Report on Thabametsi Mine and Power Plant Modeling

Dr. Ranajit (Ron) Sahu[1]

Summary

We have conducted air dispersion modeling for Sulphur Dioxide (SO_2), Oxides of Nitrogen (NO_x), and Particulate Matter ($PM_{2.5}$), as described below for the following:

(a) *the proposed Thabametsi power plant (all four proposed units, at 1200 MW in total) along with the existing Matimba and Medupi power plants approximately 15km to the south east of Thabametsi (collectively "the power plants").*

Assumptions

We have assumed that by the time the Thabametsi power plant becomes operational, all six units of the Medupi power plant would also be fully operational i.e., it would also be "existing" at that time, in addition to the Matimba power plant. Furthermore, we have assumed that there will be a period of time when the Thabametsi power plant would be operational when flue gas desulphurisation (FGD) scrubbers for SO_2 control are not yet operational on the Medupi units, consistent with the 6-year delay requested for installing FGD at Medupi after each unit becomes operational. Lastly, for SO_2 emissions from Matimba and Medupi, we have assumed that they will be allowed to emit up to 4000 mg/Nm^3 of SO_2 as requested by the operators of those power plants.

Results

The results of our modeling for the power plants show that there will be significant increases in the impacts (i.e. concentrations) of SO_2 in the areas surrounding the power plants. SO_2 impacts from just the three power plants (even without factoring in other emissions sources such as transportation sources and their SO_2 emissions) would exceed South Africa's health-based National Ambient Air Quality Standards (NAAQS), at least at some of the receptor locations.

NO_x and $PM_{2.5}$ emissions from the power plants alone do not appear to exceed the ambient standards (mainly because of the large dilution accorded to the stack emissions by virtue of their very tall stacks). Nonetheless, when added to baseline levels of NO_x and $PM_{2.5}$ in the area, which already hover near maximum allowed ambient levels due to other significant, existing sources of NO_x and $PM_{2.5}$ in the area, such as mobile sources as well as the existing Grootegeluk Mine (which provides the coal for Matimba and Medupi, and is also expected to supply coal to Thabametsi), NO_x and $PM_{2.5}$ emissions from the three power plants will cause levels of NO_x and $PM_{2.5}$ to exceed NAAQS. However, because there are currently too few air monitors, and those that are functioning are not appropriately sited, the extent of ambient air pollution in the area is not being accurately measured.

[1] The modeling was done using US EPA's AERMOD model by Dr. Andrew Gray, working in conjunction with me. Curricula vitae are attached as exhibits hereto.

(b) the proposed Thabametsi mine, which would support the adjoining proposed Thabametsi power plant.

Assumptions

Only $PM_{2.5}$ emissions were modeled for the Thabametsi mine. We used the $PM_{2.5}$ "mitigated operations" case in our calibration run using the emissions presented in the September 2012 modeling report prepared by Airshed Planning Professionals, (Pty) Ltd.[2] An important shortcoming of this modeling done previously by Airshed Planning Professionals (Pty) Ltd. is the significant underestimation of the emissions ascribed to the anticipated Thabametsi mining activities, as well as the complete lack of discussion of how the emissions were estimated and located across the mine spatially.

Results

My conclusion regarding the impacts of the mine are that the $PM_{2.5}$ (as well as PM_{10}) impacts from the mining activities on surrounding locations to the south-west are likely to be significant.[3]

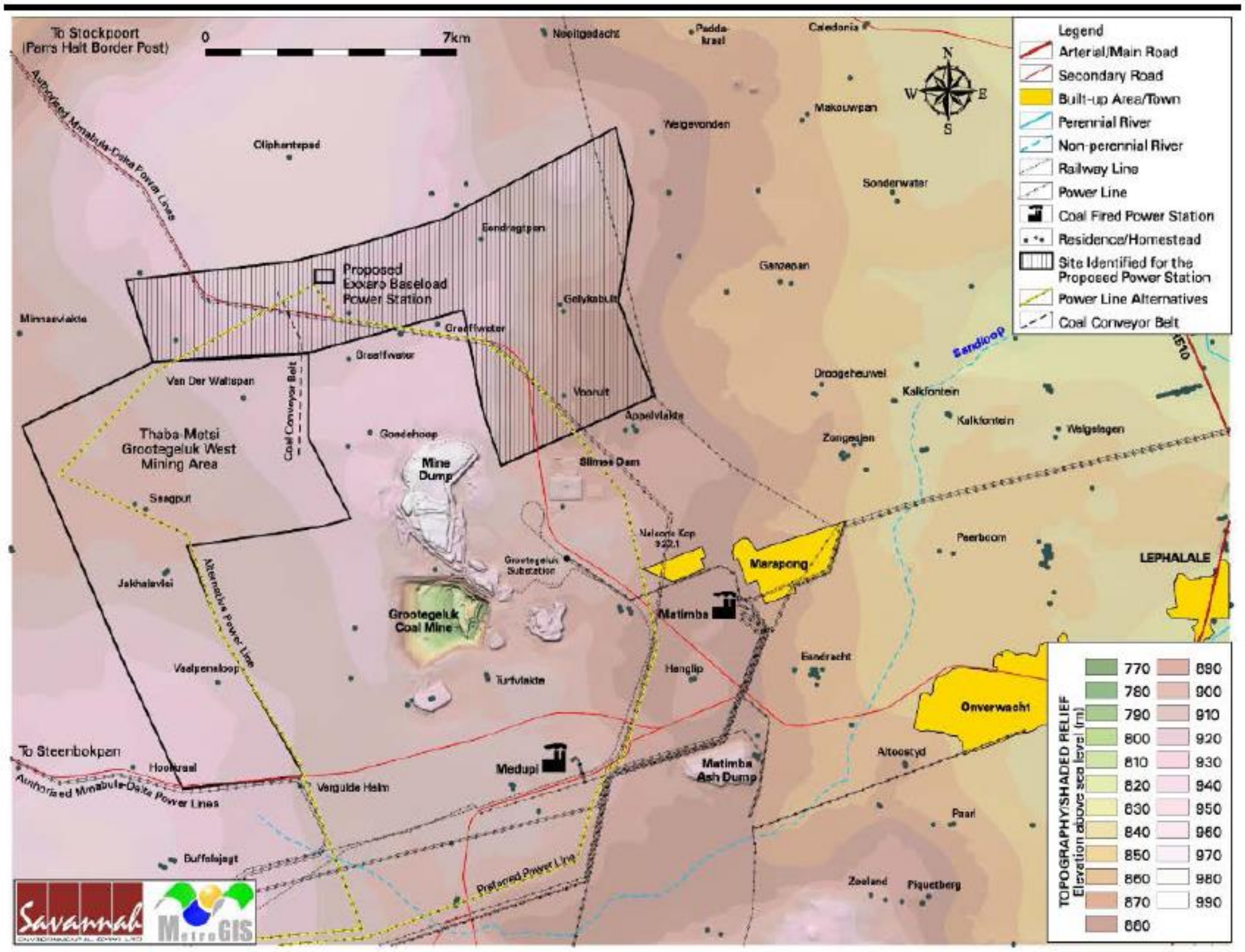
Setting

The Figure below shows all of the sources and their general relationships to each other. The Figure shows the existing Matimba power plant, the Medupi power plant, under construction, the existing Grootegeluk Mine, the proposed Thabametsi Mine, and the approximate location of the proposed Thabametsi power plant.

[2] Airshed Planning Professionals (Pty) Ltd, *Thabametsi: Air Quality Specialist Assessment*, Report No.: APP/12/EXX-01 Rev.0.1, Sept. 2012.

[3] I note that $PM_{2.5}$ and PM_{10} emissions from the nearby, existing, Grootegeluk were not explicitly modeled. It is assumed that impacts from sources at this mine would be manifested in the actual monitoring data being collected at different locations nearby. Of course, one of the important shortcomings in the area is the lack of adequate air monitoring stations.

Location of the Thabametsi Power Station



Source: Environmental Resources Management Southern Africa Pty (Ltd), *Greenhouse Gas Assessment for the 1 200 MW Thabametsi Coal-Fired Power Station in Lephalale, Limpopo Province, South Africa*, Final Report, v2, June 2017, p. 9.

<u>Meteorological Data</u>

Dispersion modeling requires, as an input, processed hourly meteorological data, typically for multiple years, collected near to the source(s) being modeled, in order to ensure that the meteorological data are representative. The meteorological data are usually made available electronically. Unfortunately, even though such data exist (and have been used by consultants who have conducted modeling for the Thabametsi Mine, the Thabametsi power plant, the existing Matimba power plant, as well as the Medupi power plant), we were unable to obtain the hourly data electronically (or in any other format) despite considerable effort.[4] However, summaries of

[4] We initially requested the air quality modeling data for the Thabametsi mine from the consultancy firm that prepared the environmental impact assessment but were referred to Exxaro. We then submitted a request for access to information in term of the Promotion of Access to Information Act 2 of 2000 for the emissions inventory and modeling data, but were told that these data were not part of the record because

the meteorological data are available in various reports in windrose format. Relying on the windroses, we used a meteorological data set from a location in the United States of America (US) that is generally consistent with the windroses shown in the various South African reports. The chosen US data are also from a location that is topographically consistent (i.e. relatively flat terrain) with the location of the Thabametsi mine and power plant.

While this is not an ideal situation: (a) it is the only option that was available to us; and (b) importantly, we were satisfied that the results predicted by our meteorological data set were generally consistent with that obtained by the local consultants. We confirmed this by running the model simulating the Thabametsi mine. Results at the most impacted receptors to the south-west of the mine were consistent between our and the local consultant model runs.

<u>Source Inputs</u>

For the Matimba and Medupi power plants, the emissions are shown below in addition to the stack locations:

Emission Source				**Emissions (tonnes/year)**			**Current Emission Limits (mg/m^3)**		
Power Station	**Stack**	**Latitude**	**Longitude**	**NO_x**	**SO_2**	**PM_{10}**	**NO_x**	**SO_2**	**PM_{10}**
Matimba	Stack 1	-23.67	27.61	33796	154631	2452	750	3700	100
Matimba	Stack 2	-23.67	27.61	33796	154631	2452	750	3700	100
Medupi	Stack 1	-23.70	27.56	30691	224308	2046	750	4000	50
Medupi	Stack 2	-23.70	27.56	30691	224308	2046	750	4000	50

We adjusted the SO_2 emissions for the Matimba power plant to reflect the currently requested limit of 4000 mg/Nm^3 instead of the 3700 mg/Nm^3 shown in the table above.

Stack details required for modeling for the Matimba units/stacks are shown below:

Point Source Code	Source name	Latitude (UTM)	Longitude (UTM)	Height of Release Above Ground (m)	Height Above nearby building (m)	Diameter at Stack Tip / Vent Exit (m)	Actual Gas Exit Temp (°C)	Actual gas volumetric flow per flue (Am^3/s)	Actual Gas Exit Velocity (m/s)	Type of emissions (continuous / batch)
Stack 1	Boiler unit 1 Boiler unit 2 Boiler unit 3	7 382.199 S	562.317 E	250	Boiler House 113m	12.82*	120-135 (405 K)	1140-1200	20-25	Continuous
Stack 2	Boiler unit 4 Boiler unit 5 Boiler unit 6	7 382.446 S	562.256 E	250	Boiler House 113m	12.82*	120-135 (405 K)	1140-1200	20-25	Continuous

** Modelled stack diameter, individual flues have a diameter of 8.5 m (stack 1) and 8.8 m (stack 2).*

Source: ESCIENCE Associates (Pty) Ltd, *Atmospheric Impact Report – Matimba and Medupi Power Stations*, May 2017, p. 9.

Similarly, stack details required for modeling for the Medupi units/stacks are shown below:

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the consultancy firm had not submitted them to Exxaro. In addition, the online SA Ambient Air Quality Information System, which should make current and accurate data available, does not provide this information.

Point Source Code	Source name	Latitude (UTM) (m)	Longitude (UTM) (m)	Height of Release Above Ground (m)	Height above nearby building (m)	Diameter at Stack Tip / Vent Exit (m)	Actual Gas Exit Temp (ºC)	Actual gas volumetric flow per unit (m^3/hr)	Actual Gas Exit Velocity (m/s)	Type of emission (continuous/ batch)
Stack 1	Boiler unit 1 Boiler unit 2 Boiler unit 3	7 378 553 E	557 231 S	220	100	21.9*	140 (413 K)	4 000 000	18-24	Continuous
Stack 2	Boiler unit 4 Boiler unit 5 Boiler unit 6	7 378 553 E	557 231 S	220	100	21.9*	140 (413 K)	4 000 000	18-24	Continuous

** Effective stack diameter*

Source: ESCIENCE Associates (Pty) Ltd, Atmospheric Impact Report – Matimba and Medupi Power Stations, May 2017, p. 10.

Finally, the stack details and the emissions for the proposed Thabametsi units are shown below:

Table 7.1: Point sources at the Thabametsi Power Station

Stack parameters							
Source ID	**Stack height (m)**	**Stack diameter (m)**	**Latitude of centre of stack (UTM)**	**Longitude of centre of stack (UTM)**	**Emission release temperature (K)**	**Emission exit velocity (m/s)**	**Gas flow rate (Nm^3/h)**
Stack 1	150/185/220	11.5	549.715	7390.002	418.6	18.29	1804000
Stack 2	150/185/220	11.5	550.391	7389.988	418.6	18.29	1804000
Stack 3	150/185/220	11.5	549.706	7389.422	418.6	18.29	1804000
Stack 4	150/185/220	11.5	550.383	7389.445	418.6	18.29	1804000

Table 7.2: Proposed emission rates for the Thabametsi Power Station

	Emission rate (tons/year)		
Source ID	**SO_2**	**NO_x**	**PM_{10}**
Stack 1	53778.8	25945.9	162.2
Stack 2	53778.8	25945.9	162.2
Stack 3	53778.8	25945.9	162.2
Stack 4	53778.8	25945.9	162.2

Source: uMoya-NILU Consulting (Pty) Ltd, Thabametsi FEIR, Appendix E, *Air Quality and Health Risk Specialist Study for the EIA for the Proposed Thabametsi Coalfired Power Station Near Lehpalale, Limpopo Province*, December 2013.

We chose the 220-meter stack height for the four Thabametsi units, to be conservative, i.e. provide the smallest impacts, with the largest dilution. Using the lower heights would have: (a) limited the impact area of the power plant; and (b) created higher impact concentrations.

For the Thabametsi mine, for our "calibration run" to validate the use of the meteorological data, we relied on the emissions presented in the September 2012 modeling report prepared by Airshed Planning Professionals, (Pty) Ltd. This is shown below:

Table 4-7: Calculated particulate emissions for the Thabametsi Colliery Operations

Description	Emissions (TPA)		
	TSP	PM_{10}	$PM_{2.5}$
Unmitigated Operations			
Windblown dust from stockpiles	0.05	0.01	0.01
Materials Handling	58.09	41.79	6.33
Crushing and screening	2 694.41	1 000.38	185.07
Vehicle entrainment	1 277.53	691.90	69.19
Drilling and blasting in opencast pits	52.11	27.09	1.56
Total	**4 082.19**	**1 761.17**	**262.16**
Mitigated Operations			
Windblown dust from stockpiles	0.05	0.01	0.01
Materials Handling	58.09	41.79	6.33
Crushing and screening	1 347.21	500.19	92.53
Vehicle entrainment	319.38	172.97	17.30
Drilling and blasting in opencast pits	52.11	27.09	1.56
Total	**1 776.83**	**742.06**	**117.73**

Source: Airshed Planning Professionals (Pty) Ltd, *Thabametsi: Air Quality Specialist Assessment*, Report No.: APP/12/EXX-01 Rev.0.1, Sept. 2012, p. 4-9.

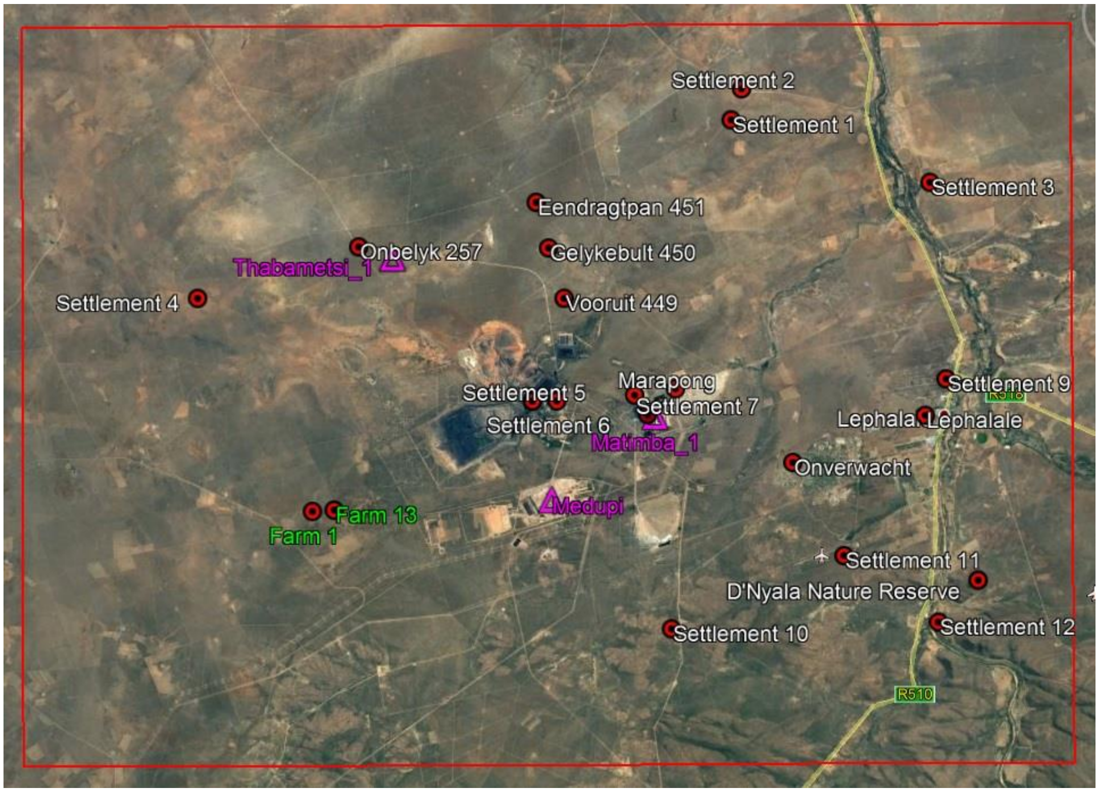
We used the $PM_{2.5}$ "mitigated operations" case in our calibration run. As seen above, the modeling by Airshed Planning Professionals (Pty) Ltd. only used 5 sources to depict all of the mining operations, of which the two dominant sources by far are crushing and screening, followed by vehicle entrainment. Materials handling is a distant third. I comment on this further below.

Sources Not Included

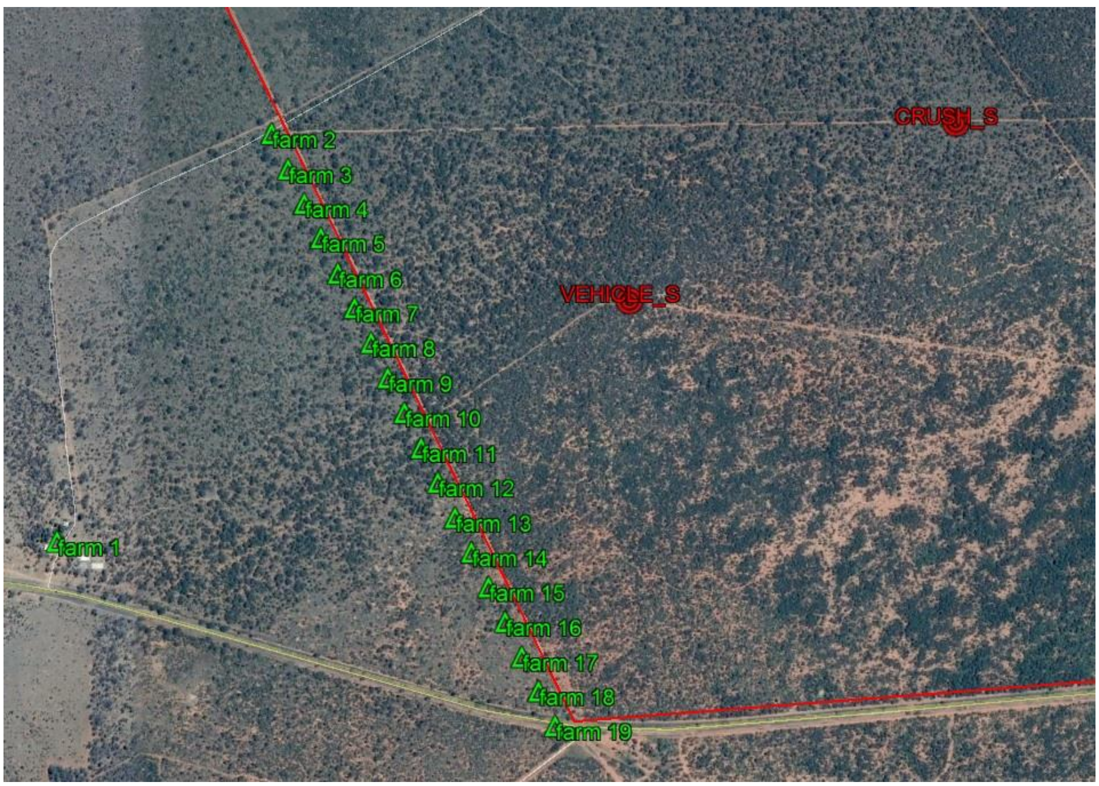
Due to lack of available information, we have not included PM emissions due to ash disposal (and associated transportation emissions) either for the Thabametsi power plant or the Medupi power plant. We assume that the effect of ash dumping from the existing Matimba power plant are already reflected in the baseline PM levels being monitored in the area. I expect that fugitive $PM_{2.5}$ emissions would be significant from ash disposal (comparable to mining emissions), including transport of the ash and the actual ash handling and dumping at the disposal site.

Receptors

The Figure below shows the receptors we used in our modeling from the power plants. The area within the outer red box was gridded. In addition, we included the specific receptors shown in the Figure below.



The receptors used for the Thabametsi mine modeling are shown in the Figure below.

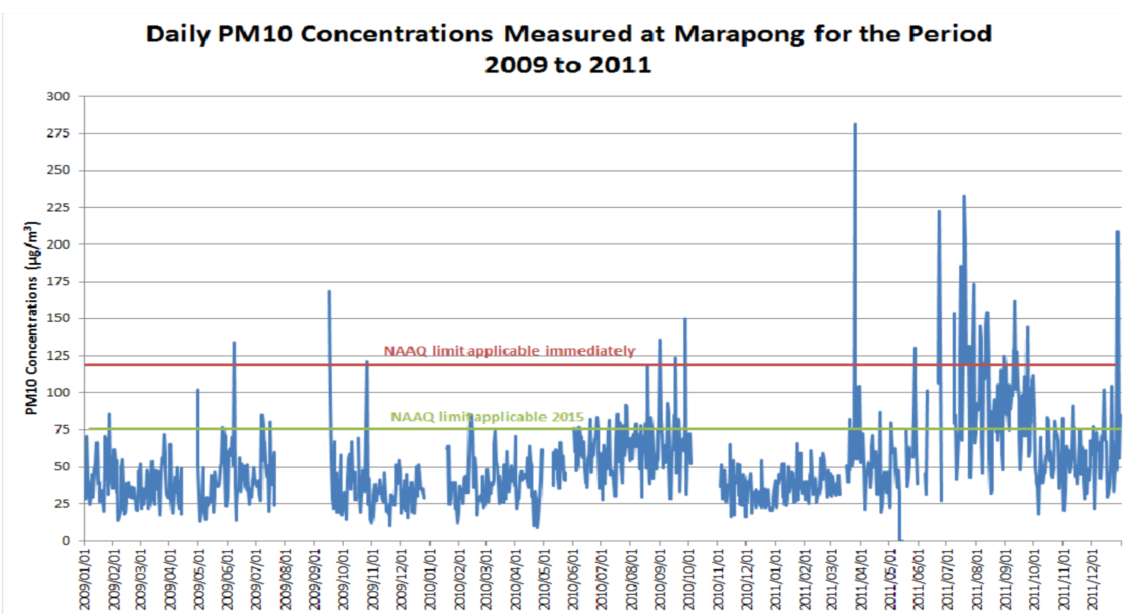


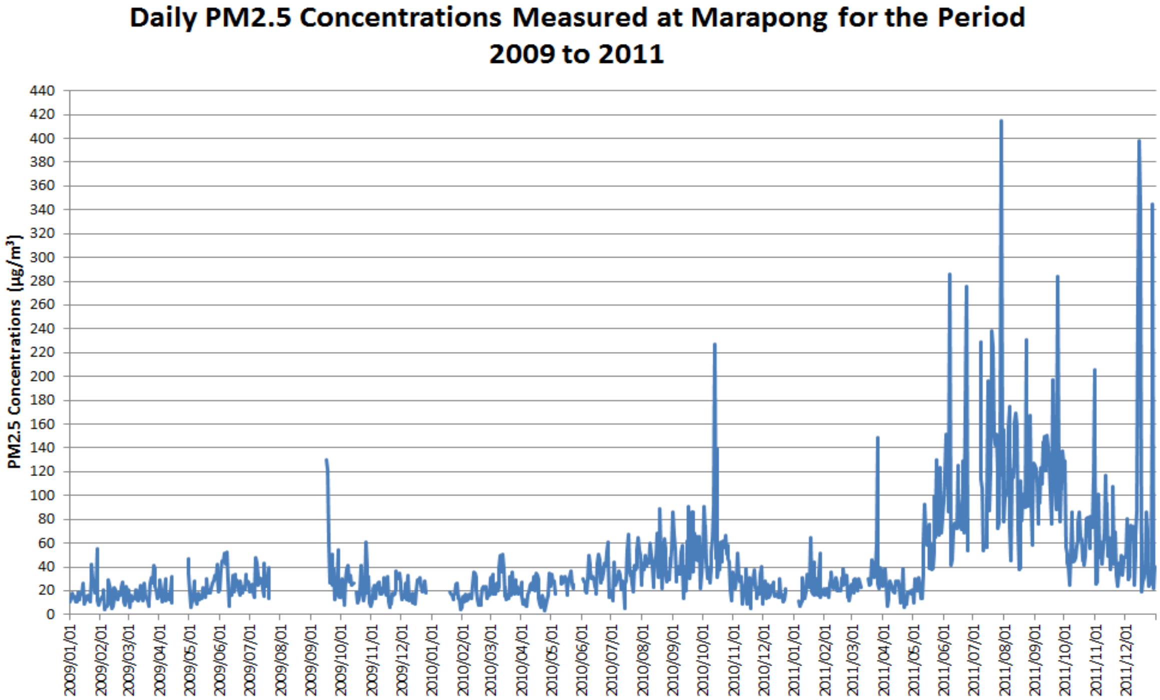
Baseline Emissions

The NAAQS for PM_{10}, $PM_{2.5}$, SO_2 and NO_2 are shown in the table below:

Parameter	Averaging Period	Concentration	Frequency of Exceedence
PM_{10}	24-hour	75 µg/m³	4
	annual	40 µg/m³	0
$PM_{2.5}$	24-hour	40 µg/m³	4
	annual	20 µg/m³	0
SO_2	10-minutes	500 µg/m³	526
	1-hour	350 µg/m³	88
	24-hour	125 µg/m³	4
	annual	50 µg/m³	0
NO_2	1-hour	200 µg/m³	88
	annual	40 µg/m³	0

The closest ambient monitoring station to the Thabametsi site is located at the residential area of Marapong just east of the Grootegeluk mine. The daily PM_{10} and $PM_{2.5}$ ambient concentrations at Marapong for the period 2009 to 2011 are provided in Figure 3-7 and Figure 3-8, respectively, of the 2012 Report, reproduced below. Current data for the Marapong monitoring station is not available. However, the 2012 Report notes that the annual average PM_{10} and $PM_{2.5}$ ground level concentrations for the period 2009 to 2011 were 51 µg/m³ and 43 µg/m³,respectively. The current annual ambient standard for PM_{10} is 40 µg/m³ and the current ambient standard for $PM_{2.5}$ is 20 µg/m³. Thus, baseline PM levels for the period 2009 to 2011 exceeded the current ambient standards.





Source: Airshed Planning Professionals (Pty) Ltd, *Thabametsi: Air Quality Specialist Assessment*, Report No.: APP/12/EXX-01 Rev.0.1, Sept. 2012, p. 3-14.

More recently, baseline emissions levels were assessed as part of an Air Quality Specialist Report for the Proposed Medupi Flue Gas Desulphurisation (FGD) Retrofit Project.[5] That baseline study considered a 2014[6] baseline scenario (including operations of the Matimba power plant), and concluded as follows:

- SO_2 concentrations were measured to infrequently exceed short-term NAAQS at the monitoring stations located at Marapong and Lephalale. Modeled SO_2 concentrations indicated infrequent short-term exceedances of the NAAQS limits at these receptors.
- NO_2 concentrations were measured to infrequently exceed short-term NAAQS limits at Marapong and Lephalale, which is reiterated in the modeled results.
- Measured PM_{10} concentrations exceed the daily and annual NAAQS at Marapong for the period 2014. Measured $PM_{2.5}$ concentrations at Marapong are within the daily NAAQS applicable until 2030, but exceed the more stringent daily NAAQS applicable in 2030.

[5] Airshed Planning Professionals (Pty) Ltd, *Air Quality Specialist Report for the Proposed Medupi Flue Gas Desulphurisation (FGD) Retrofit Project*, Feb. 2018.

[6] The study also considered a 2020 baseline scenario that included operations of both the Matimba and Medupi power plants. Under that scenario, which reflects the sources we modeled (minus Thabametsi), the area of non-compliance with the hourly and daily SO_2 NAAQS extended ~30km southwest of the Medupi power plant. Non-compliance with the hourly and daily SO_2 NAAQS was simulated at the residential settlement to the northwest of the Matimba power plant. Thus the air quality modeling done for the proposed Medupi FGD retrofit project supports our results.

Results for the Power Plants

These are provided in the attached Excel spreadsheet (Attachment A), for the gridded as well as the specific sensitive receptors shown above.

The results show that at certain sensitive and gridded receptors, emissions from the power plants alone, excluding any current baseline SO_2 concentrations in the area, exceed the NAAQS for SO_2. For example, at Farm 13, a sensitive receptor, the 89th highest 1-hour SO_2 concentration was modeled at over 406 ug/m^3. At Onverwacht, another sensitive receptor, the 5th highest 24-hour SO_2 concentration modeled was over 126 ug/m^3. At the gridded receptor with the highest modeled SO_2 concentrations, the 89th highest 1-hour SO_2 concentration was over 451 ug/m^3 and the 5th highest 24-hour SO_2 concentration was over 151 ug/m^3.

As noted earlier, while emissions from the power plants alone do not exceed the NAAQS for NO_x and $PM_{2.5}$: (a) the increased impacts due to the power plants are not trivial; and (b) when considered in addition to baseline or background concentrations that already infrequently exceed NAAQS for PM and NOx, it is highly likely that the operation of the Thabametsi power plant would cause exceedences of the NAAQS for NO_x and $PM_{2.5}$. Significant new contributions to ambient pollution levels from the Thabametsi power plant would further degrade air quality in the region.

For some of the receptor locations we also conducted modeling to determine the contributions of the predicted SO_2 impacts from each of the three power plants. As expected, the contributions vary depending on the location of the receptor in relation to the specific power plant.

Comment on the Emissions for Thabametsi Mine

It is my opinion, based on a review of estimated PM emissions from many open pit mining operations in the US that the emissions for $PM_{2.5}$ (as well as the other PM fractions) in the September 2012 Report for the Thabametsi mine, are significantly understated.

First, all of the mining activity emissions are grouped into just a few sources as shown in Table 4-7 above.[7] This is not representative of how mining activities and resulting emissions occur or of how those emissions are spatially distributed. For example, the list below shows a typical list of mining sources/activities for which emissions should be estimated:

- Topsoil Removal;
- Topsoil Dumping;
- Overburden Drilling;
- Overburden Blasting;
- Overburden Removal (Dragline?);
- Overburden Handling (Truck/Shovel);
- Overburden Dumping;

[7] While the report, in its description sections does provide some discussion of the additional types of mining sources and activities that I have listed, the emissions calculations do not provide corresponding calculations.

- Overburden Handling (Bulldozer);
- Overburden Storage Pile;
- Haul Roads Travel;
- Access Roads Unpaved;
- Grading;
- Coal Drilling;
- Coal Blasting;
- Coal Removal;
- Disturbed Area Fugitives;
- Coal Transport;
- Coal Primary Crusher;
- Coal Secondary Crusher;
- Coal Conveyors; and
- Support Diesel Engines.

Instead, as noted earlier, the September 2012 modeling only reports 5 sources/activities.

Second, the September 2012 modeling assumes that uncontrolled emissions would be reduced by 50-70% based on mitigations such as watering. Since these mitigation measures are poorly implemented and enforced, and are not applicable to many of these sources, that 50-70% reduction is overly optimistic. I should note that there is significant uncertainty as to whether these types of mitigation measures are consistently used in existing mines (such as the Grootegeluk mine) in the area, particularly since water scarcity is an important factor in the region.

Third, the September 2012 modeling report does not discuss how the emissions it used were spatially distributed across the proposed Thabametsi mine.

It is my opinion that emissions from the mine are underestimated by at least five times, if not more. For example, estimated $PM_{2.5}$ emissions, with mitigation, for a 5 million short tons[8] per year proposed expansion at a Colorado coal mine (the "ColoWyo" mine) are 181 short tons per year. While I believe that even these emissions are underestimated at the ColoWyo mine, nonetheless they are around 4.8 times larger than the estimates for the Thabametsi mine, after adjusting for the rate of coal extraction. Thus, the impacts predicted by the September 2012 Thabametsi mine modeling are also similarly underestimated, even accepting the assumed mitigation reduction.

<u>Conclusion</u>

The results of our modeling show that there will be significant increases in concentrations of SO_2 in the areas surrounding the power plants. SO_2 concentrations due to emissions from the Thabametsi, Matimba and Medupi power plants would exceed the NAAQS, at least at some receptor locations.

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[8] 1 short ton is 2000 pounds. I tonne (also metric ton or long ton) is 1000 kilograms. Thus, 1 metric ton = 1.1 short tons.

NO_x and $PM_{2.5}$ emissions from the power plants alone do not appear to exceed the NAAQS (mainly because of dilution of stack emissions due to the plant's very tall stacks). Nonetheless, projected emissions must be considered cumulatively with baseline levels of NO_x and $PM_{2.5}$, which already hover near maximum allowed ambient levels due to other significant, existing sources of NO_x and $PM_{2.5}$ in the area. Ambient PM levels must also include emissions from the mine that will supply Thabametsi, which have been understated by at least a factor of five. When baseline levels of NO_x and PM and emissions from mining emissions are taken into account, ambient concentrations of NO_x and $PM_{2.5}$ in the area are expected to increase significantly and are likely to exceed NAAQS.

Date: __March 23, 2018__________ [signature]

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