THE MATIMBA AND MEDUPI POWER STATIONS, LEPHALALE, LIMPOPO PROVINCE

AN ASSESSMENT OF THE AMBIENT AIR QUALITY IMPLICATIONS OF ESKOM'S MATIMBA AND MEDUPI'S APPLICATION FOR A POSTPONEMENT OF THE COMPLIANCE TIMEFRAMES FOR THE SO_2 MINIMUM EMISSION STANDARDS

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ABBREVIATIONS

AIR	Atmospheric Impact Report
AQM	Air Quality Monitoring
DEA	Department of Environmental Affairs
FGD	Flue Gas Desulphurisation
GN	Governmental Notice
MES	Minimum Emission Standard
NAAQS	National Ambient Air Quality Standards
NEM: AQA	National Environment Management: Air Quality Act, No 39 Of 2004
NO	Nitric Oxide
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxides
PM	Particulate Matter
PM_{10}	Particulate matter with an aerodynamic diameter of less than 10 μm
$PM_{2.5}$	Particulate matter with an aerodynamic diameter of less than 2.5 μm
SO_2	Sulphur Dioxide

1 INTRODUCTION

For various technical and economic reasons Eskom is unable to comply with the compliance timeframes for the sulphur dioxide (SO_2) Minimum Emissions Standard (MES) at its Matimba and Medupi coal-fired Power Stations situated west of Lephalale, in Limpopo Province. As such Eskom is applying for a formal postponement of the compliance timeframes for the 'existing plant' SO_2 MES for the two power stations. It stands to reason that for any decision to be made on the acceptability of the proposed postponement of the compliance timeframes, the implications for ambient air quality must be understood by the decision-makers. The format of the Atmospheric Impact Report (AIR) as prescribed in the Regulations (GN283: 2015) does not lend itself to presenting such an assessment. For this reason, the detailed assessment of the ambient air quality implications of the postponement application is described in this report, with a short summary of the report contained in the actual AIR.

This report includes two sections: an assessment of the air quality in the area of the two power stations as evidenced by ambient air quality monitoring, and the results of dispersion modelling predicted ambient SO_2 concentrations likely to prevail under different emission scenarios, including the requested SO_2 emission limit of 4000 mg/Nm^3. This report should be read in association with the AIR to which this report is appended. Before presenting the assessment, it is necessary to briefly describe the Waterberg-Bojanala Priority Area.

2 WATERBERG-BOJANALA PRIORITY AREA

The Matimba and Medupi Power Stations fall within the Waterberg-Bojanala Priority Area. Under the National Environmental Management: Air Quality Act (NEMA: AQA) (Act No. 39 of 2004), airshed priority areas can be declared where there is concern that elevated atmospheric pollutant concentrations may occur within the area. The Department of Environmental Affairs (DEA) identified the potential of an airshed priority area in the Waterberg District Municipality (GN 33600: 2010) based on the potential for degraded air quality in future, as more emitters are established in the area. This was later expanded to include the Bojanala Platinum District Municipality, in the North-West province (GN 34631: 2011) and the Waterberg-Bojanala Priority Area (WBPA) was officially declared on 15th June 2012 (GN 35435: 2012).

The Waterberg-Bojanala Priority Area Air Quality Management Plan: Baseline Characterisation was released for public comment on the 7th August 2014 (SAAQIS, 2014, access date: 2014-08-21). The Baseline Characterisation of the WBPA reported that there are no other listed emitters located within relative proximity to the Matimba and Medupi Power Stations and that power generation activities contribute to 95% of SO_2, 93% of NO_2 and 68% of the particulates of industrial emissions across the Waterberg District Municipality.

3 PREVAILING AMBIENT AIR QUALITY

3.1 AMBIENT SO_2 AIR QUALITY STANDARDS

The key enquiry in assessing ambient air quality is the compliance with the relevant National Ambient Air Quality Standards (NAAQS). The NAAQS for SO_2 are summarized in Table 3-1 below.

Table 3-1: South African National Ambient Air Quality Standards (NAAQS) for SO_2

Averaging Period	Limit value	Frequency of Exceedance	Compliance Date
10 minutes	500 µg/m³ (191 ppb)	526	Immediate
1 hour	350 µg/m³ (134 ppb)	88	Immediate
24 hours	125 µg/m³ (48 ppb)	4	Immediate
1 year	50 µg/m³ (19 ppb)	0	Immediate
The reference method for the analysis of Sulphur dioxide shall be ISO 6767			

As can be seen from Table 3-1, it is only the annual average limit that applies for 100% of the time. The remaining standards all apply for 99% of the time, which means that the 99th percentile of the measured data needs to be below the limit value. Because the standards are expressed as percentiles, the air quality monitoring data obtained for the AIR assessments has been presented in the form of frequency distributions where the data has been ranked from lowest to highest together with an associated frequency of occurrence. Before presenting these findings the characteristics of the three Air Quality Monitoring (AQM) stations present in the area are presented (Figure 3-1).

3.2 THE MONITORING STATIONS

3.2.1 MARAPONG AIR QUALITY MONITORING STATION

The Marapong AQM station is situated in Marapong on the upwind (to the northeast) side of the Matimba Power Station, some 2.4 km from the power station (Figure 3-1). The AQM station is equipped to conduct continuous monitoring of ambient concentrations of Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2), Ozone (O_3), Carbon Monoxide (CO), Mercury (Hg) and Particulate Matter of particulate size <10 µm (PM_{10}) and <2.5 µm ($PM_{2.5}$) in diameter. In addition, meteorological parameters of wind velocity, wind direction and ambient temperature are also recorded continuously.

3.2.2 MEDUPI AIR QUALITY MONITORING STATION

The Medupi AQM station is situated some 4.4 km downwind (to the south southwest) of the Medupi Power Station at Kroomdraai Farm (Figure 3-1). The Medupi AQM station is equipped to conduct continuous monitoring of ambient concentrations of SO_2, NO_2, O_3, CO, $PM_{2.5}$ and PM_{10}. In addition, meteorological parameters of wind velocity, ambient temperature, relative humidity, pressure, radiation and rainfall are also continuously recorded.

3.2.3 LEPHALALE AIR QUALITY MONITORING STATION

The Lephalale AQM station is situated in the town of Lephalale on the eastern side of the two power stations some 12 and 18 km from Matimba and Medupi Power Stations, respectively (Figure 3-1). The Lephalale AQM station is equipped to conduct continuous monitoring of SO_2, NO, NO_2, NO_x, O_3, CO, PM_{10}, $PM_{2.5}$, benzene, toluene and xylene. In addition, meteorological data including wind speed, wind direction, ambient temperature, relative humidity, rainfall, solar radiation and barometric pressure are also recorded continuously.

3.3 THE MONITORING DATA

3.3.1 DATA FROM THE MARAPONG AQM STATION

In Marapong there was full compliance with the NAAQS for SO_2 from 2013 through to 2015 (Figure 3-2 and Figure 3-3). More than 94 percent of the measured concentrations are less than half of the associated limit value (350 µg/m^3), exhibiting a pattern of generally low concentrations with a few peak values. Although there are some exceedances of the limit values the numbers of exceedances are well less than the allowable exceedances (Table 3-2). It is also worth noting that the annual average SO_2 concentration is less than half of the NAAQS limit further supporting the assertion that the day to day loading of SO_2 is relatively low but with occasional peak concentrations.

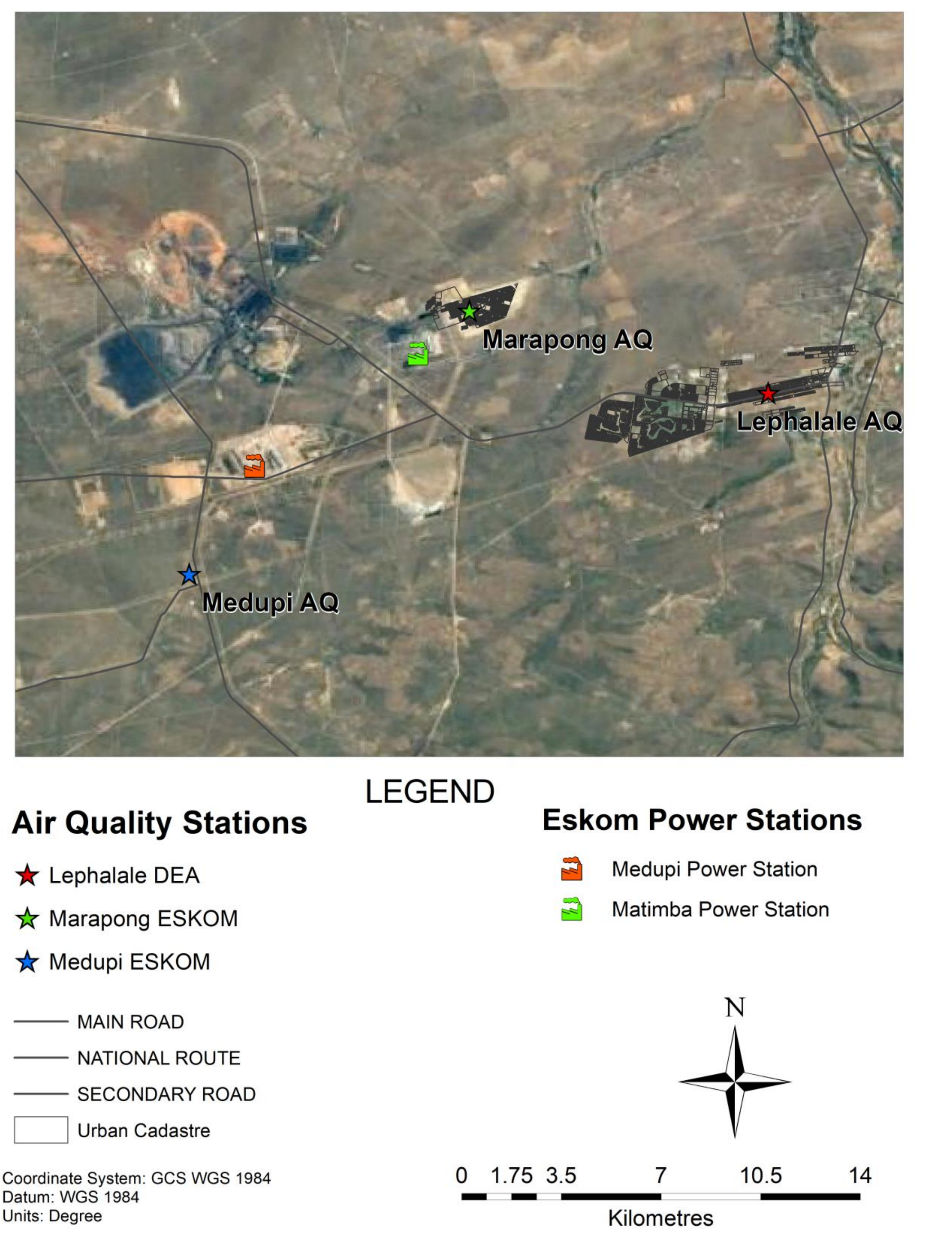


Figure 3-1: The relative positions of the AQM stations with respect to the Matimba and Medupi Power Stations

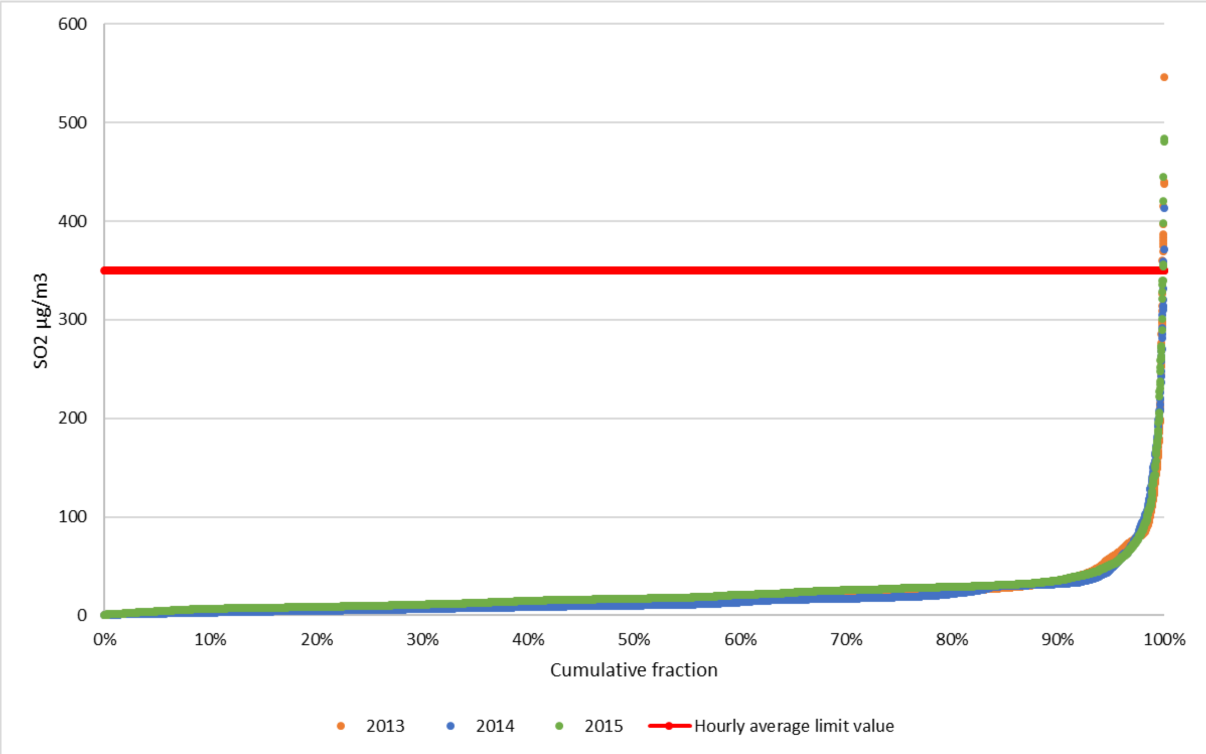


Figure 3-2: The frequency distribution of the average hourly SO_2 concentrations for the Marapong AQM station (2013-2015). The limit value is shown in red.

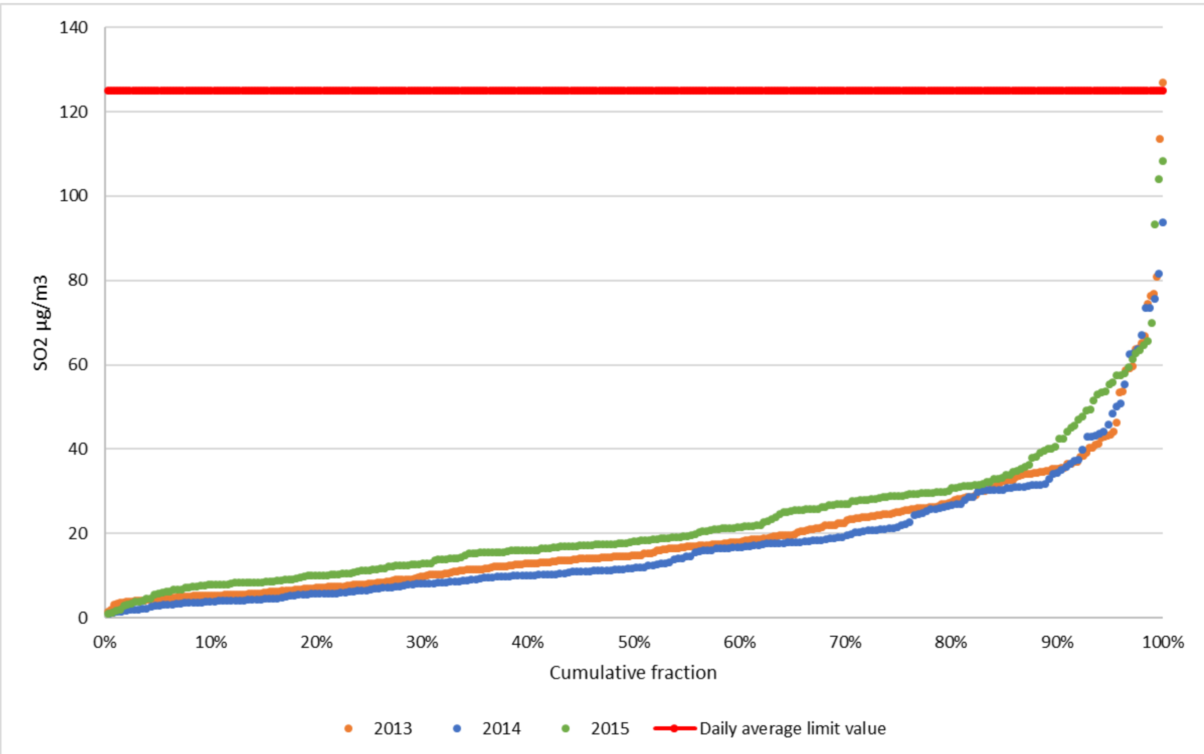


Figure 3-3: Frequency distribution of the average daily SO_2 concentrations for the Marapong AQM station (2013-2015) The limit value is shown in red.

Table 3-2: Summary of the SO_2 NAAQS compliance statistics for the Marapong AQM station (2013 – 2016). Limit and maximum values are given in µg/m^3.

Averaging period	Limit value	Allowed number of exceedances	Actual number of exceedances	Maximum value
2013				
Hourly	350	88	12	546.5
Daily	125	4	1	126.9
Annual	50	0	0	19.2
2014				
Hourly	350	88	3	413.3
Daily	125	4	0	93.8
Annual	50	0	0	17.38
2015				
Hourly	350	88	7	483.9
Daily	125	4	0	108.4
Annual	50	0	0	22.5
2016*				
Hourly	350	88	6	535.0
Daily	125	4	0	116.3
Annual	50	0	0	20.11

*January to October

3.3.2 DATA FROM THE MEDUPI AQM STATION

The SO_2 concentrations are considerably higher at the Medupi AQM station, downwind of the power stations, than at the Marapong AQM station (Figure 3-4 and Figure 3-5). Despite the higher measured concentrations there is currently still full compliance with the SO_2 NAAQS. In a similar vein to that described for the Marapong AQM station, there are exceedances of the limit values but the frequencies of such exceedances are within the allowable number of exceedances (Table 3-3).

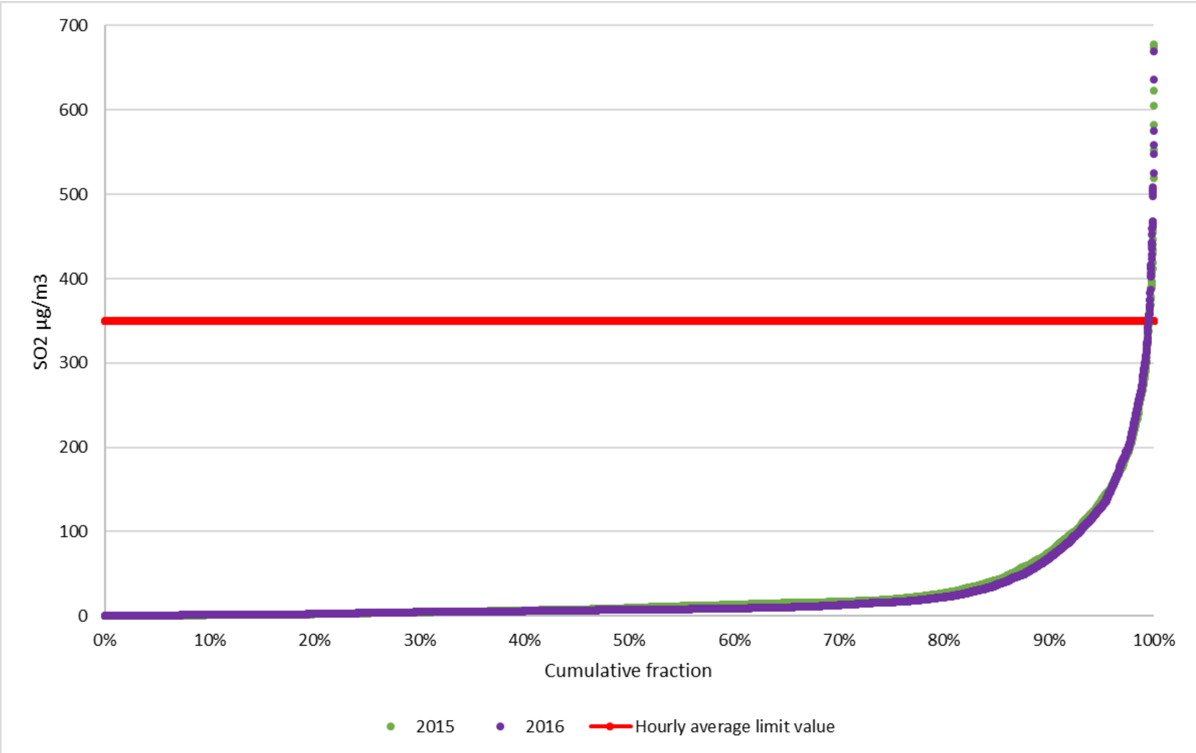


Figure 3-4: Frequency distribution of hourly average SO_2 concentrations for the Medupi AQM station (2015). The limit value is shown in red.

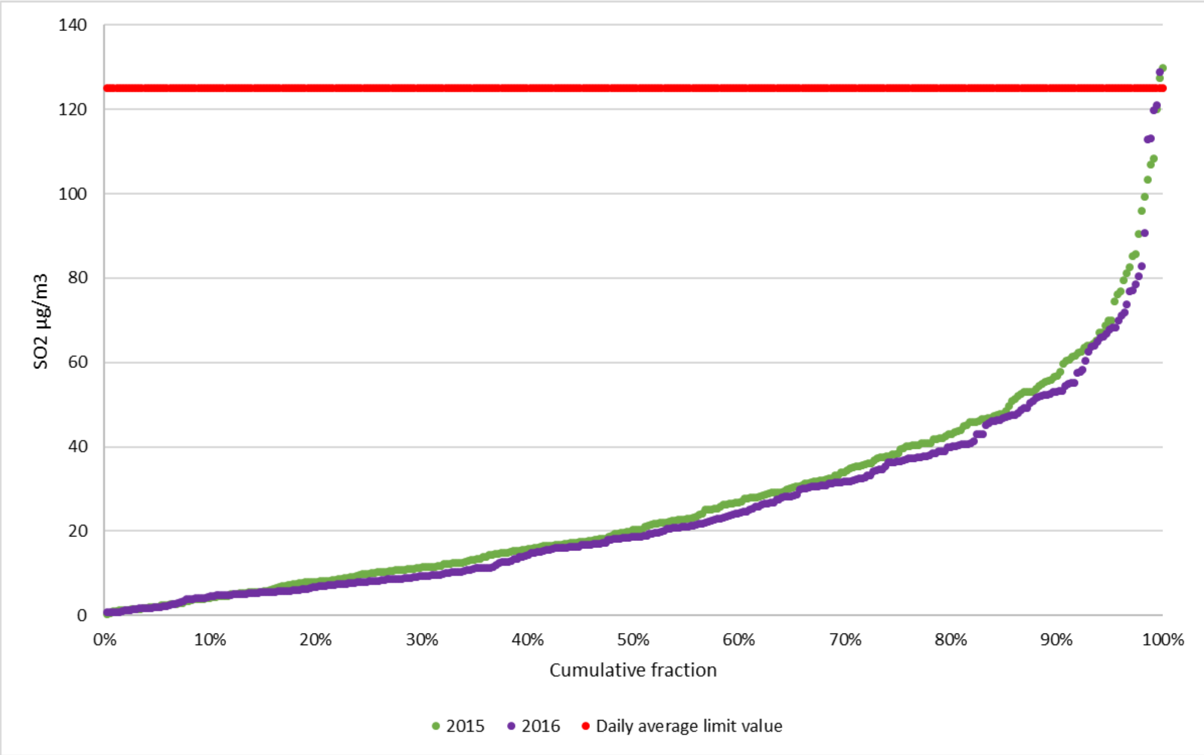


Figure 3-5: Frequency distribution of daily average SO_2 concentrations for the Medupi AQM station (2015). The limit value is shown in red.

Maximum SO_2 concentrations seen in the Medupi AQM station exceed the 1hr and 24 hr limit, 1% and 5% of the time. The 1 hr exceedances fall within the allowable number of exceedance, whilst the 24 hr exceedances exceed the allowable limit, and thus the Medupi AQM station data shows non-compliance with the 24 hr NAAQS limit.

Table 3-3: Summary of SO_2 NAAQS compliance statistics for the Medupi AQM station for 2015 and 2016. Limit and maximum values are given in µg/m³.

Averaging period	Limit value	Allowed number of exceedances	Actual number of exceedances	Maximum value
2015				
Hourly	350	88	41	677.8
Daily	125	4	2	129.8
Annual	50	0	0	27.6
2016				
Hourly	350	88	47	770.7
Daily	125	4	2	186.0
Annual	50	0	0	25.6

3.3.3 DATA FROM THE LEPHALALE AQM STATION

There is full compliance with the NAAQS for SO_2 at the Lephalale AQM station (Figure 3-6 and Figure 3-7). For 2013-2016, more than 99% of the measured hourly concentrations are less than 100 µg/m³ (limit value is 350 µg/m³), whilst more than 98% of daily average SO_2 concentrations are less than 40 µg/m³, exhibiting a pattern of generally very low concentrations with a few peak values. Although there are a few exceedances of the limit values the numbers of exceedances are well less than the allowable exceedances (Table 3-4). It is also worth noting that the annual average SO_2 concentrations are less than 20% of the NAAQS limit, again indicating that the day-to-day loading of SO_2 is relatively low but with limited peak concentrations.

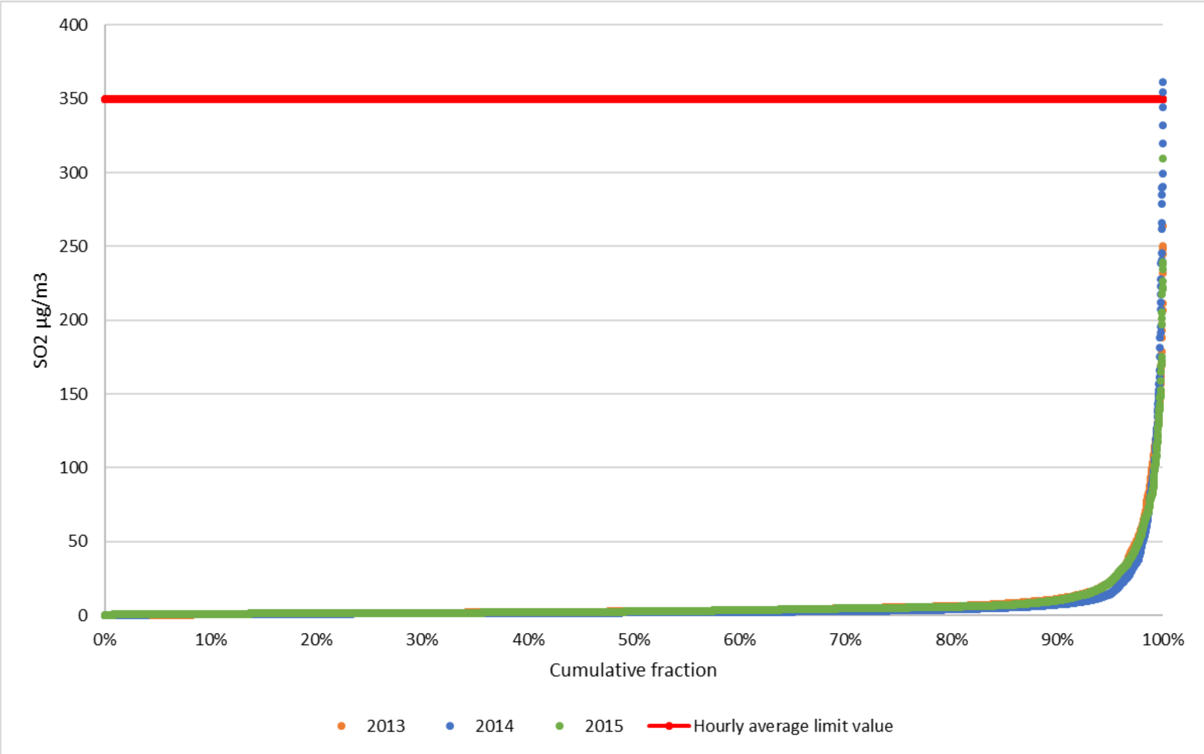


Figure 3-6: Frequency distribution of hourly average SO_2 concentrations for the Lephalale AQM station (2013-2015). The limit value is shown in red.

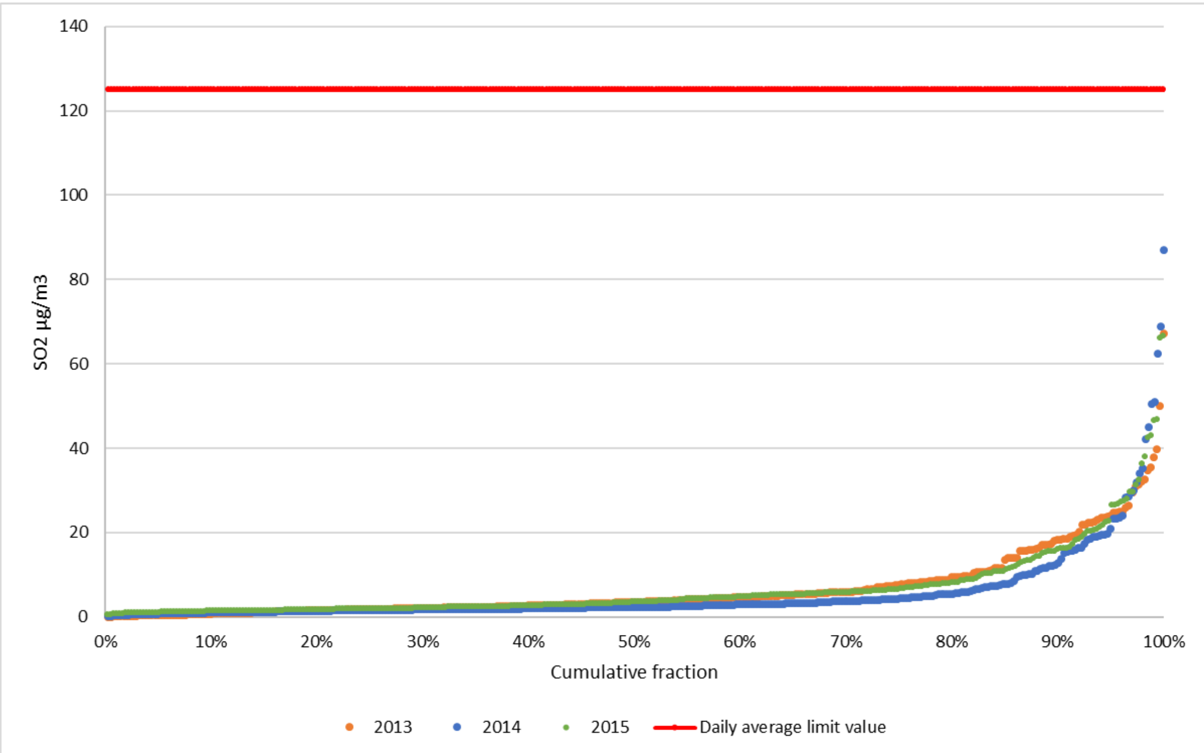


Figure 3-7: Frequency distribution of daily average SO_2 concentrations for the Lephalale AQM station (2013-2015). The limit value is shown in red.

Table 3-4: Summary of SO_2 NAAQS compliance statistics for the Lephalale AQM station for 2013 - 2016. Limit and maximum values are given in µg/m³.

Averaging period	Limit value	Allowed number of exceedances	Actual number of exceedances	Maximum value
2013				
Hourly	350	88	0	263.6
Daily	125	4	0	67.2
Annual	50	0	0	6.7
2014				
Hourly	350	88	2	361.1
Daily	125	4	0	87.1
Annual	50	0	0	5.5
2015				
Hourly	350	88	0	309.5
Daily	125	4	0	66.6
Annual	50	0	0	6.7
2016*				
Hourly	350	88	9	545.3
Daily	125	4	0	120.5
Annual	50	0	0	9.9

*January to October

3.4 SOURCE APPORTIONMENT

The question that then arises is the extent to which the power stations contribute to the measured ambient concentrations. Apportioning the sources of measured ambient concentrations is not a straightforward exercise and as such is presented qualitatively rather than quantitatively in the section that follows. Reference is made to polar plot in Figure 3-8 that plots direction of wind and wind speed as a function of SO_2 concentrations as well as diurnal graphs (Figure 3-9 to Figure 3-11) There are multiple sources of SO_2 including industrial activities, mining, and the use of domestic fuels for cooking and space heating. From the polar plot generated from Marapong AQM station data it is clear that a substantial source is located south west of Marapong (Matimba Power Station) along with a source/ sources west and west north west, most likely arising from the Exxaro Grootegeluk coal mine.

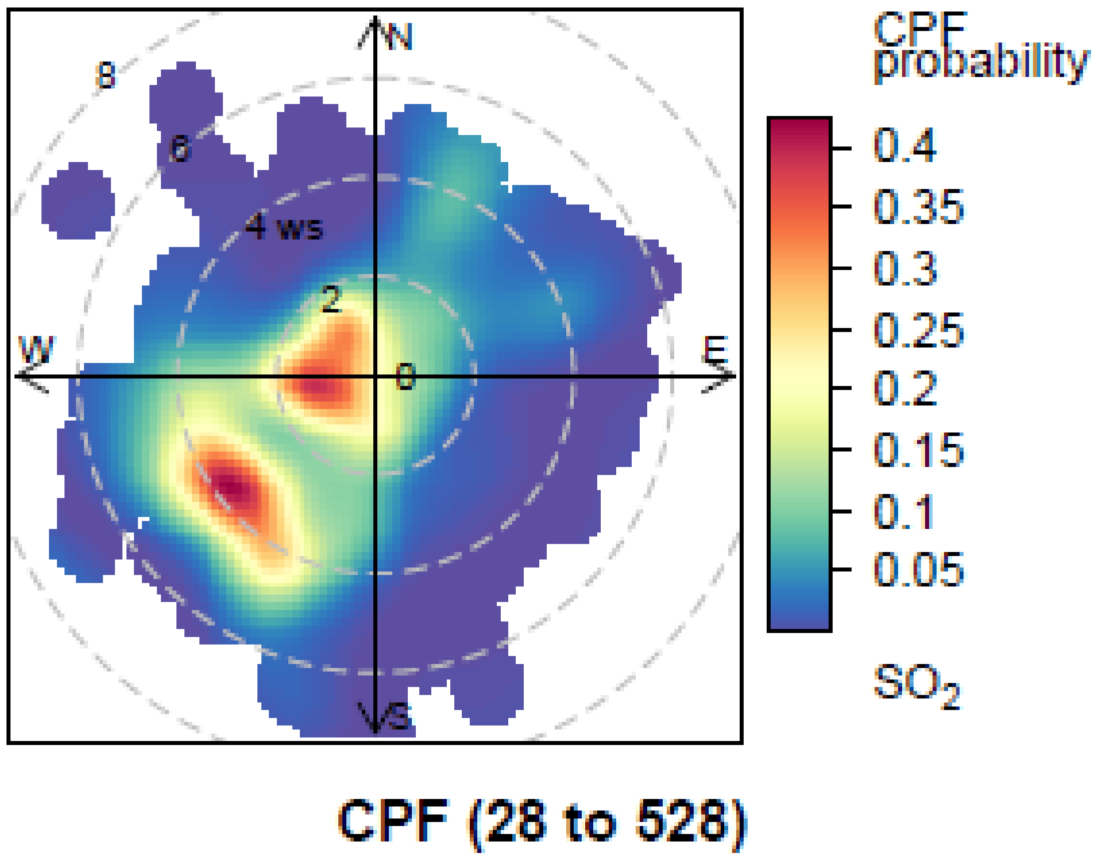


Figure 3-8: Polar Plot for the Marapong AQM station (2015)

Another important characteristic of the area is atmospheric stability, which is driven at both synoptic scale (continental anti-cyclone) and local scale (rapid cooling of the earth's surface leading to surface temperature inversions, where temperature increases rather than decreases with height). This atmospheric stability manifests as a pronounced diurnal cycle. The atmosphere is at its most unstable during the day and at its most stable during the night, especially in the early hours of the morning when the earth's surface is at its coldest. As the sun rises the surface starts to heat up and this has the effect of initiating turbulence in the atmosphere, which renders the atmosphere progressively more unstable as the day progresses.

During the afternoon, heating from the sun starts to reduce, the surface starts to cool and with the cooling of the surface the atmosphere gets progressively more stable. The cooling continues throughout the night until the rising sun once again starts the process of initiating turbulence. It must also be recognized that an unstable atmosphere is one where mixing (diffusion and dispersion of pollutants through the atmosphere) occurs freely, whereas a stable atmosphere is one where mixing is strongly inhibited.

3.4.1 MARAPONG AQM STATION

Average hourly concentrations of SO_2 are shown for a diurnal cycle for the three years of monitoring combined in Figure 3-9. It can be seen from that graph that relatively low concentrations of SO_2 are maintained throughout the night and the early morning. From about 10:00 the concentrations increase steadily until a maximum concentration is reached at approximately 15:00 where after a progressive reduction in concentration is evident through to about 23:00. It is argued here that this pattern reflects a process whereby the power station plume (which is released at some 250 and 220 m above ground level for the Matimba and Medupi Power Stations respectively) is prevented from coming to ground during the night due to the stability of the atmosphere. As the surface is warmed with the rising sun, thermal turbulence is initiated that serves to mix the atmosphere thereby bringing the power station plume to ground with the peak concentration occurring at the time of maximum turbulence and resultant mixing.

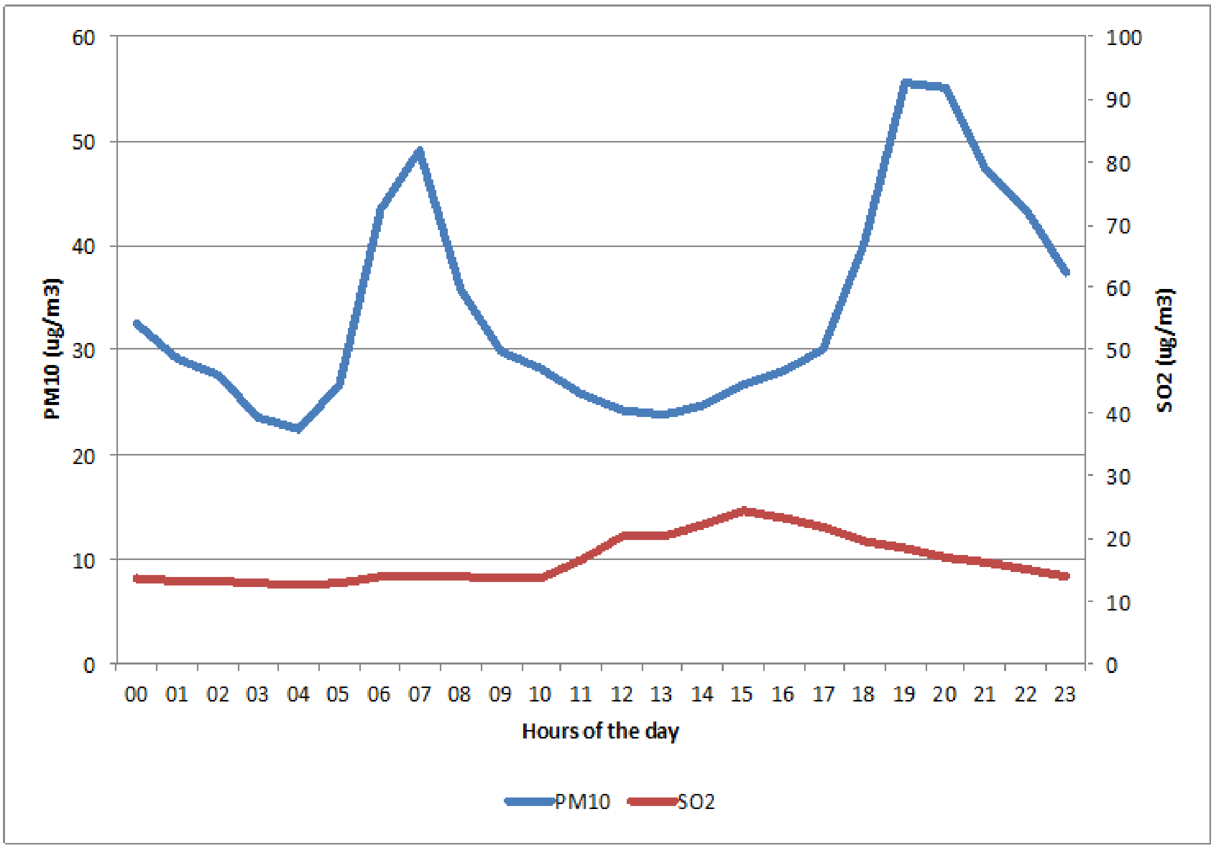


Figure 3-9: Hourly mean SO_2 and PM_{10} concentrations to illustrate the diurnal cycle of ambient air quality for the Marapong AQM station

While the subject of this assessment is not particulate matter (PM), measured concentrations of PM are briefly presented simply to make the point that PM concentrations peak in the early morning and the late afternoon/early evening and exhibit a countercyclical pattern to that of the SO_2 concentrations. With PM, the early morning and late afternoon/early evening peaks are indicative of sources at ground level. Peak PM_{10} concentrations would then be associated with early morning and early evening stability that would serve to trap the pollutants close to the ground. As the atmosphere becomes more turbulent due to convective forcing, the PM_{10} is dispersed vertically and horizontally with concentrations reducing accordingly. Again, the PM_{10} is only described as an indication of the atmospheric processes that serve to regulate the ambient concentrations. It must be remembered that both the Medupi and Matimba Power Stations are currently, and will remain fully compliant with the PM MES.

3.4.2 MEDUPI AQM STATION

The diurnal variability at the Medupi AQM station shows the same general pattern as that for Marapong, with an accentuated SO_2 peak at some 85 µg/m^3 compared to the some 25 µg/m^3 at Marapong (Figure 3-10). What is also noteworthy is that the SO_2 peak evident at the Medupi AQM station occurs quite a bit earlier in the day than at Marapong and persists for longer during the day. Again, these various patterns are consistent with the ambient air quality expected on the downwind side of the two power stations. An afternoon peak in PM_{10} is also evident (following the same pattern as that seen in Marapong) but the morning peak is noticeably absent, likely illustrative of the distance from the major sources (domestic fuel use and vehicle traffic).

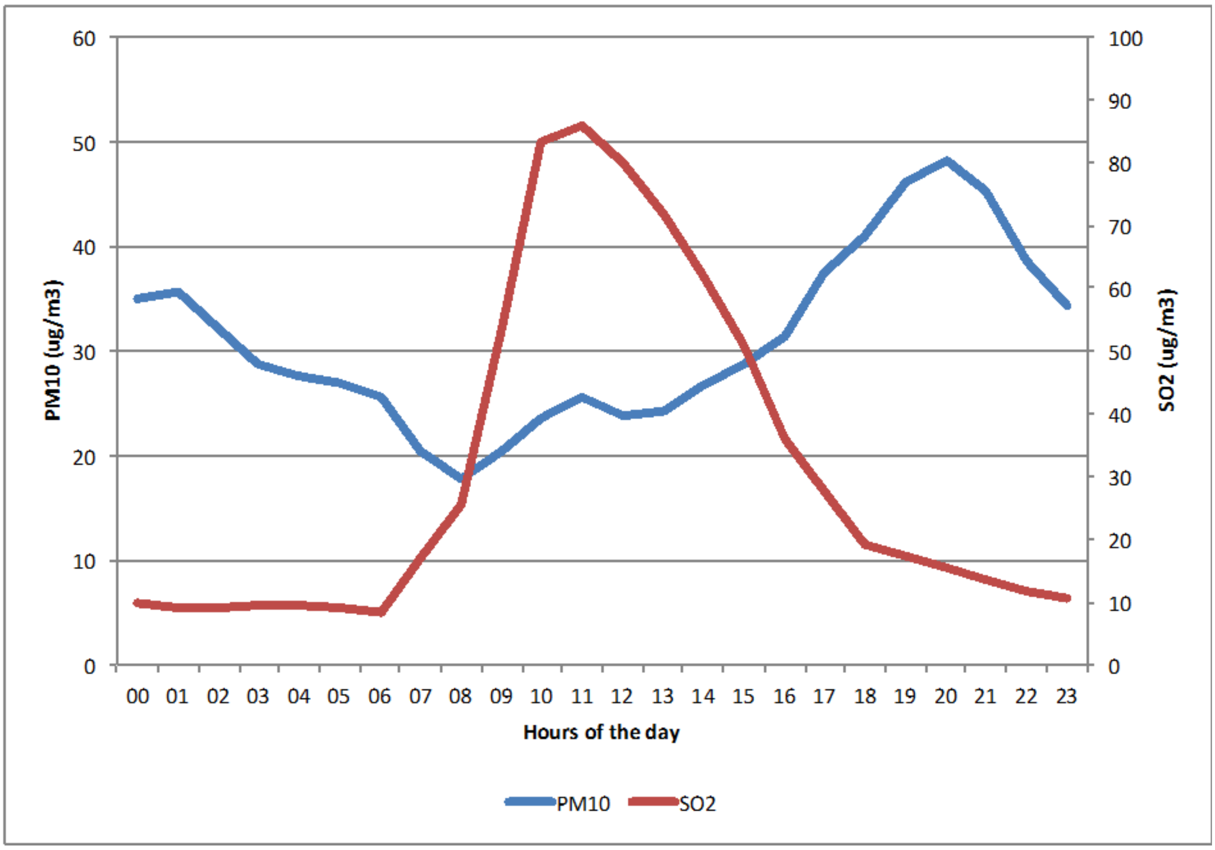


Figure 3-10: Hourly mean SO_2 and PM_{10} concentrations to illustrate the diurnal cycle of ambient air quality for the Medupi AQM station

3.4.3 LEPHALALE AQM STATION

The diurnal variability at the Lephalale AQM station shows the same general pattern as that for Marapong and Medupi, but with generally lower concentrations of both SO_2 and PM_{10} (Figure 3-11). The SO_2 concentration is seen to peak at some 15 µg/m^3 compared to the 25 µg/m^3 at Marapong and the 85 µg/m^3 at the Medupi AQM station. Unlike at the Medupi AQM station, there are two distinct peaks in the morning and the late afternoon/early evening again which is likely indicative of ground level sources of PM.

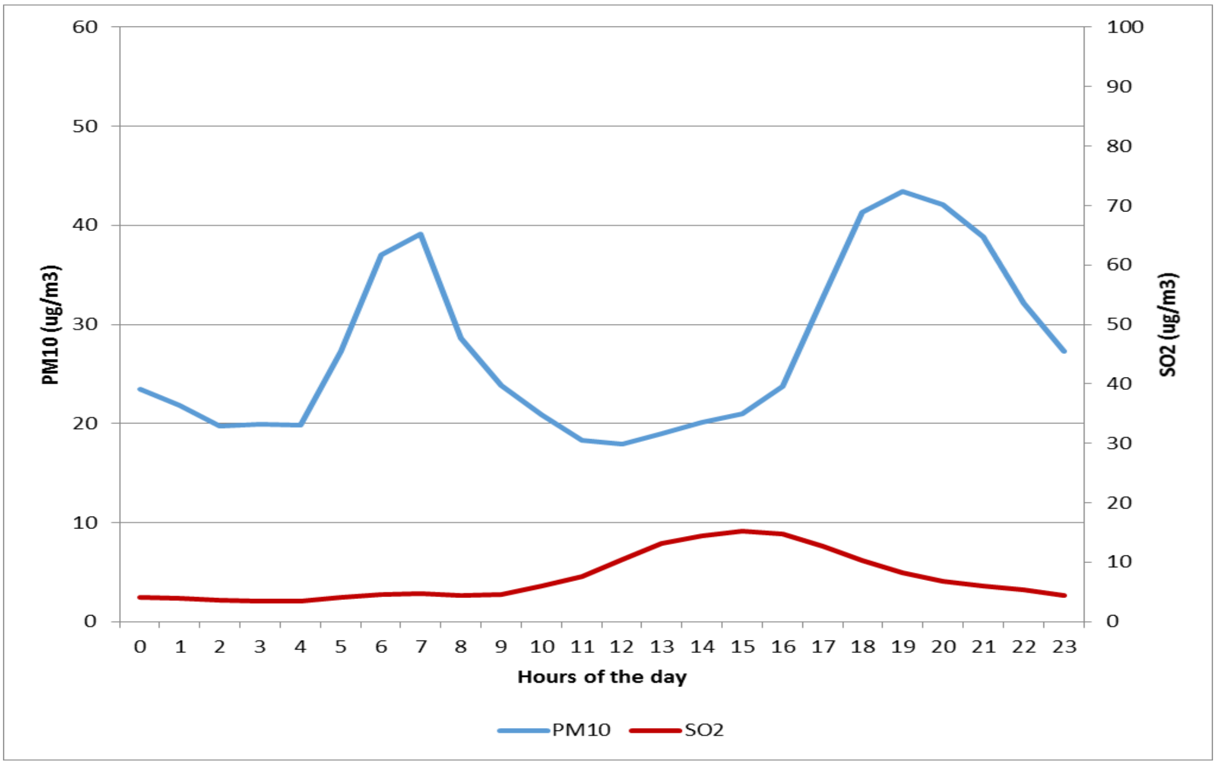


Figure 3-11: Hourly mean SO_2 and PM_{10} concentrations to illustrate the diurnal cycle of ambient air quality for the Lephalale AQM station

4 DISPERSION MODELLING

4.1 OVERVIEW

Direct physical measurements are without a doubt the most accurate indication of air quality at the point of monitoring. Not only is the air quality time resolved, but whatever is in the air at the AQM station (regardless of its source) will be reflected in the measurements. Unfortunately, AQM stations are very expensive to establish and to operate and are resource intensive, requiring regular maintenance and calibration. It is simply impractical to try and cover all possible areas with AQM stations, so the question arises as to the likely air quality in those areas where there are no direct measurements. It also stands to reason that AQM stations can only measure what is in the air at that time and so obviously do not indicate the air quality implications of future proposed activities.

For these reasons, various atmospheric dispersion models have been developed to predict the likely ambient air pollution concentrations in areas where direct monitoring does not take place and for emissions sources that are being planned or built, but are not yet fully operational (such as the Medupi Power Station). The principle of operation of the dispersion model used to predict ambient air quality for this assessment is as follows:

- A three-dimensional grid is created around the emission source. The grid provides a series of receptor points at every intersection on the grid;
- Measured atmospheric data is entered into the model, which is combined with modelled atmospheric data to predict the atmospheric dispersion potential at each of the receptor points;
- The atmospheric emission source is then entered into the model including the emission load, the temperature and the height above the ground that the emission enters the atmosphere;
- The model then 'moves' the emission plume through the grid as a function of the atmospheric dispersion characteristics that were previously determined;
- The predicted concentrations are then extracted from the model from each of the grid points that occur at ground level;
- Points of equal air pollution concentration are then connected by lines that are called 'isopleths' (in the same way that 'contours' connect points of equal height on maps); and,
- The isopleth maps are then interpreted to determine areas of possible non-compliance with the NAAQS.

As with any model, dispersion models can never be seen to be absolutely accurate, so they must be used in combination with measured data when the results are interpreted. Published validation studies have revealed that the models might over or under predict by as much as a factor of two. Again, the dispersion models should be used as nothing more than an indication and should never be interpreted to be absolute statements on air quality. In addition, it must be noted that only emissions from the power station in question have been modelled and no other sources have been included. The reason for only using the power station's emissions is that it is virtually impossible to account for all sources of pollution that may derive as a result of, for example, domestic fuel burning, veld fires, windblown dust, other industrial sources, motor vehicle emissions, etc.

The CALPUFF dispersion model was then used to predict the likely ambient air pollution concentrations that would occur as a result of the emissions from the power stations. The current actual emissions were modelled and then the requested emissions limits were modelled. The concept of requested emissions limits warrants further explanation. One of the difficulties in complying with the Minimum Emission Standard (MES) is that they do not make provision for periodic, unsustained exceedances that could be brought about by sulphur variability in the coal, for example. In order to comply all the time, the power stations would require high levels of redundancy to be built into the emissions control equipment, which is simply not cost effective. As such, Eskom is forced to apply for 'ceiling limits', which are limits that Eskom knows they will be able to comply with all the time given the vagaries of how emissions can fluctuate during any operating year.

The requested emission limits have then been modelled as if they would prevail for the entire 365 days a year, knowing full well that the emissions will not be maintained at those high levels (in 2016 the number of exceedances of the 3500 mg/Nm^3 emission limit was 101 for all six units (or 4.6% of the time per unit) for the Matimba Power Station and 15 (4.1% of the time) for the Medupi Power Station). In order to allow decision-makers to understand what they would be allowing if they agreed to the emission limits, it is necessary to predict the worst possible set of ambient concentrations that could prevail for those alternative limits.

4.2 DESCRIPTION OF THE DISPERSION MODEL

The simulation of pollutant emissions was undertaken with the well-known and widely used CALPUFF (version 5.8, US-EPA approved) dispersion model. CALPUFF is a regional Lagrangian Puff model intended for use on scales from tens of metres to hundreds of kilometres from a source (US EPA, 1998). The approach to the dispersion modelling in this assessment is based on the requirements of the DEA guideline for dispersion modelling which includes the recognition of CALPUFF as an accepted form of dispersion model for use in applications such as this one.

4.2.1 4.2.1 CALPUFF SUITE OF MODELS

The CALPUFF system consists of a suite of models; CALMET (used to model 3-D meteorology for CALPUFF), CALPUFF (to compute pollution dispersion simulations and visibility assessments) and CALPOST (used for post-processing of CALPUFF output data). The CALMET/CALPUFF modelling system can accurately simulate atmospheric dispersion on transport scales from tens of meters to tens of kilometres (near-field) and from tens of kilometres to hundreds of kilometres (far-field) (US EPA, 1998). Furthermore, CALPUFF is a multi-layer, multi-species non-steady-state puff dispersion model that simulates the effects of time- and space-varying meteorological conditions on pollution transport, transformation and removal (Scire *et al.*, 2000).

CALMET can simulate fine-scale three-dimensional wind flows in complex terrain (Scire *et al.*, 2000). CALMET has parameterizations to perform wind field adjustments of terrain, such as slope flows and terrain blocking effects. CALMET creates gridded 3-D wind fields and CALPUFF performs dispersion simulations along the wind vectors created by CALMET. This model combination is a major departure from past US-EPA Guideline models that have relied on a single hourly wind vector that applied over the entire modelling domain run in a steady-state mode. The CALMET and CALPUFF approach allows for dynamic wind fields that change spatially and temporally, a characteristic that is true to the real world.

CALMET/CALPUFF was developed to take whatever observational wind data available, and to adjust the flow fields to be consistent with the fine-scale terrain in CALMET. The adjustments made by CALMET introduce structure to the flow field that is consistent with the terrain, even in areas where observations do not exist. In complex terrain regions, the representativeness of observational data is often quite limited spatially. Often the wind flow at just a few hundred meters from an anemometer can be completely different because of terrain-induced effects. These terrain effects on the wind flow may have a substantial impact on the predicted concentrations produced by the dispersion model.

4.3 MODEL INPUT DATA

Dispersion models require input data including meteorological data (for example; wind speed and direction, temperature and humidity) and emissions data such as source location and height, diameter and exit velocity, temperature and flow rate. Input data types required for the CALMET/CALPUFF model system and for this study include; emissions source data, meteorological data and land cover/land use data. Parameters required depend on the source type (point, line, area or volume). CALPUFF requires input data in the form of modelled 3-D gridded meteorological fields. Other inputs include stack parameters for point sources including source geo-location, height and diameter. Emissions and process data are also required; including exit velocity, temperature and flow rate.

Meteorological data was obtained from the Weather, Research and Forecast Model (WRF), which is a mesoscale, prognostic atmospheric model. WRF makes use of observed data to model meteorology over a regular grid that has a coarser resolution than CALMET. The use of mesoscale model data in CALMET is advantageous compared to using limited number of observed data. More data points are provided than observed weather station data and the mesoscale model provides upper air conditions. The higher number of data points increases accuracy in CALMET when deriving fine scale flow patterns. Meteorology is an essential requirement and is the principal driver of the dispersion of pollutants in the atmosphere. Important meteorological factors that directly impact the dispersion of a pollutant include wind speed and direction, atmospheric turbulence which is related to vertical dispersion, and vertical temperature profiles associated with absolute stable layers that affect vertical dispersion.

4.3.1 MODEL DOMAIN

There were two sets of domains used for this project, namely one set for the WRF modelling suite and one set for the CALPUFF modelling suite. For WRF, a three-way nested domain was used, the first of these was a 36x36 km resolution domain located over the whole of Africa. The second nested domain was a 12x12 km resolution domain located over the whole of South Africa to ensure all local meteorological phenomena where included in the modelling. The third and last WRF domain was the 4x4 km domain situated over the Waterberg region of South Africa. This final 4x4 km domain was then fed into the CALPUFF modelling suite.

The CALPUFF modelling suite used a domain of 10 000 km^2, specifically a 100 km (west-east) by 100 km (north-south) domain which was centred on the Medupi Power Station. The domain consists of a uniformly spaced grid with 500 by 500 m spacing, giving 40 000 grid cells (200 X 200 cells to each dimension of the grid).

4.3.2 MODELLED SCENARIOS

The following scenarios, with associated emission rates, were modelled for the Matimba and Medupi Power Stations.

Table 4-1: Modelled Scenarios

	Modelling Scenarios	Emission Rates (tons/annum)
1.	Matimba only at actual emission rates	345 179
2.	Matimba only at requested SO_2 limit (4000 mg/Nm^3)	470 936
3.	Medupi only at expected emission rates (all 6 Units)	492 221
4.	Medupi only at requested SO_2 limit (4000 mg/Nm^3)	562 538
5.	Medupi with FGD with all 6 units (at 500 mg/Nm^3)	61 528
6.	Matimba Actual + Medupi Expected*	873 400 (345 179 Matimba 492 221 Medupi)
7.	Matimba requested SO_2 limit + Medupi FDG*	532 463.02 (470 936 Matimba 61 528 Medupi)
8.	Matimba requested SO_2 limit + Medupi requested SO_2 limit (both at 4000 mg/Nm^3)	1 033 474 (470 936 Matimba 562 538 Medupi)

*All emissions data were provided by Eskom, using mass balance calculations.

4.4 MODEL VERIFICATION

In order to assess the accuracy of the modelling a series of comparisons were done between the modelled and measured concentrations at the three AQM stations in the form of cumulative frequency diagrams. The comparisons are shown in Figure 4-1 to Figure 4-3. It can be seen from the comparisons that there is good agreement between the modelled data and the measured data for the Medupi and Lephalale AQM stations but the agreement for the Marapong station is slightly less convincing. The 99th percentile SO_2 1-hour average values, at Marapong, are under-predicted by an estimated 36%. There are several possible reasons for the discrepancies between the measured and the modelled data at Marapong. This includes the possibility of another source of SO_2, which was not included in the modelling, and 'instrument drift' (where the monitoring instrument loses its baseline and 'drifts' progressively upwards) that has the effect of recording higher concentrations that do not actually exist the effect of which is fairly prominent in data from the Marapong AQM station. These discrepancies notwithstanding, it is considered that the dispersion model output can be used as an acceptable representation of dispersion and ultimately, the manifestation of the ambient concentrations that are likely to prevail under the various emission scenarios.

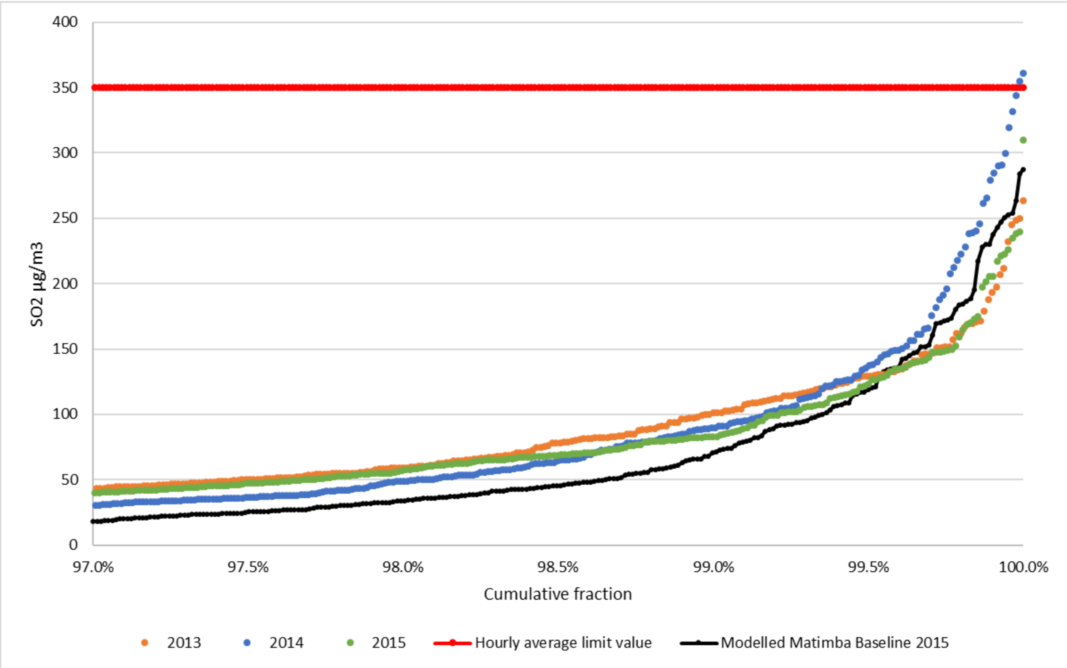


Figure 4-1: Comparison between the measured and the modelled hourly average concentrations at the Lephalale AQM station. Note the focus on only the highest 3% simply to make the comparison clear by focusing on the upper end of the data sets.

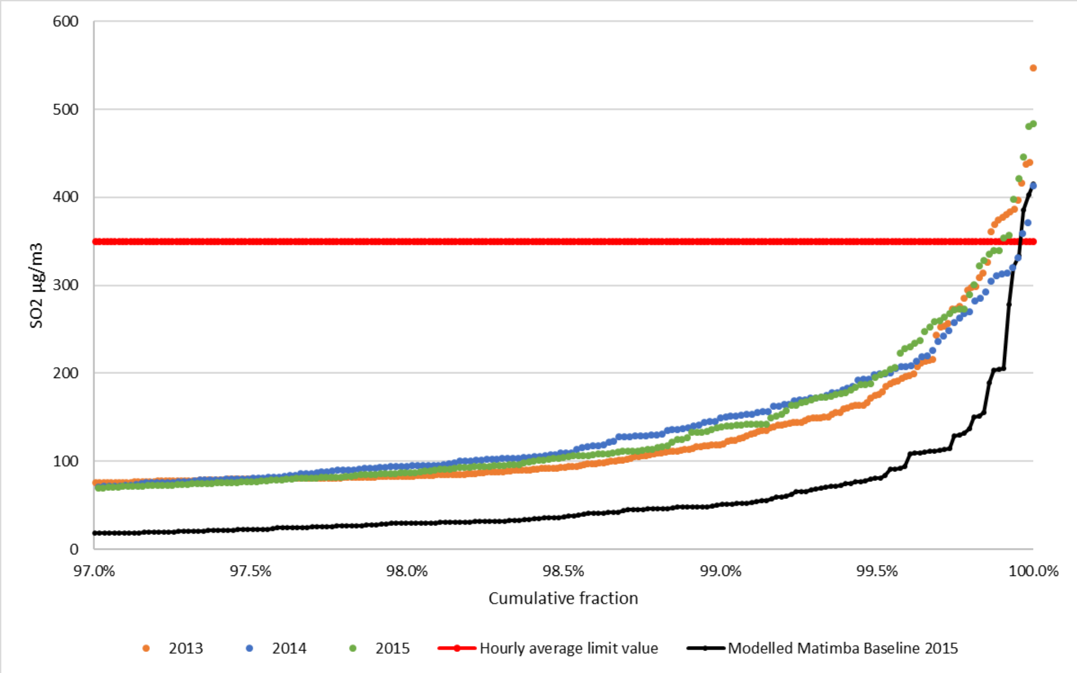


Figure 4-2: Comparison between the measured and the modelled hourly average concentrations at the Marapong AQM station. Note the focus on only the highest 3% simply to make the comparison clear by focusing on the upper end of the data sets.

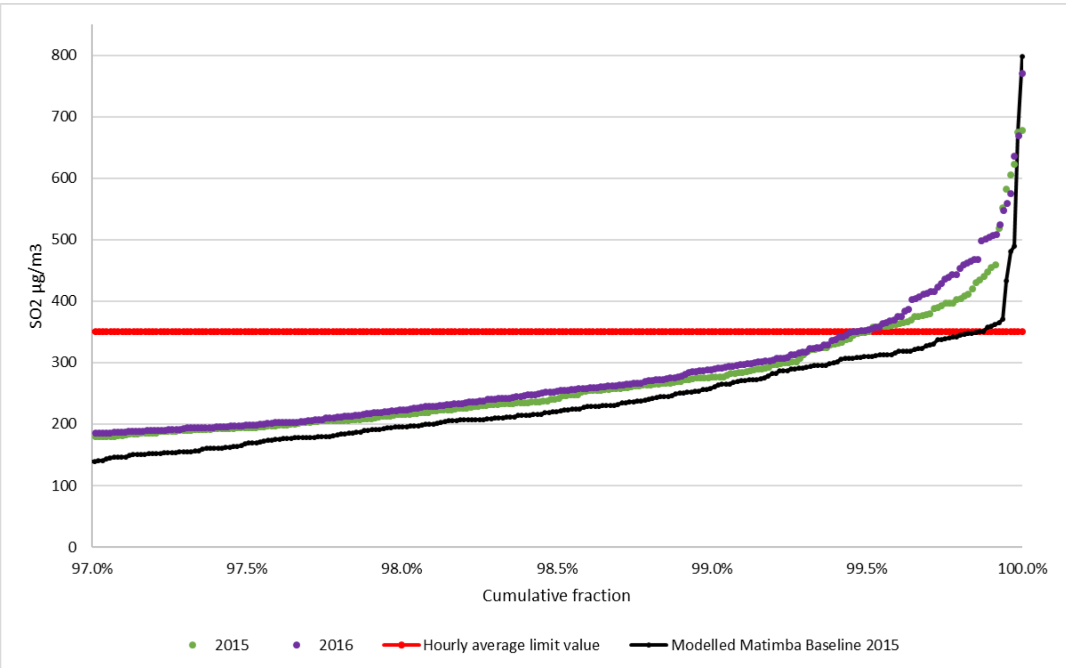


Figure 4-3: Comparison between the measured and the modelled hourly average concentrations at the Medupi AQM station. Note the focus on only the highest 3% simply to make the comparison clear by focusing on the upper end of the data sets.

5 PRESENTATION AND ANALYSIS OF MODEL RESULTS

5.1 INTERPRETATION OF ISOPLETH MAPS

Isopleths are similar to contour lines on a map, only isopleths join together points of equal predicted pollution concentrations. Thus, isopleth maps show the likely spatial distribution of a given pollutant (in this case SO_2) around the source or sources of the pollutant in question. Isopleth maps are typically an exaggeration of the extent of the impact because the isopleths join the 99th percentile predicted concentrations at each of the grid points in the modelling domain, regardless of the day and time that the 99th percentile concentration is predicted to occur. Stated differently, the 99th percentile concentration (fourth highest daily average concentration in a year, or the 88th highest hourly average concentration in a year) at Grid Point X1 could have occurred on Day 7 hour 22, whereas the 99th percentile predicted concentration at Grid Point X2 could have occurred on Day 10 hour 6. As such the isopleth maps should not be seen as 'a' plume but rather as the combined effects of the multitude of plumes that occur at any time in the three years of meteorological data used for the modelling.

As previously described, although the MES provide for upset events such as start-up and shut-down they do not provide for the variability in emissions that typically occurs even under normal operating conditions. In the current circumstance, SO_2 emission concentrations from the two power stations do not exceed the 3500 mg/Nm^3 limit continuously but rather episodically and typically for relatively short durations, as the Sulphur content of the coal varies. In order to comply with the law, the power stations would have to be managed to ensure that they never exceeded the emissions limit (i.e. when coal with the highest sulphur content is burnt). Accordingly, Eskom has to apply for an emissions limit that they know they can comply with, given the coal supply to the power stations. Eskom have specified 4000 mg/Nm^3 as this requested emission limit. This does not mean that the power stations will then be operated at the requested limit, but rather they will operate as they do now where for most of the time the emissions are within the 3500 mg/Nm^3.

It is simply impossible to predict with any certainty when the exceedances in emissions will occur and for that reason it is necessary to model the power stations operating at the requested emissions limit throughout the year, because decision-makers will need to know what the worst possible ambient air quality concentrations could be if they were to allow the requested emissions limit. Here the exaggeration is twofold. Firstly, the isopleth maps will again show the predicted 99th percentile concentrations across the modelling domain, regardless of when in the year they occur, and secondly, they will depict the predicted 99th percentile ambient concentrations that could occur if both power stations operate at the requested emissions limits every day of the year for three years.

The reason for the use of the 99th percentile is that the 99th percentile concentration should be less than the limit value in the ambient air quality standards for there to be compliance. Moreover, '*the highest predicted ground-level concentrations can be considered outliers due to complex variability of meteorological processes. This might cause exceptionally high concentrations that the facility may never actually exceed in its lifetime*' (DEA Regulations regarding air dispersion modelling, 2014). The 99th

percentile can only be used for averaging periods of 24-hours and shorter. Annual average concentrations must be presented as predicted by the model.

Finally, but importantly, the NAAQS are based on a specified limit value and an allowable Frequency of Exceedance (FOE) of the limit value. As a result, it is not adequate simply to use the maximum predicted concentrations of the pollutant in question, it is necessary to determine the predicted FOE for each of the grid points in the modelling domain. The FOE isopleths are then a collective representation of the areas in which the NAAQS limit values are predicted to be exceeded and the numbers of times per year that the NAAQS limit values are predicted to be exceeded. Again, it should be noted that the FOE isopleth map should not be interpreted as a single representation in time, but rather as the collective effect of maintaining the emissions in question for the three years of meteorological data.

The modelled output is presented in the form of colour coded isopleth maps. The colour coding follows the general format shown in Table 5-1 and Table 5-2.

Table 5-1: Predicted 99th Percentile Ambient Concentrations – Colour Coding

	Shades of Blue	99th percentile concentration is significantly lower than ambient limit value (typically < 60% of the limit value) (compliance)
	Shades of Green	99th percentile concentration is relatively close to the limit (60% - 100% of the limit value) (compliance)
	Shades of Orange and Red	99th percentile concentration exceeds the limit value (non-compliance)

Table 5-2: Predicted Frequency of Exceedances– Colour Coding

	Shades of Blue	Significantly lower than the allowable FOE (typically < 60% allowed FOE) (compliance)
	Shades of Green	Relatively close to the maximum allowable FOE (60% - 100% of allowed FOE) (compliance)
	Shades of Orange and Red	Over the maximum allowable FOE (non-compliance)

- Note that results are presented for a modelled period spanning 3 calendar years

5.1.1 PREDICTED AMBIENT SO_2 CONCENTRATIONS FOR MATIMBA POWER STATION ONLY AT ACTUAL EMISSION RATES

The predicted ambient SO_2 concentrations for the Matimba Power Station at actual emission rates are shown in Figure 5-1to Figure 5-3. It can be seen from the figures that there is compliance with the ambient SO_2 standards everywhere in the vicinity of the power stations considering emissions from the Matimba Power Station alone. Despite an extensive area of elevated SO_2 concentrations extending southwestwards from the two power stations, the predicted 99th percentile concentrations are below the NAAQS SO_2 limit values for both hourly and 24-hourly averaging periods. The predicted FOE is seen to be well within the allowable FOE for both the hourly and 24-hourly SO_2 NAAQS. For the populated areas of Marapong, Lephalale and Onverwacht there is full compliance for the hourly and daily NAAQS averaging periods. The annual average SO_2 concentrations follows a similar pattern with the annual average concentrations predicted to be between 11 and 20 µg/m^3 over a large area southwestwards of the Matimba Power Station. The predicted annual average SO_2 concentrations are predicted at well less than the NAAQS of 50 µg/m^3. For the annual NAAQS standard, full compliance is seen in the populated areas of Marapong, Lephalale and Onverwacht.

5.1.2 PREDICTED AMBIENT SO_2 CONCENTRATIONS FOR MATIMBA POWER STATION ONLY AT THE REQUESTED EMISSION LIMIT (4000 MG/NM^3)

Unsurprisingly, the predicted ambient SO_2 concentrations for Matimba Power Station at the requested emissions limit of 4000 mg/Nm^3 are seen to be noticeably higher than those for the Matimba Power Station at actual emission rates, to the extent that the SO_2 NAAQS limit values are exceeded in a small area in and around the Medupi Power Station (Figure 5-4 to Figure 5-6). In addition, the predicted FOE is seen to exceed the allowable FOE in the same area implying non-compliance with the NAAQS for the predicted hourly average concentrations (Figure 5-4). Although there is a small area of predicted exceedances of the 24-hourly NAAQS SO_2 limit value, the FOE is within the standard's allowable FOE implying compliance with the NAAQS for predicted 24-hourly concentrations (Figure 5-2). For the populated areas of Marapong, Lephalale and Onverwacht there is full compliance of the hourly and daily NAAQS averaging periods. The predicted annual average concentrations are seen to be within the NAAQS SO_2 limit value and thus no exceedances are predicted (Figure 5-6). For the annual NAAQS standard, full compliance is seen in the populated areas of Marapong, Lephalale and Onverwacht.

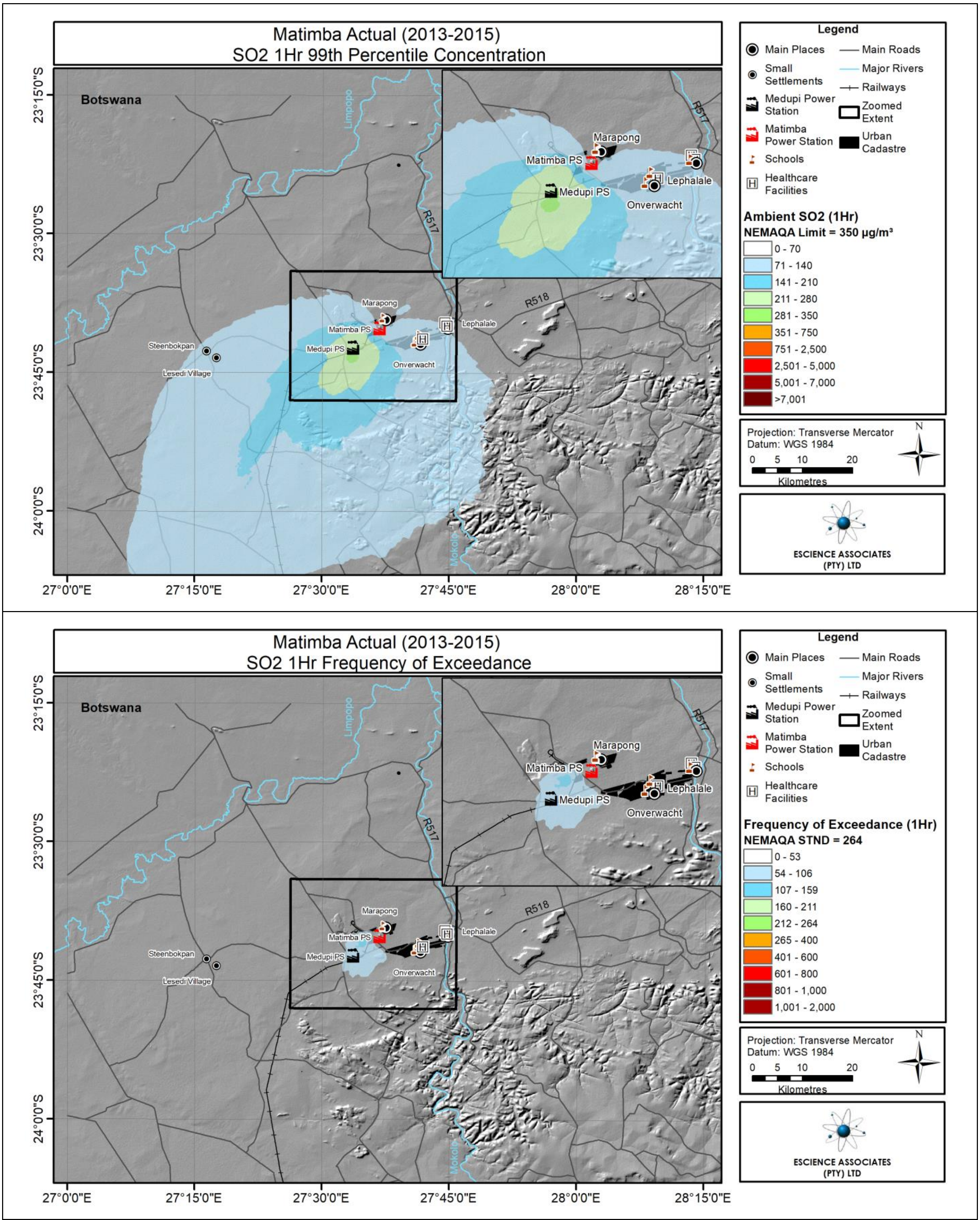


Figure 5-1: Predicted 99th Percentile hourly ambient SO_2 concentrations (above) and hourly FOEs (below) for Matimba Power Station only at actual emission rates (2013-2015)

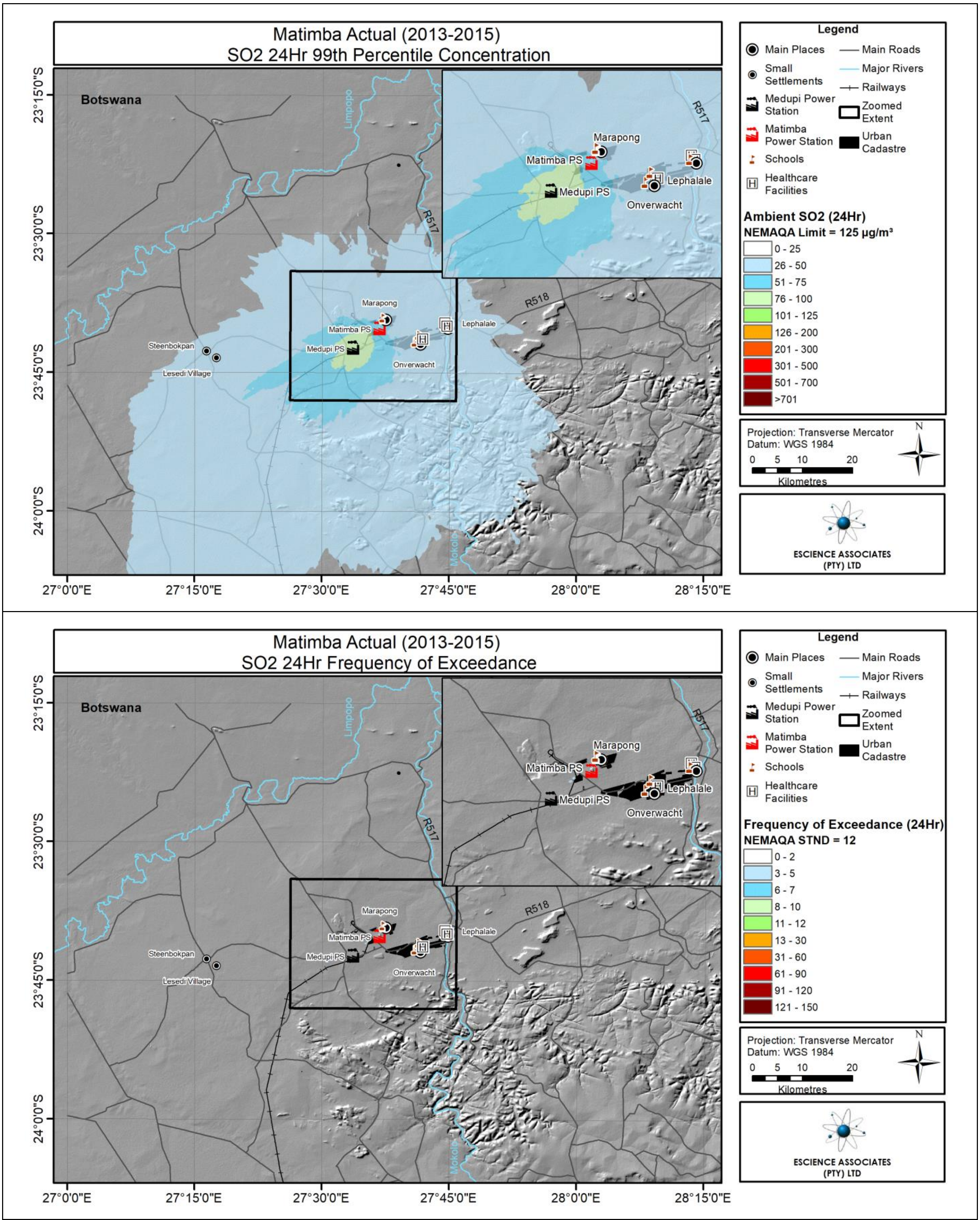


Figure 5-2: Predicted 99th Percentile daily ambient SO_2 concentrations (above) and daily FOEs (below) for Matimba Power Station only at actual emission rates (2013-2015)

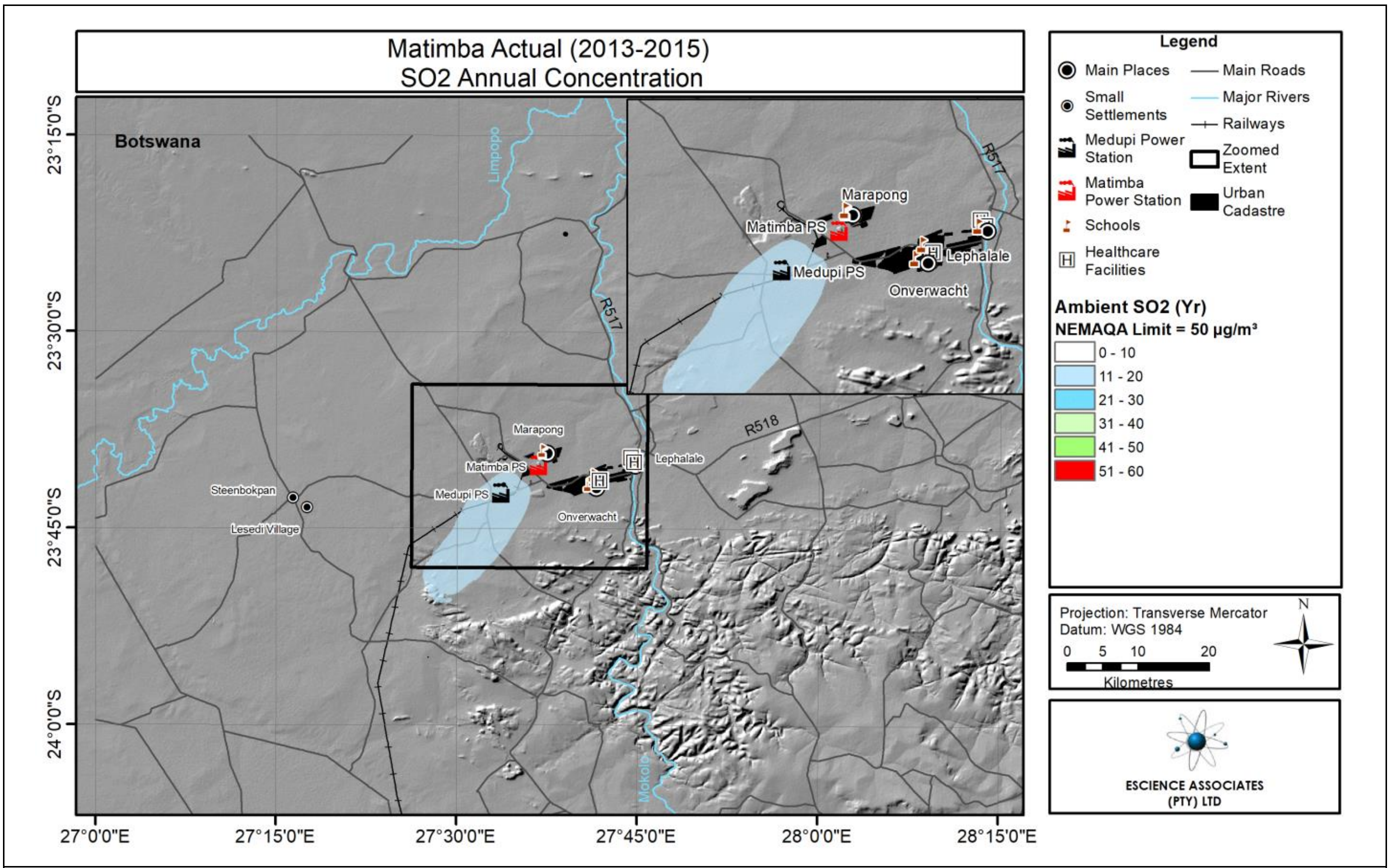
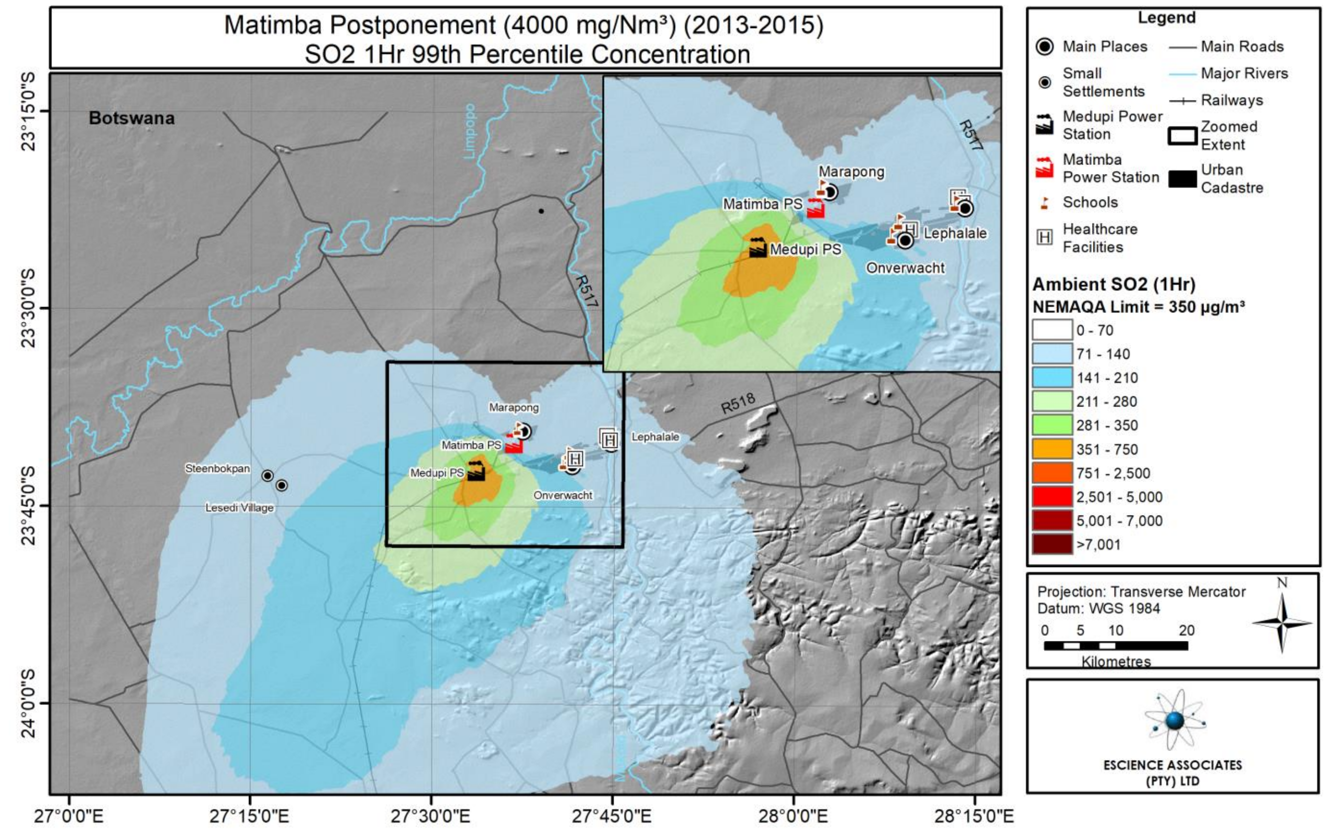


Figure 5-3: Predicted Annual Average ambient SO_2 concentrations for Matimba Power Station only at actual emission rates (2013-2015)



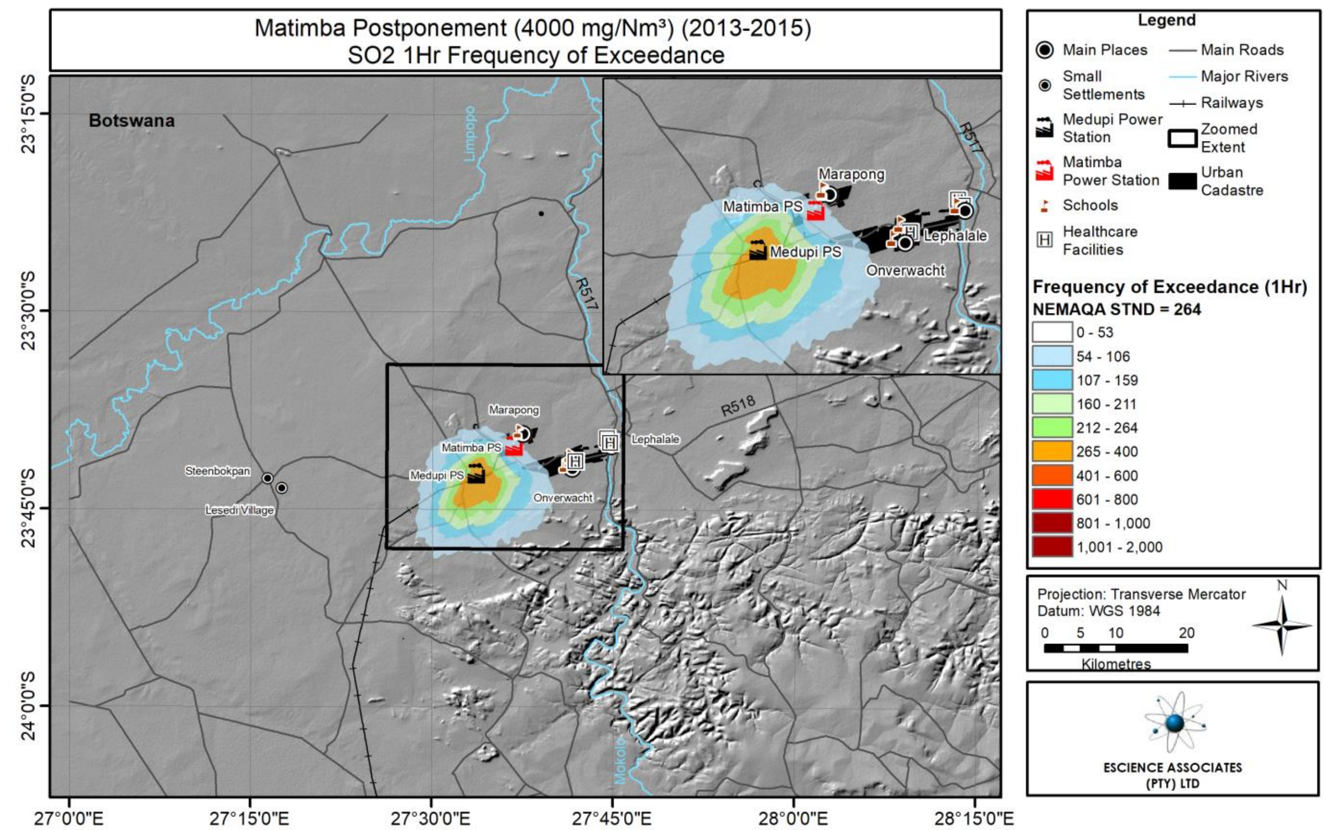
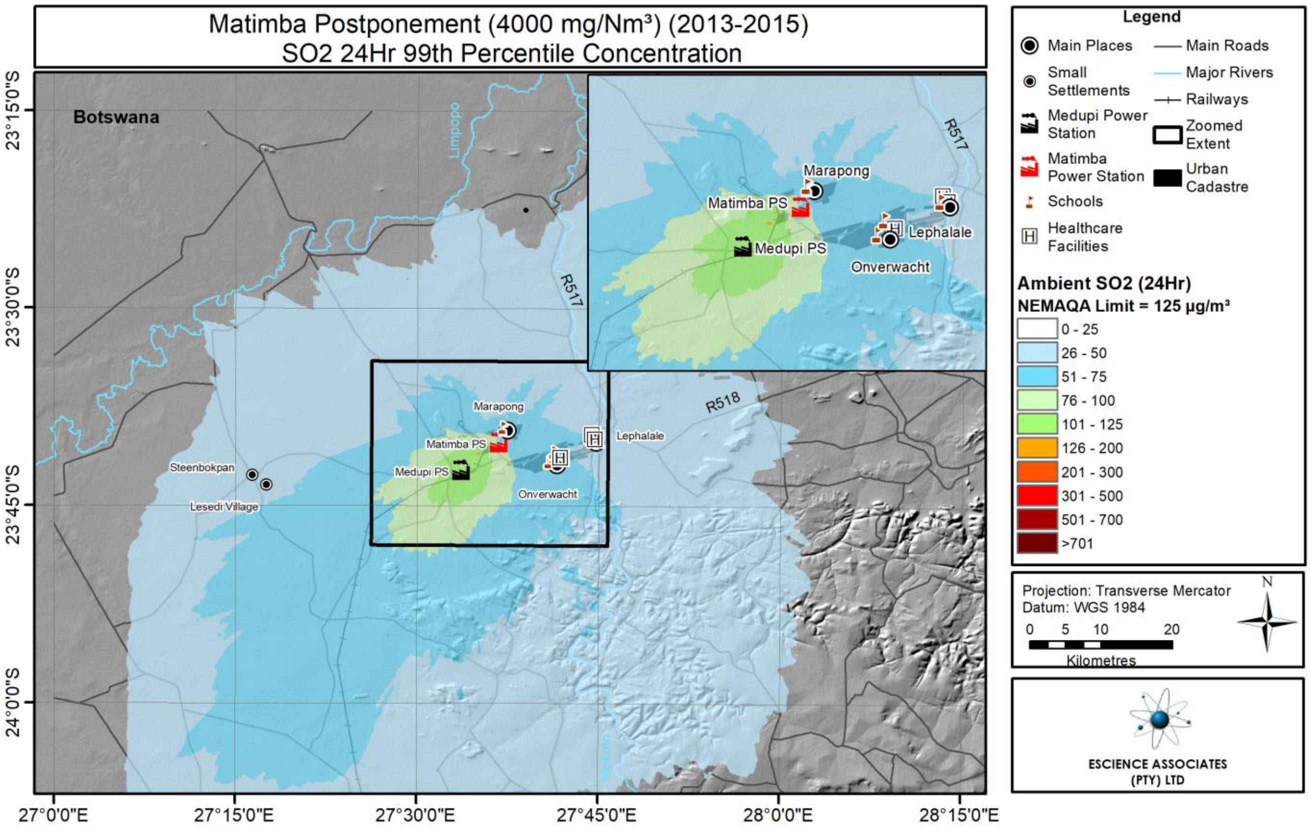


Figure 5-4: Predicted 99th Percentile hourly ambient SO_2 concentrations (above) and hourly FOEs (below) for Matimba Power Station at the requested postponement emission rates of 4000 mg/Nm³ (2013-2015)



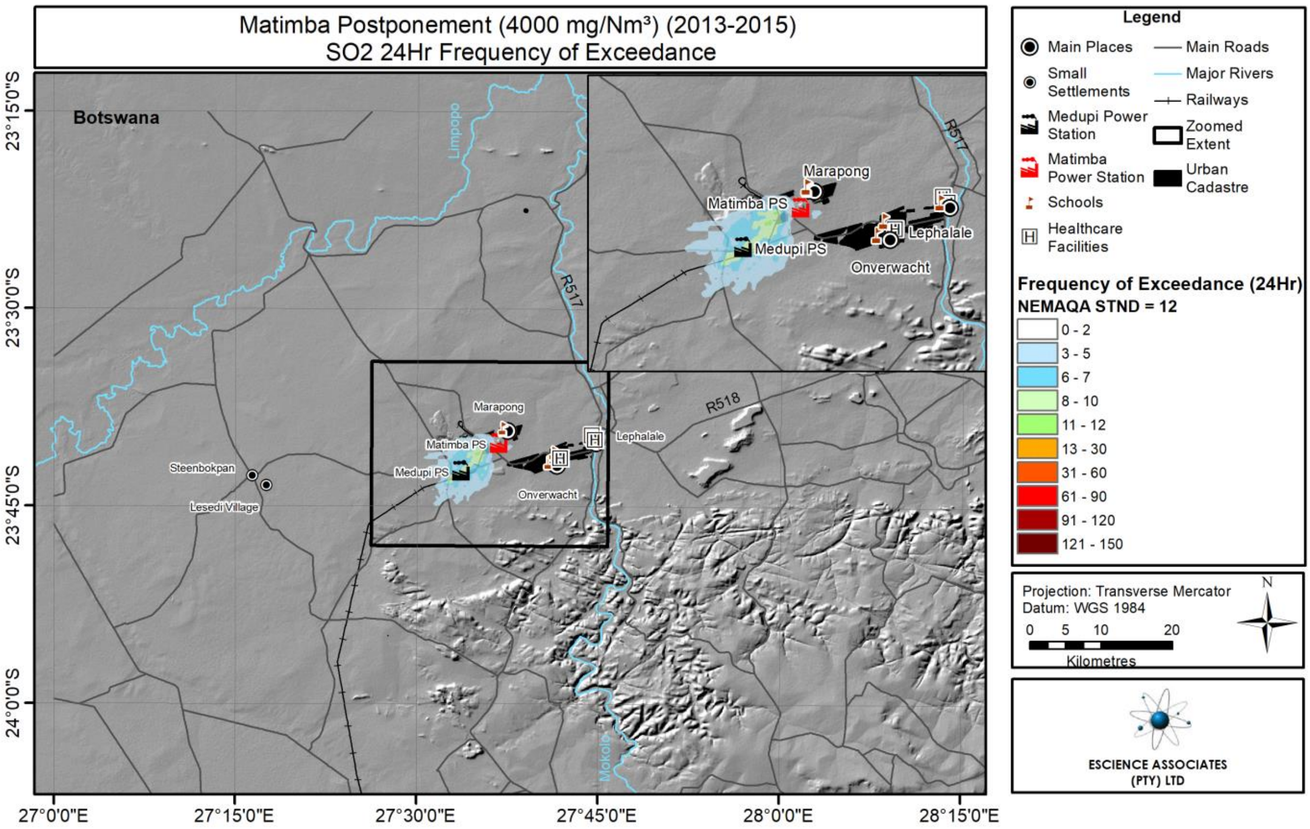


Figure 5-5: Predicted 99th Percentile daily ambient SO_2 concentrations (above) and daily FOEs (below) for the Matimba Power Station at the requested postponement emission rates of 4000 mg/Nm^3 (2013-2015)

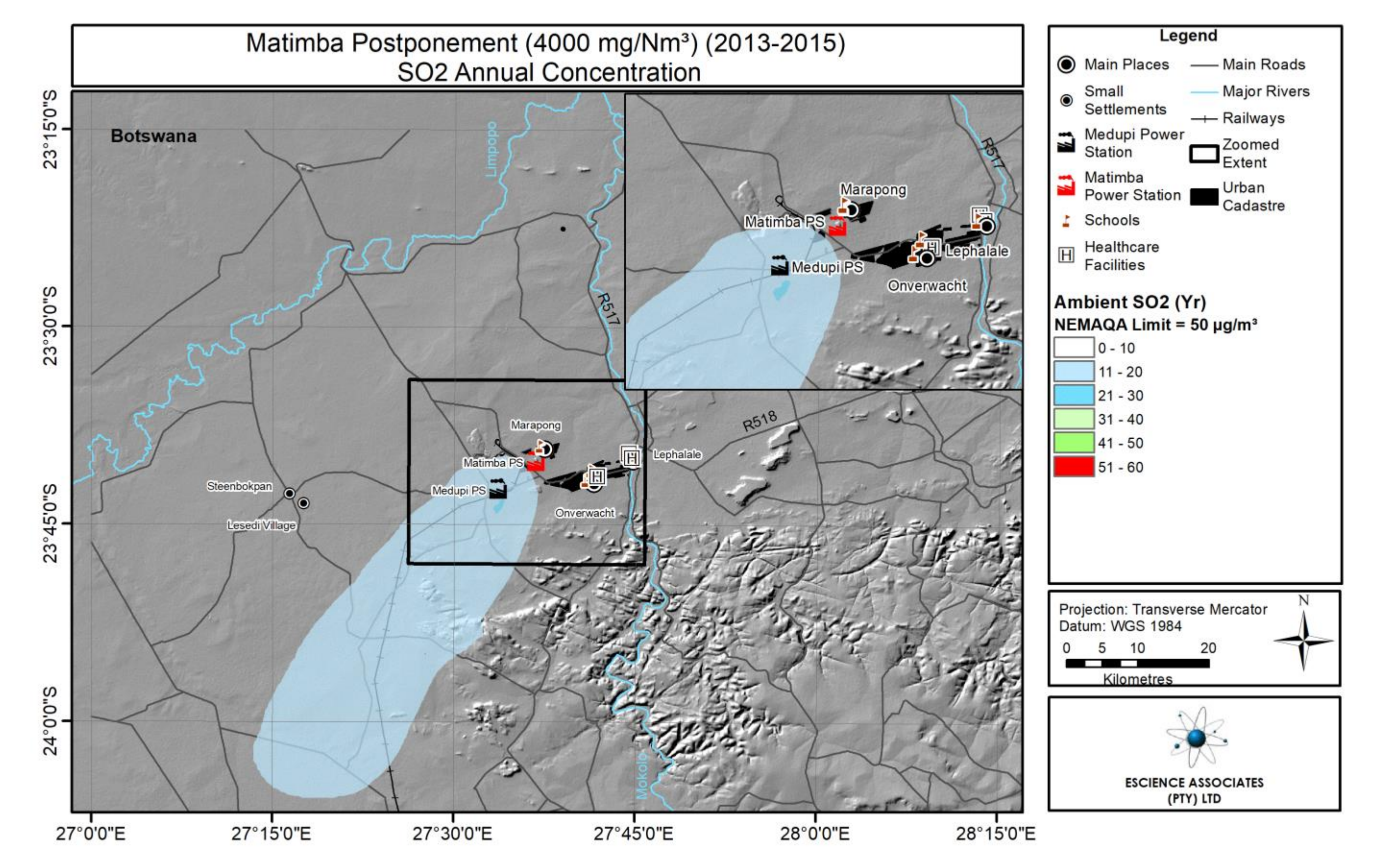


Figure 5-6: Predicted Annual Average ambient SO_2 concentrations for the Matimba Power Station at the requested postponement emission rates of 4000 mg/Nm^3 (2013-2015)

5.1.3 PREDICTED AMBIENT SO_2 CONCENTRATIONS FOR MEDUPI POWER STATION ONLY AT EXPECTED EMISSION RATES

Medupi has only one generating unit currently in commission (Unit 6). However, it was decided to model the power station with expected emission rates for when all 6 units were operational. It must be noted that this scenario will only occur for two years at most, the two years between the time the last unit becomes operational and the first unit's FGD is commissioned. This is expected to be between June 2019 and August 2021, based on the current commissioning schedule.

The resultant predicted ambient hourly and daily SO_2 concentrations are shown in Figure 5-7 and Figure 5-8. It can be seen from the figures that the predicted concentrations exceed the NAAQS SO_2 limit values for both hourly and daily averaging periods. The predicted FOE will exceed the allowable FOE, again for both the hourly and daily averaging periods, implying non-compliance with the NAAQS for SO_2. These areas of predicted non-compliance are seen to lie to the southwest of the Medupi Power Station. For the populated areas of Marapong, Lephalale and Onverwacht there is full compliance for the hourly and daily NAAQS averaging periods. The predicted average annual SO_2 concentration is seen in Figure 5-9. There are no predicted concentration exceedances for the annual NAAQS limit, and subsequently Medupi Power Station with all six units operating at expected emission rates is predicted to be in full compliance for annual concentrations. For the annual NAAQS standard, full compliance is seen in the populated areas of Marapong, Lephalale and Onverwacht.

5.1.4 PREDICTED AMBIENT SO_2 CONCENTRATIONS FOR MEDUPI POWER STATION ONLY AT THE REQUESTED EMISSIONS LIMIT (4000 MG/NM^3)

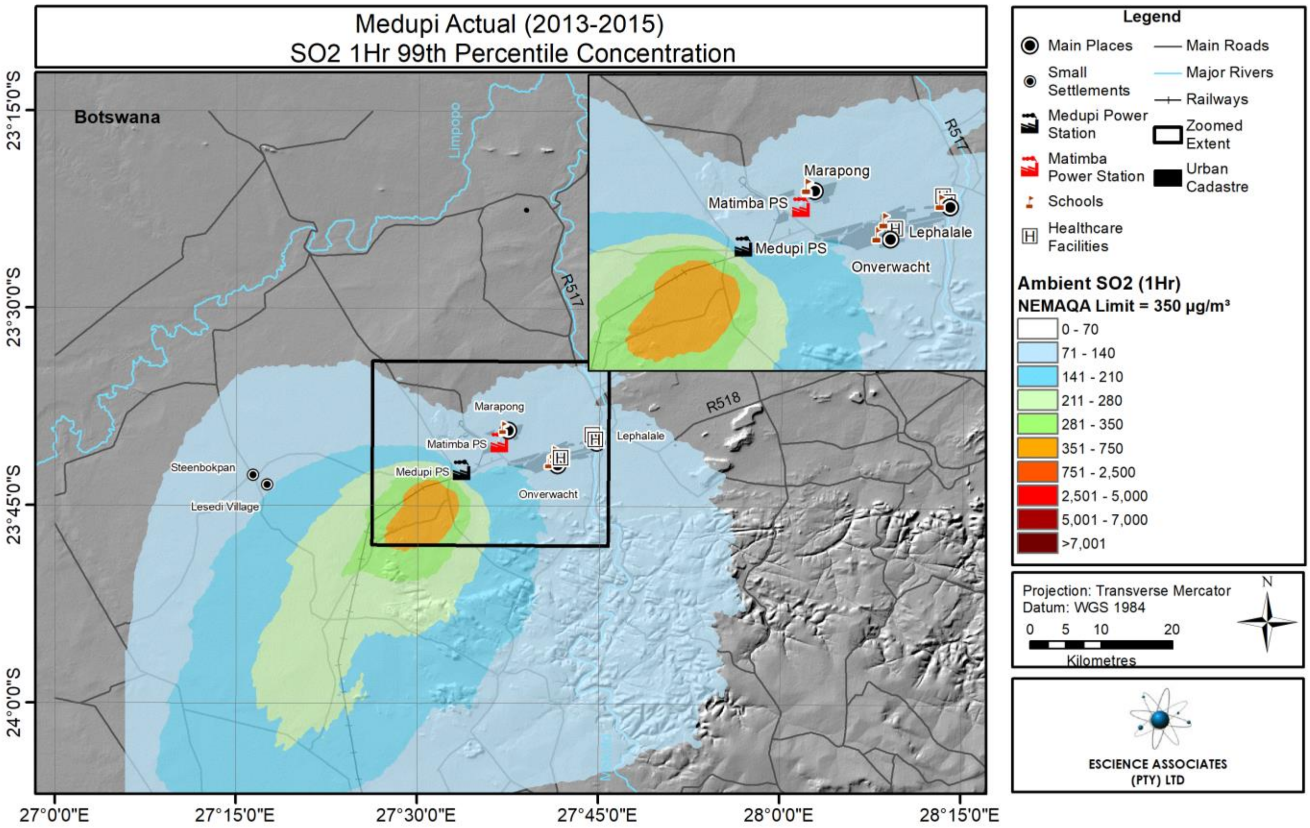
This scenario was modelled to indicate the absolute worst case scenario whereby all six units at Medupi are operating at 4000 mg/Nm^3. This scenario has a high probability of never occurring. With Medupi operating at the requested emissions limit of 4000 mg/Nm^3 it is predicted that there is non-compliance with the hourly and daily ambient SO_2 standards to the immediate south-west of the Medupi Power Station (Figure 5-10 and Figure 5-11). The extent of the area in non-compliance is large (estimated 40 km^2 and 20 km^2 for the hourly and daily averaging periods respectively) and again this area extends southwestwards from the Medupi Power Station. For the populated areas of Marapong, Lephalale and Onverwacht there is full compliance for the hourly and daily NAAQS averaging periods.

The predicted annual average SO_2 concentrations for the Medupi Power Station at the requested SO_2 emissions limit are still less than the NAAQS limit value as there are subsequently no exceedances predicted (Figure 5-12). For the annual NAAQS standard, full compliance is seen in the populated areas of Marapong, Lephalale and Onverwacht.

5.1.5 PREDICTED AMBIENT SO_2 CONCENTRATIONS FOR MEDUPI WITH FGD (AT 500 MG/NM^3)

The Medupi Power Station's FGD units will be commissioned sequentially, whereby one unit will be switched to FGD one at a time. The first FGD unit will be commissioned around two years after the last unit becomes operational, according to the current schedule. It is expected that SO_2 emissions will average around 400 mg/Nm^3 once FGD has been installed, but the limit value is 500 mg/Nm^3. It was assumed that FGD was installed on all 6 generating units. The reality is somewhat more complicated where FGD is planned to be installed progressively on each generating unit 6 years after the unit is commissioned. Emissions will be staggered as a result and realized progressively as opposed to the full installation modelled here.

Nonetheless the modelled scenario is instructive in highlighting the significant improvements in ambient air quality that will occur once FGD is fully installed at Medupi Power Station. The predicted ambient SO_2 concentrations for this emissions scenario are shown in Figure 5-13 and Figure 5-14 where the improvement in ambient air quality compared to the scenario with Medupi Power Station at expected emission levels before FGD (Figure 5-10 and Figure 5-11) is installed is immediately evident. There are no predicted exceedances of the NAAQS SO_2 limit value for any of the averaging periods, hourly, daily or annual. As such there are no FOE for the averaging periods and full compliance with the NAAQS is predicted under this emissions scenario. As seen with the previous scenarios, the populated areas of Marapong, Lephalale and Onverwacht show to be in full compliance of the hourly, daily and annual NAAQS averaging periods.



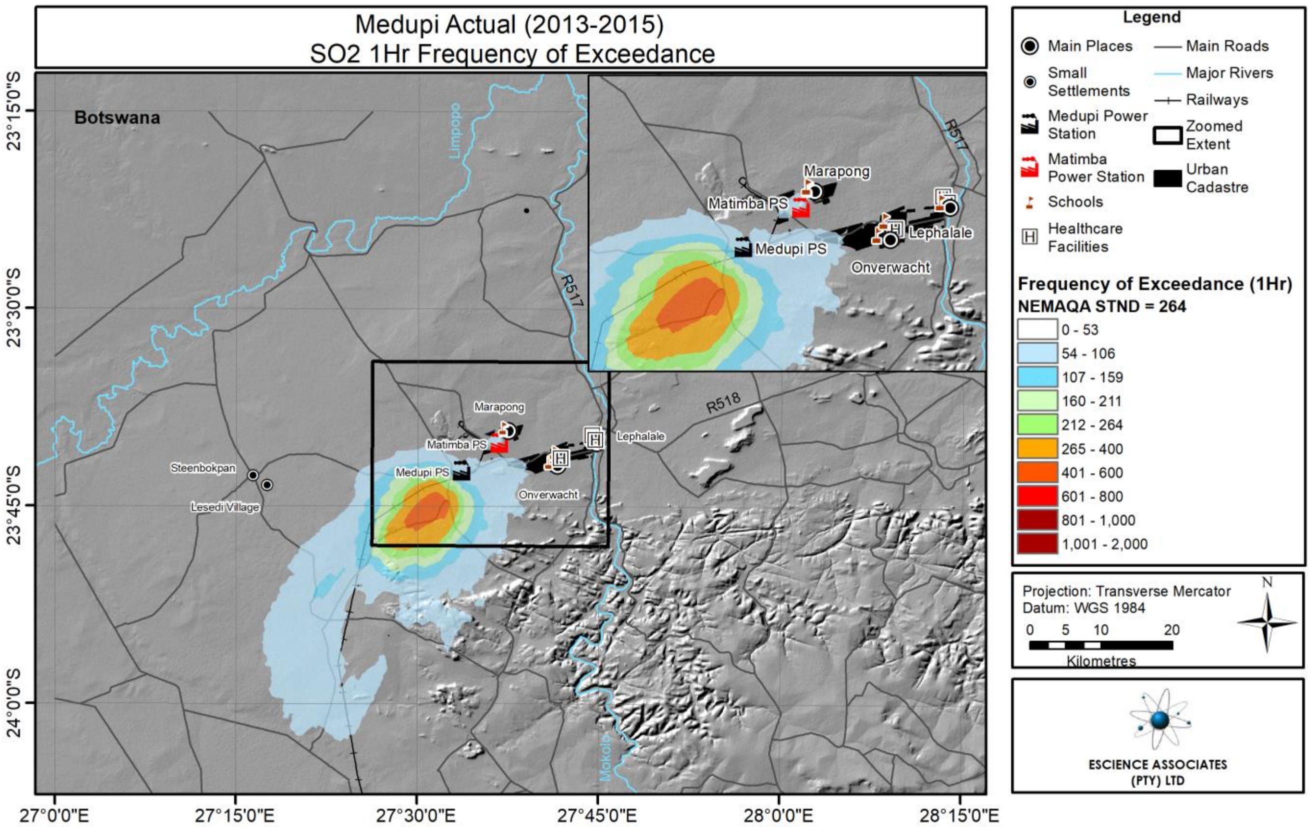


Figure 5-7:Predicted 99th Percentile hourly ambient SO_2 concentrations (above) and hourly FOEs (below) for Medupi Power Station at expected emission rates (2013-2015)

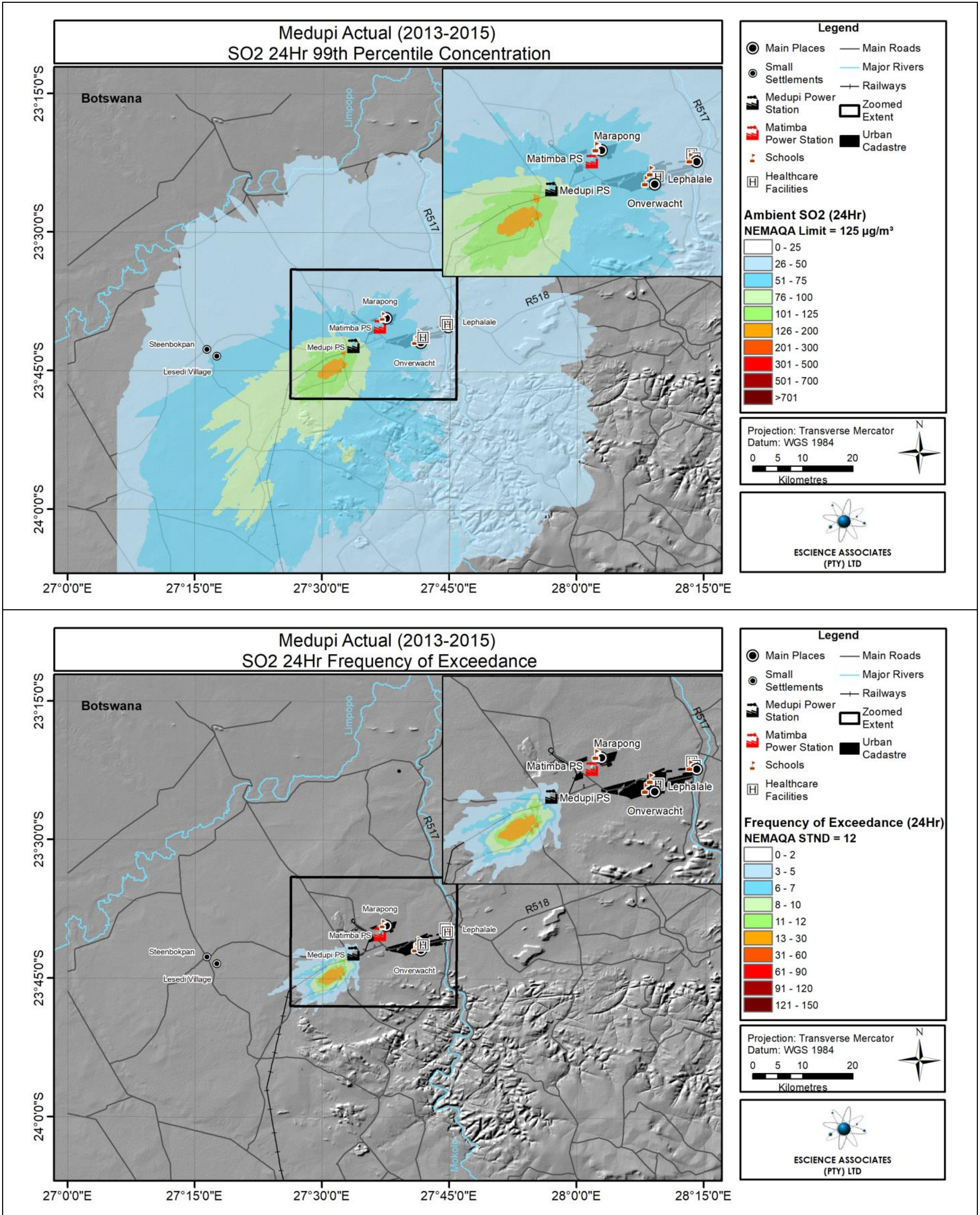


Figure 5-8: Predicted 99th Percentile daily ambient SO_2 concentrations (above) and daily FOEs (below) for Medupi Power Station at expected emission rates (2013-2015)

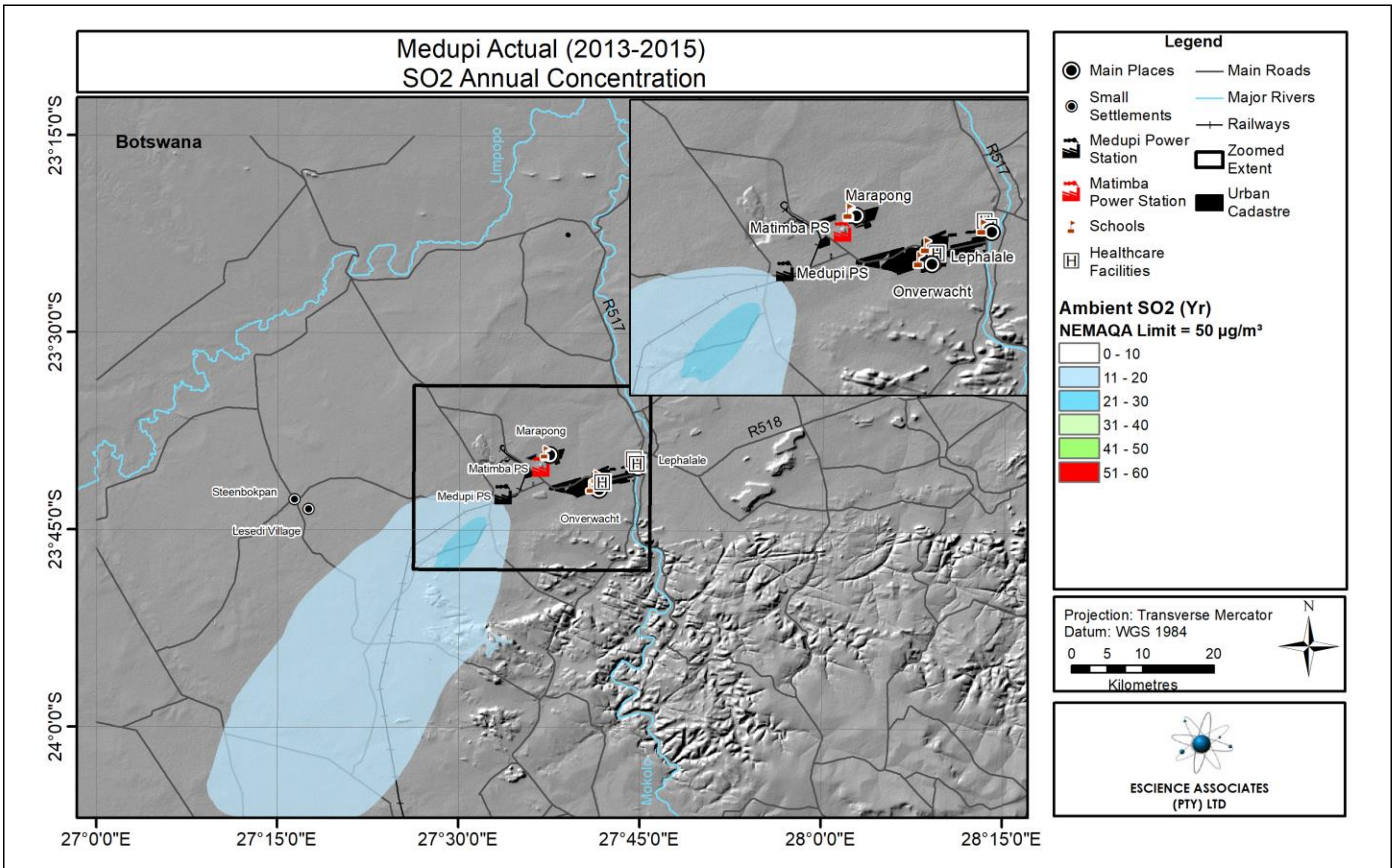


Figure 5-9: Predicted Annual Average (above) ambient SO_2 concentrations for the Medupi Power Station at the expected emission rates (2013-2015)

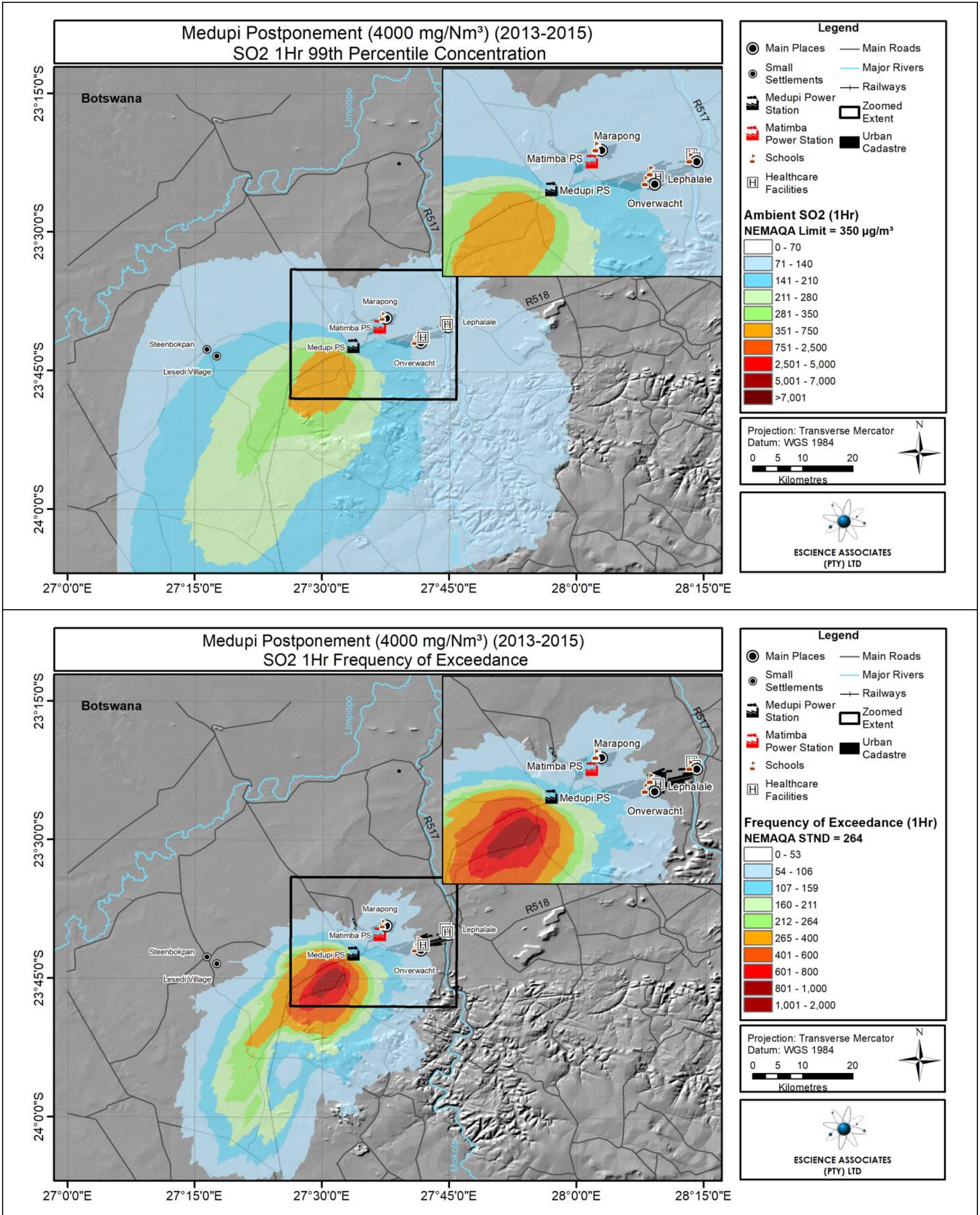


Figure 5-10: Predicted 99th Percentile hourly ambient SO_2 concentrations (above) and hourly FOEs (below) for the Medupi Power Station at the requested postponement emission rates of 4000 mg/Nm³ (2013-2015)

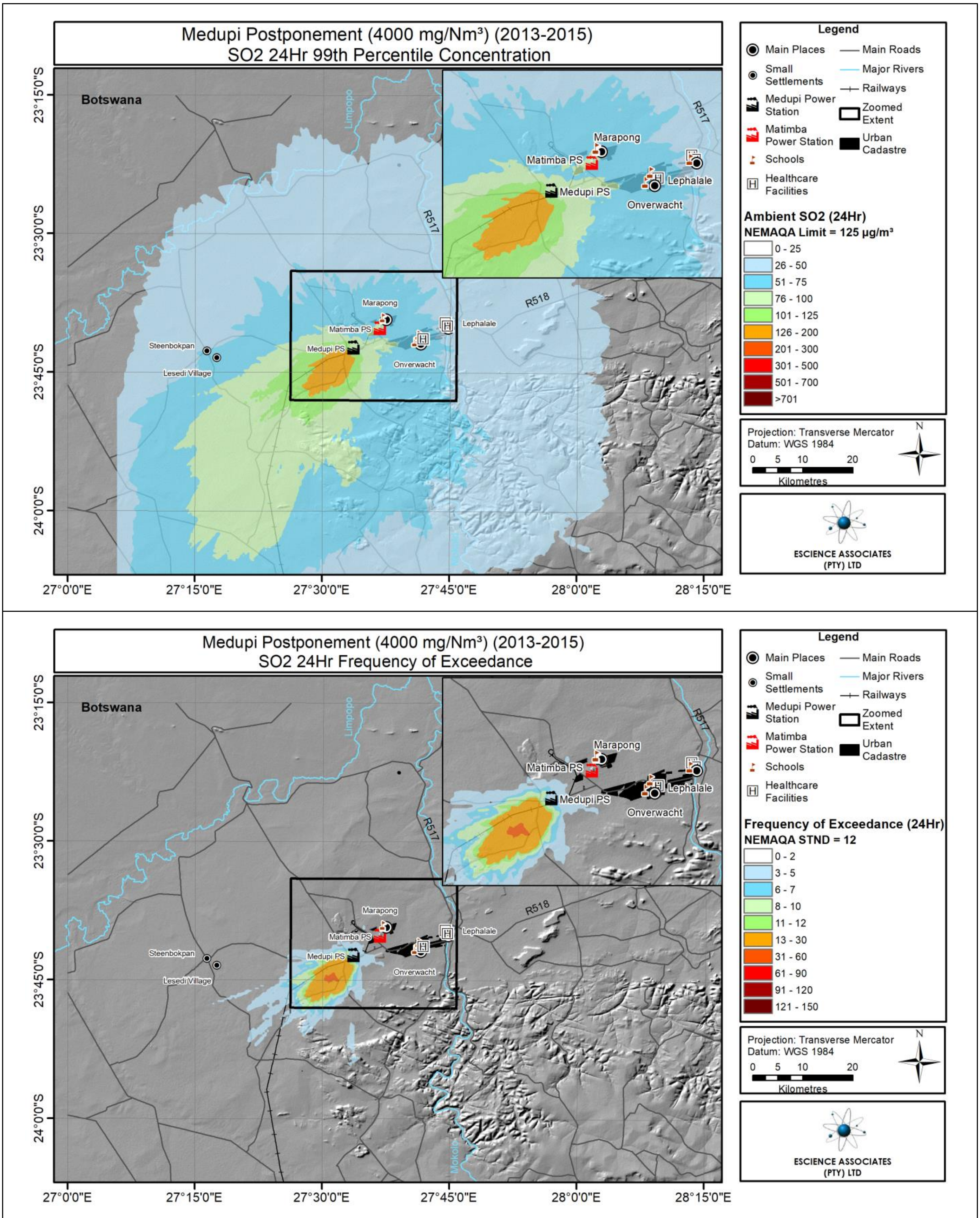


Figure 5-11: Predicted 99th Percentile daily ambient SO_2 concentrations (above) and daily FOEs (below) for the Medupi Power Station at the requested postponement emission rates at 4000 mg/Nm³ (2013-2015)

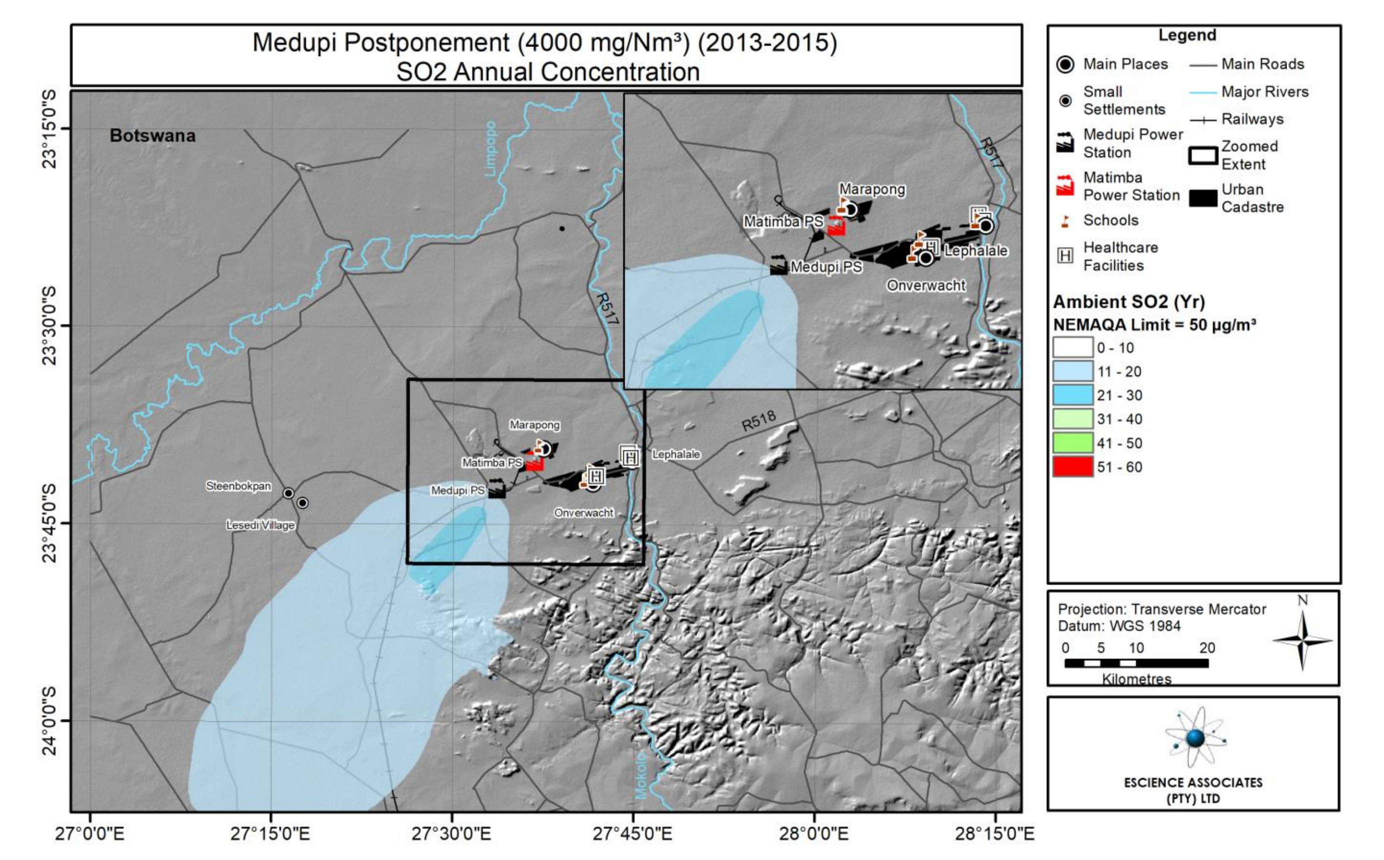


Figure 5-12: Predicted Annual Average ambient SO_2 concentrations for Medupi Power Station at the requested postponement emission rates of 4000 mg/Nm³ (2013-2015)

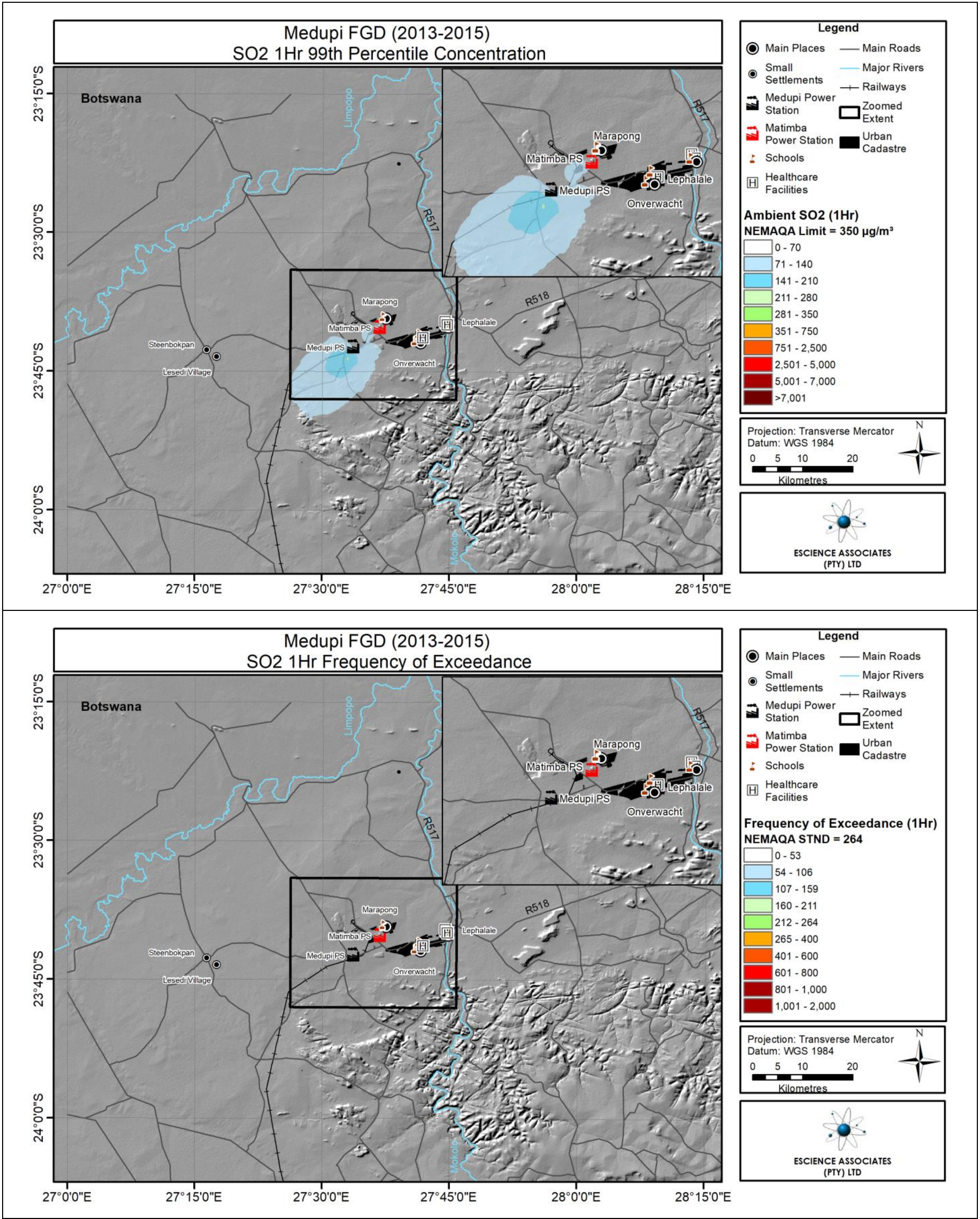
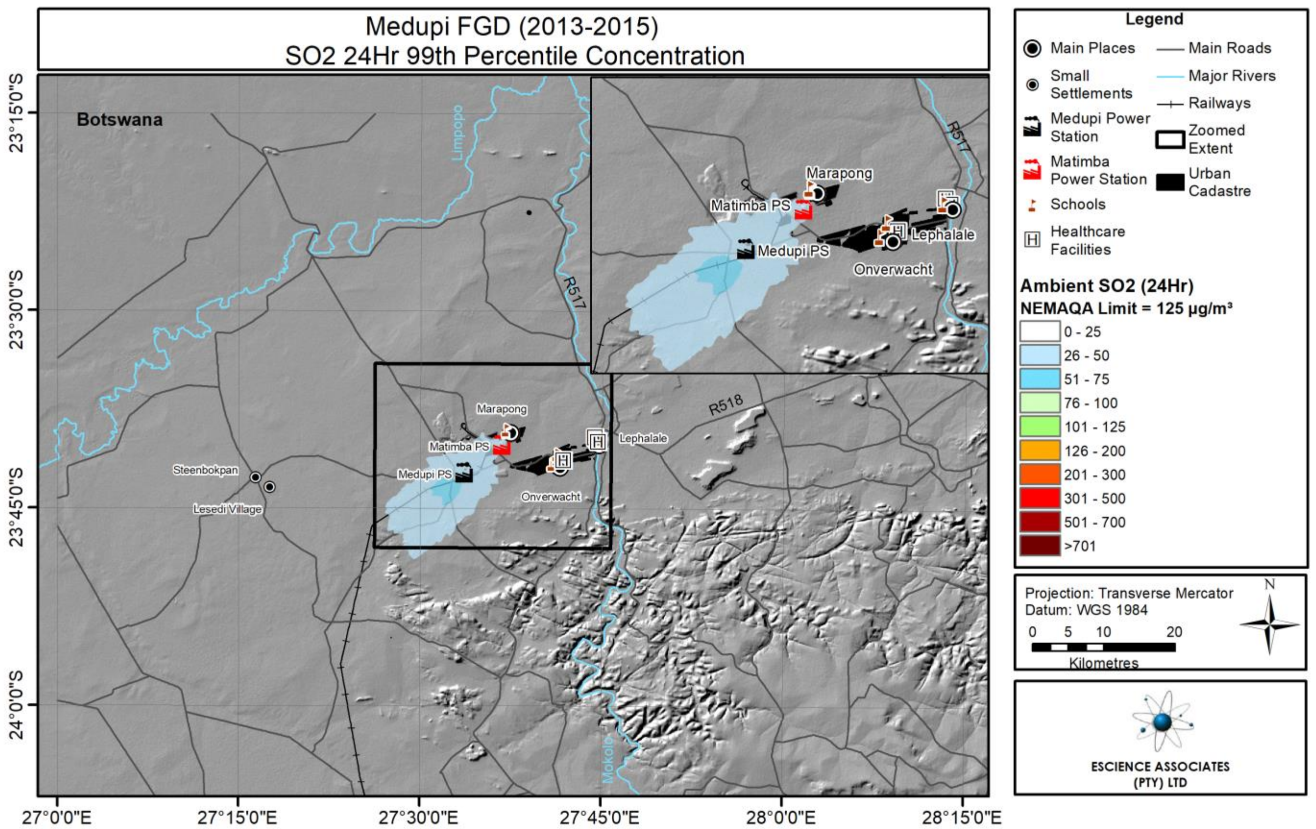


Figure 5-13: Predicted 99th Percentile hourly ambient SO_2 concentrations (above) and hourly FOEs (below) for Medupi Power Station at the FGD emission rates of 500 mg/Nm³ (2013-2015)



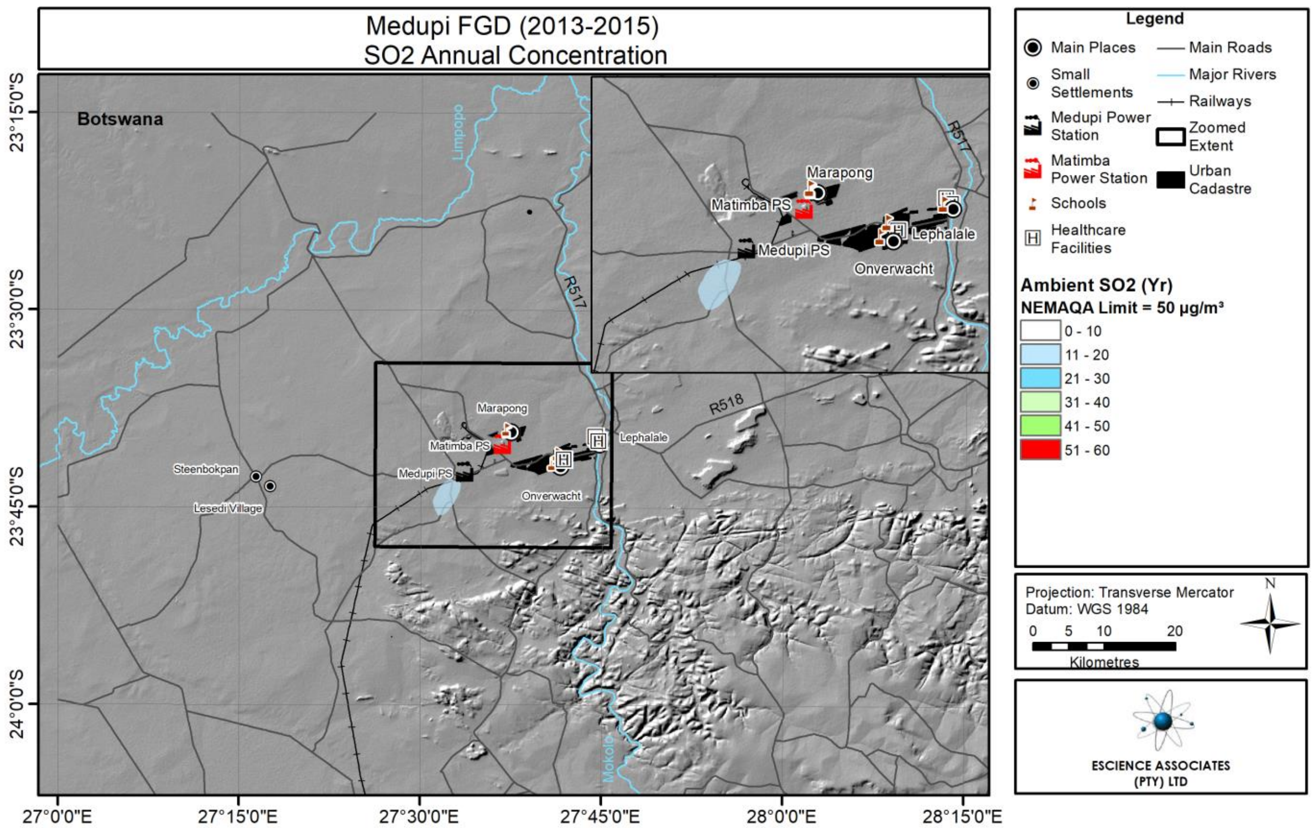


Figure 5-14: Predicted 99th Percentile daily (top) and yearly (bottom) ambient SO_2 concentrations for the Medupi Power Station with the FGD emission rates at 500 mg/Nm^3 (2013-2015)

5.1.6 PREDICTED AMBIENT SO_2 CONCENTRATIONS FOR MATIMBA ACTUAL AND MEDUPI EXPECTED COMBINED

The Matimba Power Station's actual emissions rates and Medupi Power Station's expected emission rates (with all 6 units modelled) was modelled to determine likely ambient concentrations for the two years (June 2019 to August 2021) between the last unit at Medupi Power Station going online and the first unit's FGD being commissioned. The predicted ambient SO_2 concentrations of this scenario are shown in Figure 5-15 and Figure 5-16.

A large area to the southwest of Medupi Power Station is seen to have elevated SO_2 concentrations and this for both the hourly and daily averaging periods. This area also shows exceedance of the allowable number of exceedances for both averaging periods, and subsequently both averaging periods showing non-compliance with NAAQS. The predicted annual SO_2 concentration is not expected to exceed the NAAQS limit (Figure 5-17) although there is an area to the southwest of Medupi where the predicted annual average is between 31 and 40 $\mu g/m^3$ (the limit value is 50 $\mu g/m^3$). As seen with the previous scenarios, the populated areas of Marapong, Lephalale and Onverwacht show to be in full compliance of the hourly, daily and annual NAAQS averaging periods.

5.1.7 PREDICTED AMBIENT SO_2 CONCENTRATIONS FOR MATIMBA AT THE REQUESTED SO_2 LIMIT (AT 4000 MG/NM^3) PLUS MEDUPI WITH FGD (AT 500 MG/NM^3)

Again, it must be noted that this scenario will be highly unlikely due to the fact that the Matimba Power Station will not be emitting at 4000 mg/Nm^3 on a continuous basis and therefore is an over estimation of the likely scenario. For the Matimba Power Station at the requested emissions limit (of 4000 mg/Nm^3) plus Medupi with FGD (at 500 mg/Nm^3) the hourly and daily predicted ambient concentrations are shown in Figure 5-18 and Figure 5-19.

It can be seen from these figures that there is a considerable improvement in predicted ambient air quality under this emissions scenario compared to the previous. There is still a large area to the southwest of the two power stations with elevated SO_2 concentrations but area of these higher concentrations is smaller when compared to the previous. When this scenario is compared against Matimba Power Station's actual emissions rates and Medupi Power Station's expected emission rates (with all 6 units modelled), this scenario results in a smaller area of non-compliance. For the annual average concentrations, the maximum predicted concentrations of 11-30$\mu g/m^3$ is well below the NAAQS limit value of 50$\mu g/m^3$ and accordingly no FOE is predicted. As seen with the previous scenarios, the populated areas of Marapong, Lephalale and Onverwacht show to be in full compliance of the hourly, daily and annual NAAQS averaging periods.

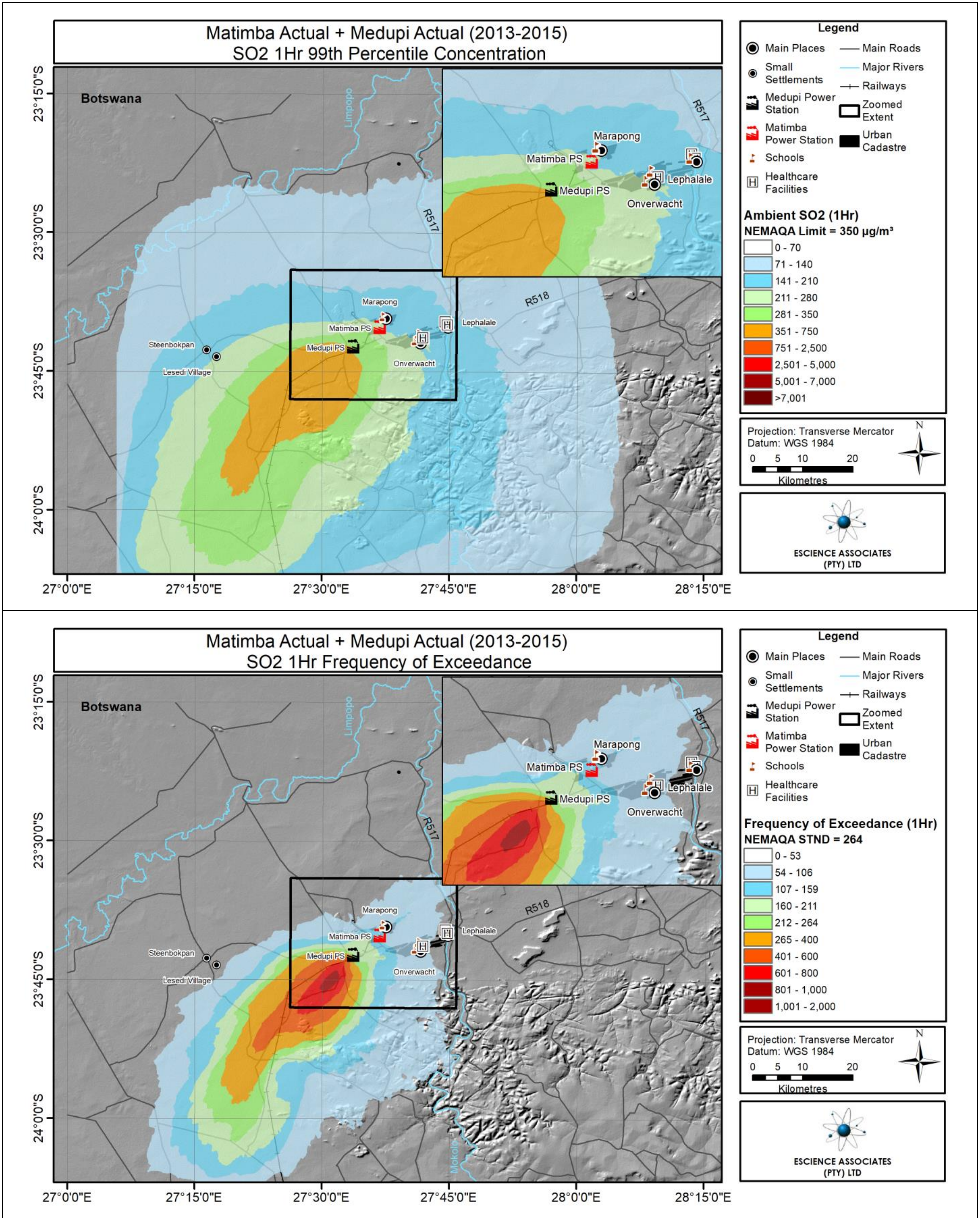


Figure 5-15: Predicted 99th Percentile hourly ambient SO_2 concentrations (above) and hourly FOEs (below) for Matimba Power Station at actual emission rates and the Medupi Power Station at expected emission rates (2013-2015)

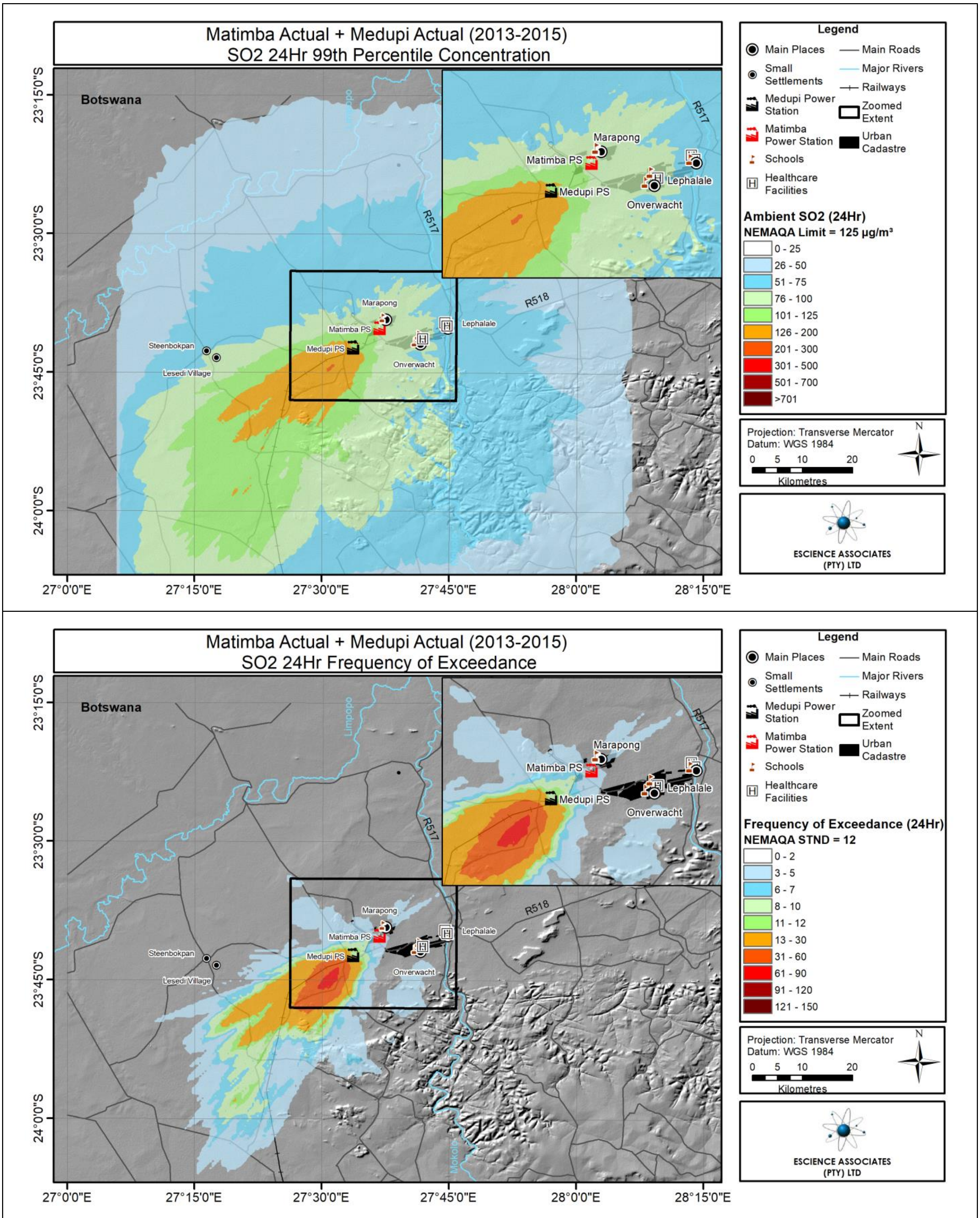


Figure 5-16: Predicted 99th Percentile daily ambient SO_2 concentrations (above) and daily FOEs (below) for the Matimba Power Station at actual emission rates and the Medupi Power Station at expected emission rates (2013-2015)

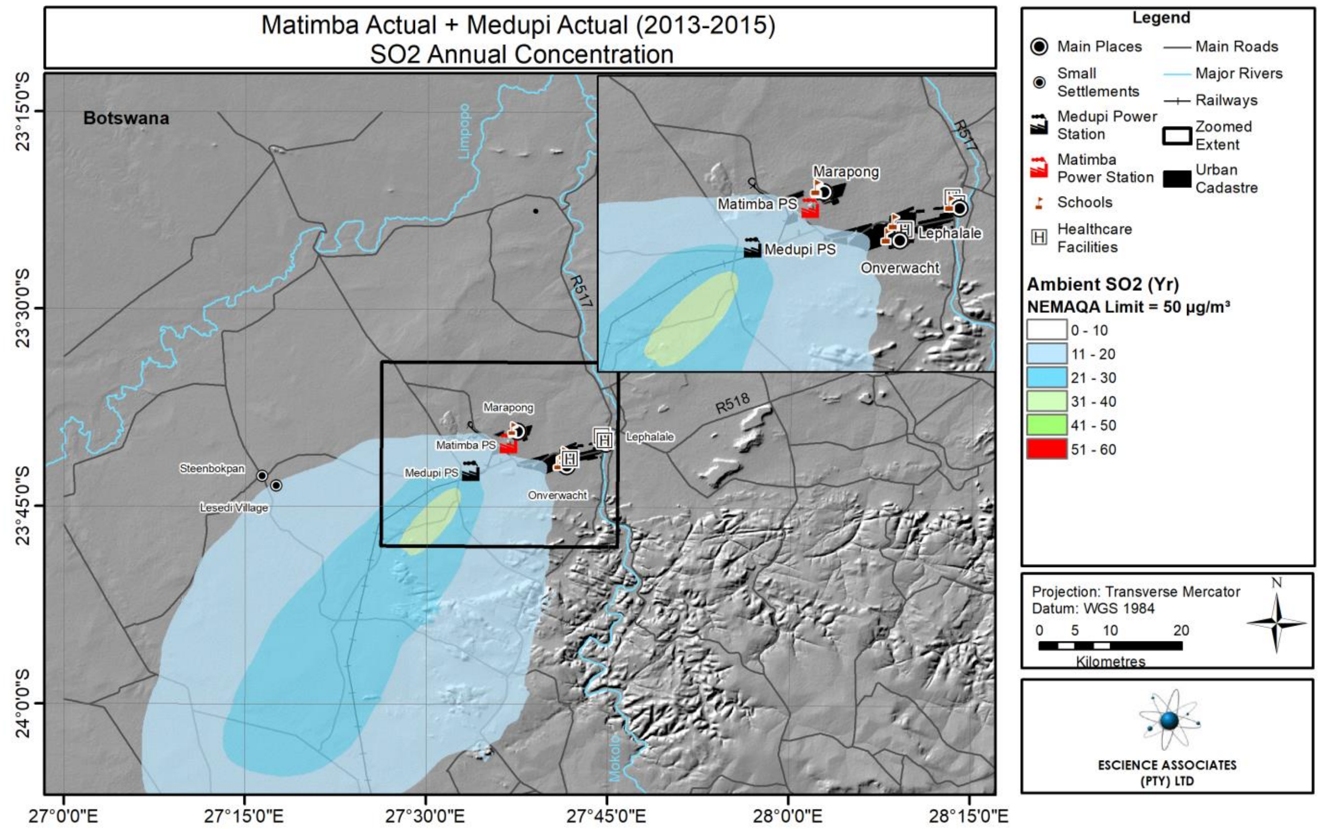
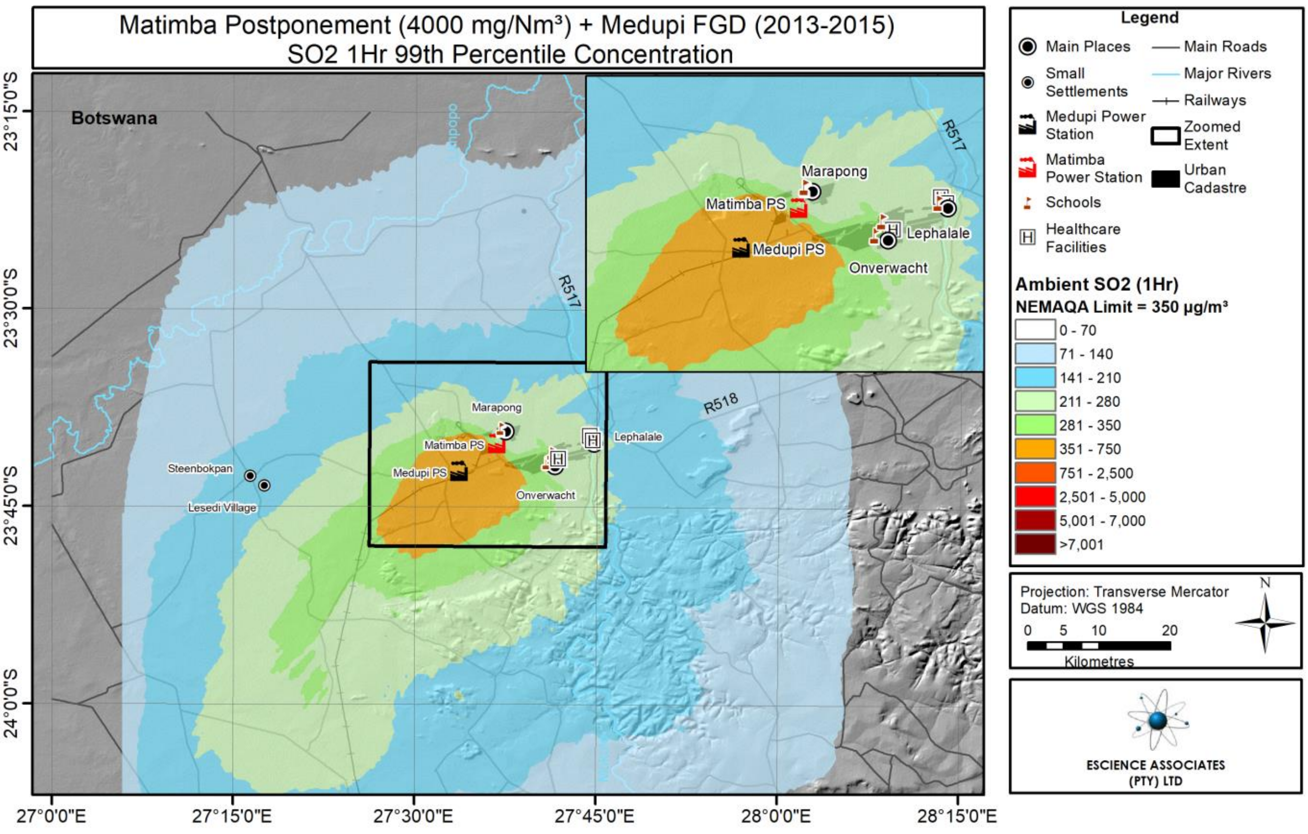


Figure 5-17: Predicted Annual Average ambient SO_2 concentrations for the Matimba Power Station at actual emission rates and the Medupi Power Station at expected emission rates (2013-2015)



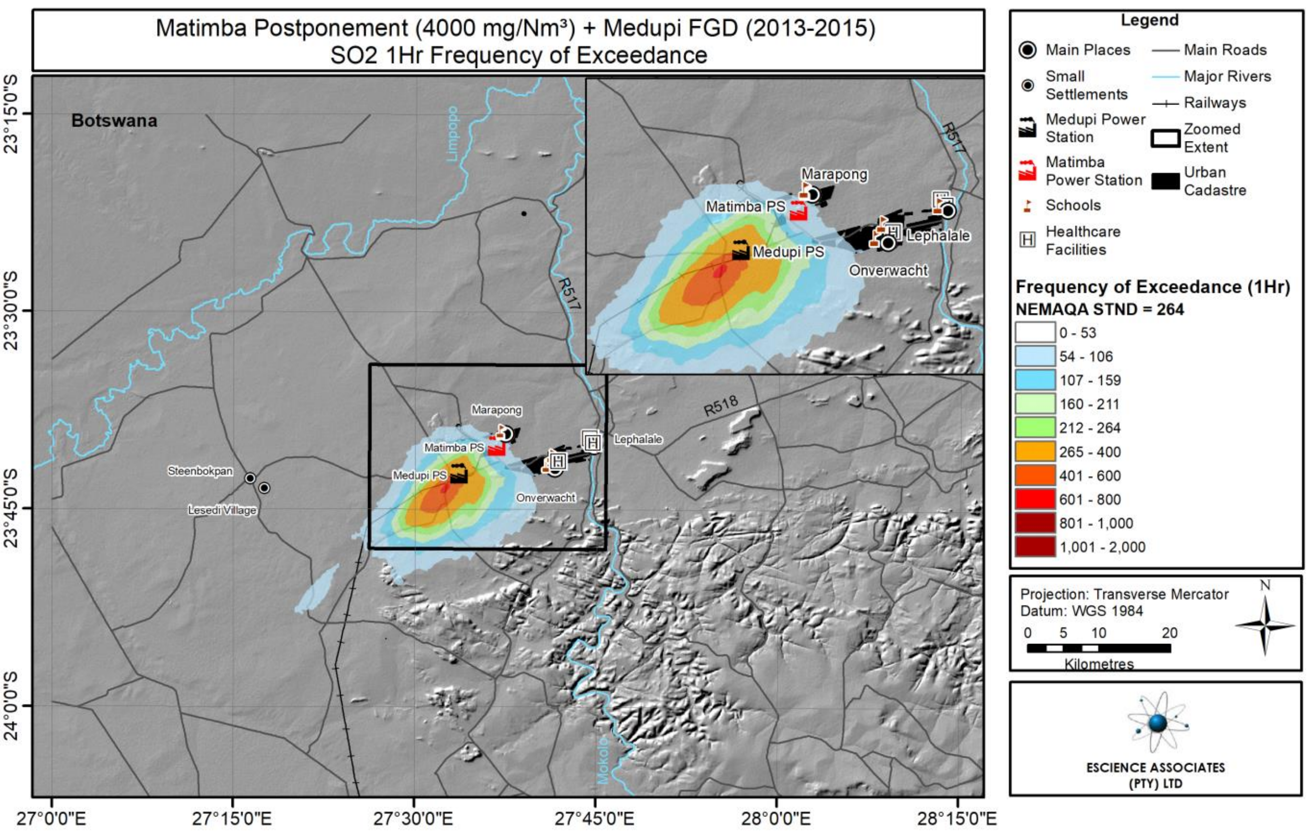
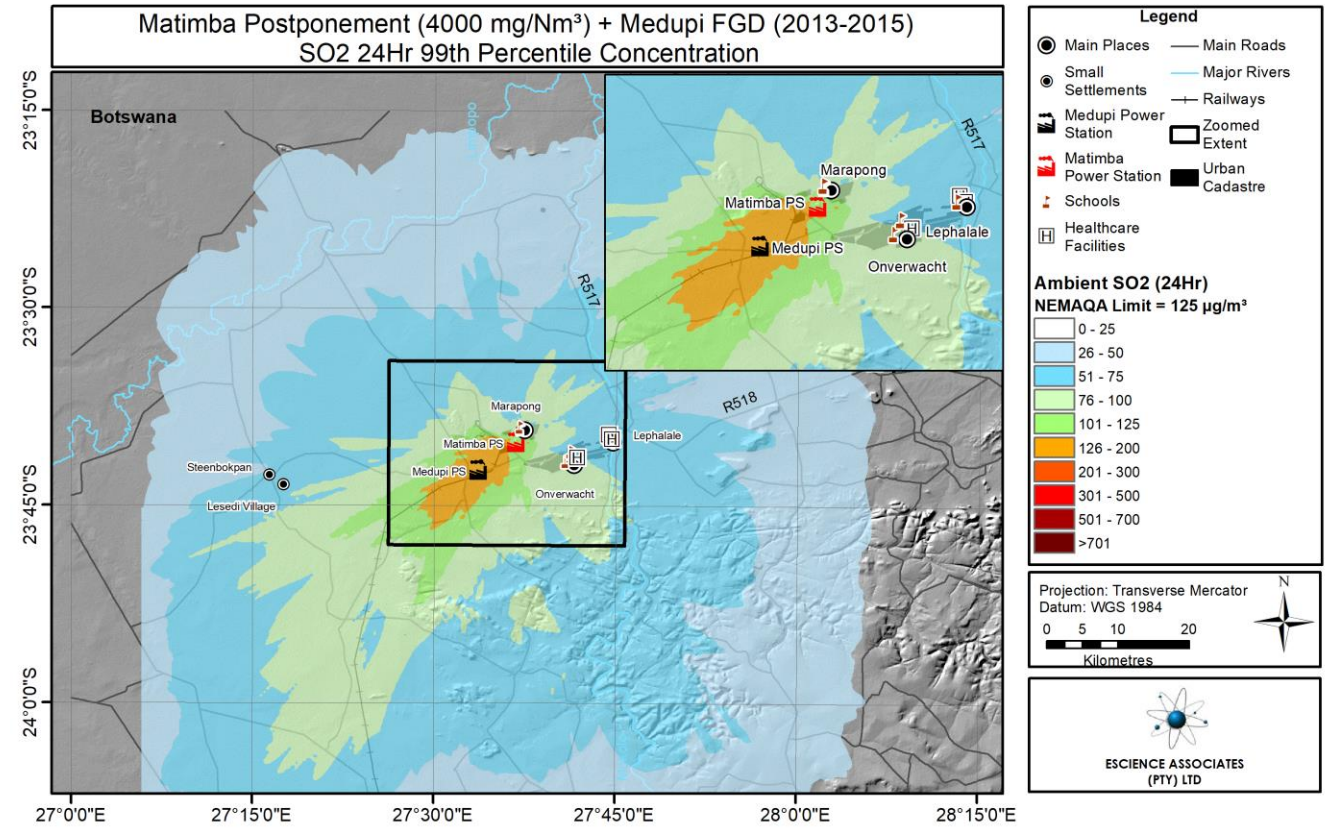


Figure 5-18: Predicted 99th Percentile hourly ambient SO_2 concentrations (above) and hourly FOEs (below) for the Matimba Power Station at the requested postponement emission rates (of 4000 mg/Nm³) and the Medupi Power Station at the FGD emission rates (of 500 mg/Nm³) (2013-2015)



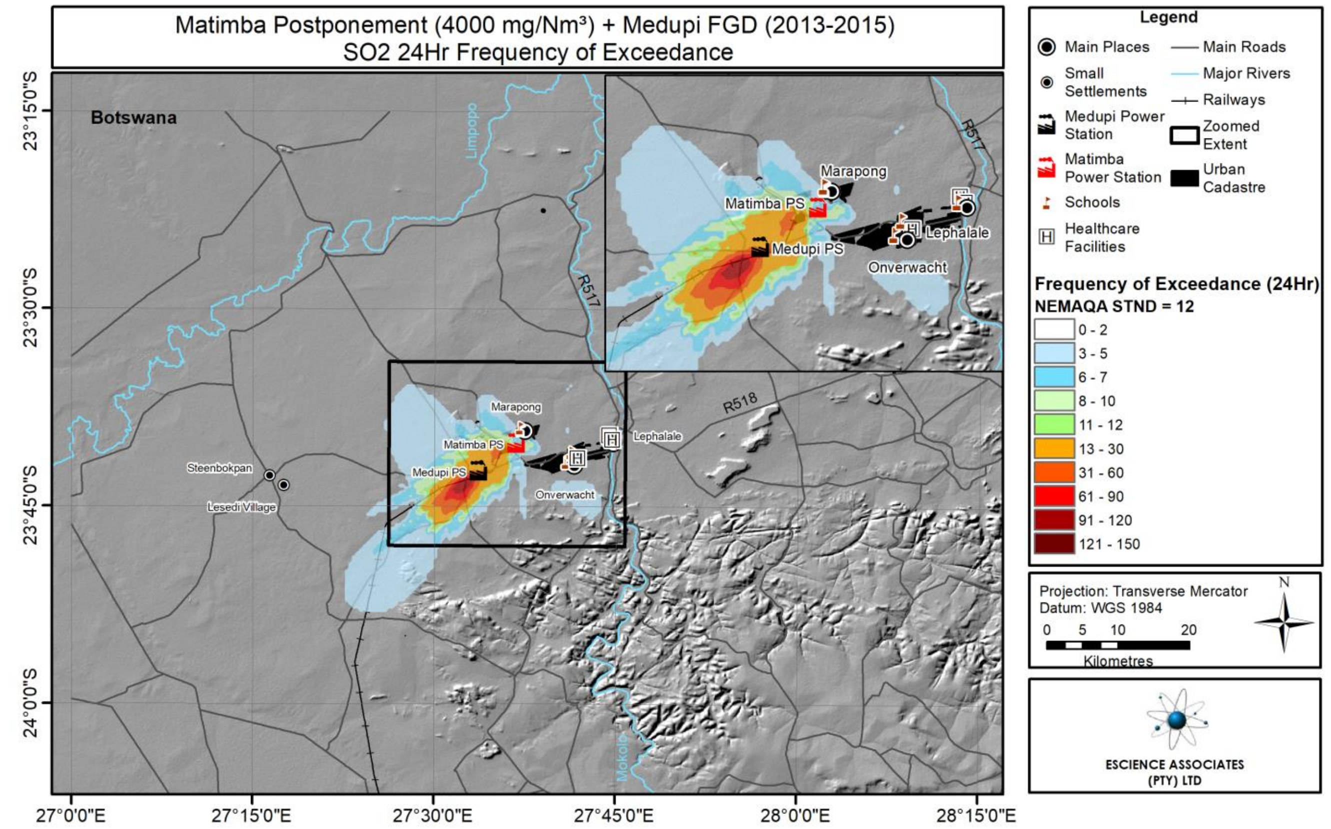


Figure 5-19: Predicted 99th Percentile daily ambient SO_2 concentrations (above) and daily FOEs (below) for the Matimba Power Station at the requested postponement emission rates (of 4000 mg/Nm³) and the Medupi Power Station at FGD emission rates (of 500 mg/Nm³) (2013-2015)

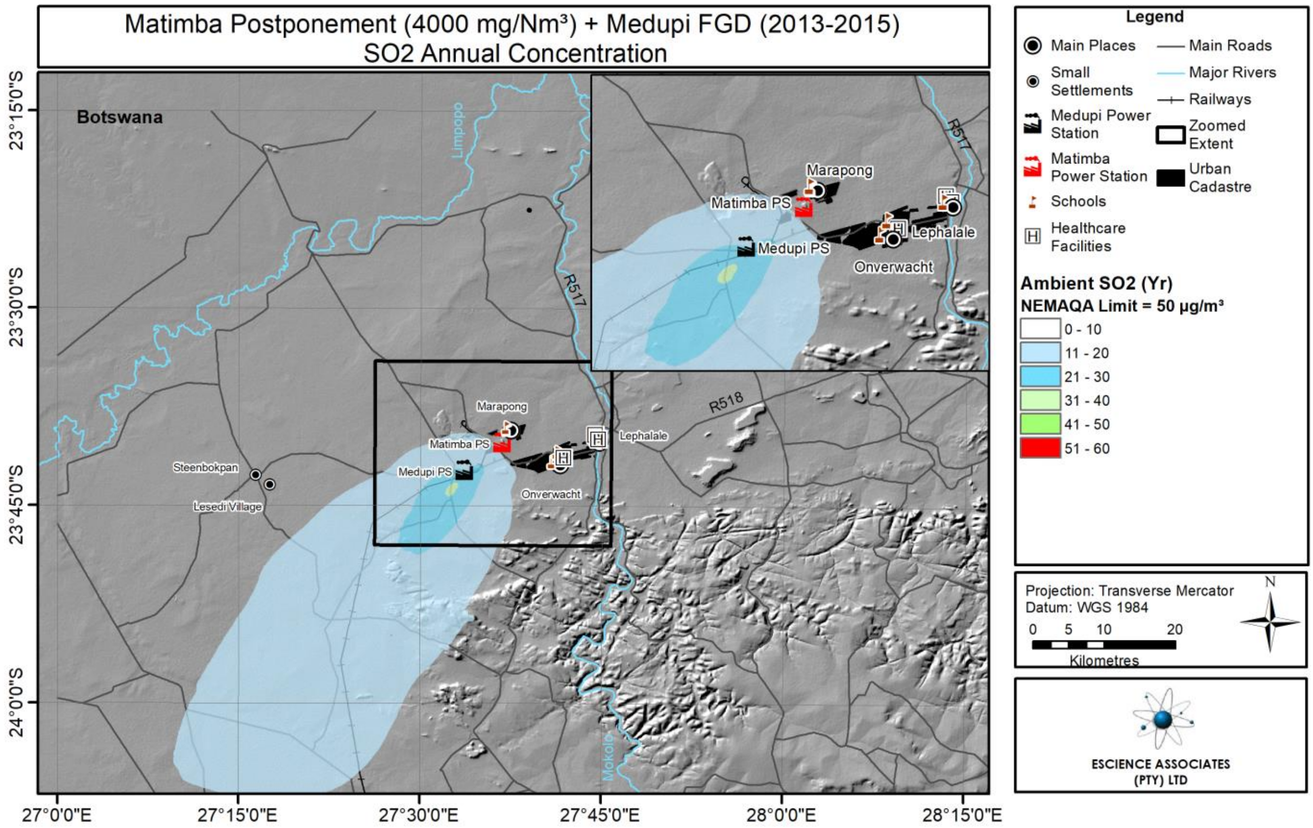


Figure 5-20: Predicted Annual Average ambient SO_2 concentrations for the Matimba Power Station at the requested postponement emission rates (of 4000 mg/Nm³) and the Medupi Power Station at FGD emission rates (of 500 mg/Nm³) (2013-2015)

5.1.8 PREDICTED AMBIENT SO_2 CONCENTRATIONS FOR MATIMBA AT THE REQUESTED SO_2 LIMIT PLUS MEDUPI AT THE REQUESTED SO_2 LIMIT (OF 4000 MG/NM^3)

The predicted ambient SO_2 concentrations with Matimba Power Station plus Medupi Power Station at the postponement limit emission rates for the hourly and daily averaging periods are shown in Figure 5-21 and Figure 5-22. A large part of the south-eastern side of the modelling domain is seen to have elevated SO_2 concentrations and this is seen for both the hourly and 24-hourly average concentrations. These areas of elevated SO_2 concentrations are in excess of the hourly and daily NAAQS SO_2 limit value of 350 and 125 $\mu g/m^3$ respectively. The predicted annual SO_2 average is predicted to not exceed the NAAQS limit and therefore is in full compliance (Figure 5-23). As seen with the previous scenarios, the populated areas of Marapong, Lephalale and Onverwacht show to be in full compliance of the hourly, daily and annual NAAQS averaging periods.

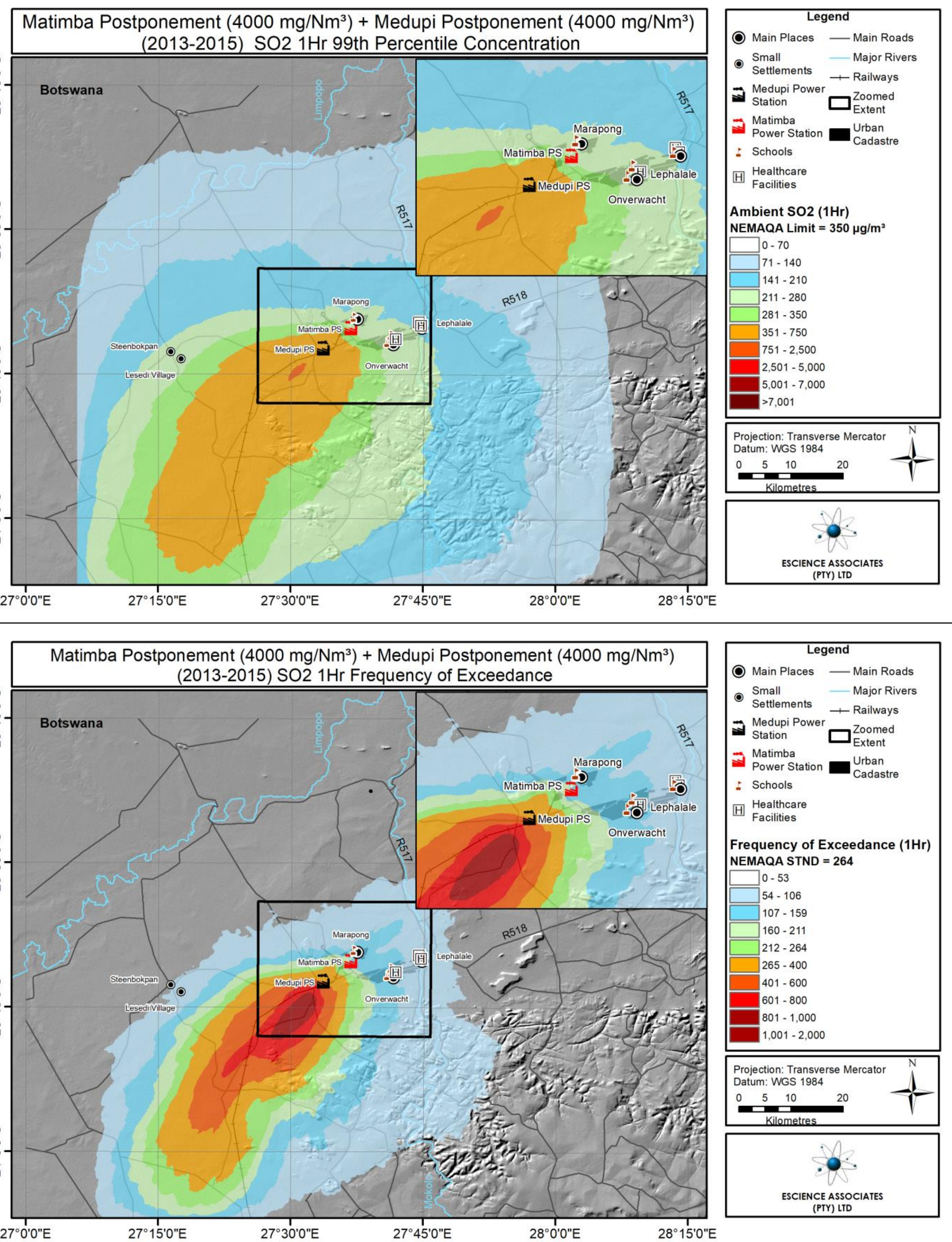
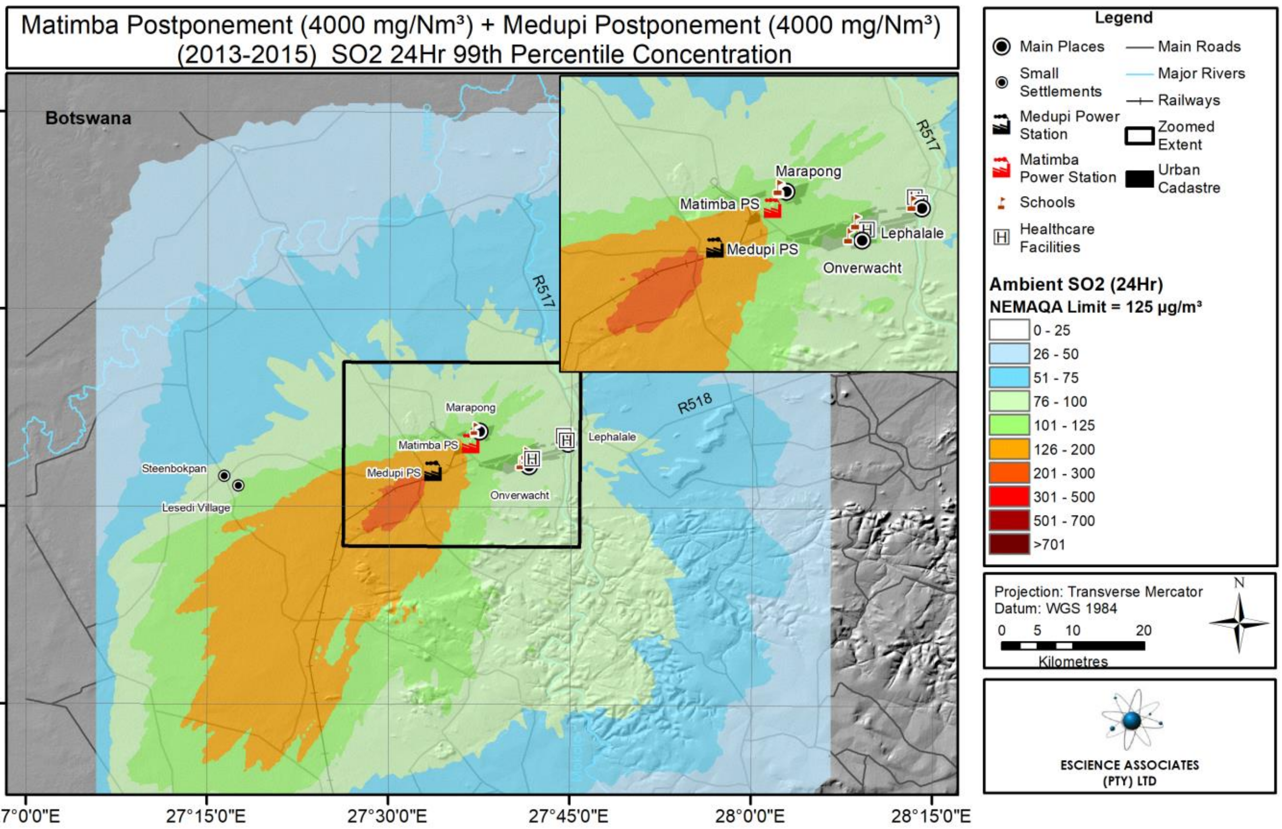


Figure 5-21: Predicted 99th Percentile hourly ambient SO_2 concentrations (above) and hourly FOEs (below) for the Matimba Power Station at the requested postponement emission rates (of 4000 mg/Nm³) and Medupi Power Station at the requested postponement emission rates (of 4000 mg/Nm³) (2013-2015)



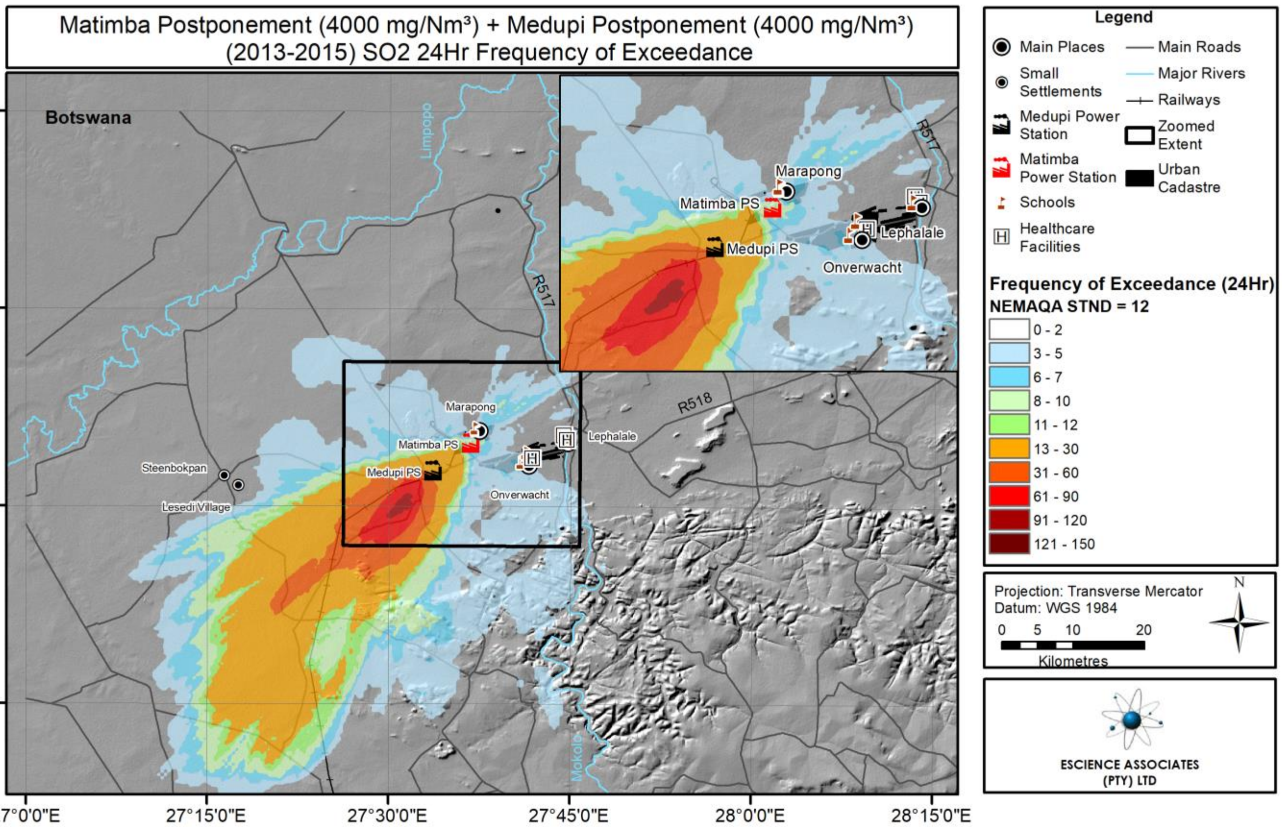


Figure 5-22: Predicted 99th Percentile daily ambient SO_2 concentrations (above) and daily FOEs (below) for Matimba Power Station at the requested postponement emission rates (of 4000 mg/Nm³) and the Medupi Power Station at the requested postponement emission rates (of 4000 mg/Nm³) (2013-2015)

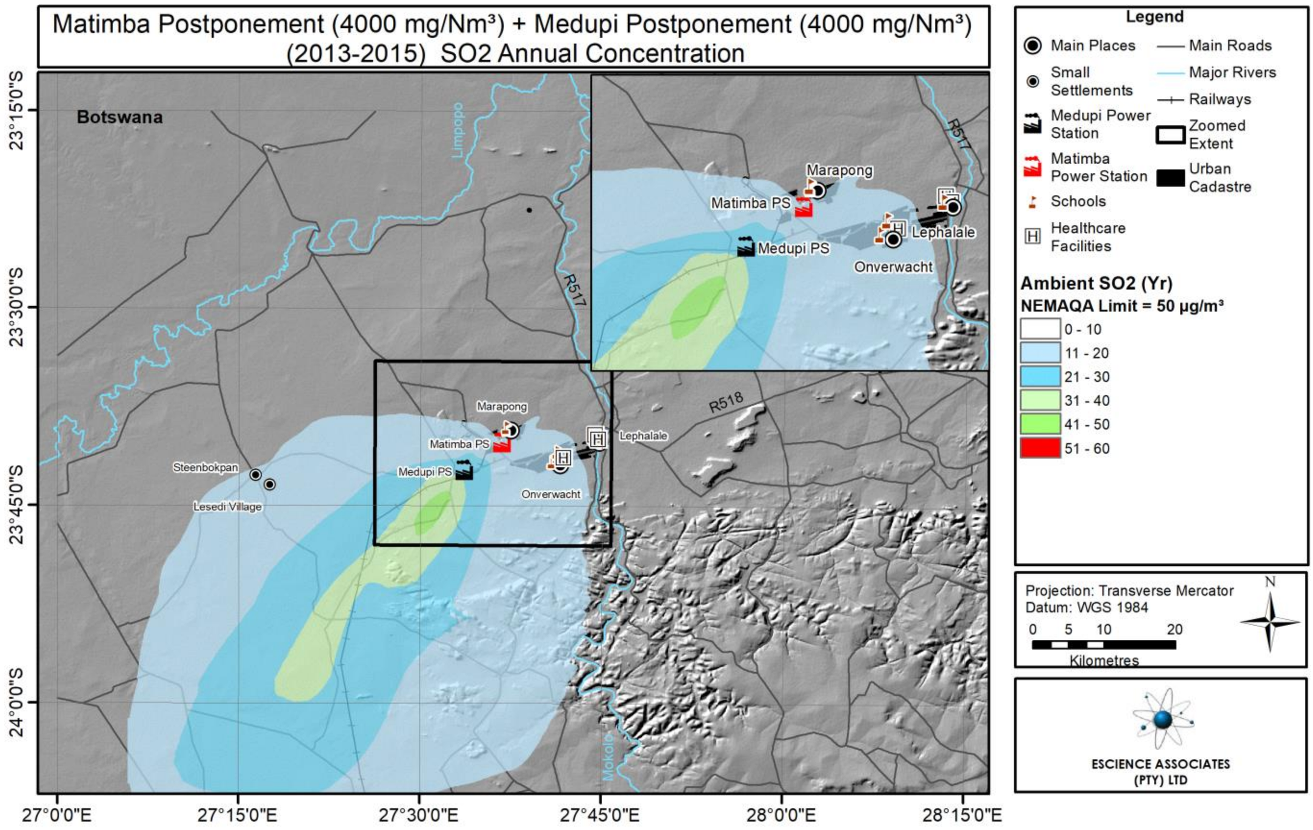


Figure 5-23: Predicted Annual Average ambient SO_2 concentrations for the Matimba Power Station at the requested postponement emission rates (of 4000 mg/Nm³) and the Medupi Power Station at FGD emission rates (of 500 mg/Nm³) (2013-2015)

6 SUMMARY AND CONCLUSIONS

In terms of the requirements of the Minimum Emissions Standards, Eskom as a listed emitter is required to comply with prescribed emissions limits at its various power stations. Because of variations in the sulphur content of the coal from the Grootegeluk mine, the Matimba and Medupi Power Stations, which both use coal from Grootegeluk, are not able to consistently comply with the 2015 SO_2 MES daily limit of 3500 mg/Nm^3. For this reason, Eskom is seeking a postponement of the compliance timeframes of the existing plant SO_2 MES for the Matimba and Medupi Power Stations, as well as requesting more lenient daily average limits of 4000 mg/Nm^3 for both stations. In making such an application, it is necessary to ascertain the ambient air quality implications of the requested limits and whether the application would result in non-compliance with the NAAQS.

To assess the ambient air quality implications of Eskom's requested emissions limits there have been two primary courses of action. The first of these has been a detailed review of measured ambient air quality data and the second, the modelling of different emissions scenarios using the CALPUFF suite of dispersion models. The modelled concentrations have been compared to the measured concentrations to verify the accuracy of the model predictions. Data from the Marapong and Lephalale AQM stations (on the upwind side of the two power stations) and the Medupi AQM station (on the downwind side of the power stations) have been sourced and analysed for a three and sometimes (in the case of Marapong and Lephalale) for a four-year period. Measured ambient SO_2 concentrations show that there is currently compliance with ambient SO_2 standards at all three monitoring stations. There are several occurrences of exceedances of the NAAQS SO_2 limit values for hourly and 24-hourly averaging periods but the number of exceedances is less than the allowed number of exceedances in the NAAQS. As such, full compliance with the SO_2 NAAQS is evident for all three years for all three stations. Following patterns that have been described elsewhere, there is clear evidence of SO_2 concentrations peaking only in the afternoon, whereas PM_{10} peaks are seen to occur in the morning and in the late afternoon/early evening.

Eight different emissions scenarios were modelled, including the two power stations separately under current emissions and at the requested emission limits (4000 mg/Nm^3), Medupi alone with FGD installed and then three scenarios where the power station emissions were combined. The first combined scenario was at current emissions and the second, the requested emissions limit at the Matimba Power Station and FGD installed at the Medupi Power Station. Comparisons between the modelled and the measured concentrations indicated good agreement at the Medupi and Lephalale AQM stations but poorer agreement for the Marapong data. Reasons for the poorer agreement at Marapong may derive from an additional, unmodelled source of SO_2 and/or from instrument drift that results in higher concentrations being recorded than exist. The verification exercise confirmed the adequacy of the modelling approach. The dispersion modelling results have been presented as a series of isopleth (lines joining points of equal ambient air pollutant) concentrations.

The isopleth maps reveal one main area of elevated predicted SO_2 concentrations. This area is on the downwind (southwestern) side of the Medupi Power Station. The risk of adverse health effects is reduced on the downwind side of the power stations by the low population densities that prevail. The Matimba Power Station alone under current emissions scenario reveals compliance with the NAAQS for all averaging periods for SO_2, but for the Matimba and Medupi Power Stations under current emissions (with 6 units operating) there is predicted non-compliance on the downwind side. Again, it should be noted that this scenario will only be applicable for a short period of time, namely for the time between when the last generating unit has been commissioned at the Medupi Power Station and the time when the first unit is retrofitted with FGD (June 2019 through to August

2021). The predicted non-compliance area is seen to grow in spatial extent when the requested emission limits are modelled. There is compliance currently (an assertion supported by the measured ambient air quality data) but that at some point, as additional units are brought on-line at the Medupi Power Station, there is a high likelihood of non-compliance in the downwind area. It is predicted that there will be compliance with ambient SO_2 standards in Marapong and Lephalale under all modelled scenarios. The largest population groupings in the area are thus not expected to be exposed to unacceptably high SO_2 levels. Based on the modelling done to date, it is not possible to indicate precisely when the non-compliances would start. Predicted non-compliance with the NAAQS for SO_2 seriously questions the acceptability of the requested emissions by Eskom.

Based on the work done to date, what is implied is that the power stations operating at the requested limits will likely result in non-compliance with the NAAQS for SO_2 downwind (i.e south-west) of the power stations.

7 REFERENCES

Air Pollution. 2011. Impacts of Air Pollution & Acid Rain on Wildlife. [online] Air Pollution. Available at: http://www.air-quality.org.uk/17.php [Accessed 15/03/2017].

Austnes, K., Curtis, C.J., Khuzwayo, C.J. and Piketh, S.J. (2015). Acid deposition and acidification of waters in South Africa: status and prognoses given future climate change (AcidWater) In: 9th International Conference on Acid Deposition. New York.

Scire, J.S., Robe, F.R., Fernau, M.E. and Yamartino, R.J. (2000). A User's Guide for the CALMET Meteorological Model (Version 5). Michigan: Earth Tech, Inc.

Josipovic, M. (2009). Acid deposition emanating from the South African Highveld - A critical levels and critical loads assessment. PhD. University of Johannesburg.

US EPA. 2008. Integrated Science Assessment for Sulphur Oxides – Health Criteria. [online]. Available at: http://www.epa.gov/ncea/isa/