103.87	18.29	no data	no data	no data
		Stack 3	150	145.6	418.6	11.5	103.87	18.29	no data	no data	no data
		Stack 4	150	145.6	418.6	11.5	103.87	18.29	no data	no data	no data
	IPP: Boikarabelo Power Station - Phase I (3 units: 45 MW)	Stack 1	100	140	413	5.3	22.06	15	980	331	212
	IPP: Unknown IPP Power Station - Phase I (2 units: 300 MW)	Stack 1	100	140	413	5.3	22.06	15	980	331	212
	Morupule B Power Station - Phase II (2 units: 300 MW)	Stack 1	150	130	403	5.2	21.24	21.1	980	448	294
	Greenfields IPP Power Station (2 units: 300 MW)	Stack 1	100	140	413	5.3	22.06	15	980	331	212
2025	Medupi Power Station (6 units: 4800 MW, with FGD)	Stack 1	220	50	323	15.4	186.26	17.4	920	3241	1946
		Stack 2	220	50	323	15.4	186.26	17.4	920	3241	1946
	IPP: Boikarabelo Power Station - Phase 2 (1 unit: 215 MW)	Stack 1	100	140	413	5.3	22.06	15	980	331	212
	IPP: Unknown IPP Power Station - Phase 2 (4 units: 600 MW)	Stack 1	100	140	413	5.3	22.06	15	980	331	212
	Mmamabula Power Station - Phase 1 (4 units: 600 MW)	Stack 1	100	140	413	5.3	22.06	15	980	331	212
	Mmamabula Power Station - Phase 2 (2 units: 600 MW)	Stack 1	100	140	413	5.3	22.06	15	980	331	212
2030	Coal 3 Power Station - Site 1 (2 units: 300MW)	Stack 1	100	140	413	5.3	22.06	15	980	331	212
	Coal 3 Power Station - Site 2 (2 units: 300MW)	Stack 1	100	140	413	5.3	22.06	15	980	331	212
	Coal 3 Power Station - Site 3 (2 units: 300MW)	Stack 1	100	140	413	5.3	22.06	15	980	331	212
	Coal 3 Power Station - Site 4 (2 units: 300MW)	Stack 1	100	140	413	5.3	22.06	15	980	331	212
	Coal 3 Power Station - Site 5 (2 units: 300MW)	Stack 1	100	140	413	5.3	22.06	15	980	331	212
	Pulverised Fuel Power Station (6 units: 4500MW)	Stack 1	220	140	413	15.4	186.26	17.4	920	3241	1946
		Stack 2	220	140	413	15.4	186.26	17.4	920	3241	1946
	Mmamantswe (3 units: 1050MW)	Stack 1	100	140	413	5.3	22.06	15	980	331	212
	CTL	Stack 1	250	160	433	13	132.73	20	980	2655	1619
		Stack 2	250	160	433	13	132.73	20	980	2655	1619

Table A5-3: Emissions Inventory – emission concentration and emission rates for energy-based projects

	Facility	Source name	SO_2 Emission Concentration (mg/Nm^3)	SO_2 Emission Rate (ton/annum)	NOx Emission Concentration (mg/Nm^3)	NOx Emission Rate (ton/annum)	Particulate Emission Concentration (mg/Nm^3)	Particulate Emission Rate (ton/annum)
Baseline	Matimba Power Station (6 units: 3990 MW)	Stack 1	2224	154631	486	33796	35	2452
		Stack 2	2224	154631	486	33796	35	2452
	Morupule B Power Station - Phase I (4 units: 600 MW)	Stack 1	900	8335	510	4723	50	463
		Stack 2	900	8335	510	4723	50	463
2015	Medupi Power Station (6 units: 4800 MW, no FGD)	Stack 1	4000	245436	750	46019	50	3068
		Stack 2	4000	245436	750	46019	50	3068
	Morupule A Power Station (4 units: 132 MW)	Stack 1	no data	4595	no data	1463	no data	94
		Stack 2	no data	4595	no data	1463	no data	94
2020	IPP: Thabametsi Power Station (4 units: 1200 MW)	Stack 1	no data	53779	no data	25946	no data	162
		Stack 2	no data	53779	no data	25946	no data	162
		Stack 3	no data	53779	no data	25946	no data	162
		Stack 4	no data	53779	no data	25946	no data	162
	IPP: Boikarabelo Power Station - Phase I (3 units: 45 MW)	Stack 1	500	3337	750	5005	50	334
	IPP: Unknown IPP Power Station - Phase I (2 units: 300 MW)	Stack 1	500	3337	750	5005	50	334
	Morupule B Power Station - Phase II (2 units: 300 MW)	Stack 1	900	8335	510	4723	50	463
	Greenfields IPP Power Station (2 units: 300 MW)	Stack 1	900	6006	510	3404	50	334
2025	Medupi Power Station (6 units: 4800 MW, with FGD)	Stack 1	500	30679	750	46019	50	3068
		Stack 2	500	30679	750	46019	50	3068
	IPP: Boikarabelo Power Station - Phase 2 (1 unit: 215 MW)	Stack 1	500	3337	750	5005	50	334
	IPP: Unknown IPP Power Station - Phase 2 (4 units: 600 MW)	Stack 1	500	3337	750	5005	50	334
	Mmamabula Power Station - Phase 1 (4 units: 600 MW)	Stack 1	900	6006	510	3404	50	334
	Mmamabula Power Station - Phase 2 (2 units: 600 MW)	Stack 1	900	6006	510	3404	50	334
2030	Coal 3 Power Station - Site 1 (2 units: 300MW)	Stack 1	500	3337	750	5005	50	334
	Coal 3 Power Station - Site 2 (2 units: 300MW)	Stack 1	500	3337	750	5005	50	334
	Coal 3 Power Station - Site 3 (2 units: 300MW)	Stack 1	500	3337	750	5005	50	334
	Coal 3 Power Station - Site 4 (2 units: 300MW)	Stack 1	500	3337	750	5005	50	334
	Coal 3 Power Station - Site 5 (2 units: 300MW)	Stack 1	500	3337	750	5005	50	334
	Pulverised Fuel Power Station (6 units: 4500MW)	Stack 1	4000	245436	750	46019	50	3068
		Stack 2	4000	245436	750	46019	50	3068
	Mmamantswe (3 units: 1050MW)	Stack 1	900	6006	510	3404	50	334
	CTL	Stack 1	500	25531	750	38297	50	2553
		Stack 2	500	25531	750	38297	50	2553

Table A5-4: Emissions Inventory – extent and emission rates for coal mines

		top left		top right		bot left		bot right			
	Area Name	UTMx (km)	UTMy (km)	UTMx (km)	UTMy (km)	UTMx (km)	UTMy (km)	UTMx (km)	UTMy (km)	Area (m2)	PM10 (t/a)
Baseline	Grootegeluk Coal Mine (Class 4)	554.686	7384.744	557.686	7384.744	554.686	7381.744	557.686	7381.744	9000000	537
	Morupule Coal Mine (Class 2)	502.055	7510.592	503.055	7510.592	502.055	7509.592	503.055	7509.592	1000000	134
2015	Grootegeluk Coal Mine (expanded to Class 5)	554.186	7385.244	558.186	7385.244	554.186	7381.244	558.186	7381.244	16000000	1074
	Morupule Coal Mine (expanded to Class 3)	501.555	7511.092	503.555	7511.092	501.555	7509.092	503.555	7509.092	4000000	268
2020	Boikarabelo Coal Mine (Class 2)	516.833	7382.921	517.833	7382.921	516.833	7381.921	517.833	7381.921	1000000	134
	Thabametsi Coal Mine (Class 2)	546.947	7387.196	547.947	7387.196	546.947	7386.196	547.947	7386.196	1000000	134
	Sekoko Coal Mine (Class 2)	540.951	7386.194	541.951	7386.194	540.951	7385.194	541.951	7385.194	1000000	134
	Mookane Coal Mine (Class 2)	466.416	7385.065	467.416	7385.065	466.416	7384.065	467.416	7384.065	1000000	134
2025	Boikarabelo Coal Mine (expanded to Class 3)	516.333	7383.421	518.333	7383.421	516.333	7381.421	518.333	7381.421	4000000	268
	Thabametsi coal Mine (expanded to Class 3)	546.447	7387.696	548.447	7387.696	546.447	7385.696	548.447	7385.696	4000000	268
	Mookane Coal Mine (expanded to Class 3)	465.916	7385.565	467.916	7385.565	465.916	7383.565	467.916	7383.565	4000000	268
2030	Mmamantswe Coal Mine (Class 2)	457.286	7332.100	458.286	7332.100	457.286	7331.100	458.286	7331.100	1000000	134