

5.1.6.1 Understanding of Observed Concentrations

An analysis of the observed SO₂, NO₂ and PM₁₀ concentrations at six monitoring stations was completed, in which the concentration values were categorised into wind speed and direction bins for different concentrations. This information is most easily visualised as polar plots, where the centre of the polar plot refers to the location of the monitoring station, as shown in Figure 5-53 for Leitrim and Figure 5-55 for Eco Park for SO₂ observations (other stations Figure 5-56 to Figure 5-58). The corresponding NO₂ analyses are summarised in Figure 5-59 to Figure 5-64. Polar plots for PM analyses are presented in Figure 5-65 and Figure 5-70.

These polar plots (Carslaw and Ropkins, 2012; Carslaw, 2013) provide an indication of the directional contribution as well as the dependence of concentrations on wind speed. Whereas the directional display is fairly obvious, i.e. when higher concentrations are shown to occur in a certain sector, e.g. east and south for SO₂ at Eco Park (Figure 5-55), it is understood that most of the high concentrations occur when winds blow from that sector (i.e. east or south). When the high concentration pattern is more symmetrical around the centre of the plot, it is an indication that the contributions are near-equally distributed, as is displayed for SO₂ in Figure 5-56.

Furthermore, since the observed concentrations have also been categorised according to wind speed categories, it provides an indication of the plume height. As explained in Section 5.1.4.1 (plume buoyancy), stronger winds reduce the amount of plume rise, and may effectively increase ground level concentrations. However, since an increased wind speed also enhances plume dispersion, a concentration maximum would be reached for a wind speed where the plume rise and dilution effects cancel each other. These conditions would be different for day- and night-time atmospheric stabilities. It is expected that high ground level concentrations from elevated stacks would be more prevalent during stronger wind speeds during stable conditions than daytime, convective conditions, when the plume buoyancy is often not as effective in lifting the plume centreline. Low-level emissions behave differently, and higher concentrations would normally be observed during weak-wind conditions.

The SO₂ concentrations observed at Leitrim (Figure 5-53) show elevated concentrations occurring with north-easterly winds above 5 m/s. Sasol operations are located towards the north-west and the increased concentrations due to emissions from this direction are also evident at wind speeds above 2 m/s. The dominant contribution of median SO₂ concentrations above 100 µg/m³ originate to the north-east of the AJ Jacobs at wind speeds between 2 m/s and 8 m/s (Figure 5-54). The SO₂ concentrations observed at Eco Park (Figure 5-55) indicate that most of the high concentrations occur with easterly winds between 6 m/s and 10 m/s. Albeit not as high as the concentrations from the easterly sector, the observations also show elevated concentrations from a southerly direction. The Three Rivers station recorded relatively low median hourly SO₂ concentrations from all directions (Figure 5-56). Median SO₂ concentrations above 50 µg/m³ originate from the east and north-west at wind speeds above 2 m/s at the Sharpeville station (Figure 5-57). The Zamdela station recorded elevated SO₂ concentrations (above 100 µg/m³) at wind speeds above 6 m/s from the north-east (Figure 5-58). Other SO₂ contributions originate to the north-west and north of the Zamdela station.

The NO₂ concentrations observed at Leitrim (Figure 5-59) indicate that most of the elevated concentrations occur from the north-westerly winds of between 2 m/s and 6 m/s, northerly winds at winds less than 2 m/s or above 10 m/s. Since vehicular exhaust emissions are significant NO₂ contributors, the observations from the northern sector most likely indicates this source. Median NO₂ concentrations originate to the north-east of the AJ Jacobs at all wind speeds (Figure 5-60). The NO₂ concentrations observed at Eco Park (Figure 5-61) showed higher concentrations occurring during relatively weak winds of about 2 m/s and at higher wind speeds around 10 m/s, primarily from the south-south-west of the station. Median NO₂ concentrations observed at the Three Rivers station showed a local source at low wind speeds contributing NO₂ concentrations of approximately 50 µg/m³ (Figure 5-62). Higher NO₂ concentrations were recorded during high wind speeds

(above 8 m/s) from the east of the Three Rivers station. A similar pattern of a local NO₂ source at low wind speeds is evident at the Sharpeville station (Figure 5-63), while NO₂ concentrations above 100 µg/m³ originate to the north-west of the Sharpeville station at wind speeds 8 m/s. Median NO₂ concentrations measured at the Zamdela station show contributions of NO₂ above 50 µg/m³ from the north-west and north east at all wind speeds (Figure 5-64).

Elevated particulate concentrations at Leirim show contributions from the north and north-west at higher (between 8 and 10 m/s) wind speeds (Figure 5-65). Sources to the south-east and south-west at wind speeds above 6 m/s also contribute to elevated PM concentrations at Leirim. At low wind speeds (2 m/s or less) the almost symmetrical plot shows a local contribution, most likely a result of community activities. Elevated particulate matter concentrations at AJ Jacobs are shown to originate from the north-west and west at wind speeds above 5 m/s, and north at wind speeds above 8 m/s (Figure 5-66). Other sources of particulate matter contribute to concentrations of approximately 50 µg/m³ from the north-east, south-east and south-west at wind speeds varying between 2 and 6 m/s. Particulate concentrations observed at the Eco Park station are lower than at the other stations, where the sources of elevated concentrations (greater than 40 µg/m³) are located to the north-west of the station and contribute at high wind speeds (10 m/s or greater) (Figure 5-67). Other particulate sources are also located to the north-east and south-west of the Eco Park station contributing at lower wind speeds (5 to 10 m/s). A local source also contributes at low wind speeds. The Three Rivers station recorded elevated particulate concentrations from all directions at wind speeds greater than 6 m/s (Figure 5-68). A local source contributes at wind speeds lower than 2 m/s. Similarly, the Sharpeville station recorded elevated particulate concentrations from nearly all wind directions at speeds greater than 6 m/s, with the south-easterly direction showing the lowest particulate concentrations (Figure 5-69). A local source (possibly community activities) is a large contributor at low wind speeds (less than 2 m/s). Particulate concentrations recorded at the Zamdela show high concentrations from the west, north-west, north-east, east, and south, at high wind speeds (above 6 m/s), and a local source at low wind speeds (Figure 5-70). Sources in the northerly and south-easterly sectors contribute the lowest concentrations, especially at higher wind speeds.

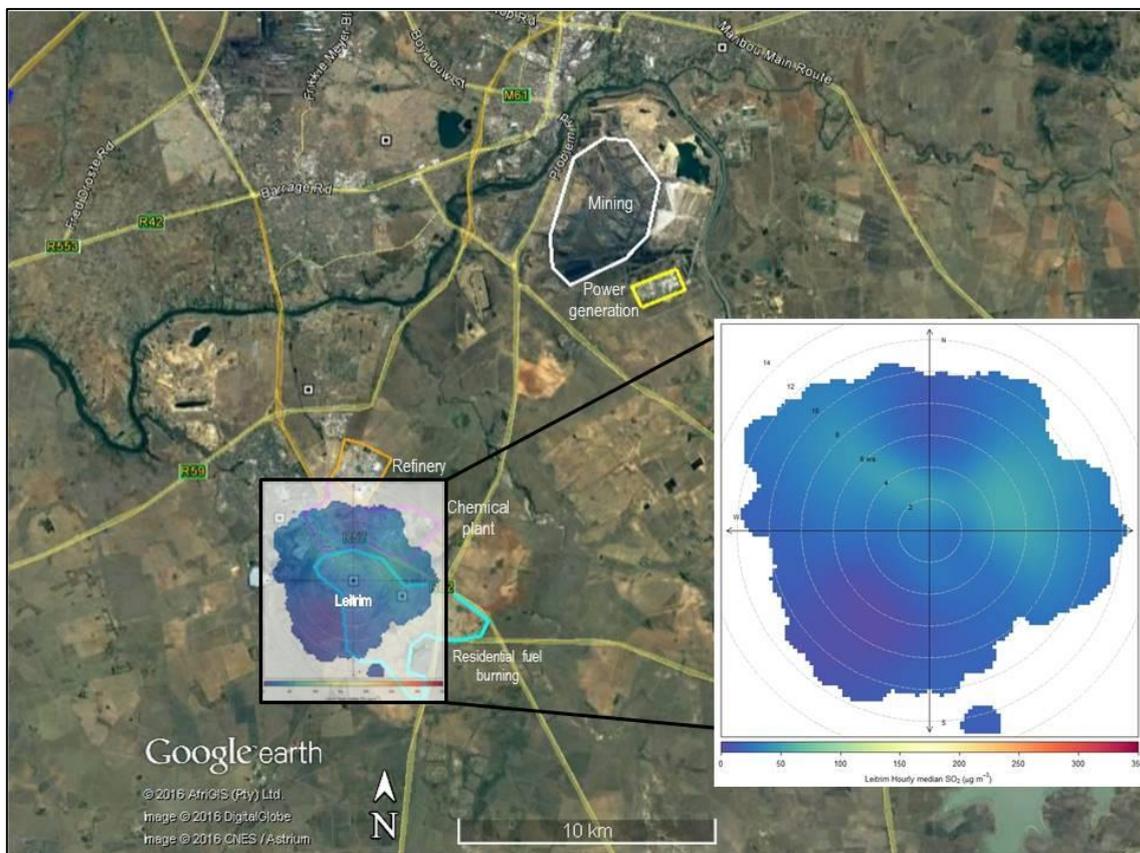


Figure 5-53: Polar plot of hourly median SO₂ concentration observations at Leirim for 2013 to 2015

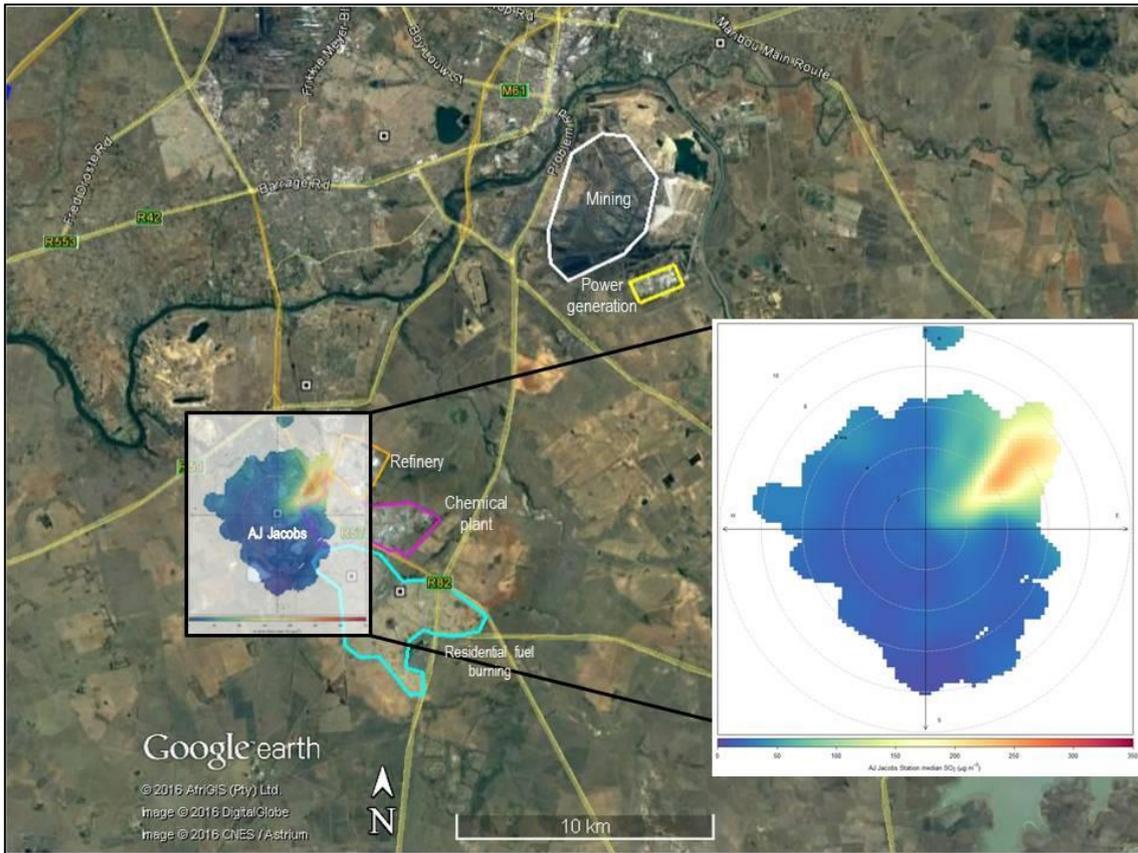


Figure 5-54: Polar plot of hourly median SO₂ concentration observations at AJ Jacobs for 2013 to 2015

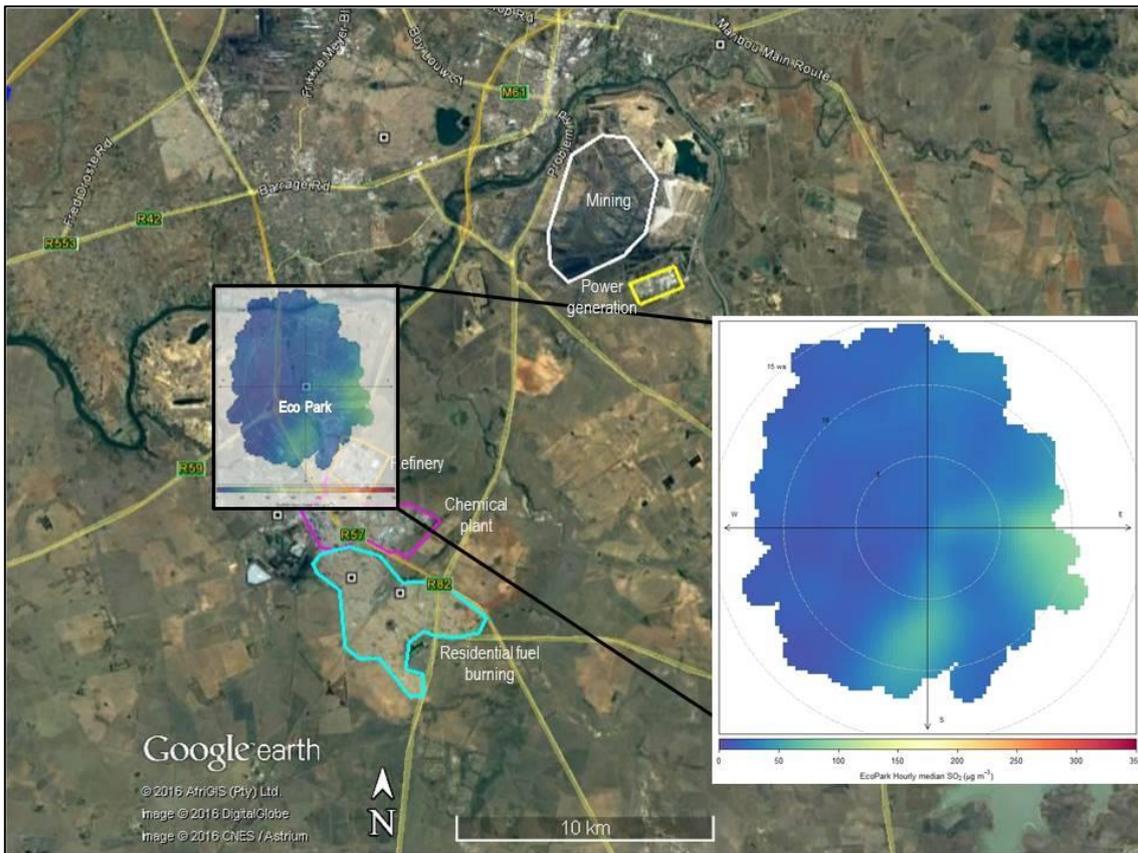


Figure 5-55: Polar plot of hourly median SO₂ concentration observations at Eco Park for 2013 to 2015

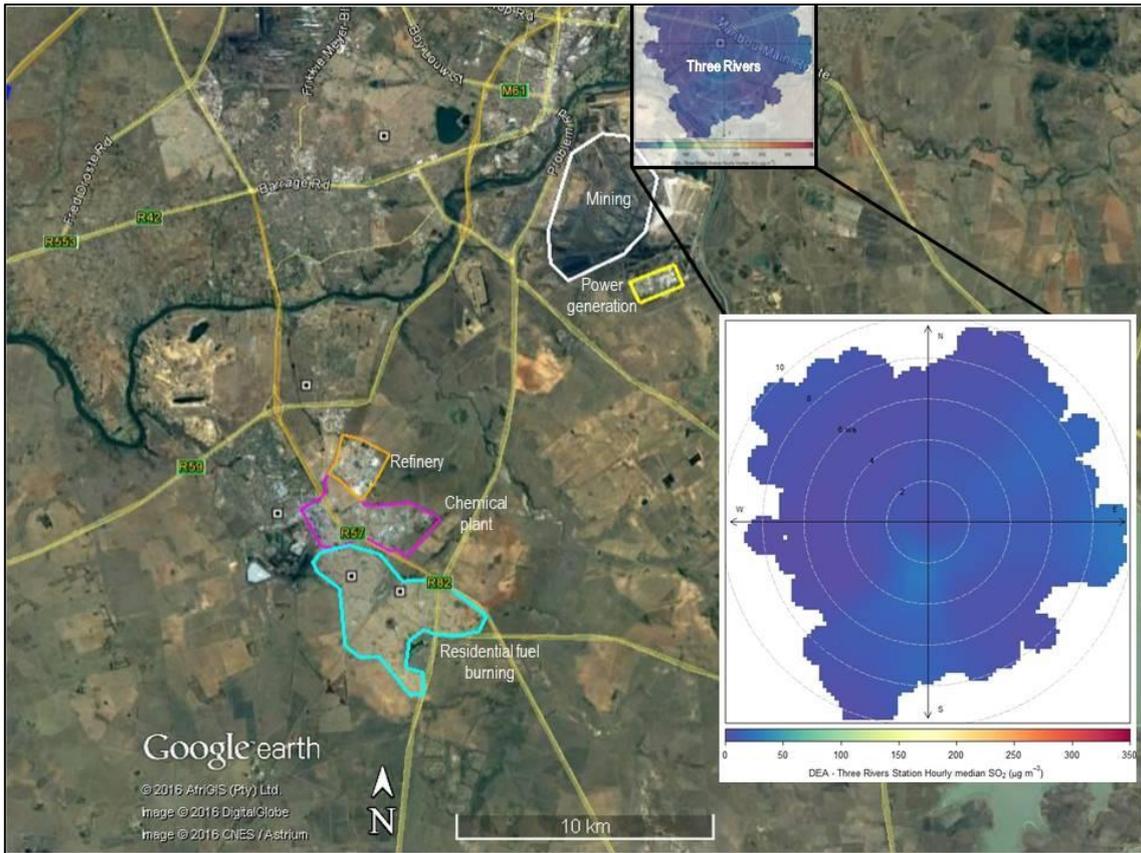


Figure 5-56: Polar plot of hourly median SO₂ concentration observations at Three Rivers for 2013 to 2015

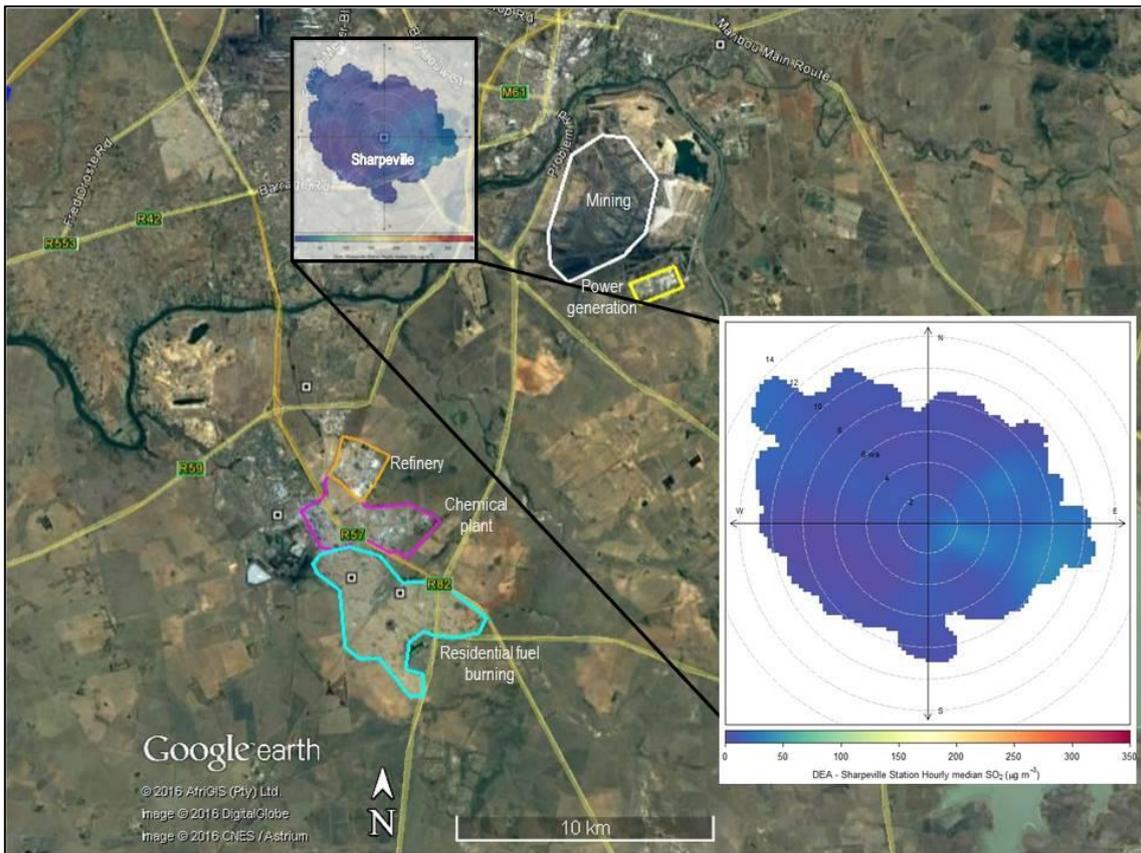


Figure 5-57: Polar plot of hourly median SO₂ concentration observations at Sharpeville for 2013 to 2015

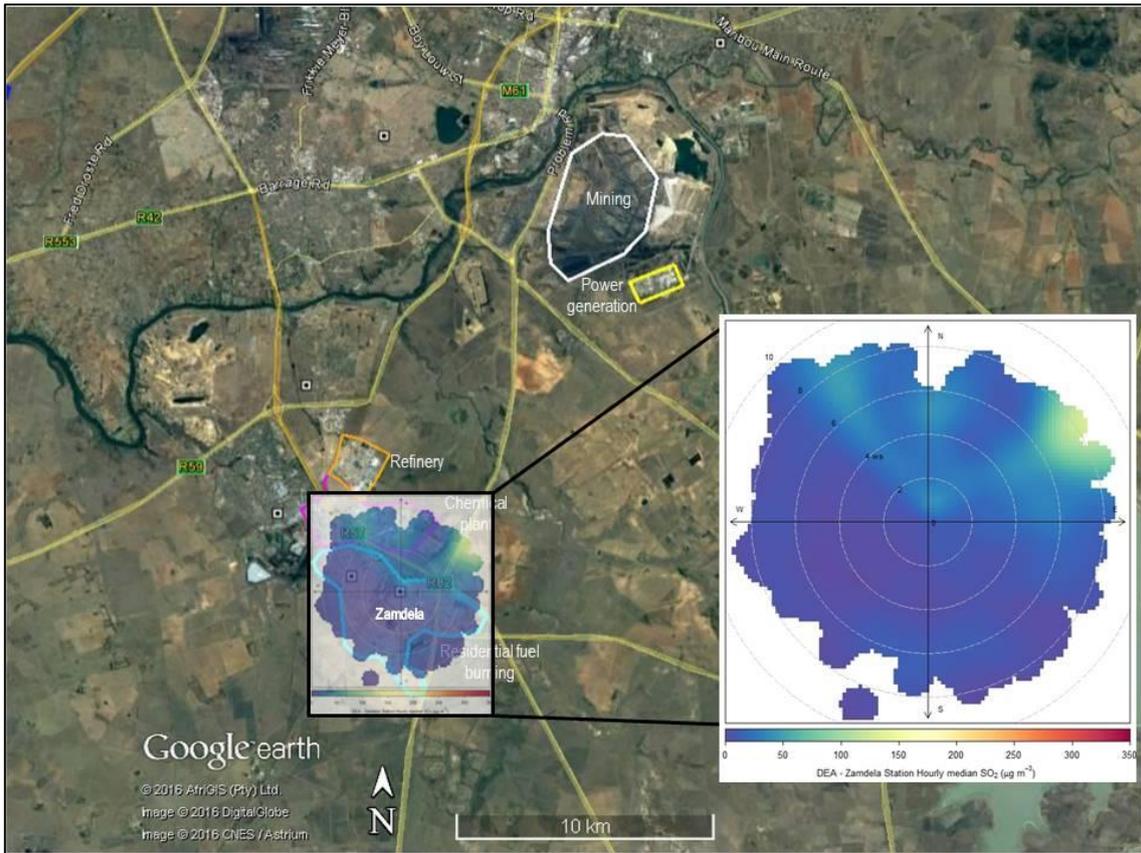


Figure 5-58: Polar plot of hourly median SO₂ concentration observations at Zamdela for 2013 to 2015

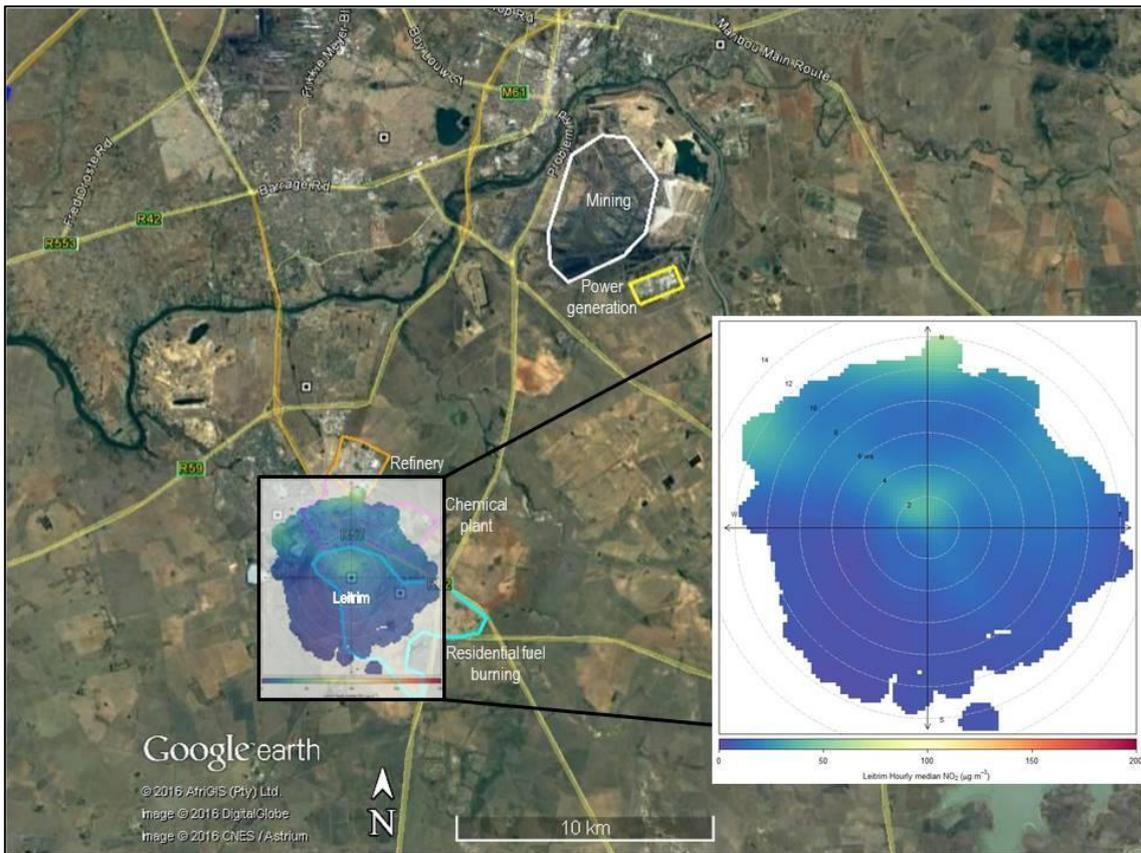


Figure 5-59: Polar plot of hourly median NO₂ concentration observations at Leitrim for 2013 to 2015

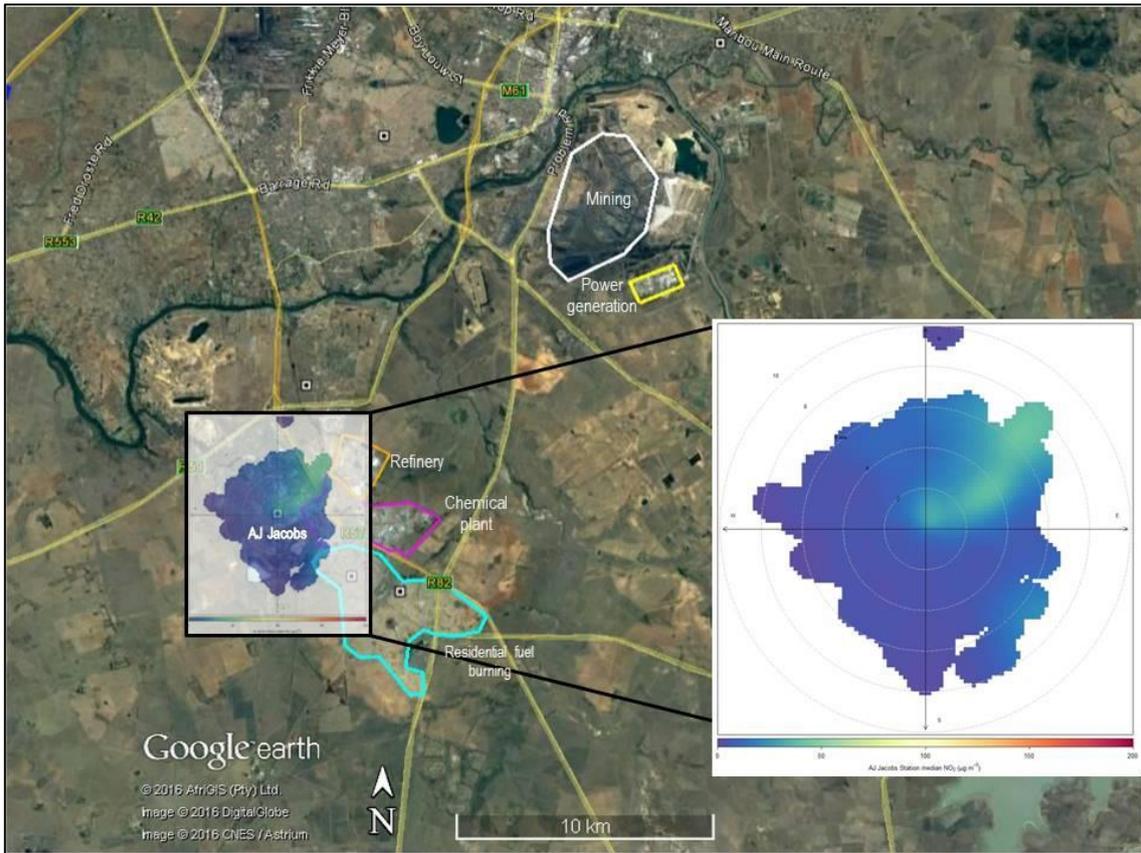


Figure 5-60: Polar plot of hourly median NO₂ concentration observations at AJ Jacobs for 2013 to 2015

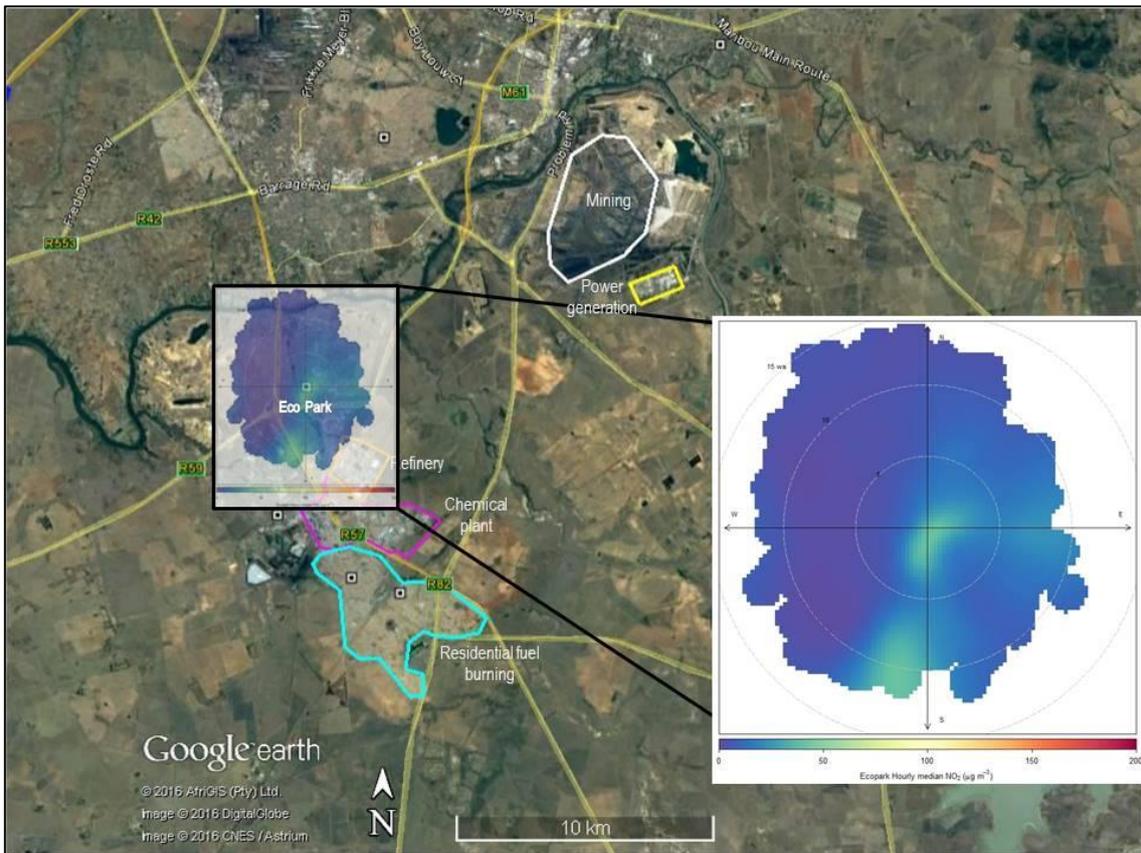


Figure 5-61: Polar plot of hourly median NO₂ concentration observations at Eco Park for 2013 to 2015

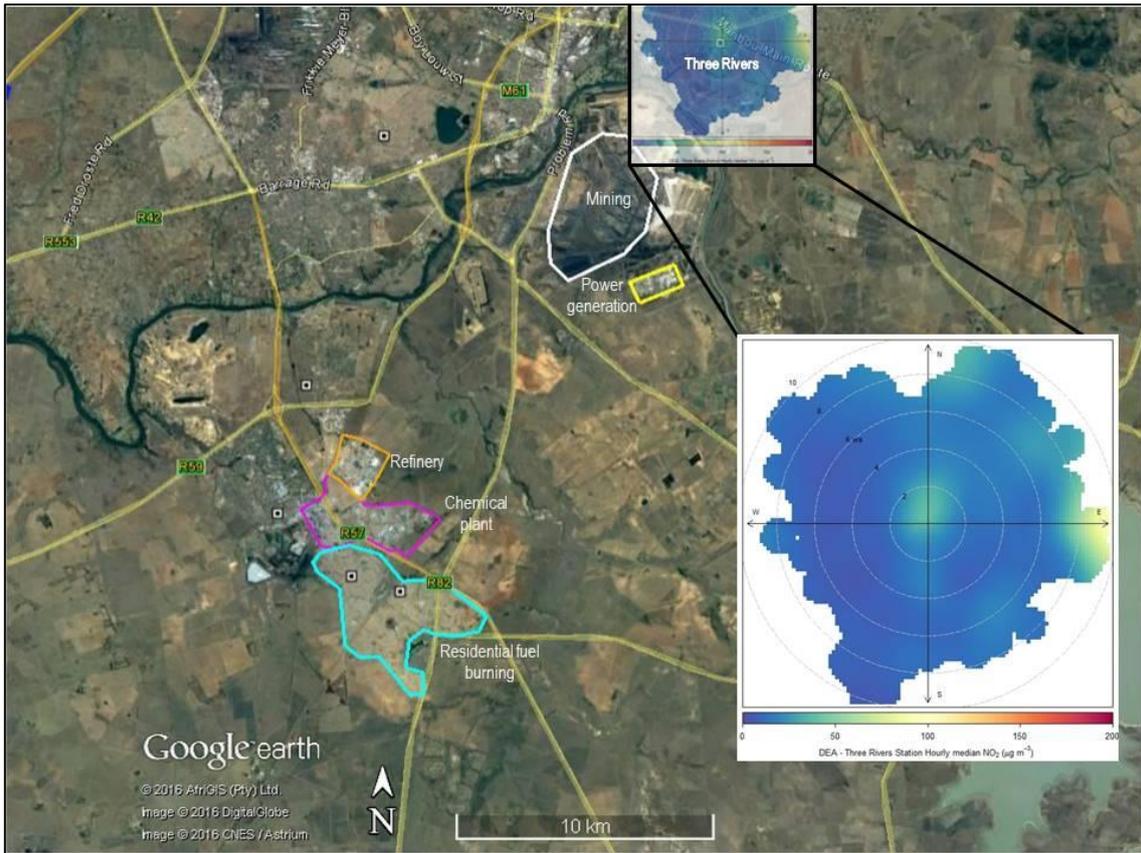


Figure 5-62: Polar plot of hourly median NO₂ concentration observations at Three Rivers for 2013 to 2015

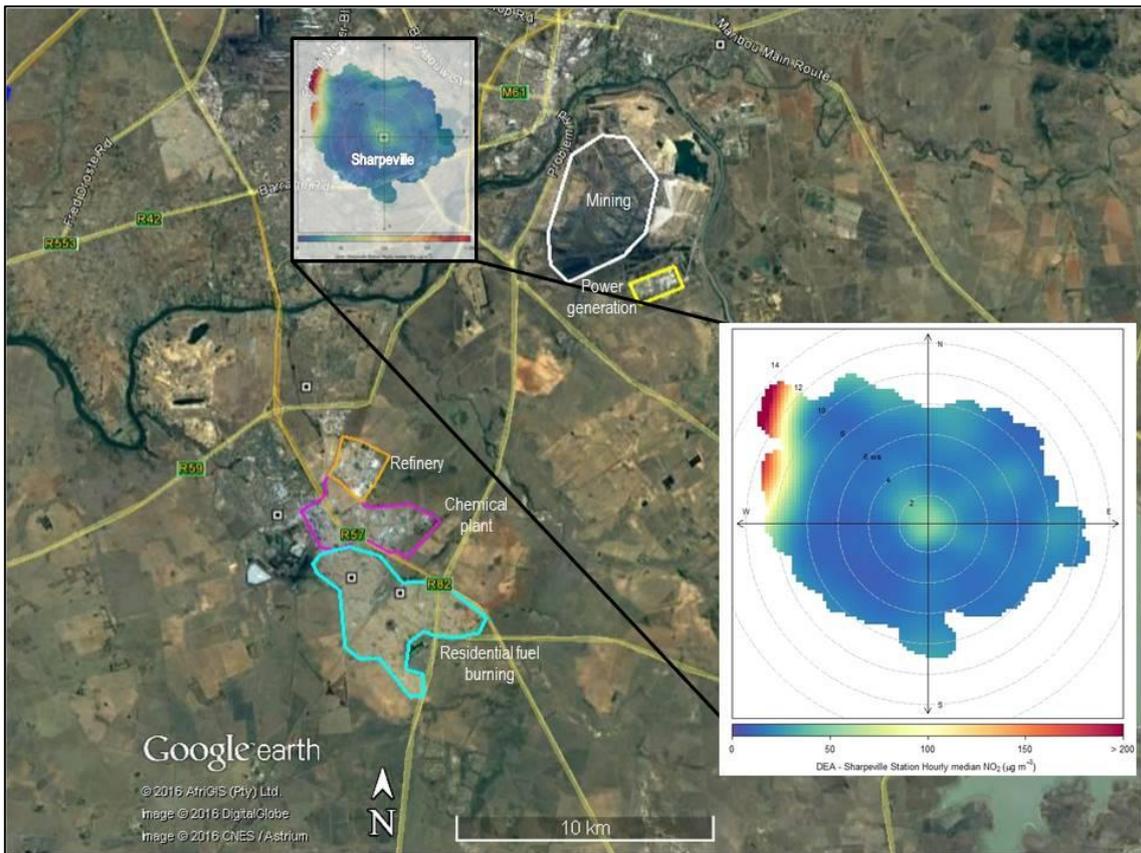


Figure 5-63: Polar plot of hourly median NO₂ concentration observations at Sharpeville for 2013 to 2015

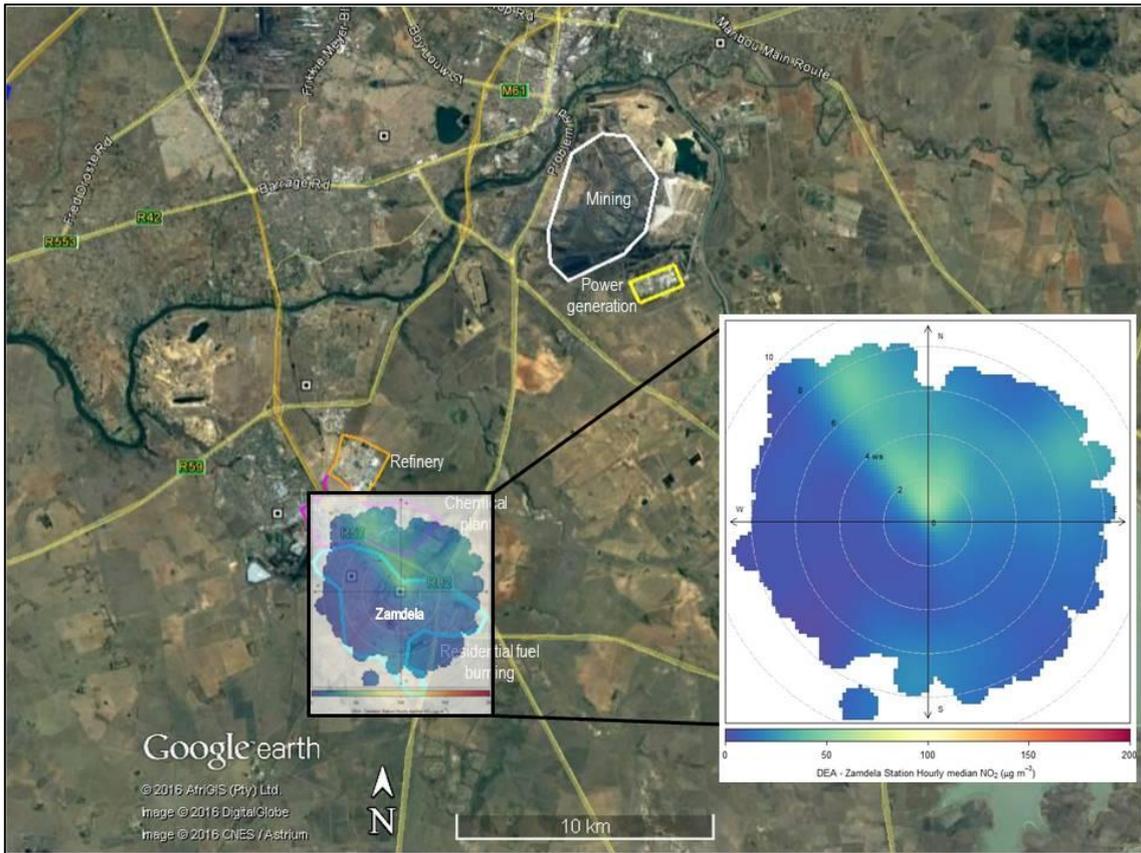


Figure 5-64: Polar plot of hourly median NO₂ concentration observations at Zamdela for 2013 to 2015

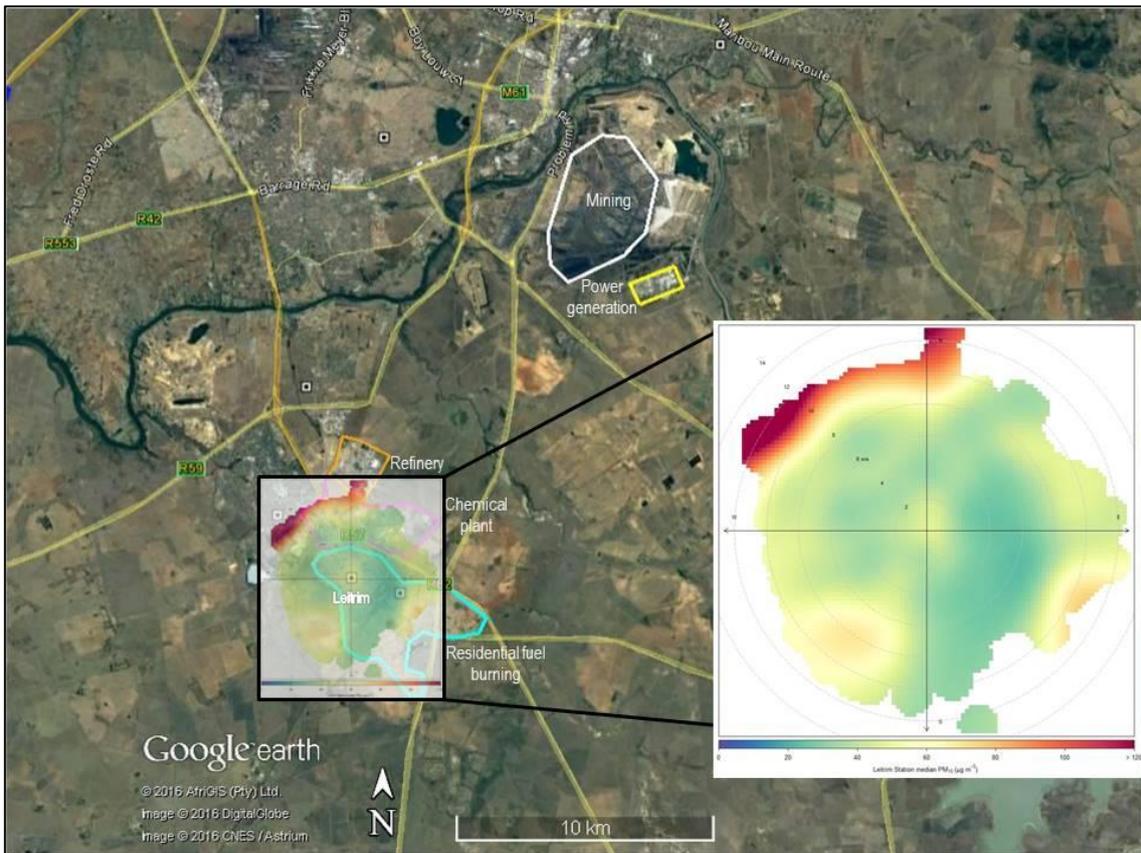


Figure 5-65: Polar plot of hourly median PM₁₀ concentration observations at Leitrim for 2013 to 2015

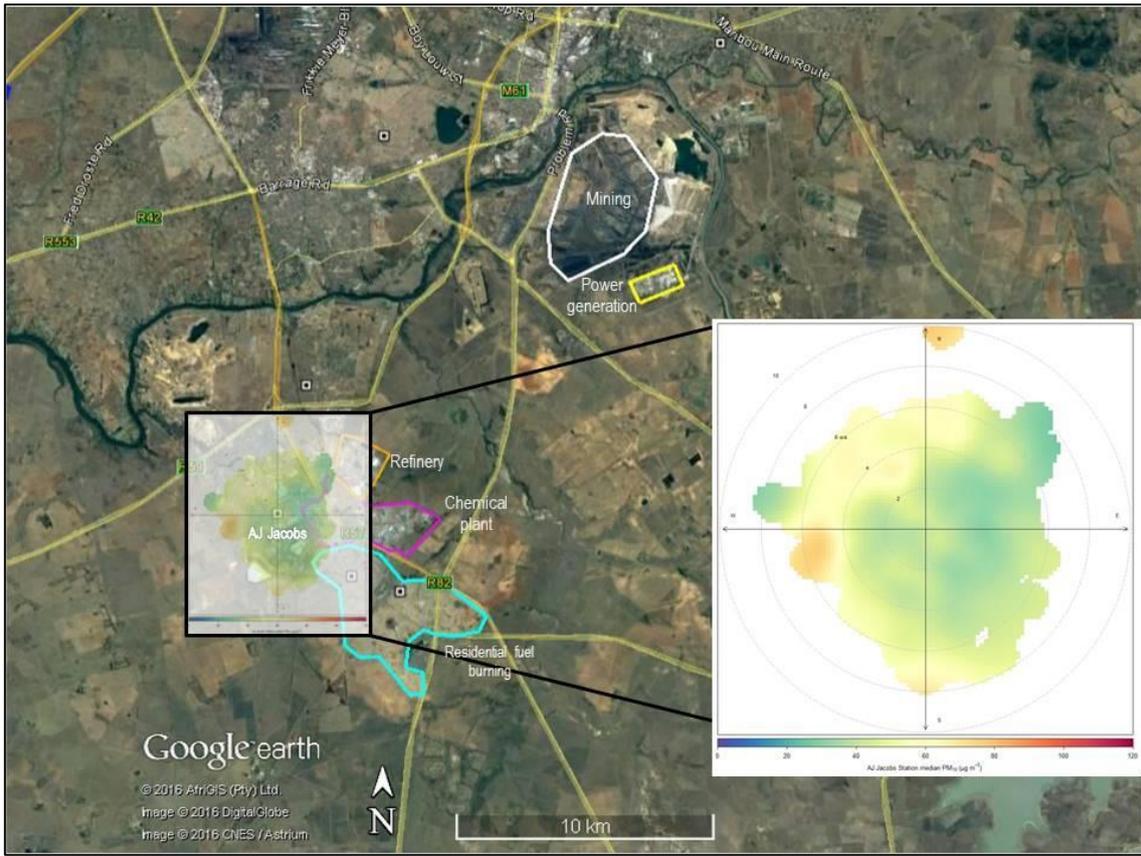


Figure 5-66: Polar plot of hourly median PM_{10} concentration observations at AJ Jacobs for 2013 to 2015

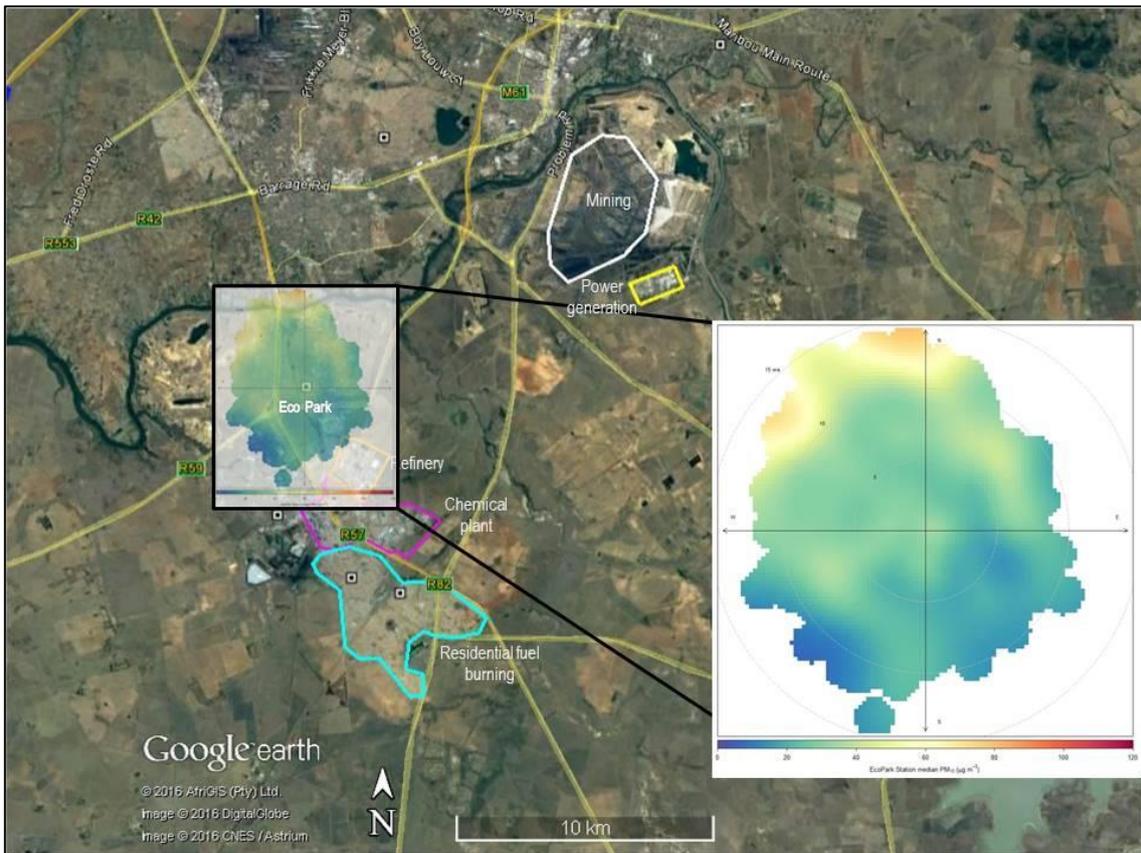


Figure 5-67: Polar plot of hourly median PM_{10} concentration observations at Eco Park for 2013 to 2015

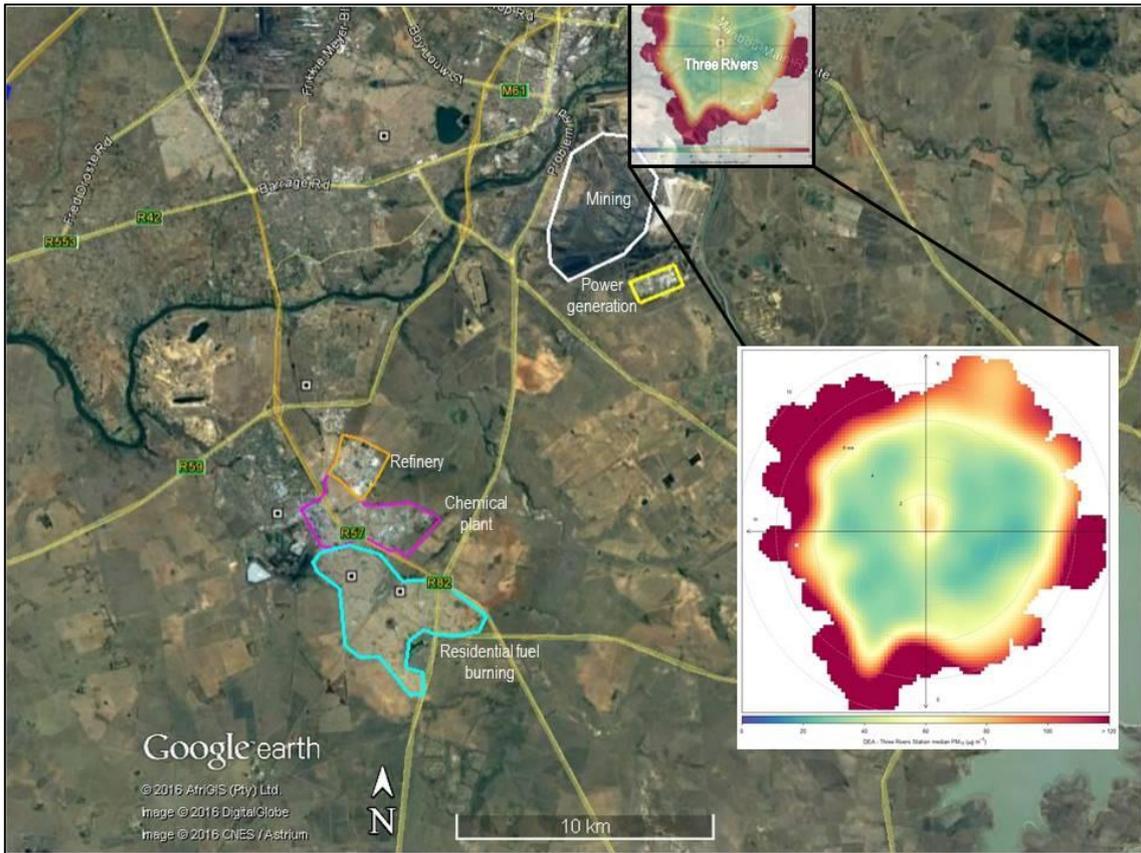


Figure 5-68: Polar plot of hourly median PM_{10} concentration observations at Three Rivers for 2013 to 2015

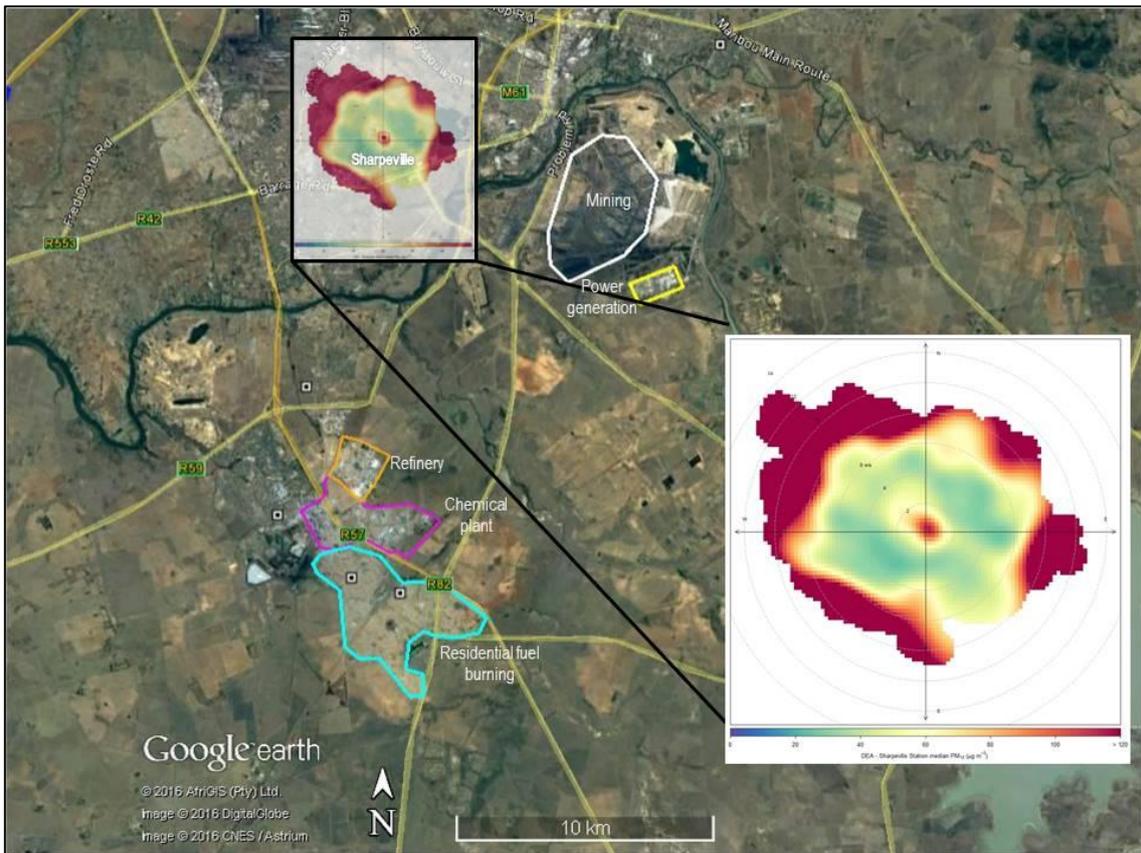


Figure 5-69: Polar plot of hourly median PM_{10} concentration observations at Sharpeville for 2013 to 2015

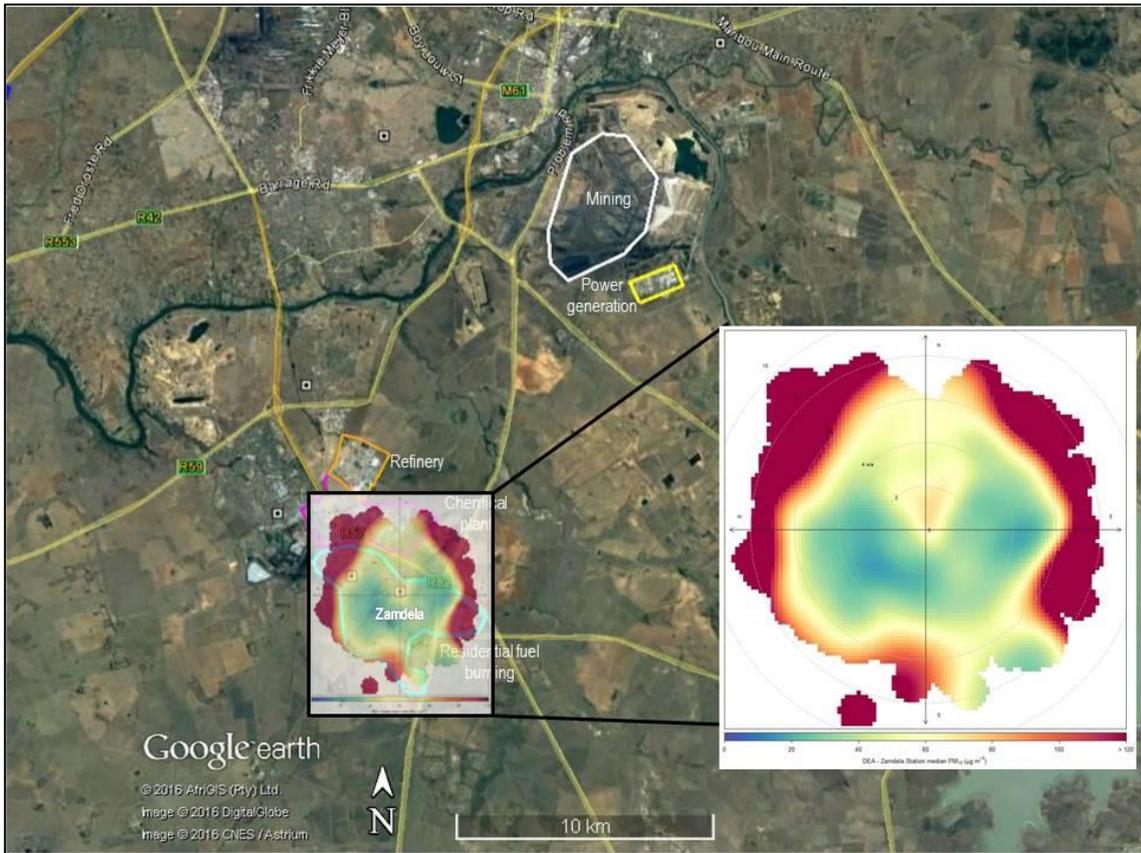


Figure 5-70: Polar plot of hourly median PM₁₀ concentration observations at Zamdela for 2013 to 2015

5.1.6.2 Model validation

Ambient concentrations of NO₂, SO₂, and PM₁₀ measured by Sasol and the DEA in Sasolburg help provide an understanding of existing ambient air concentrations as well as providing a means of verifying the dispersion modelling. Since the aim of the investigation is to illustrate the change in ground level concentrations from the current levels (i.e. baseline emission scenario) to those levels resulting from the introduction of the required emission limits (i.e. existing and new plant emission standards), the intention was not to comprehensively include all air emissions within Sasolburg. Unaccounted emissions include those from unintended leaks within the plant (fugitive emissions) and small vents, as well as air emissions from other industries, emissions from activities occurring within the communities, and biomass burning (especially during winter season), as well as long-range transport into the modelling domain. However, information about community activities, such as the amount of traffic within the community and the amount of fuel used for heating is often difficult to estimate.

These emissions, when combined, may potentially add up to be a significant portion of the observed concentrations in the modelling domain. In terms of the current investigation, the portion of air quality due to air emission sources that is not included in the model's emissions inventory constitutes the background concentration.

Discrepancies between predicted and observed concentrations may also be as a result of process emission variations, and may include upset emissions and shutdowns. These conditions could result in significant under-estimating or over-estimating the air concentrations. In order to accommodate these upset emission conditions, a time varying emissions database would be required as input into the model.

A summary of the predicted concentrations and their comparison with observations are given in Appendix G. In order to establish model performance under average emission conditions, it is not uncommon to use a certain percentile of predicted and observed concentrations for comparison. Although these may range from a 90th to 99.9th percentile, it was decided to use the DEA NAAQS for guidance. For criteria pollutants SO₂, NO₂ and PM₁₀, the NAAQS requires compliance with the 99th percentile. As hourly averages, this allows exceedances of the limit value of 88 hours (SO₂ and NO₂) or 4 days (SO₂ and PM₁₀) per year. Estimated short-term (hourly or daily) background concentrations (not associated with the emissions included in the simulations) used the observed concentration value when simulated concentrations from SO indicate very small contributions (0.1 µg/m³).

From the polar plots provided in Section 5.1.6.1, a clear contribution of SO₂ concentrations from large non-Sasol/Natref industrial activities within the study area are observed at Eco Park (Figure 5-55), Three Rivers (Figure 5-56), Sharpeville (Figure 5-57) and Zamdela (Figure 5-58). The contributions of SO₂ concentrations measured at Leitrim (Figure 5-53) and AJ Jacobs (Figure 5-54) show a clear contribution from SO and Natref. Leitrim unfortunately had poor data availability for the period 2013-2015 (51%). Measured SO₂ concentrations at AJ Jacobs were therefore assessed against simulated results.

Table 5-17 Table 5 17 is a summary of comparisons between simulated and observed SO₂ concentrations at AJ Jacobs. As shown in the table of the observed peak concentration only 12% could not be accounted for. The difference between simulated and observation increases significantly when considering long-term comparisons (i.e. 50th percentile and annual average), clearly illustrating the contribution of emission sources not included in the dispersion model's emissions inventory. Not shown in the table is the observed concentration at the percentile where the prediction was zero; namely, 38 µg/m³ (average of 2013, 2014 and 2015).

Table 5-17: Comparison of predicted and observed SO₂ concentrations at AJ Jacobs monitoring station in Sasolburg

Description	AJ Jacobs			Unaccounted Fraction*
	SO ₂ concentration (µg/m ³)			
	Simulated	Observed	Unaccounted	
Peak	562	641	79	0.12
99th Percentile	242	293	51	0.17
90th Percentile	17	103	86	0.83
50th Percentile	0	32	32	1
Annual Average	11	48	37	0.77

* unaccounted fraction as a percentage of observed concentration

The performance evaluation was completed using the fractional bias method. Fractional bias is one of the evaluation methods recommended by the U.S. EPA for determining dispersion model performance (U.S. EPA 1992). Fractional bias provides a comparison of the means and standard deviation of both modelled and monitored concentrations for any given number of locations.

In this assessment, the background concentrations were added to the simulated concentrations prior to the calculation of the fractional bias. The 99th percentile (with background concentration) was compared to the same ranked monitored concentrations.

In Figure 5-71, the fractional bias is plotted with the means on the X-axis and the standard deviations on the Y-axis. The box on the plot encloses the area of the graph where the model predictions are within a fractional bias between -0.67 and +0.67; indicating a good correlation. The U.S. EPA states that predictions within a factor of two are a reasonable performance target for a model before it is used for refined regulatory analysis (U.S. EPA 1992). Data points appearing on the left half of the plot indicate an over-prediction and those on the right half of the plot represent under-predictions.

The fractional bias of the means were less than 0.67, clearly showing good model performance. Using the individual fractional biases, the model's prediction is shown to be well within acceptable model performance range, with fractional biases of the mean at -0.04 for AJ Jacobs. The fractional bias of the standard deviation for AJ Jacobs was -0.13 and is an indication that the model depicted the wide range of SO₂ concentrations at this location well.

The fractional bias was calculated for the other monitoring stations within the study area with the mean ranging from 0.48 (Leitrim) to 1.3 (Three Rivers) and the standard deviation ranging from 0.9 (Leitrim) to 1.72 (Three Rivers). The simulated SO₂ concentrations at these sites under-predicted the mean and the wide range of concentrations observed.

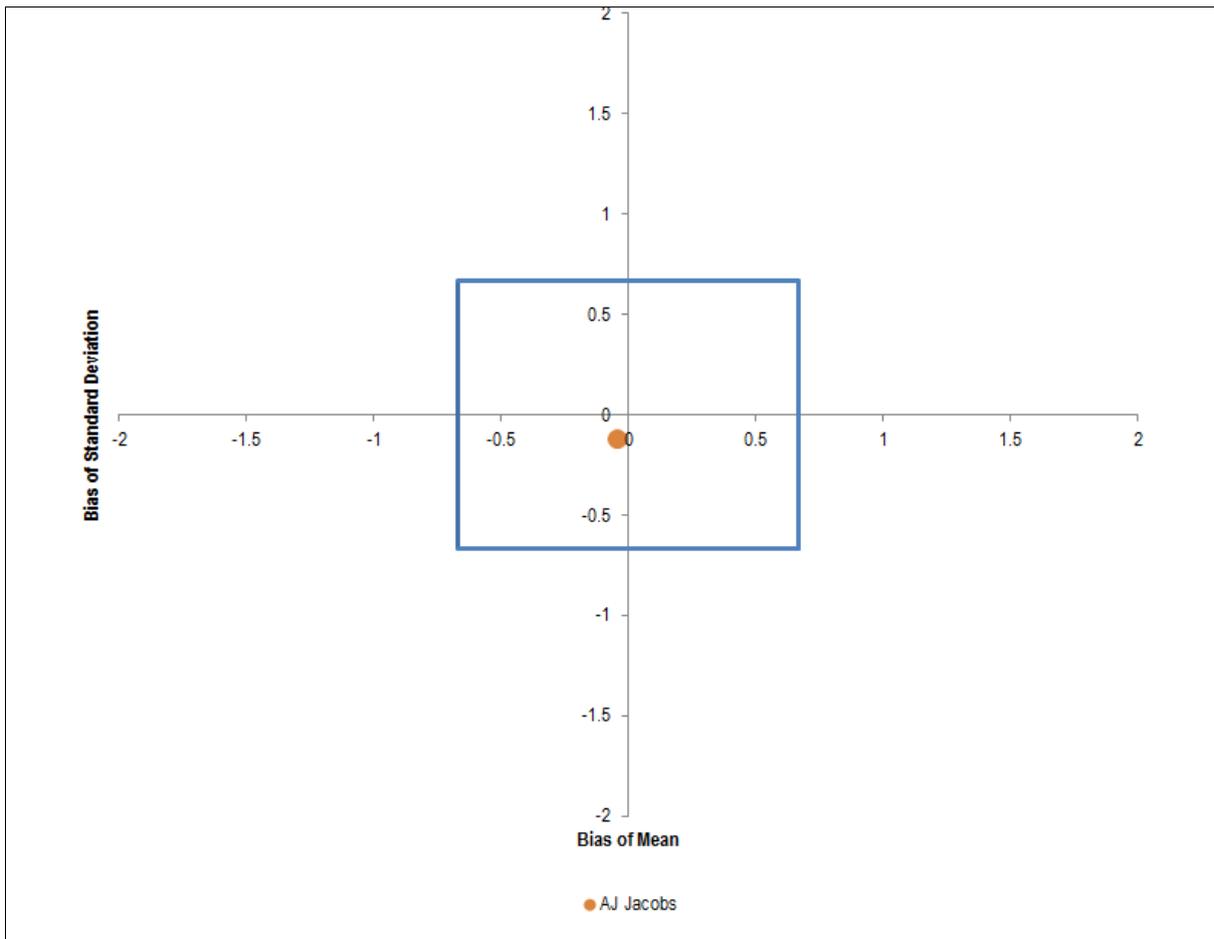


Figure 5-71: Fractional bias of means and standard deviation for SO₂

The same calculations and comparisons were repeated for NO₂ simulations and observations. The CALPUFF simulations were specifically for NO_x and the formation of HNO₃ and other nitrates using the MESOPUFF II chemical transformation mechanism, as discussed in Section 5.1.4.3.

Table 5-16 to Table 5-21 are a summary of comparisons between simulated and observed NO₂ concentrations at the monitoring stations in the study area. For AJ Jacobs (Table 5-17), higher concentrations were simulated than the observed peak concentrations. This may be due to the rather simplistic methodology of applying a constant conversion rate from NO_x to NO₂ (Section 5.1.4.3). As shown in Appendix E, the conversion ratio at high concentration levels (i.e. closer to the point of emission) generally varies between 14% and 27% for NO_x concentrations above 188 µg/m³. In this investigation, a NO₂ conservative ratio of not less than 40% was adopted for high concentrations of NO_x. Concentrations similar to the observed peak would be simulated if the lower conversions of 27% were used instead.

As for SO₂, the difference between simulated and observation increases significantly when considering long-term comparisons (i.e. 50th percentile and annual average), clearly illustrating the contribution of emission sources not included in the dispersion model's emissions inventory.

Table 5-18: Comparison of predicted and observed NO₂ concentrations at Leitrim monitoring station in Sasolburg

Description	Leitrim			
	NO ₂ concentration (µg/m ³)			Unaccounted Fraction*
	Simulated	Observed	Unaccounted	
Peak	183	242	60	0.25
99th Percentile	57	120	63	0.53
90th Percentile	14	46	32	0.70
50th Percentile	0	12	12	1.00
Annual Average	5	21	17	0.78

* unaccounted fraction as a percentage of observed concentration

Table 5-19: Comparison of predicted and observed NO₂ concentrations at AJ Jacobs monitoring station in Sasolburg

Description	AJ Jacobs			
	NO ₂ concentration (µg/m ³)			Unaccounted Fraction*
	Simulated	Observed	Unaccounted	
Peak	356	119	0	0.00
99th Percentile	141	73	0	0.00
90th Percentile	25	43	18	0.43
50th Percentile	0	15	15	1.00
Annual Average	8	20	11	0.57

* unaccounted fraction as a percentage of observed concentration

Table 5-20: Comparison of predicted and observed NO₂ concentrations at Eco Park monitoring station in Sasolburg

Description	Eco Park			
	NO ₂ concentration (µg/m ³)			Unaccounted Fraction*
	Simulated	Observed	Unaccounted	
Peak	148	152	4	0.02
99th Percentile	31	84	53	0.63
90th Percentile	1	51	51	0.99
50th Percentile	0	16	16	1.00
Annual Average	1	22	21	0.95

* unaccounted fraction as a percentage of observed concentration

Table 5-21: Comparison of predicted and observed NO₂ concentrations at Three Rivers monitoring station in Sasolburg

Description	Three Rivers			
	NO ₂ concentration (µg/m ³)			Unaccounted Fraction*
	Simulated	Observed	Unaccounted	
Peak	47	148	101	0.68
99th Percentile	10	84	74	0.88
90th Percentile	0	50	50	0.99
50th Percentile	0	20	20	1.00
Annual Average	0	25	25	0.98

* unaccounted fraction as a percentage of observed concentration

Table 5-22: Comparison of predicted and observed NO₂ concentrations at Sharpeville monitoring station in Sasolburg

Description	Sharpeville			
	NO ₂ concentration (µg/m ³)			Unaccounted Fraction*
	Simulated	Observed	Unaccounted	
Peak	57	265	209	0.79
99th Percentile	13	134	121	0.90
90th Percentile	0	73	72	1.00
50th Percentile	0	26	26	1.00
Annual Average	0	35	34	0.99

* unaccounted fraction as a percentage of observed concentration

Table 5-23: Comparison of predicted and observed NO₂ concentrations at Zamdela monitoring station in Sasolburg

Description	Zamdela			
	NO ₂ concentration (µg/m ³)			Unaccounted Fraction*
	Simulated	Observed	Unaccounted	
Peak	112	199	87	0.44
99th Percentile	58	100	42	0.42
90th Percentile	21	59	38	0.64
50th Percentile	0	22	22	1.00
Annual Average	6	28	22	0.80

* unaccounted fraction as a percentage of observed concentration

Table 5-19 and Table 5-20 are a summary of comparisons between simulated and observed NO₂ concentrations at Three Rivers and Sharpeville respectively. In contrast to AJ Jacobs, where the peak concentration was definitely shown to be from Sasol's Sasolburg Operations and Natref, only about 30% (Three Rivers) and 20% (Sharpeville) of the observed concentration was simulated. Although this may still have resulted from the Sasol's Sasolburg Operations and Natref, there is also a strong likelihood that more localised sources may have added to the observed peak. Other sources of NO₂ concentrations are also observed at these two sites in the polar plots (Figure 5-62 for Three Rivers and Figure 5-63 for Sharpeville). This is also illustrated by the 99th percentile that indicates a similar fraction of unaccounted for concentrations.

Subsequently, fractional biases (i.e. using the 99th percentile simulated concentrations and the estimated background concentration) were calculated for the monitoring stations within the study area. The results are summarised in Figure 5-72. The fractional bias of the means and standard deviations for AJ Jacobs indicated an over-prediction of the simulated NO₂ concentrations. The fractional bias of the means and standard deviations for Eco Park were less than 0.67, clearly showing good model performance (i.e. within -0.67 to +0.67). The model's simulations are shown to be within a factor of two for the fractional bias mean (x-axis) at Three Rivers, Leitrim, Sharpeville and Zamdela; however, the model under-predicting at these monitoring sites on the fractional bias standard deviation (y-axis) based on the range of NO₂ concentrations. The simulated NO₂ concentrations at Leitrim and Sharpeville stations are therefore outside of the range of good model performance (-0.67 to +0.67) but within the acceptable model performance range (-2.0 to +2.0).

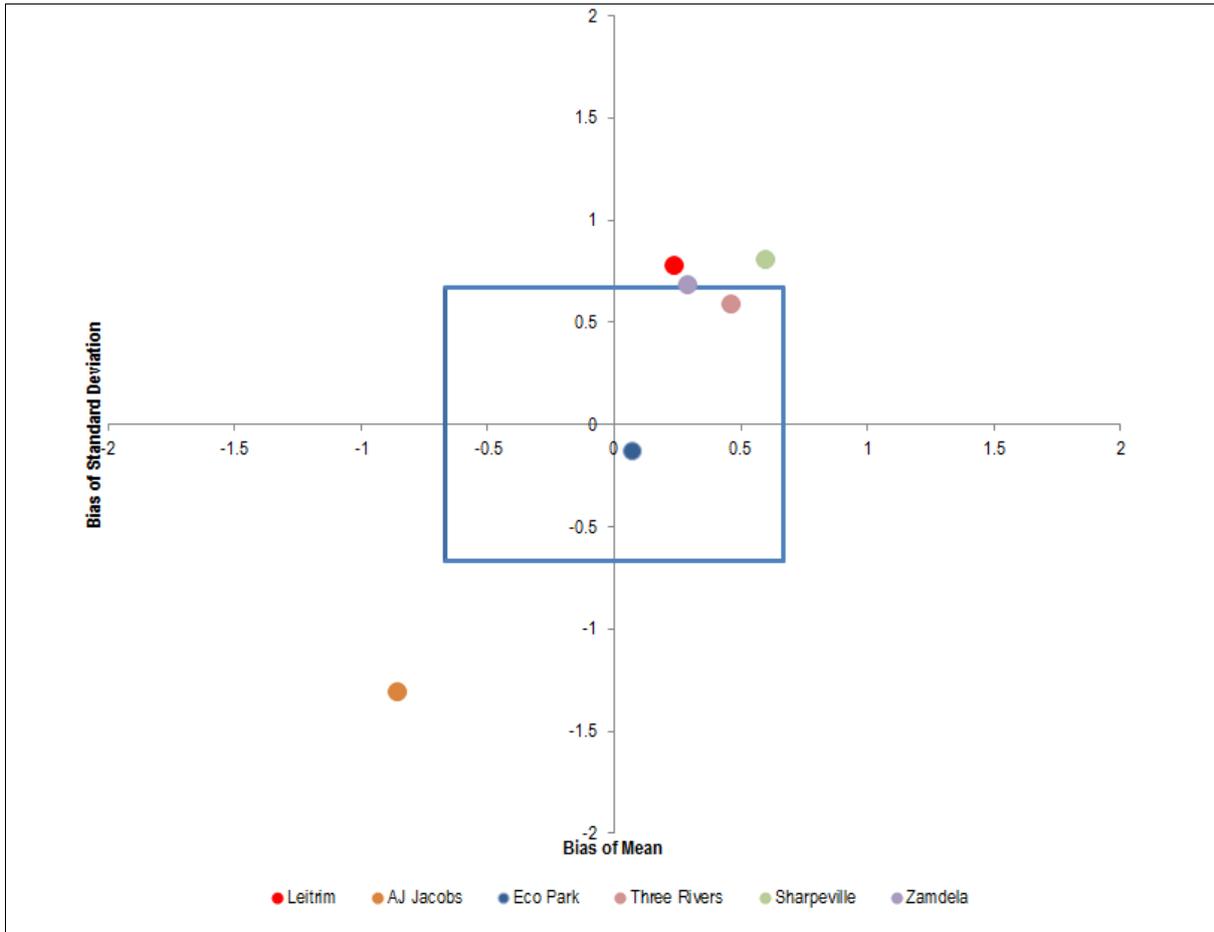


Figure 5-72: Fractional bias of means and standard deviation for NO₂

5.1.7 Scenario Emission Inventory

Dispersion modelling included all point sources in all scenarios (Table 4-1 and Table 4-2); however only three sources (Section 6900 Thermal Oxidation sources) had emission rates which varied between the four scenarios assessed. The baseline (i.e. unvarying) sources were modelled as per parameters and emission rates provided in Table 4-1 and Table 4-2. The thermal oxidation source parameters and emissions per scenario were provided by Sasol for the assessment and are given in Table 5-24 and Table 5-25 respectively.

Table 5-24: Source parameters per scenario provided for SO

Source Group	Source name	Latitude (decimal degrees)	Longitude (decimal degrees)	Height of Release Above Ground (m)	Diameter at Stack Tip / Vent Exit (m)	Actual Gas Exit Temperature (°C)	Actual Gas Volumetric Flow (m³/hr)	Actual Gas Exit Velocity (m/s)
All scenarios								
Section 6900	Heavy Ends B incinerator (B6990)	-26.82549	27.84035	40	1.5	650	64 000	10
	High sulfur pitch incinerator (B6930)	-26.82537	27.84022	40	1.5	180	140 000	22
	Spent caustic incinerator (B6993)	-26.82553	27.84043	40	1.2	83	51 000	12.5

Table 5-25: Thermal oxidation source emissions per scenario provided for SO (units: g/s)

Source group	Source name	SO ₂	NO _x as NO ₂	PM	CO	HF	Sum of heavy metals	Hg	Cd+Tl	TOCs	HCl	NH ₃	Dioxins/Furans
Baseline													
Incinerators	B6990	2.00	1.14	1.08	0.04	0.00E+00	1.27E-01	0.00E+00	0.00E+00	3.17E-02	1.07E-02	4.25E-03	1.90E-04
	B6930	28.64	7.00	0.80	0.07	1.20E-02	1.59E-01	3.17E-04	6.34E-03	1.49E-01	4.77E-02	1.43E-02	3.17E-04
	B6993	2.51	3.10	2.66	12.53	0.00E+00	2.85E-03	0.00E+00	0.00E+00	1.27E-01	2.21E-02	4.06E-02	4.12E-04
At Existing Plant Emission Standards													
Incinerators	B6990	0.09	0.38	0.05	0.14	1.87E-03	9.51E-04	9.51E-05	9.51E-05	1.88E-02	1.88E-02	1.88E-02	1.90E-04
	B6930	0.45	1.81	0.23	0.68	9.04E-03	4.53E-03	4.44E-04	4.44E-04	9.04E-02	9.04E-02	9.04E-02	9.20E-04
	B6993	0.43	1.74	0.22	0.65	8.69E-03	4.34E-03	4.44E-04	4.44E-04	8.70E-02	8.70E-02	8.70E-02	8.56E-04
At New Plant Emission Standards													
Incinerators	B6990	0.09	0.38	0.02	0.09	1.87E-03	9.51E-04	9.51E-05	9.51E-05	1.88E-02	1.88E-02	1.88E-02	1.90E-04
	B6930	0.45	1.81	0.09	0.45	9.04E-03	4.53E-03	4.44E-04	4.44E-04	9.04E-02	9.04E-02	9.04E-02	9.20E-04
	B6993	0.43	1.74	0.09	0.43	8.69E-03	4.34E-03	4.44E-04	4.44E-04	8.70E-02	8.70E-02	8.70E-02	8.56E-04
At Alternative Emissions													
Incinerators	B6990	2.82	1.20	1.13	0.04	6.22E-03	1.13E-01	3.17E-05	3.17E-05	2.82E-02	1.13E-02	4.50E-03	2.22E-04
	B6930	32.54	7.95	0.90	0.09	1.08E-02	1.45E-01	4.12E-04	5.07E-04	1.36E-01	5.42E-02	1.63E-02	3.49E-04
	B6993	2.96	3.65	3.13	14.79	5.23E-03	1.74E-01	6.34E-05	3.17E-05	1.74E-01	2.61E-02	4.79E-02	4.76E-04

5.1.8 Model Results

Air quality standards are fundamental tools to assist in air quality management. The NAAQS (Section 5.1.2.2) are intended to reduce harmful effects on health of the majority of the population, including the very young and the elderly. In this section, predicted ambient concentrations of criteria pollutants at specific sensitive receptors are compared against the promulgated local NAAQS (Table 5-2).

Prior to dispersion modelling, 52 receptors were identified in the vicinity of SO (within the 50-by-50 km modelling domain). Sensitive receptors included residential areas, schools, hospitals and clinics, monitoring stations (Figure 5-73 and Table 5-26). Ambient air quality monitoring stations (AQMS) were the first receptors identified because comparison of the predicted concentrations could be compared with measured concentrations for model validation. Schools, hospitals and clinics within the domain were identified and included as sensitive receptors in the dispersion model (full list provided in Appendix K). All receptors are presented in the isopleth plots, where the AQMS are included in results figures and the 20 closest receptors are included in the results tables at increasing distance from the centre of SO.

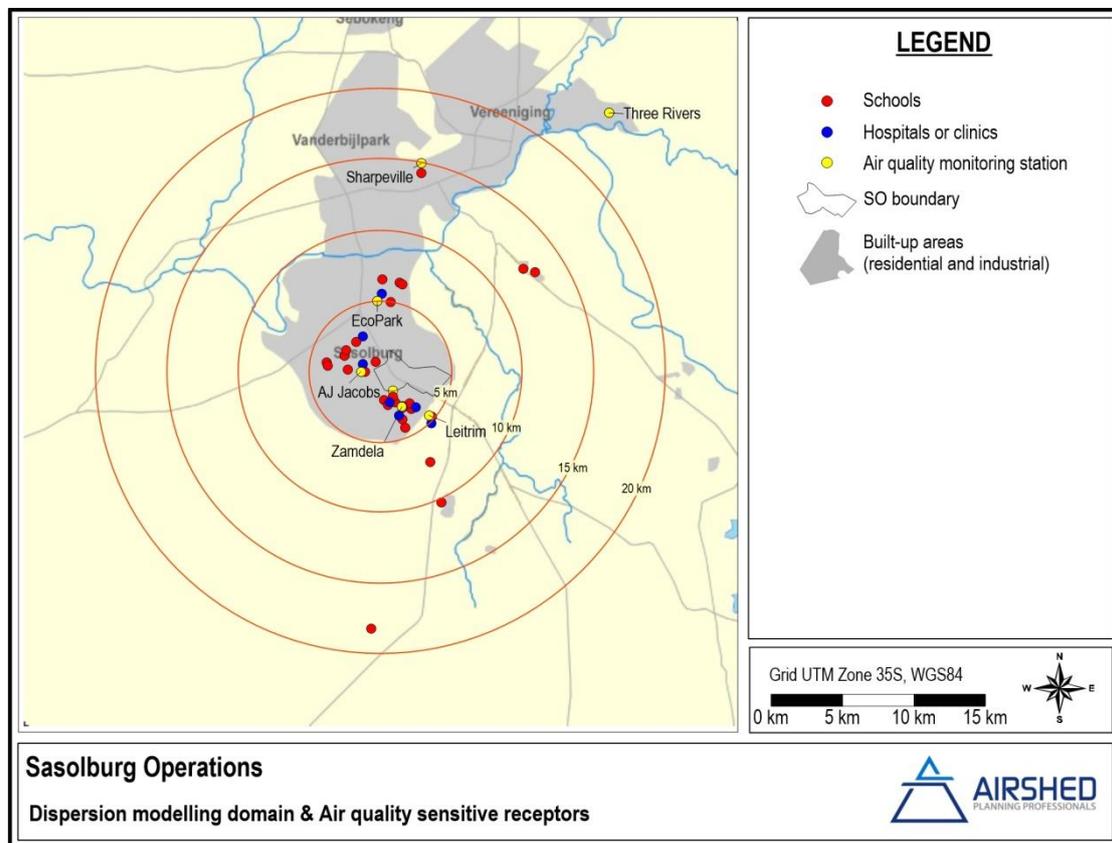


Figure 5-73: Sensitive receptors identified for assessment of impact as a result of Sasol Operations, Sasolburg

Table 5-26: Receptors identified for assessment of impact as a result of SO emissions

Receptor code name ^(a)	Receptor details	Distance from centre of operations (km) ^(b)
Zamdela	VTAPA Zamdela monitoring station	2.1
Leitrim	Sasol Leitrim monitoring station	3.1
AJ Jacobs	Sasol AJ Jacobs monitoring station	3.2
EcoPark	Sasol EcoPark monitoring station	5.7
Sharpeville	VTAPA Sharpeville monitoring station	15.1
Three Rivers	VTAPA Three Rivers monitoring station	23.4
25	Malakabeng Primary School	1.7
32	Cedar Secondary School	1.9
15	Bofula-Tshepe Primary School	2.0
49	Clinic A Zamdela	2.1
51	Zamdela Hospital Zumayear	2.2
35	Iketsetseng Secondary School	2.2
48	Clinic B Zamdela	2.2
29	Tsatsi Primary School	2.3
20	Isaac Mhlambi Primary School	2.3
37	Nkopoleng Secondary School	2.4
34	HTS Secondary School	2.4
44	Zamdela Community Clinic	2.8
14	AJ Jacobs Primary School	2.9
28	Theha Setjhaba Primary School	3.0
52	Sasolburg Clinic	3.2
18	Credo Primary School	3.3
23	Lehutso Primary School	3.6
50	Harry Gwala Clinic Creche	3.7
36	Kahobotjha-Sakubusha Secondary School	4.1
43	Sasolburg Provincial Hospital	4.2

Since the focus of the study is to illustrate the relative changes in ambient concentrations of pollutants theoretically arising from different point source emission scenarios, the predicted concentration differences from scenario to scenario were provided as percentage increase or decrease over the modelled baseline scenario ($C_{Baseline\ Scenario}$).

$$\frac{C_{S, Future\ Scenario} - C_{S, Baseline\ Scenario}}{C_{Baseline\ Scenario}}$$

Equation 1

It should be noted that the changes in ground-level concentrations, at the receptors, between the scenarios shown in the results: (1) are theoretical changes and may not necessarily be technically possible, and; (2) represent the maximum achievable improvements and are, therefore, not indicative of the day-to-day average reduction at every receptor point cumulatively.

5.1.8.1 Criteria pollutants

The findings for each of the criteria pollutants (SO₂, NO₂ and PM) are presented for the SO in three forms. The first figure presents the predicted pollutant concentration (99th percentile) at the AQMS (Table 5-26) for each of the emission scenarios (baseline operating conditions, emissions in theoretical compliance with Existing Plant Standards [2015], and with New Plant Standards [2020]; and the Alternative Emission) relative to the appropriate NAAQS. A table then presents the percentage change in ground-level concentrations between the emission scenarios and the baseline at the AQMS and 20 closest sensitive receptors (Table 5-26). Finally, isopleth plots have been included for the all relevant emission scenarios and pollutants.

5.1.8.1.1 Sulfur dioxide (SO₂)

Ambient concentrations of SO₂ as a result of SO baseline emissions are predicted to fall below the hourly NAAQS at the AQMS (Figure 5-74 to Figure 5-76) and receptors (Table 5-27 to Table 5-29). Reductions in ambient SO₂ concentrations are evident with theoretical compliance with existing and new plant emission standards, by up to 26% (Table 5-27 to Table 5-29). The alternative emission scenario results in an increase in ground-level concentrations relative to the baseline (Figure 5-74 and Table 5-27 to Table 5-29) by a maximum of 4.8%.

Isopleth plots are presented for all averaging periods ground-level SO₂ concentrations as a result of all emission scenarios for SO, as per the figure numbers below:

Scenario	Hourly	Daily	Annual
Baseline concentrations	Figure 5-77	Figure 5-81	Figure 5-85
Existing Plant standards	Figure 5-78	Figure 5-82	Figure 5-86
New Plant standards	Figure 5-79	Figure 5-83	Figure 5-87
Alternative emissions	Figure 5-80	Figure 5-84	Figure 5-88

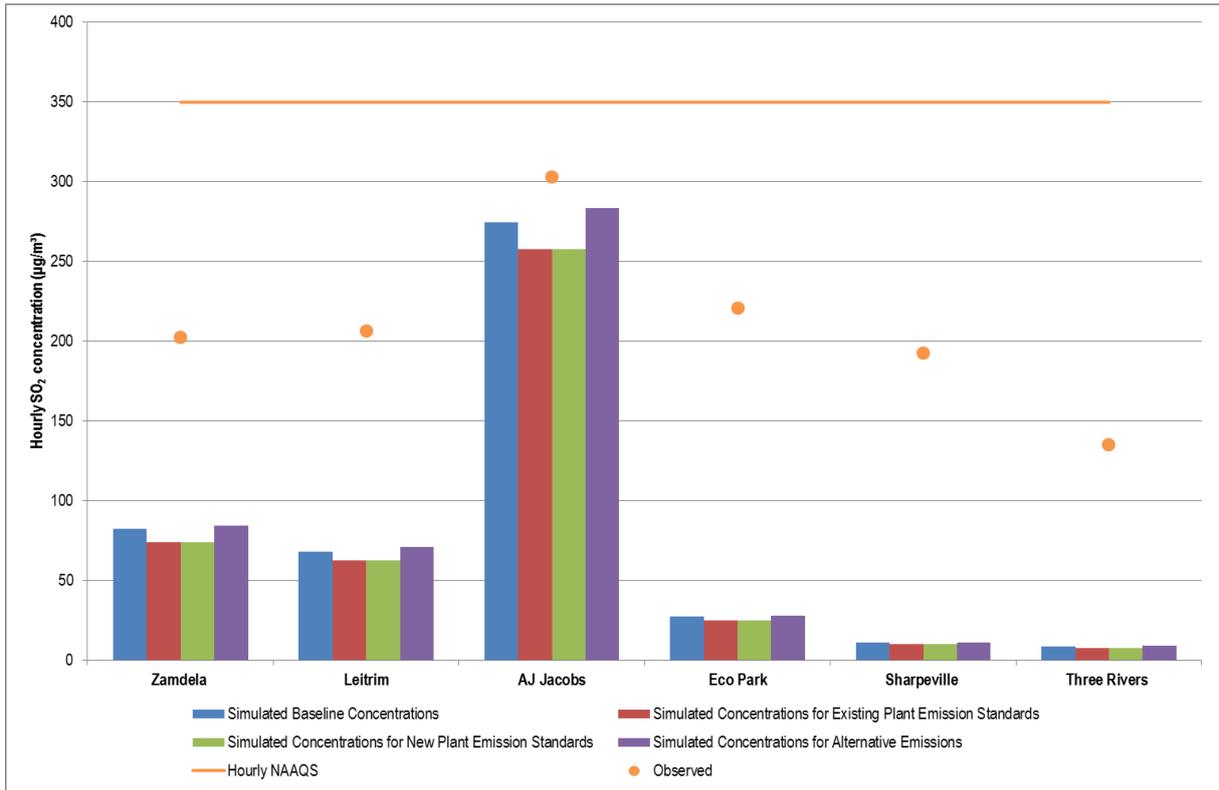


Figure 5-74: Simulated hourly SO₂ concentrations (99th percentile) at AQMS for Sasolburg Operations

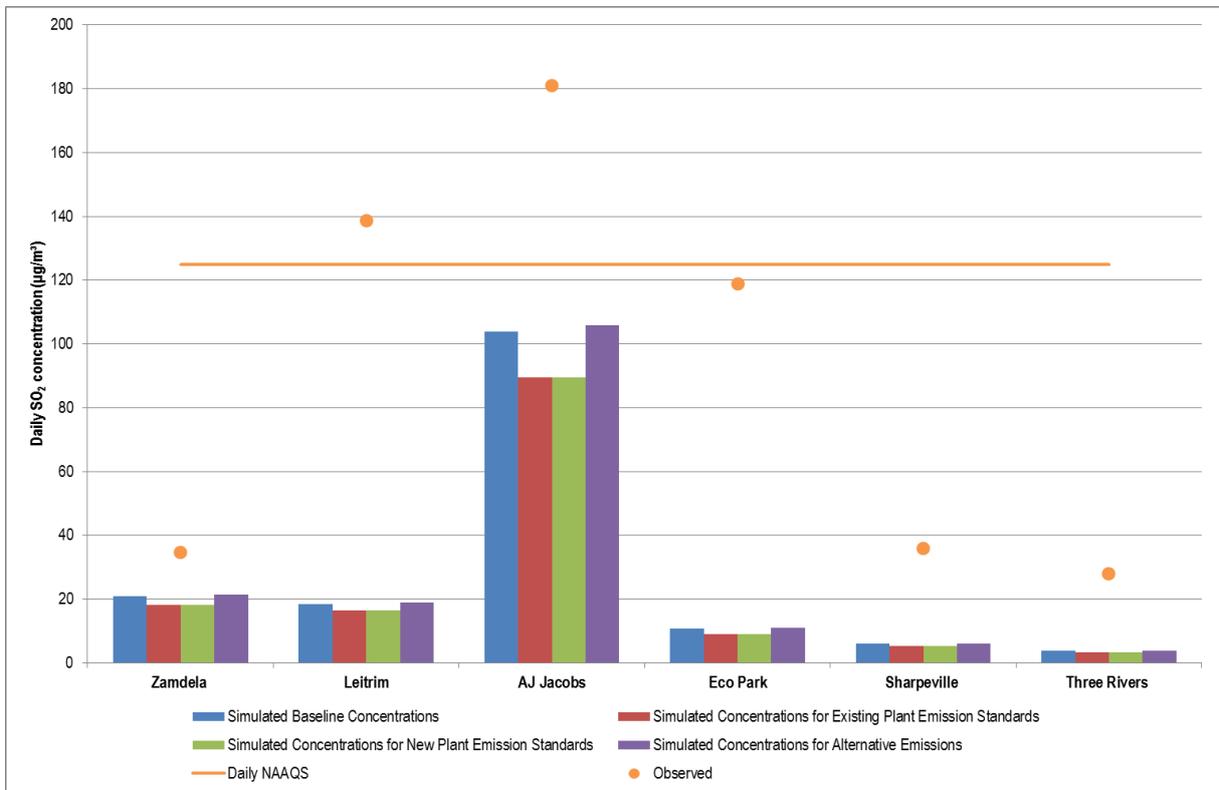


Figure 5-75: Simulated daily SO₂ concentrations (99th percentile) at AQMS for Sasolburg Operations

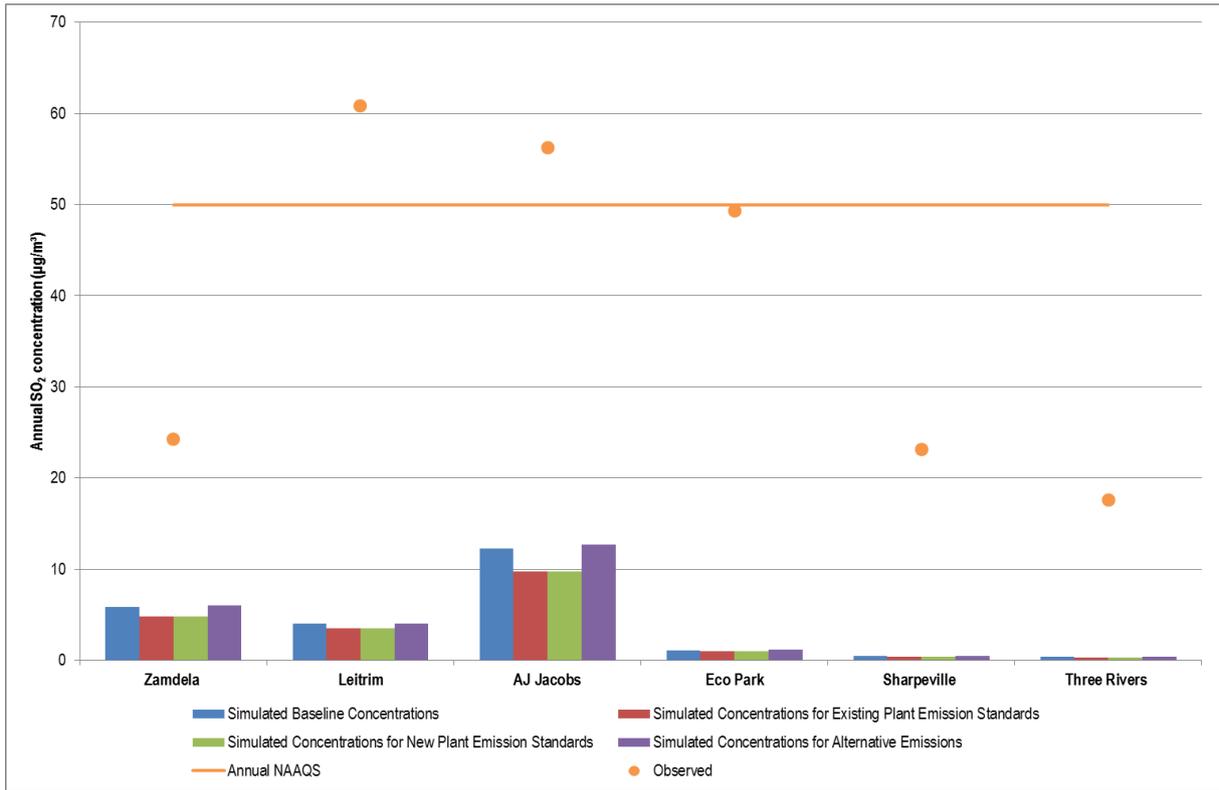


Figure 5-76: Simulated annual SO₂ concentrations at AQMS for Sasolburg Operations

Table 5-27: Simulated baseline hourly SO₂ concentrations and the theoretical change in concentrations relative to the baseline at the AQMs and 20 closest receptors

Receptor	Hourly SO ₂ (99 th percentile)						
	Baseline	Existing		New		Alternative	
	Concentration (µg/m ³)	Concentration (µg/m ³)	Relative change	Concentration (µg/m ³)	Relative change	Concentration (µg/m ³)	Relative change
Zamdela AQMS	72.6	65.2	-10.3%	65.1	-10.3%	74.7	2.9%
Leitrim AQMS	64.1	58.7	-8.3%	58.7	-8.3%	65.4	2.1%
AJ Jacobs AQMS	237.1	214.0	-9.7%	214.0	-9.7%	242.0	2.1%
Eco Park AQMS	24.6	21.9	-10.9%	21.8	-11.0%	25.0	2.0%
Sharpeville AQMS	9.4	8.2	-13.1%	8.2	-13.1%	9.7	2.7%
Three Rivers AQMS	8.1	7.2	-11.3%	7.2	-11.3%	8.3	2.6%
Malakabeng Primary School	94.7	79.9	-15.6%	79.9	-15.6%	98.6	4.1%
Cedar Secondary School	74.9	69.0	-7.8%	69.0	-7.9%	76.5	2.1%
Bofula- Tshepe Primary School	71.6	64.5	-9.9%	64.5	-9.8%	73.4	2.5%
Clinic A Zamdela	73.5	65.7	-10.6%	65.7	-10.6%	75.7	3.0%
Zamdela Hospital Zumayear	85.5	73.9	-13.6%	73.9	-13.5%	87.6	2.6%
Iketsetseng Secondary School	71.6	64.5	-9.9%	64.5	-9.8%	73.4	2.5%
Clinic B Zamdela	72.0	65.8	-8.6%	65.8	-8.6%	73.5	2.1%
Tsatsi Primary School	107.6	86.8	-19.4%	86.7	-19.4%	112.2	4.3%
Isaac Mhlambi Primary School	70.5	64.5	-8.5%	64.5	-8.5%	71.9	1.9%
Nkopoleng Secondary School	83.9	71.6	-14.6%	71.6	-14.6%	86.4	2.9%
HTS Secondary School	189.0	167.2	-11.5%	167.0	-11.6%	194.9	3.1%
Zamdela Community Clinic	66.6	60.7	-8.9%	60.7	-8.9%	68.0	2.1%
AJ Jacobs Primary School	258.3	223.6	-13.4%	223.2	-13.6%	261.9	1.4%
Theha Setjhaba Primary School	63.8	58.6	-8.0%	58.6	-8.1%	66.0	3.5%
Sasolburg Clinic	225.9	208.7	-7.6%	209.0	-7.5%	228.5	1.2%
Credo Primary School	62.9	57.2	-8.9%	57.2	-9.0%	64.1	2.0%
Lehutso Primary School	61.8	55.1	-10.8%	55.1	-10.8%	63.5	2.9%
Harry Gwala Clinic Creche	59.8	54.7	-8.6%	54.7	-8.6%	61.4	2.6%
Kahobotjha-Sakubusha Secondary School	143.6	131.3	-8.6%	131.2	-8.6%	146.4	2.0%
Sasolburg Provincial Hospital	58.9	52.6	-10.7%	52.6	-10.7%	59.3	0.7%

Table 5-28: Simulated baseline daily SO₂ concentrations and the theoretical change in concentrations relative to the baseline at the AQMs and 20 closest receptors

Receptor	Daily SO ₂ (99 th percentile)						
	Baseline	Existing		New		Alternative	
	Concentration (µg/m ³)	Concentration (µg/m ³)	Relative change	Concentration (µg/m ³)	Relative change	Concentration (µg/m ³)	Relative change
Zamdela AQMS	20.1	17.5	-13.0%	17.5	-13.0%	20.6	2.1%
Leitrim AQMS	18.2	15.6	-14.1%	15.6	-14.1%	18.5	1.5%
AJ Jacobs AQMS	85.4	73.4	-14.0%	73.4	-14.0%	87.1	2.0%
Eco Park AQMS	9.9	8.6	-13.5%	8.6	-13.5%	10.3	3.8%
Sharpeville AQMS	5.1	4.4	-15.1%	4.4	-15.1%	5.3	2.5%
Three Rivers AQMS	3.5	3.0	-15.2%	3.0	-15.2%	3.7	4.0%
Malakabeng Primary School	26.7	22.5	-15.6%	22.5	-15.6%	27.5	3.0%
Cedar Secondary School	21.2	17.9	-15.4%	17.9	-15.4%	21.4	0.8%
Bofula- Tshepe Primary School	19.4	17.1	-12.0%	17.1	-12.0%	20.3	4.7%
Clinic A Zamdela	21.2	17.7	-16.5%	17.7	-16.5%	21.7	2.4%
Zamdela Hospital Zumayear	25.8	21.7	-15.9%	21.7	-15.9%	26.9	4.1%
Iketsetseng Secondary School	19.4	17.1	-12.0%	17.1	-12.0%	20.3	4.7%
Clinic B Zamdela	18.2	17.2	-5.5%	17.2	-5.5%	18.9	4.0%
Tsatsi Primary School	31.9	24.3	-23.8%	24.3	-23.8%	33.0	3.5%
Isaac Mhlambi Primary School	19.5	17.8	-8.8%	17.8	-8.8%	19.8	1.6%
Nkopoleng Secondary School	25.5	20.4	-20.0%	20.4	-20.0%	26.8	5.1%
HTS Secondary School	58.6	52.3	-10.7%	52.3	-10.7%	59.6	1.6%
Zamdela Community Clinic	18.7	16.9	-9.5%	16.9	-9.5%	19.1	1.9%
AJ Jacobs Primary School	87.9	76.3	-13.2%	76.3	-13.2%	90.7	3.2%
Theha Setjhaba Primary School	17.8	16.1	-9.6%	16.1	-9.6%	18.7	4.8%
Sasolburg Clinic	82.1	75.4	-8.2%	75.4	-8.2%	83.8	2.0%
Credo Primary School	17.2	15.8	-8.1%	15.8	-8.1%	17.4	1.0%
Lehutso Primary School	18.3	15.4	-15.7%	15.4	-15.7%	18.4	0.4%
Harry Gwala Clinic Creche	15.9	14.5	-8.6%	14.5	-8.6%	16.8	6.1%
Kahobotjha-Sakubusha Secondary School	57.1	52.1	-8.7%	52.1	-8.7%	57.8	1.2%
Sasolburg Provincial Hospital	22.8	20.9	-8.2%	20.9	-8.2%	23.4	2.3%

Table 5-29: Simulated baseline annual SO₂ concentrations and the theoretical change in concentrations relative to the baseline at the AQMs and 20 closest receptors

Receptor	Annual SO ₂						
	Baseline	Existing		New		Alternative	
	Concentration (µg/m ³)	Concentration (µg/m ³)	Relative change	Concentration (µg/m ³)	Relative change	Concentration (µg/m ³)	Relative change
Zamdela AQMS	4.9	3.9	-20.0%	3.9	-20.0%	5.0	3.3%
Leitrim AQMS	3.8	3.2	-16.2%	3.2	-16.2%	3.9	2.7%
AJ Jacobs AQMS	9.6	7.6	-20.6%	7.6	-20.6%	9.9	3.4%
Eco Park AQMS	1.0	0.8	-12.0%	0.8	-12.0%	1.0	2.0%
Sharpeville AQMS	0.4	0.3	-16.9%	0.3	-16.9%	0.4	2.8%
Three Rivers AQMS	0.3	0.3	-16.1%	0.3	-16.1%	0.3	2.7%
Malakabeng Primary School	6.7	5.1	-24.0%	5.1	-24.0%	7.0	3.9%
Cedar Secondary School	5.0	4.1	-18.6%	4.1	-18.6%	5.2	3.1%
Bofula- Tshepe Primary School	4.7	3.8	-19.8%	3.8	-19.8%	4.9	3.3%
Clinic A Zamdela	4.9	3.9	-20.4%	3.9	-20.4%	5.1	3.4%
Zamdela Hospital Zumayear	5.6	4.3	-23.3%	4.3	-23.3%	5.8	3.8%
Iketsetseng Secondary School	4.7	3.8	-19.8%	3.8	-19.8%	4.9	3.3%
Clinic B Zamdela	4.5	3.8	-17.1%	3.8	-17.1%	4.7	2.8%
Tsatsi Primary School	6.2	4.6	-25.8%	4.6	-25.8%	6.5	4.2%
Isaac Mhlambi Primary School	4.4	3.6	-18.3%	3.6	-18.3%	4.6	3.0%
Nkopoleng Secondary School	5.2	4.0	-22.7%	4.0	-22.7%	5.3	3.7%
HTS Secondary School	6.8	5.8	-15.0%	5.8	-15.0%	7.0	2.4%
Zamdela Community Clinic	4.1	3.3	-19.1%	3.3	-19.1%	4.2	3.1%
AJ Jacobs Primary School	9.9	7.8	-21.2%	7.8	-21.2%	10.2	3.5%
Theha Setjhaba Primary School	3.9	3.2	-18.4%	3.2	-18.4%	4.0	3.0%
Sasolburg Clinic	7.9	6.9	-12.8%	6.9	-12.8%	8.1	2.1%
Credo Primary School	3.7	3.1	-16.0%	3.1	-16.0%	3.8	2.6%
Lehutso Primary School	3.6	2.9	-18.4%	2.9	-18.4%	3.7	3.0%
Harry Gwala Clinic Creche	3.4	2.8	-16.7%	2.8	-16.7%	3.5	2.7%
Kahobotjha-Sakubusha Secondary School	5.9	5.0	-15.6%	5.0	-15.6%	6.1	2.6%
Sasolburg Provincial Hospital	2.1	1.8	-11.8%	1.8	-11.8%	2.1	1.9%

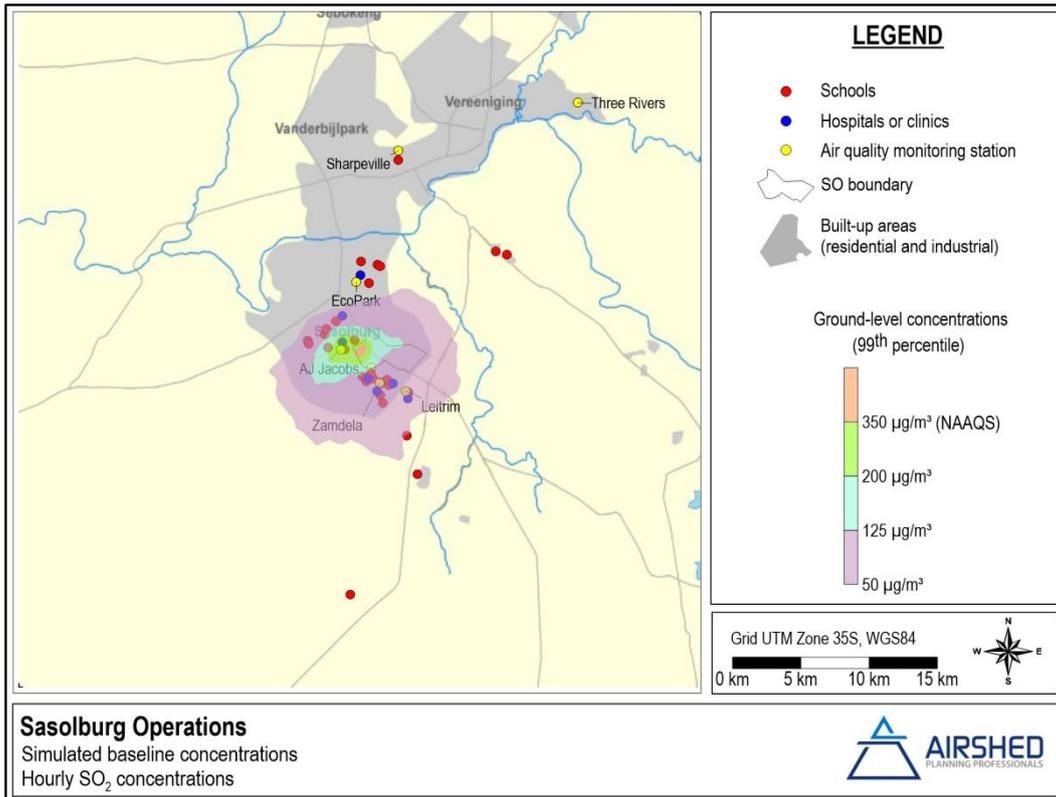


Figure 5-77: Simulated hourly SO₂ concentrations (99th percentile) as a result of baseline emissions

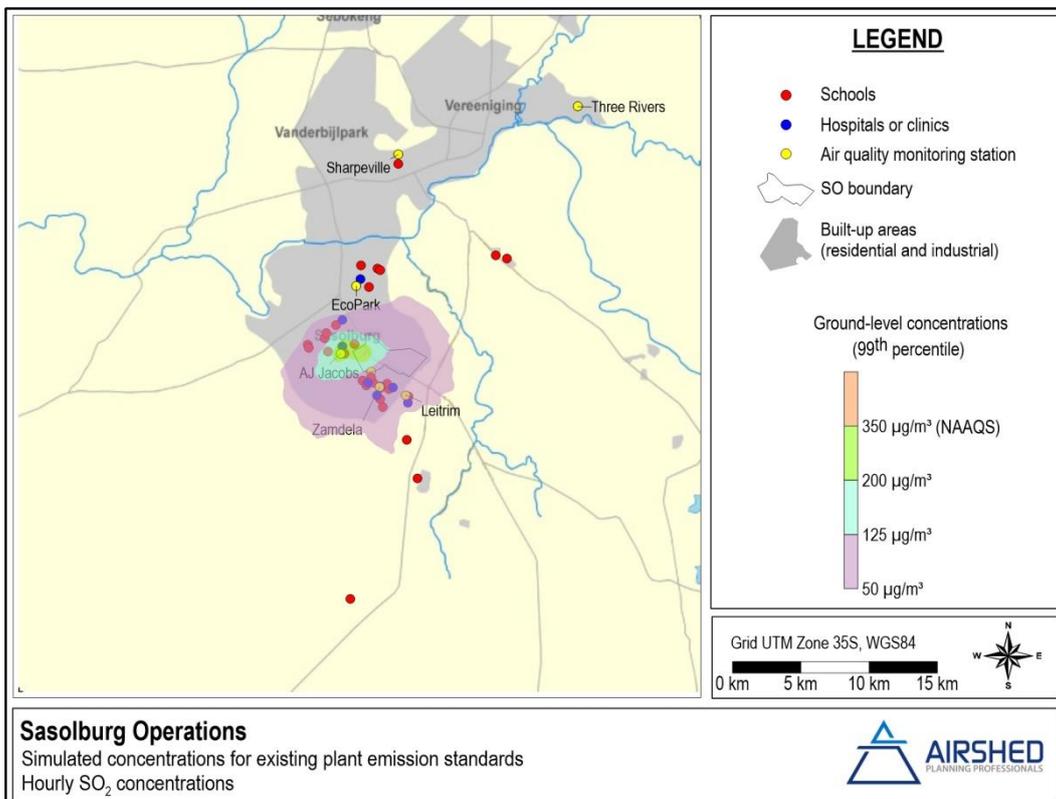


Figure 5-78: Simulated hourly SO₂ concentrations (99th percentile) as a result of theoretical compliance with existing plant emission standards

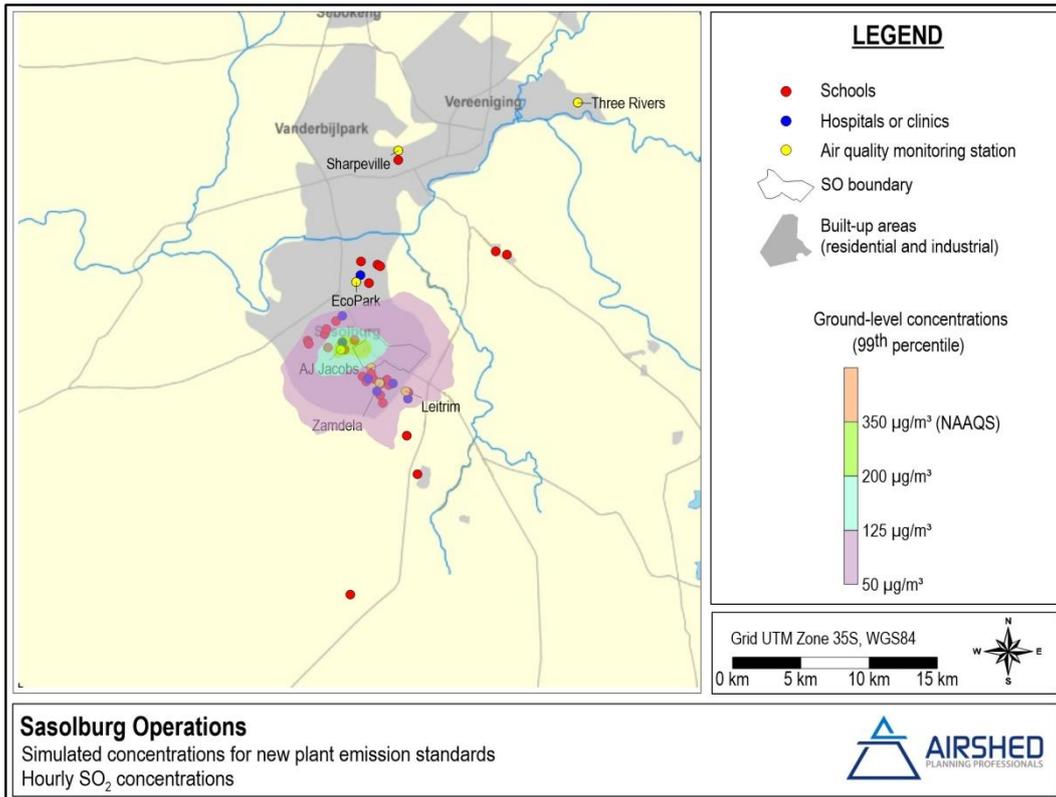


Figure 5-79: Simulated hourly SO₂ concentrations (99th percentile) as a result of theoretical compliance with new plant emission standards

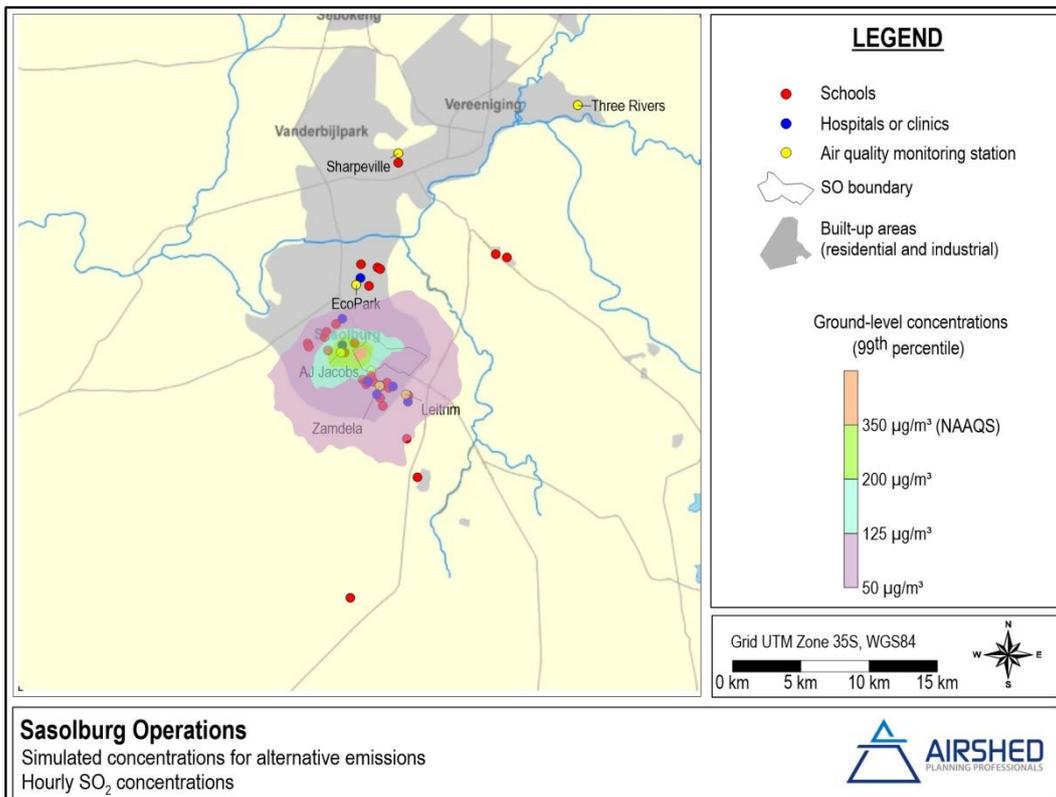


Figure 5-80: Simulated hourly SO₂ concentrations (99th percentile) as a result of alternative emissions

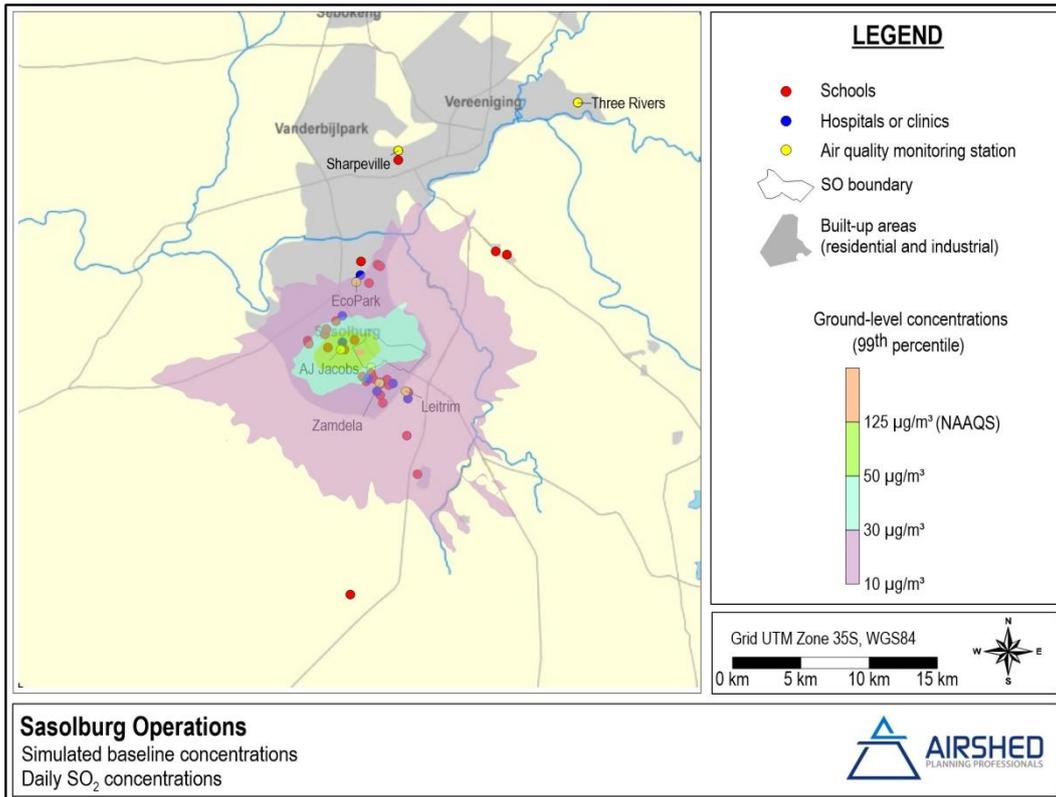


Figure 5-81: Simulated daily SO₂ concentrations (99th percentile) as a result of baseline emissions

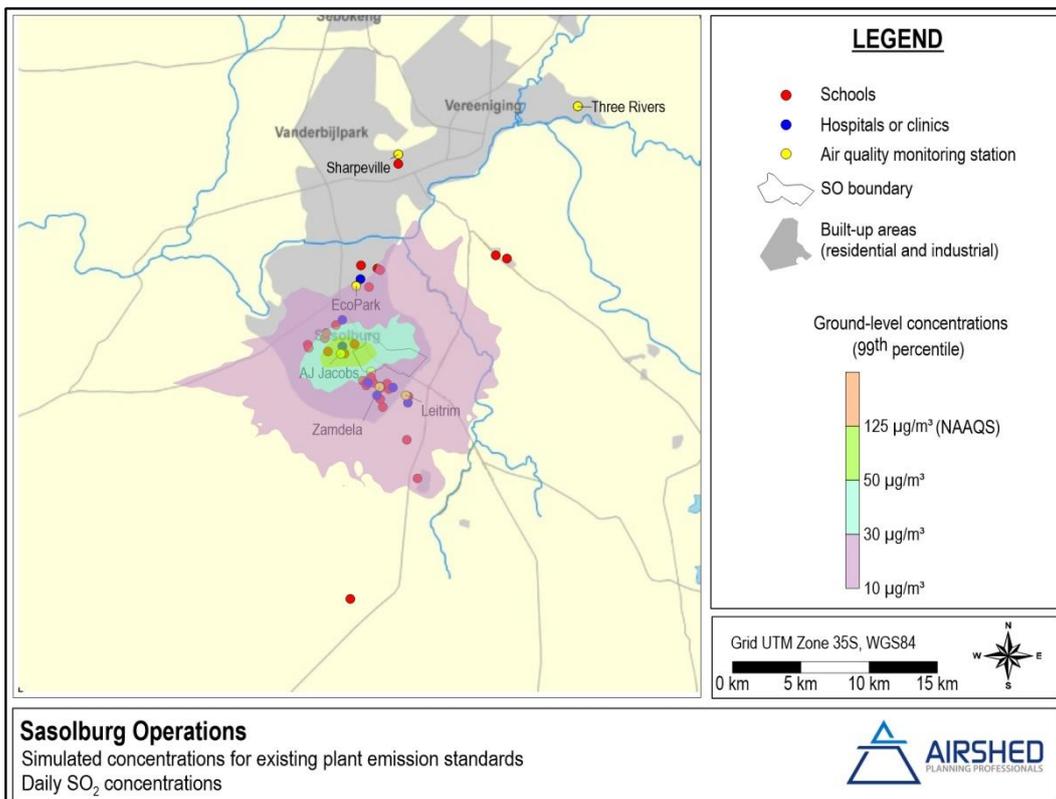


Figure 5-82: Simulated daily SO₂ concentrations (99th percentile) as a result of theoretical compliance with existing plant emission standards

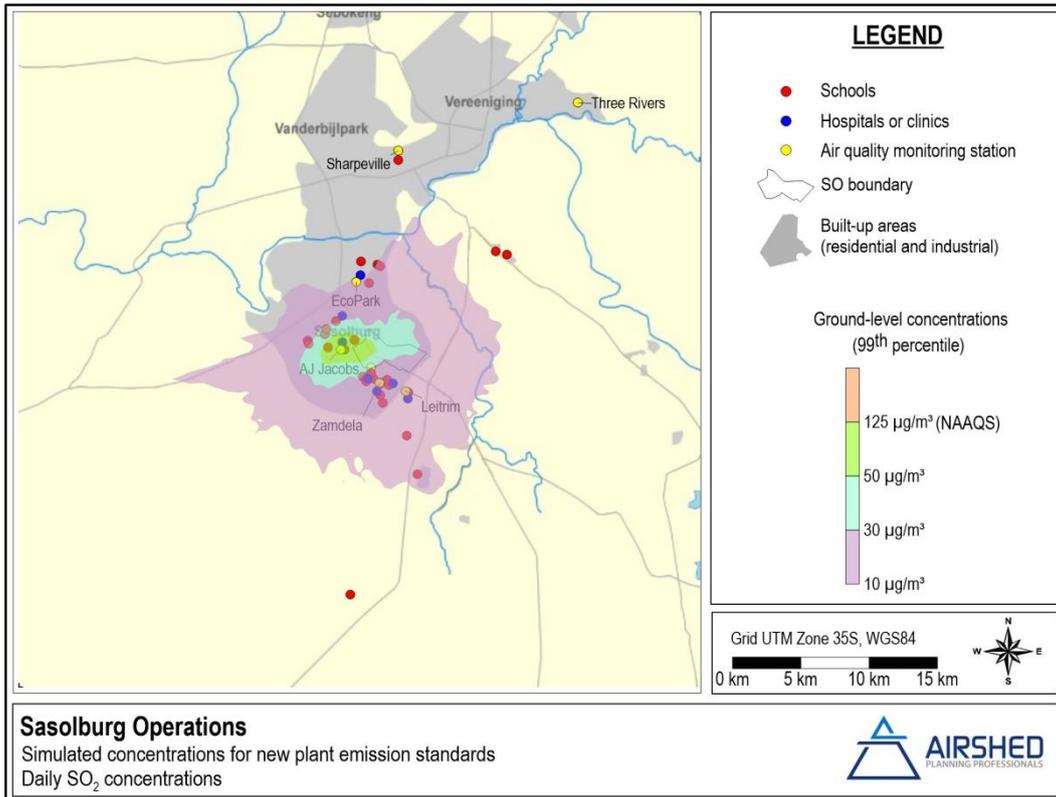


Figure 5-83: Simulated daily SO₂ concentrations (99th percentile) as a result of theoretical compliance with new plant emission standards

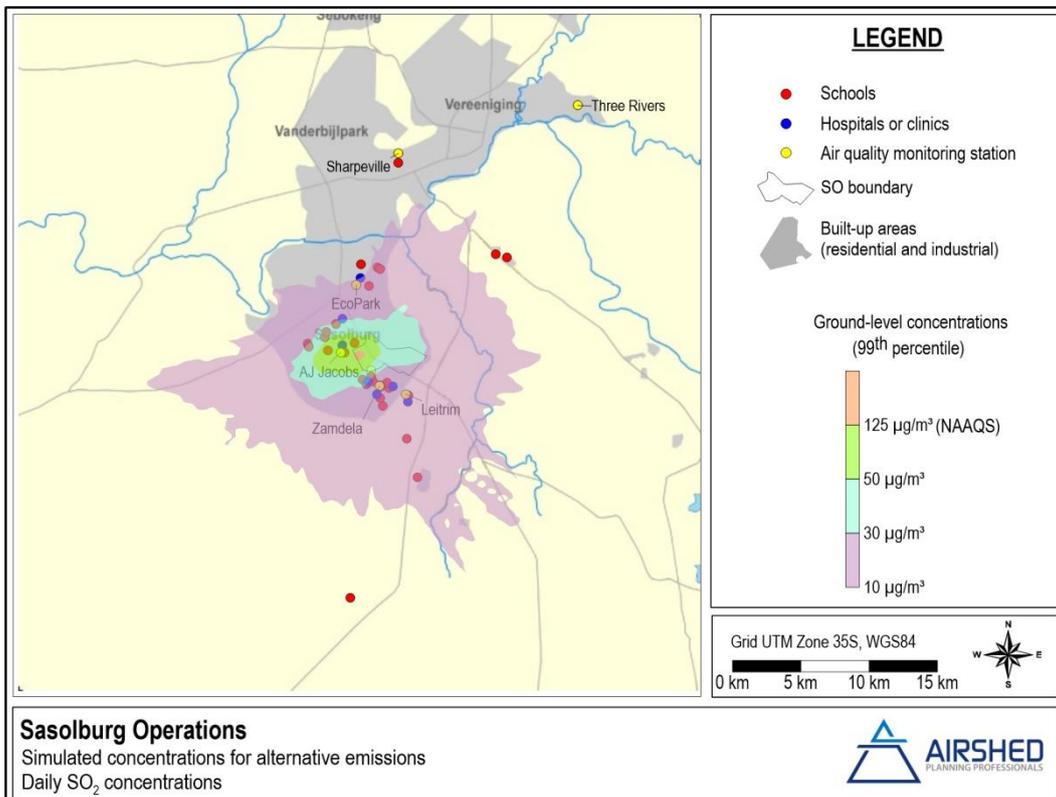


Figure 5-84: Simulated daily SO₂ concentrations (99th percentile) as a result of alternative emissions

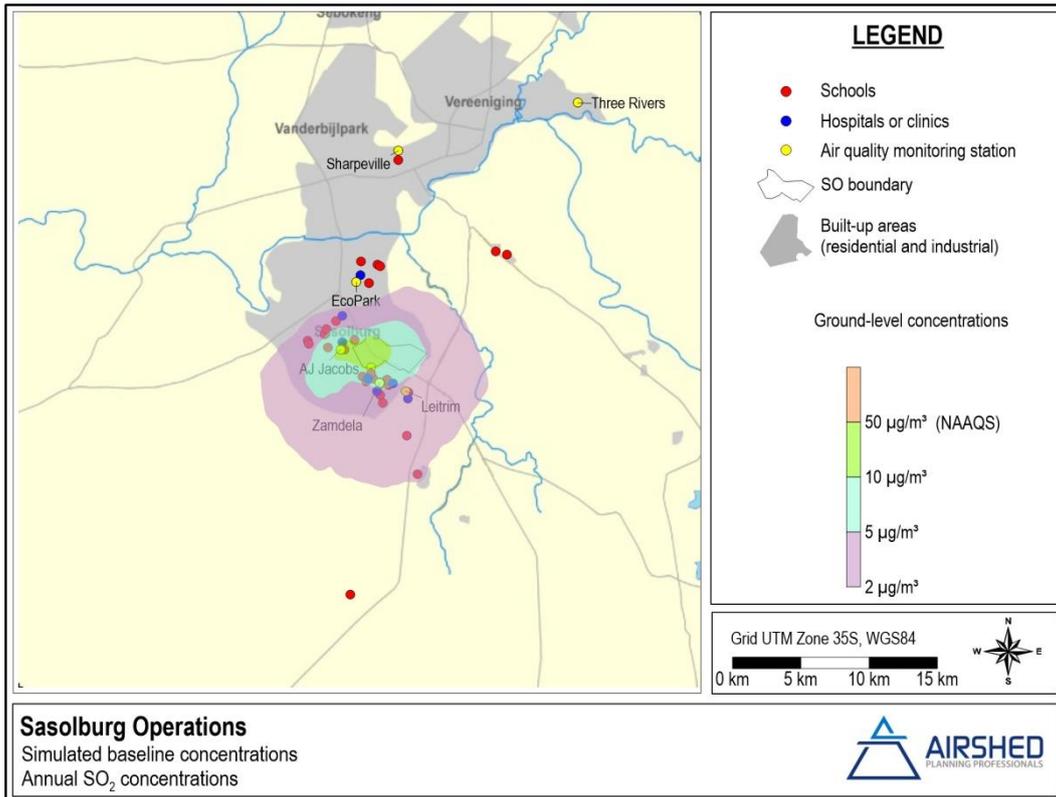


Figure 5-85: Simulated annual SO₂ concentrations as a result of baseline emissions

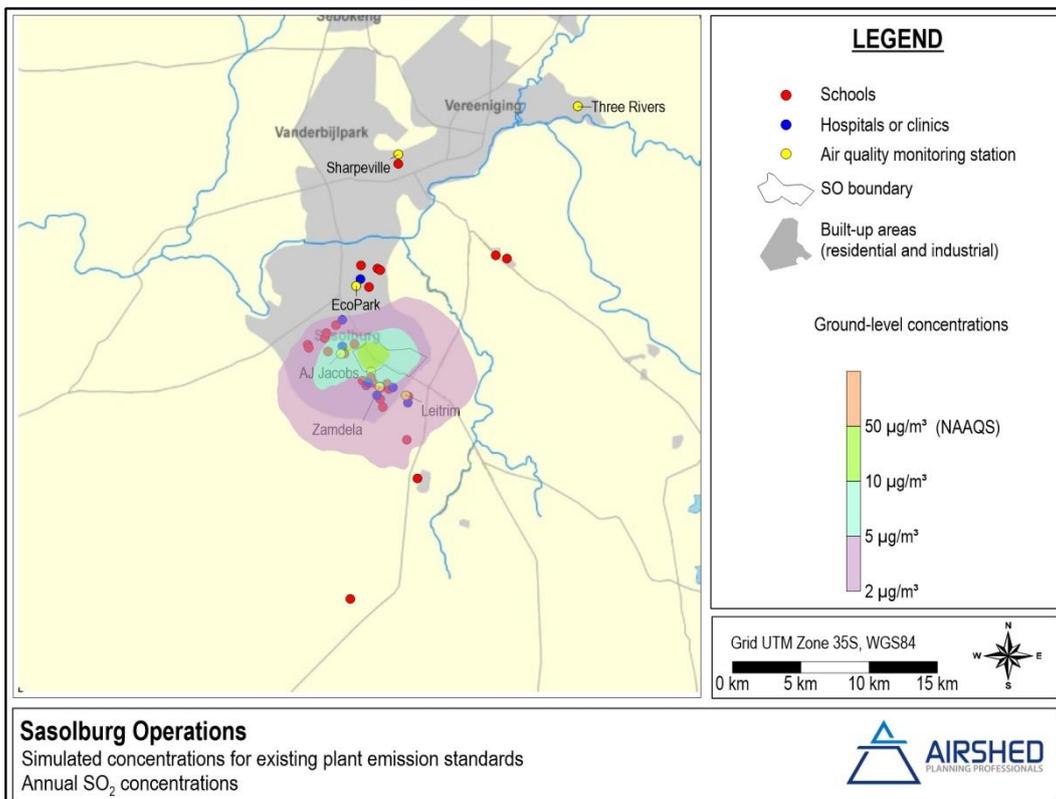


Figure 5-86: Simulated annual SO₂ concentrations as a result of theoretical compliance with existing plant emission standards

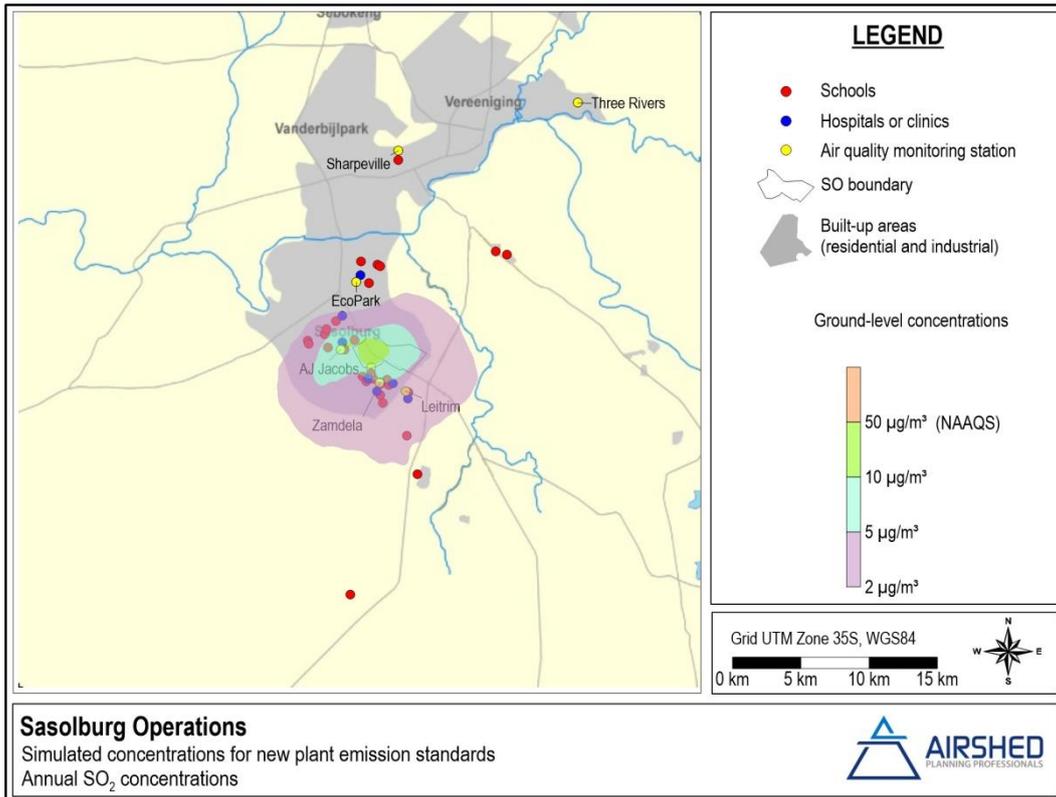


Figure 5-87: Simulated annual SO₂ concentrations as a result of theoretical compliance with new plant emission standards

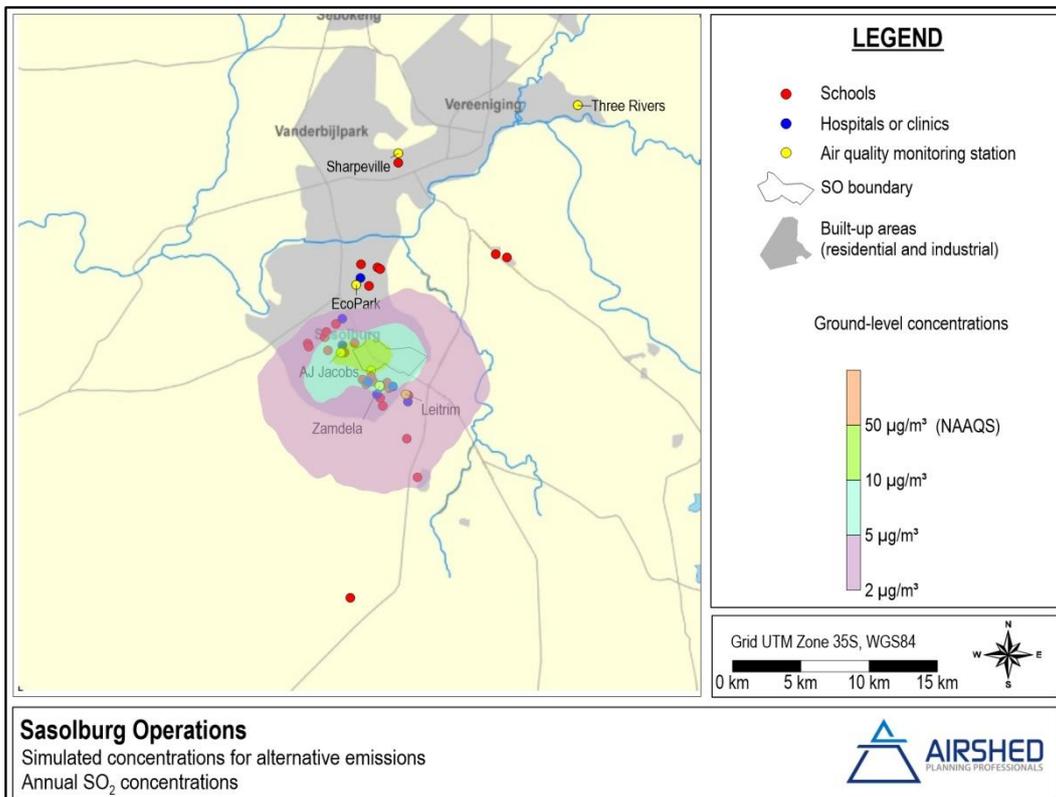


Figure 5-88: Simulated annual SO₂ concentrations as a result of alternative emissions

5.1.8.1.2 Nitrogen dioxide (NO₂)

Compliance with the hourly and annual NAAQS is simulated at the AQMS (Figure 5-89 and Figure 5-90) and receptors (Table 5-30 and Table 5-31) for all scenarios. Theoretical compliance with the existing and new plant emission standards will result in a reduction in ground-level concentrations by up to a maximum of 6% (Table 5-30 and Table 5-31). On average the reduction is less than 1% at the AQMS and receptors. The alternative emission scenario results in slight increases in hourly and annual NO₂ concentrations (maximum of 1.2%).

Isopleth plots are presented for all averaging periods ground-level NO₂ concentrations as a result of all emission scenarios for SO₂, as per the figure numbers below:

Scenario	Hourly	Annual
Baseline concentrations	Figure 5-91	Figure 5-95
Existing Plant standards	Figure 5-92	Figure 5-96
New Plant standards	Figure 5-93	Figure 5-97
Alternative emissions	Figure 5-94	Figure 5-98

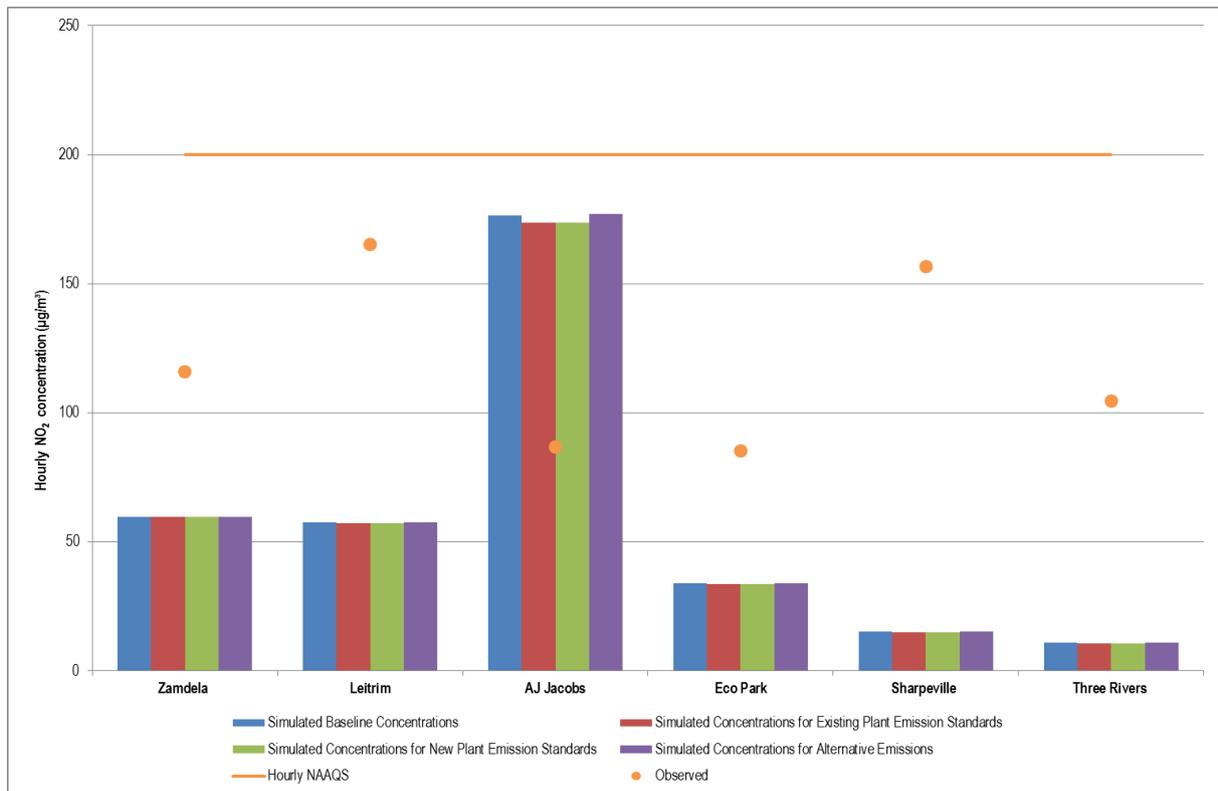


Figure 5-89: Simulated hourly NO₂ concentrations (99th percentile) at AQMS for Sasolburg Operations

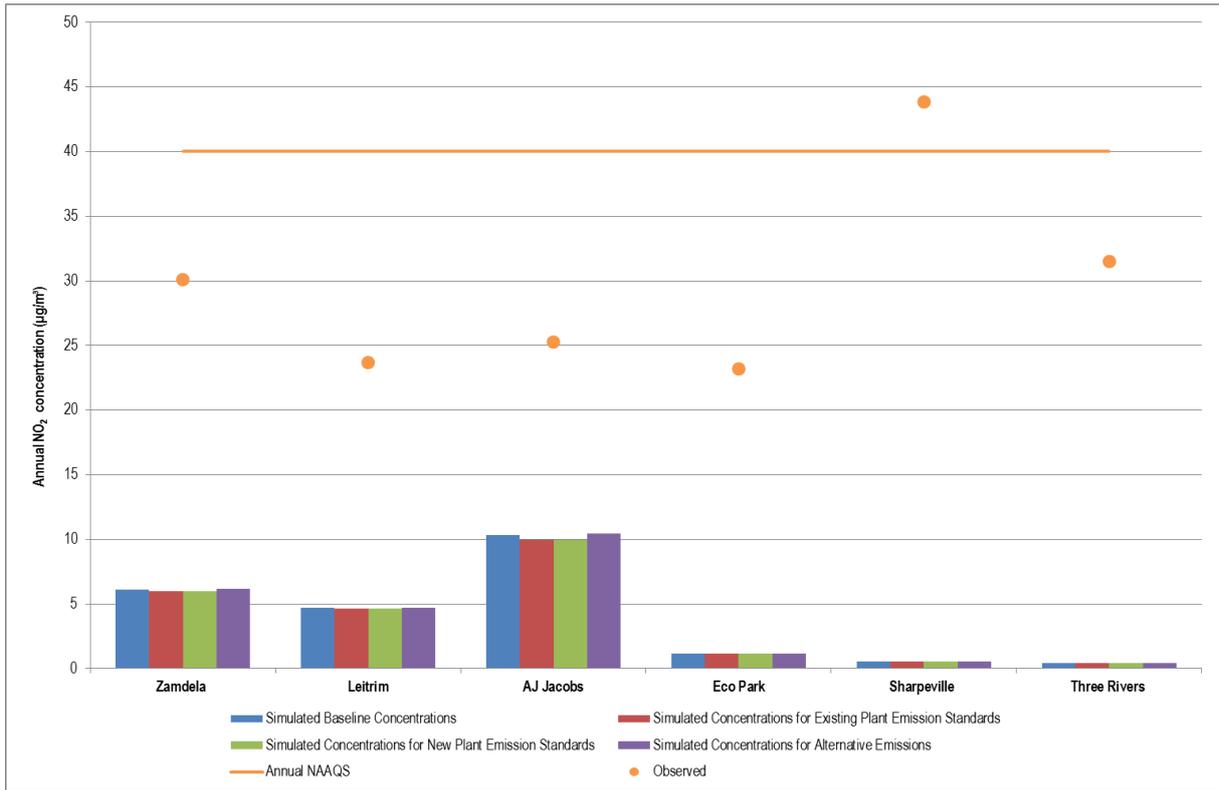


Figure 5-90: Simulated annual NO₂ concentrations at AQMS for Sasolburg Operations

Table 5-30: Simulated baseline hourly NO₂ concentrations and the theoretical change in concentrations relative to the baseline at the AQMs and 20 closest receptors

Receptor	Hourly NO ₂ (99th percentile)						
	Baseline	Existing		New		Alternative	
	Concentration (µg/m ³)	Concentration (µg/m ³)	Relative change	Concentration (µg/m ³)	Relative change	Concentration (µg/m ³)	Relative change
Zamdela AQMS	58.4	58.2	-0.2%	58.2	-0.2%	58.4	0.1%
Leitrim AQMS	56.4	56.5	0.1%	56.5	0.1%	56.4	0.1%
AJ Jacobs AQMS	146.5	144.7	-1.2%	144.7	-1.2%	147.1	0.4%
Eco Park AQMS	29.7	29.3	-1.3%	29.3	-1.3%	29.8	0.1%
Sharpeville AQMS	12.4	11.8	-4.3%	11.8	-4.3%	12.5	1.2%
Three Rivers AQMS	9.9	9.4	-5.7%	9.4	-5.7%	10.0	1.0%
Malakabeng Primary School	60.3	60.1	-0.3%	60.1	-0.3%	60.5	0.3%
Cedar Secondary School	58.8	58.7	-0.1%	58.7	-0.1%	58.8	0.1%
Bofula- Tshepe Primary School	58.3	57.9	-0.7%	57.9	-0.7%	58.4	0.0%
Clinic A Zamdela	58.5	58.6	0.3%	58.6	0.3%	58.5	0.0%
Zamdela Hospital Zumayear	59.4	59.1	-0.4%	59.1	-0.4%	59.4	0.1%
Iketsetseng Secondary School	58.3	57.9	-0.7%	57.9	-0.7%	58.4	0.0%
Clinic B Zamdela	57.9	57.7	-0.3%	57.7	-0.3%	58.0	0.2%
Tsatsi Primary School	65.0	63.2	-2.7%	63.2	-2.7%	65.4	0.6%
Isaac Mhlambi Primary School	57.8	57.9	0.1%	57.9	0.1%	57.9	0.1%
Nkopoleng Secondary School	58.9	58.5	-0.8%	58.5	-0.8%	59.0	0.0%
HTS Secondary School	111.9	110.5	-1.3%	110.5	-1.3%	112.5	0.5%
Zamdela Community Clinic	57.5	57.2	-0.5%	57.2	-0.5%	57.6	0.2%
AJ Jacobs Primary School	153.4	150.8	-1.7%	150.8	-1.7%	154.0	0.4%
Theha Setjhaba Primary School	56.8	56.8	0.1%	56.8	0.1%	56.8	0.1%
Sasolburg Clinic	137.9	136.7	-0.9%	136.7	-0.9%	138.2	0.2%
Credo Primary School	56.5	56.4	-0.2%	56.4	-0.2%	56.5	0.1%
Lehutso Primary School	56.5	56.4	-0.3%	56.4	-0.3%	56.6	0.1%
Harry Gwala Clinic Creche	55.5	55.2	-0.4%	55.2	-0.4%	55.5	0.0%
Kahobotjha-Sakubusha Secondary School	87.8	86.9	-1.0%	86.9	-1.0%	87.9	0.1%
Sasolburg Provincial Hospital	54.0	53.9	-0.3%	53.9	-0.3%	53.9	-0.2%

Table 5-31: Simulated baseline annual NO₂ concentrations and the theoretical change in concentrations relative to the baseline at the AQMs and 20 closest receptors

Receptor	Annual NO ₂						
	Baseline	Existing		New		Alternative	
	Concentration	Concentration	Relative change	Concentration	Relative change	Concentration	Relative change
Zamdela AQMS	5.5	5.3	-3.0%	5.3	-3.0%	5.5	0.7%
Leitrim AQMS	4.4	4.3	-2.4%	4.3	-2.4%	4.4	0.6%
AJ Jacobs AQMS	8.1	7.8	-3.9%	7.8	-3.9%	8.2	0.9%
Eco Park AQMS	1.0	1.0	-1.9%	1.0	-1.9%	1.0	0.4%
Sharpeville AQMS	0.5	0.4	-3.0%	0.4	-3.0%	0.5	0.7%
Three Rivers AQMS	0.4	0.4	-2.9%	0.4	-2.9%	0.4	0.7%
Malakabeng Primary School	7.0	6.8	-3.3%	6.8	-3.3%	7.1	0.8%
Cedar Secondary School	5.7	5.5	-2.8%	5.5	-2.8%	5.7	0.6%
Bofula- Tshepe Primary School	5.4	5.2	-3.0%	5.2	-3.0%	5.4	0.7%
Clinic A Zamdela	5.6	5.4	-3.0%	5.4	-3.0%	5.6	0.7%
Zamdela Hospital Zumayear	6.1	5.9	-3.2%	5.9	-3.2%	6.1	0.8%
Iketsetseng Secondary School	5.4	5.2	-3.0%	5.2	-3.0%	5.4	0.7%
Clinic B Zamdela	5.1	5.0	-2.7%	5.0	-2.7%	5.2	0.6%
Tsatsi Primary School	6.5	6.3	-3.5%	6.3	-3.5%	6.6	0.8%
Isaac Mhlambi Primary School	5.1	4.9	-2.7%	4.9	-2.7%	5.1	0.7%
Nkopoleng Secondary School	5.5	5.4	-3.2%	5.4	-3.2%	5.6	0.7%
HTS Secondary School	6.3	6.2	-1.7%	6.2	-1.7%	6.4	0.4%
Szamdela Community Clinic	4.8	4.7	-2.7%	4.7	-2.7%	4.8	0.6%
AJ Jacobs Primary School	8.0	7.7	-3.8%	7.7	-3.8%	8.0	0.9%
Theha Setjhaba Primary School	4.6	4.4	-2.5%	4.4	-2.5%	4.6	0.6%
Sasolburg Clinic	6.6	6.4	-1.9%	6.4	-1.9%	6.6	0.5%
Credo Primary School	4.3	4.2	-2.3%	4.2	-2.3%	4.3	0.6%
Lehutso Primary School	4.2	4.1	-2.7%	4.1	-2.7%	4.3	0.6%
Harry Gwala Clinic Creche	4.0	3.9	-2.7%	3.9	-2.7%	4.0	0.6%
Kahobotjha-sakubusha Secondary School	5.3	5.1	-2.5%	5.1	-2.5%	5.3	0.6%
Sasolburg Provincial Hospital	2.1	2.1	-1.6%	2.1	-1.6%	2.1	0.4%

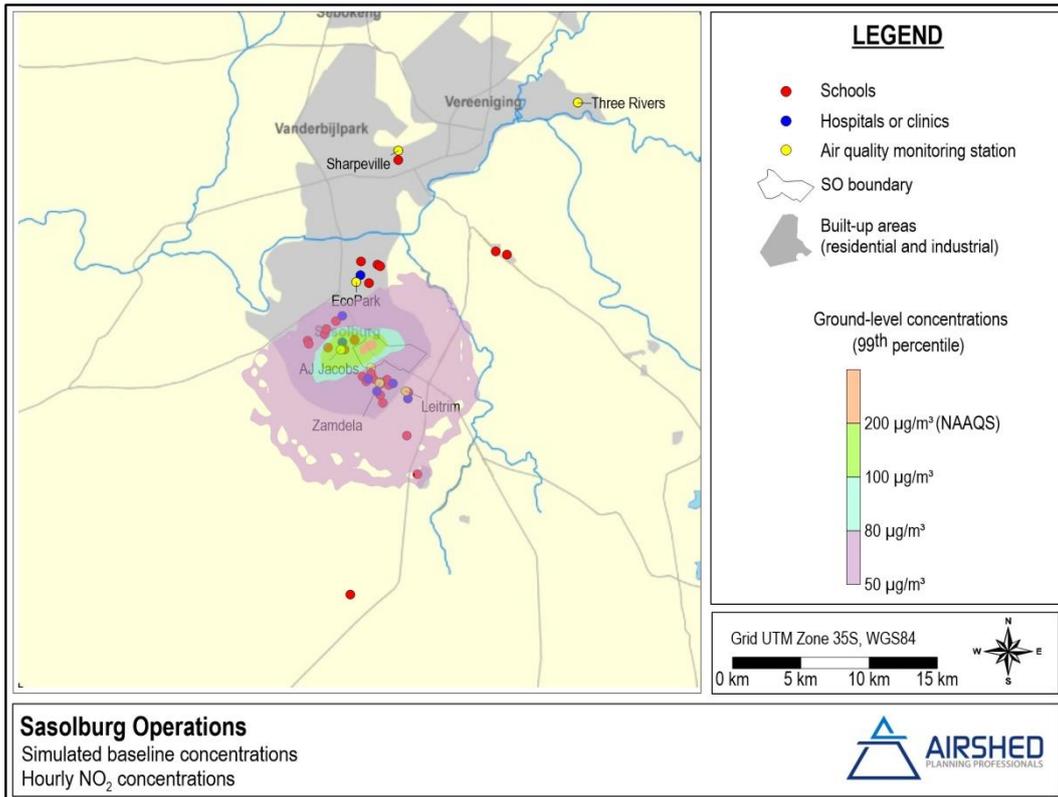


Figure 5-91: Simulated hourly NO₂ concentrations (99th percentile) as a result of baseline emissions

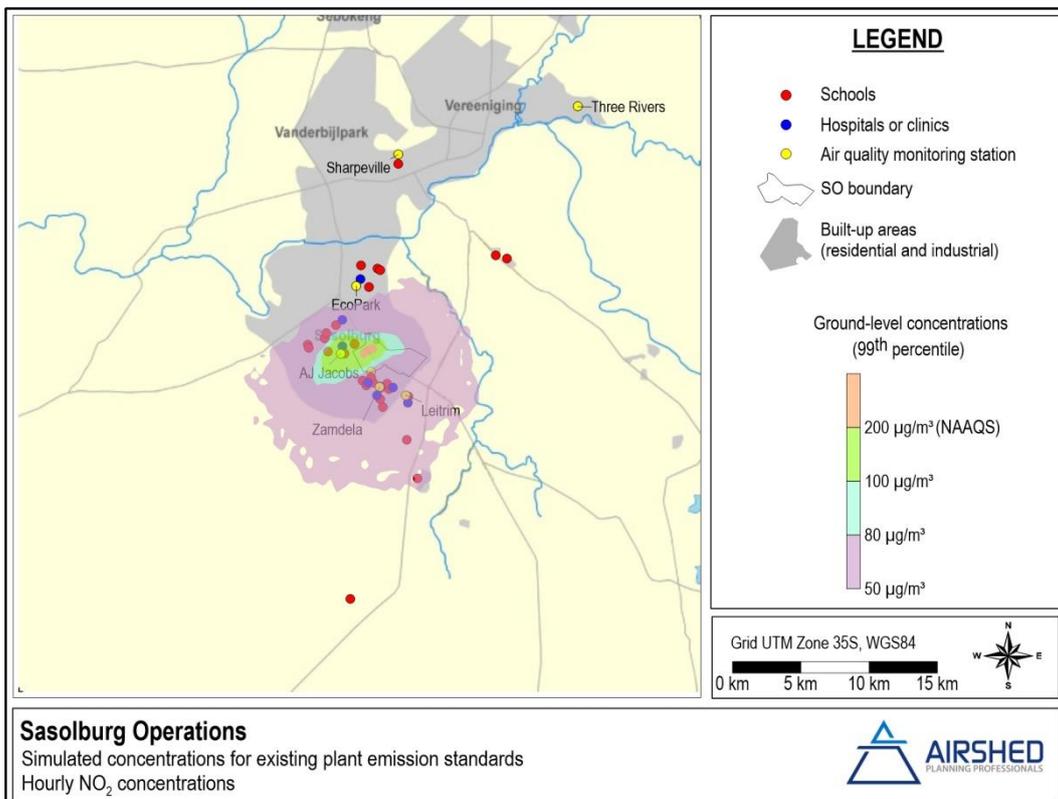


Figure 5-92: Simulated hourly NO₂ concentrations (99th percentile) as a result of theoretical compliance with existing plant emission standards

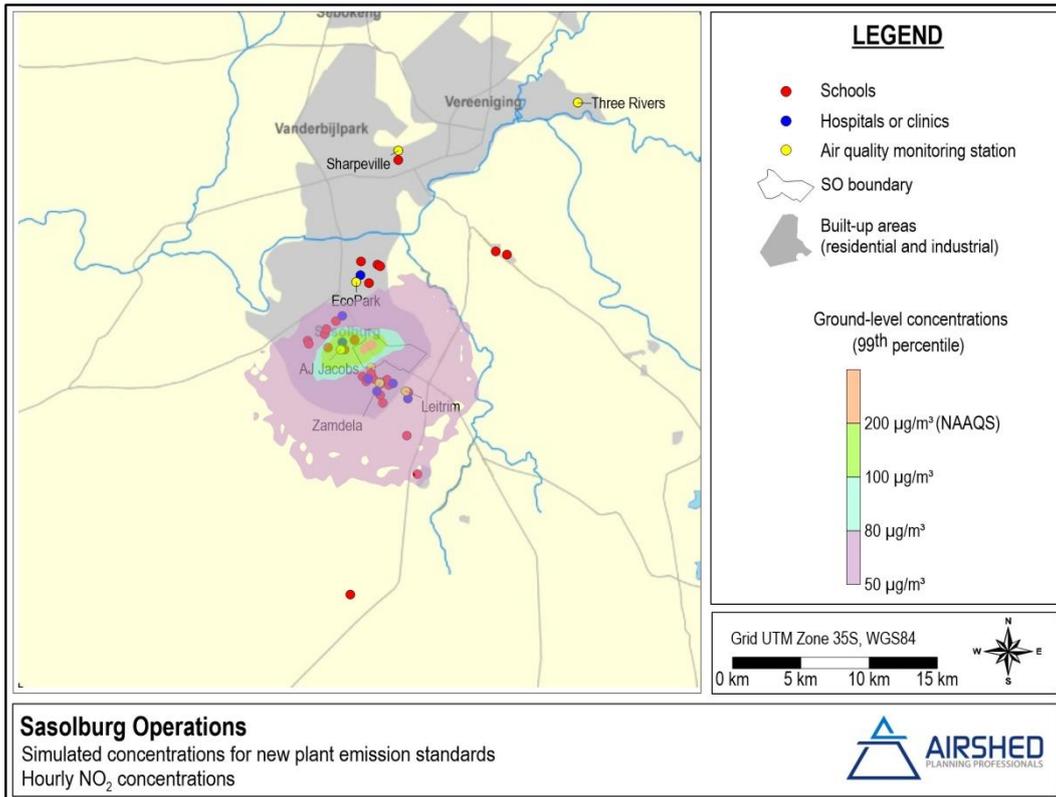


Figure 5-93: Simulated hourly NO₂ concentrations (99th percentile) as a result of theoretical compliance with new plant emission standards

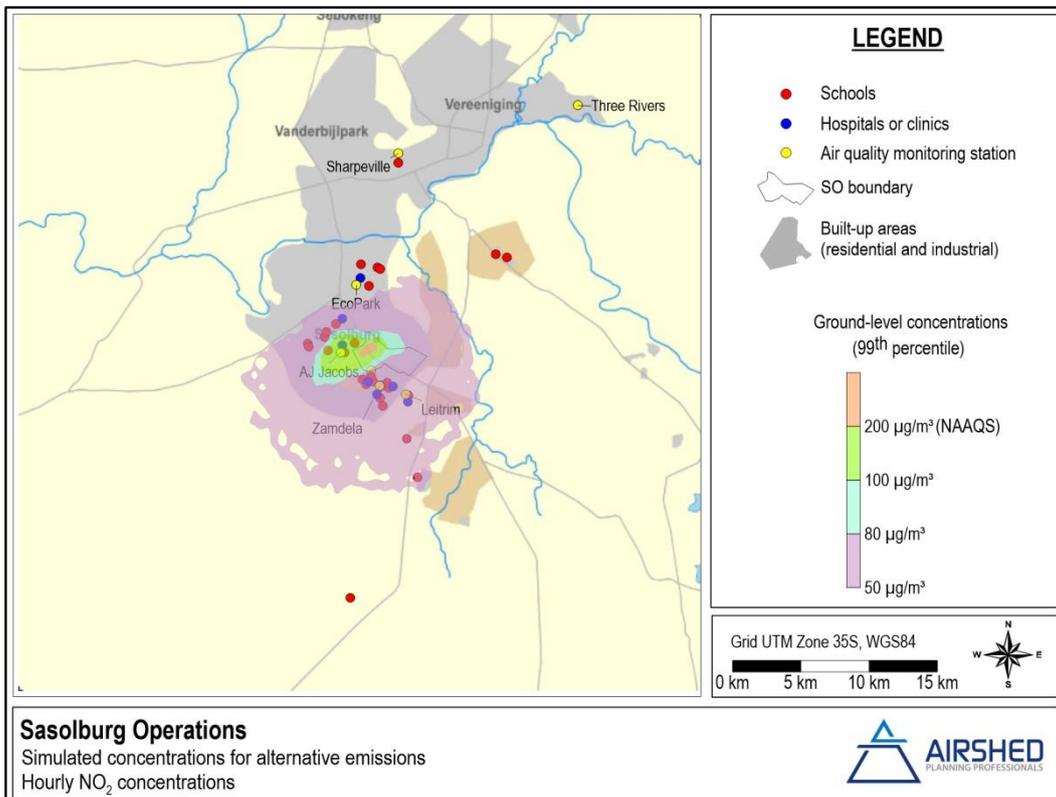


Figure 5-94: Simulated hourly NO₂ concentrations (99th percentile) as a result of alternative emissions

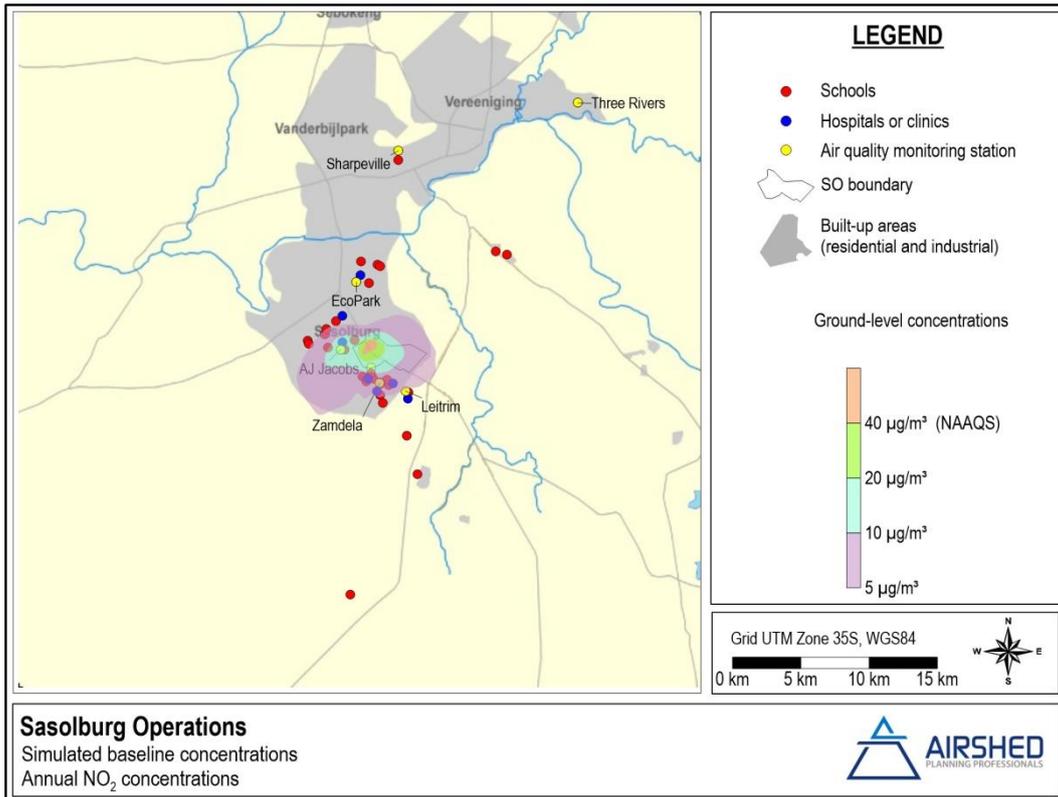


Figure 5-95: Simulated annual NO₂ concentrations as a result of baseline emissions

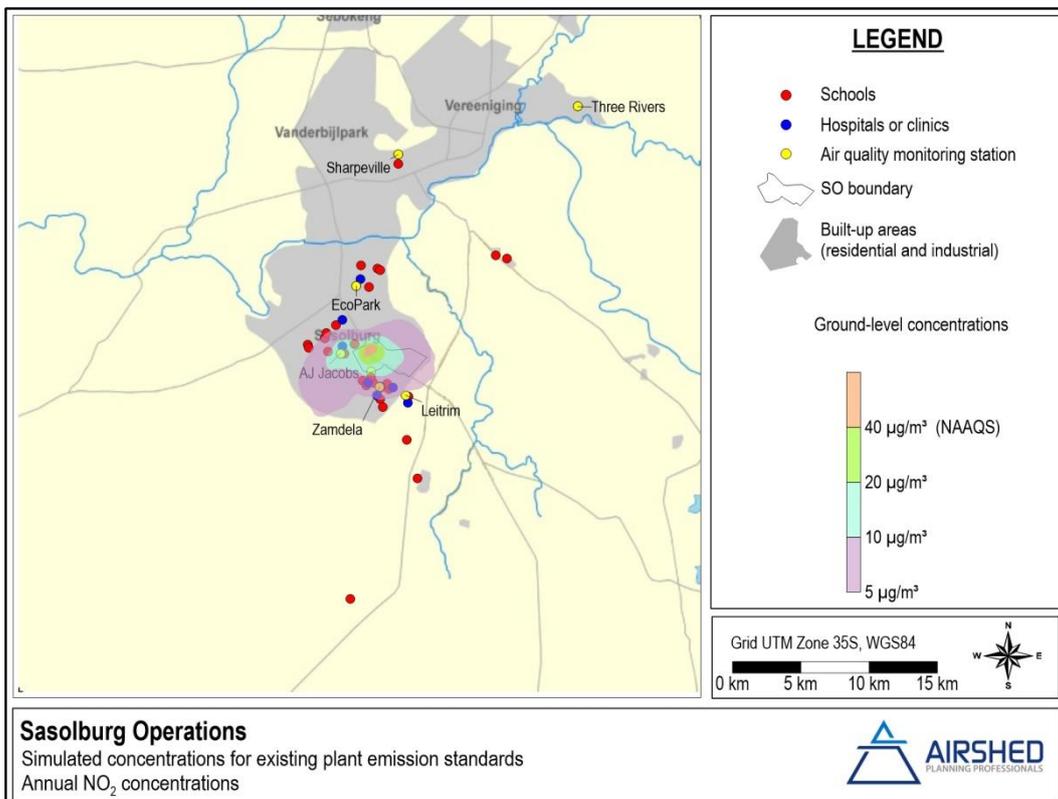


Figure 5-96: Simulated annual NO₂ concentrations as a result of theoretical compliance with existing plant emission standards

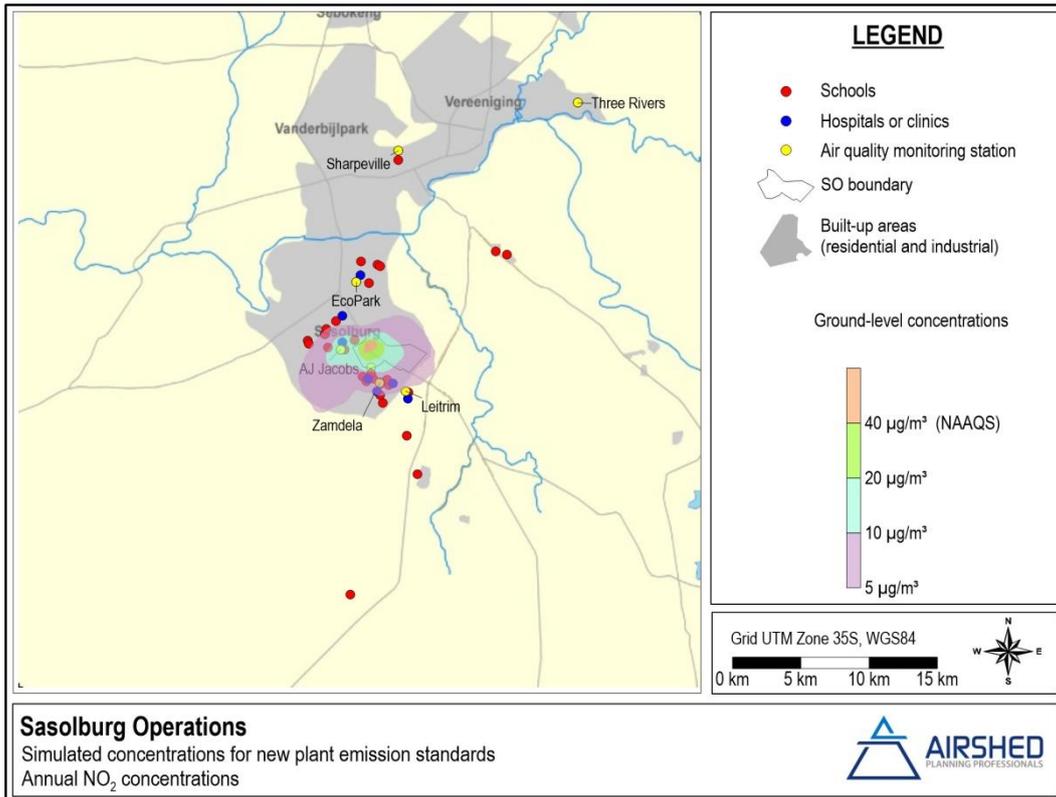


Figure 5-97: Simulated annual NO₂ concentrations as a result of theoretical compliance with new plant emission standards

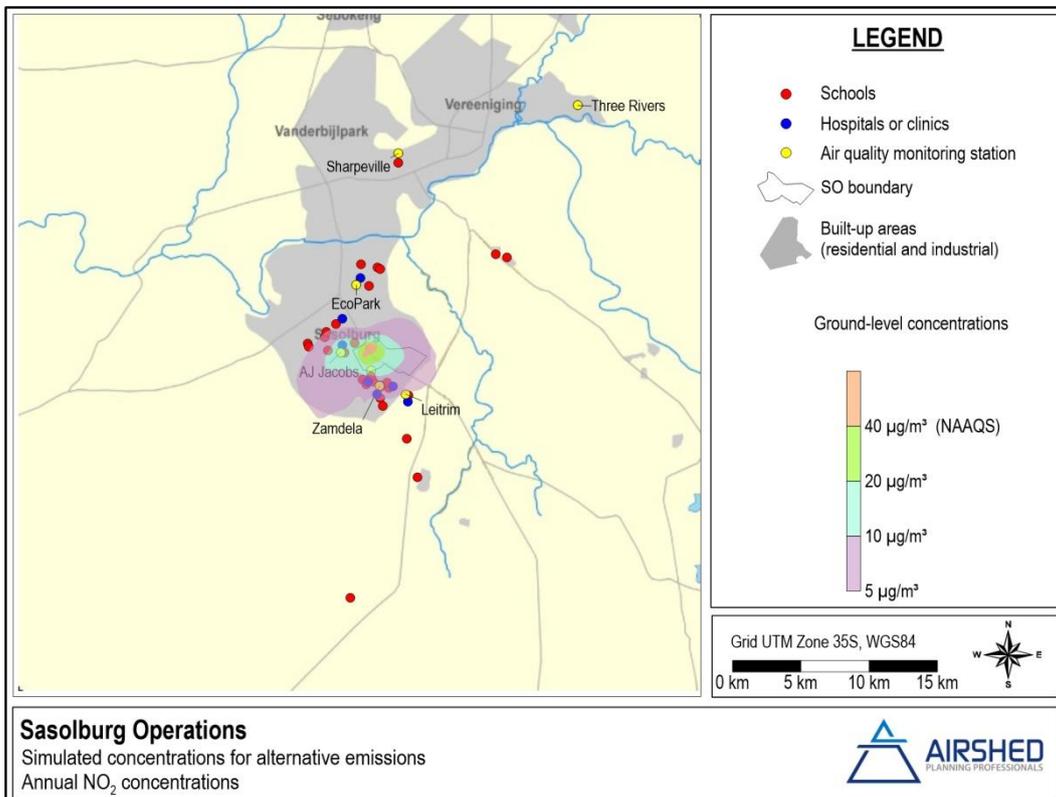


Figure 5-98: Simulated annual NO₂ concentrations as a result of alternative emissions

5.1.8.1.3 Particulate Matter (PM₁₀ and PM_{2.5})

The baseline emissions from SO result in low ground-level concentrations of PM; less than 20 µg/m³ at all AQMS (Figure 5-99). Simulated annual PM concentrations are less than 5 µg/m³ at all AQMS (Figure 5-100). Theoretical compliance with the existing and new plant standards will result in reduction of ground-level PM concentrations by up to 16%, while the alternative emissions will result in increased ground-level concentrations by up to 7.5% (Table 5-32 and Table 5-33).

For particulate matter, NAAQS are available for PM₁₀ and PM_{2.5}. Ambient air quality impacts for both particulate fractions (i.e. PM₁₀ and PM_{2.5}) thus need to be considered. Simulated concentrations of particulate matter (PM) are conservatively assumed to be PM_{2.5} since it is not possible to establish the PM_{2.5}/PM₁₀ split of emissions from SO only. Figure 5-99 and Figure 5-100 present predicted PM concentrations at the AQMS relative to both the PM₁₀ and PM_{2.5} NAAQS.

PM₁₀ and PM_{2.5} measurements at the AQMS suggest a 50% contribution of PM_{2.5} to PM₁₀; however the sources contributing to the PM signature at the AQMS are varied, including the SO sources, other industrial sources, windblown particulates, vehicles, domestic fuel burning, mining, agriculture, and power generation. The range of the 2013 – 2015 PM_{2.5}:PM₁₀ ratios at the AQMS in the Sasolburg domain ranged between 0.39 and 0.57 (Section 5.1.5.4); while the urban population-weighted average across South Africa in 2000 - reported by Norman *et al.* (2007) - was 0.57. A study in the Vaal Triangle used the PM_{2.5}:PM₁₀ ratio of 0.59 based on the concentrated industrial activity in the area (Witi, 2005). This value (0.59) is slightly more conservative than the measured ambient data and the population-weighted country average.

Based on the conservative assumption that all PM is in the PM_{2.5} fraction, the simulated daily PM_{2.5} concentrations potentially exceeded the current daily PM_{2.5} NAAQS (40 µg/m³), for all scenarios, at one receptor (Tsatsi Primary School - Table 5-32). However, using the PM_{2.5}:PM₁₀ ratio of 0.59, the 99th percentile daily PM_{2.5} concentration at the Tsatsi Primary School was simulated to be 26 µg/m³; indicating compliance with the current daily PM_{2.5} NAAQS. Compliance with the annual PM_{2.5} and PM₁₀ NAAQS is likely (Table 5-33).

Isopleth plots are presented for all averaging periods ground-level PM concentrations as a result of all emission scenarios for SO, as per the figure numbers below:

Scenario	Daily	Annual
Baseline concentrations	Figure 5-101	Figure 5-105
Existing Plant standards	Figure 5-102	Figure 5-106
New Plant standards	Figure 5-103	Figure 5-107
Alternative emissions	Figure 5-104	Figure 5-108

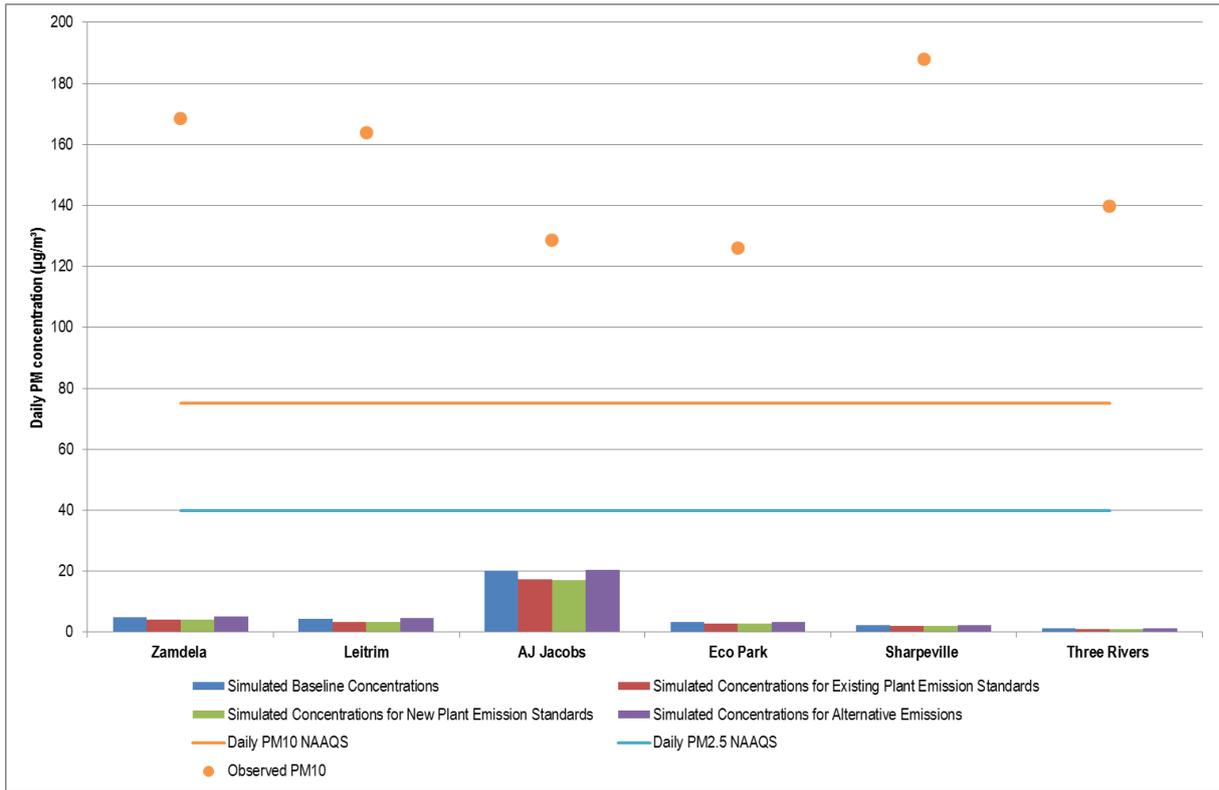


Figure 5-99: Simulated daily PM concentrations (99th percentile) at AQMS for Sasolburg Operations

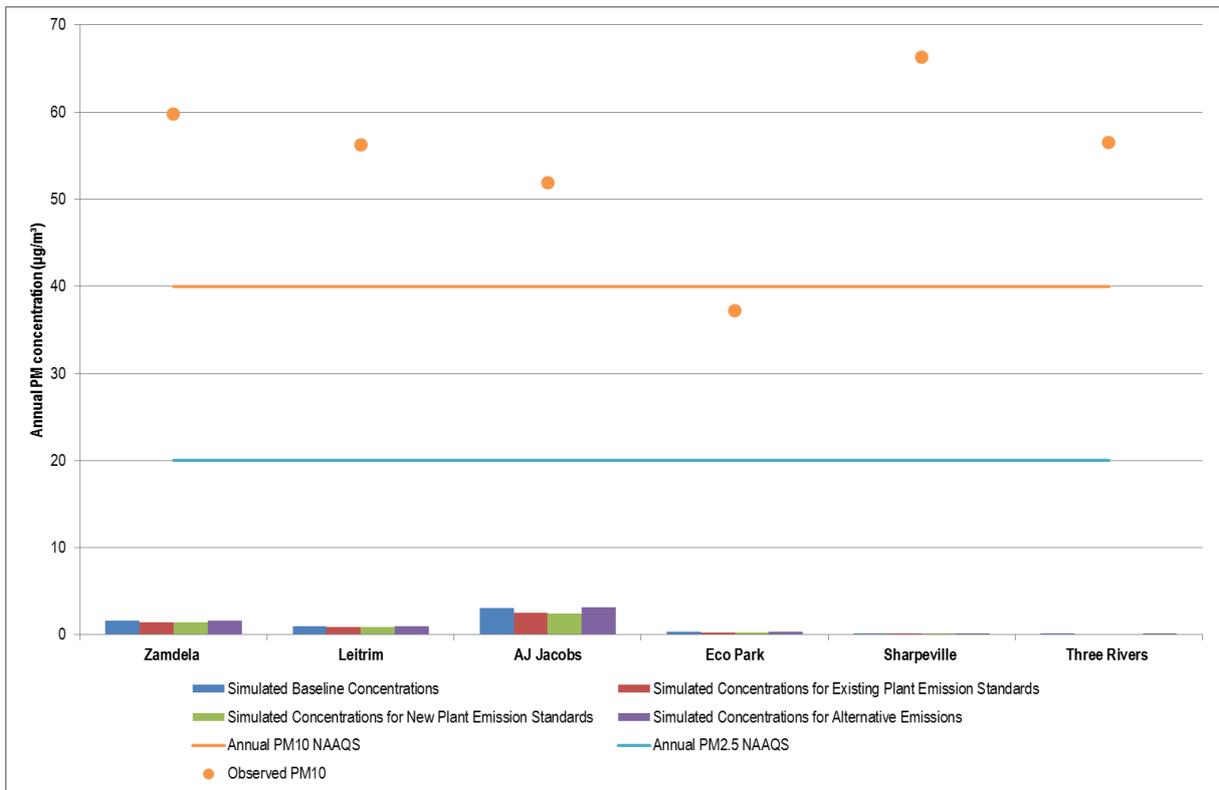


Figure 5-100: Simulated annual PM concentrations at AQMS for Sasolburg Operations

Table 5-32: Simulated baseline daily PM concentrations and the theoretical change in concentrations relative to the baseline at the AQMs and 20 closest receptors

Receptor	Daily PM (99th percentile)						
	Baseline	Existing		New		Alternative	
	Concentration (µg/m³)	Concentration (µg/m³)	Relative change	Concentration (µg/m³)	Relative change	Concentration (µg/m³)	Relative change
Zamdela AQMS ^(a)	4.4	3.9	-12.1%	3.8	-12.8%	4.6	3.9%
Leitrim AQMS ^(a)	3.3	3.1	-6.5%	3.0	-7.1%	3.3	1.1%
AJ Jacobs AQMS ^(a)	15.1	13.4	-11.3%	13.2	-12.6%	15.5	2.7%
Eco Park AQMS ^(a)	2.9	2.7	-8.3%	2.6	-8.6%	2.9	1.6%
Sharpeville AQMS ^(a)	1.8	1.5	-12.2%	1.5	-12.2%	1.8	3.0%
Three Rivers AQMS ^(a)	1.2	1.1	-9.2%	1.1	-9.3%	1.2	0.7%
Malakabeng Primary School ^(a)	6.8	5.8	-15.6%	5.7	-15.9%	7.1	4.6%
Cedar Secondary School ^(a)	4.3	3.7	-13.8%	3.7	-14.2%	4.4	2.5%
Bofula- Tshepe Primary School ^(a)	4.5	3.9	-14.0%	3.9	-14.2%	4.6	3.1%
Clinic A Zamdela ^(a)	4.5	3.8	-16.0%	3.8	-16.3%	4.6	2.5%
Zamdela Hospital Zumayear ^(a)	6.5	5.2	-19.7%	5.1	-20.6%	6.6	2.3%
Iketsetseng Secondary School ^(a)	4.5	3.9	-14.0%	3.9	-14.2%	4.6	3.1%
Clinic B Zamdela ^(a)	3.8	3.4	-11.9%	3.4	-12.6%	4.1	7.5%
Tsatsi Primary School – PM ^(b)	44.0	43.2	-1.8%	43.2	-1.9%	44.1	0.3%
Tsatsi Primary School – PM _{2.5} ^(c)	26.0	25.5	0.0%	25.5	0.0%	26.0	0.0%
Isaac Mhlambi Primary School ^(a)	3.8	3.4	-8.5%	3.4	-8.8%	4.0	5.3%
Nkopoleng Secondary School ^(a)	6.2	5.5	-10.9%	5.5	-11.4%	6.4	2.2%
HTS Secondary School ^(a)	10.8	9.4	-12.8%	9.3	-13.7%	11.2	3.4%
Zamdela Community Clinic ^(a)	4.2	3.7	-11.9%	3.7	-12.4%	4.2	0.8%
AJ Jacobs Primary School ^(a)	15.1	13.2	-12.6%	13.0	-14.0%	15.6	2.9%
Theha Setjhaba Primary School ^(a)	4.0	3.6	-9.2%	3.6	-9.7%	4.1	2.9%
Sasolburg Clinic ^(a)	13.0	12.0	-7.6%	12.0	-7.6%	13.2	1.2%
Credo Primary School ^(a)	3.4	3.0	-11.4%	3.0	-12.0%	3.5	1.5%
Lehutso Primary School ^(a)	4.0	3.4	-13.6%	3.4	-14.1%	4.0	1.4%
Harry Gwala Clinic Creche ^(a)	3.3	2.8	-14.6%	2.8	-14.9%	3.4	3.1%
Kahobotjha-Sakubusha Secondary School ^(a)	10.7	9.5	-11.2%	9.5	-11.6%	10.9	1.7%
Sasolburg Provincial Hospital ^(a)	5.3	4.8	-8.6%	4.8	-9.2%	5.3	1.2%

Note:

- (a) Conservatively assumes all PM is either PM₁₀ or PM_{2.5}.
- (b) Conservatively assuming all PM is PM_{2.5}, there is potential for exceedance of the current PM_{2.5} NAAQS. Assuming all PM is PM₁₀, concentrations are compliant with PM₁₀ NAAQS.
- (c) Assuming 59% of PM is PM_{2.5}, based on measured ambient ratios and literature values, compliance with current NAAQS is likely.

Table 5-33: Simulated baseline annual PM concentrations and the theoretical change in concentrations relative to the baseline at the AQMs and 20 closest receptors

Receptor	Annual PM						
	Baseline	Existing		New		Alternative	
	Concentration (µg/m³)	Concentration (µg/m³)	Relative change	Concentration (µg/m³)	Relative change	Concentration (µg/m³)	Relative change
Zamdela AQMS	1.3	1.2	-12.9%	1.1	-13.7%	1.4	2.1%
Leitrim AQMS	0.9	0.8	-12.0%	0.8	-12.7%	0.9	2.0%
AJ Jacobs AQMS	2.4	2.0	-17.2%	2.0	-18.2%	2.5	2.9%
Eco Park AQMS	0.3	0.3	-8.4%	0.3	-8.9%	0.3	1.4%
Sharpeville AQMS	0.1	0.1	-10.9%	0.1	-11.6%	0.1	1.9%
Three Rivers AQMS	0.1	0.1	-10.6%	0.1	-11.2%	0.1	1.8%
Malakabeng Primary School	2.2	1.9	-12.7%	1.9	-13.6%	2.2	2.1%
Cedar Secondary School	1.3	1.1	-12.5%	1.1	-13.3%	1.3	2.0%
Bofula- Tshepe Primary School	1.3	1.1	-12.9%	1.1	-13.7%	1.3	2.1%
Clinic A Zamdela	1.3	1.2	-13.2%	1.2	-14.1%	1.4	2.2%
Zamdela Hospital Zumayear	2.1	1.8	-10.5%	1.8	-11.1%	2.1	1.7%
Iketsetseng Secondary School	1.3	1.1	-12.9%	1.1	-13.7%	1.3	2.1%
Clinic B Zamdela	1.1	1.0	-12.1%	1.0	-12.8%	1.2	2.0%
Tsatsi Primary School	11.3	11.0	-2.4%	11.0	-2.6%	11.3	0.4%
Isaac Mhlambi Primary School	1.1	1.0	-12.4%	1.0	-13.2%	1.2	2.0%
Nkopoleng Secondary School	1.8	1.6	-10.7%	1.6	-11.4%	1.8	1.7%
HTS Secondary School	1.6	1.4	-10.4%	1.4	-11.1%	1.6	1.7%
Zamdela Community Clinic	1.1	1.0	-12.0%	1.0	-12.8%	1.1	2.0%
AJ Jacobs Primary School	2.4	2.0	-17.4%	1.9	-18.5%	2.5	2.9%
Theha Setjhaba Primary School	1.0	0.9	-11.9%	0.9	-12.7%	1.0	2.0%
Sasolburg Clinic	1.7	1.6	-10.5%	1.5	-11.1%	1.8	1.7%
Credo Primary School	0.9	0.8	-11.9%	0.8	-12.6%	0.9	2.0%
Lehutso Primary School	0.9	0.8	-12.1%	0.8	-12.9%	0.9	2.0%
Harry Gwala Clinic Creche	0.8	0.7	-12.5%	0.7	-13.3%	0.9	2.1%
Kahobotjha-Sakubusha Secondary School	1.5	1.3	-12.2%	1.3	-13.0%	1.5	2.1%
Sasolburg Provincial Hospital	0.5	0.5	-9.0%	0.5	-9.6%	0.6	1.5%

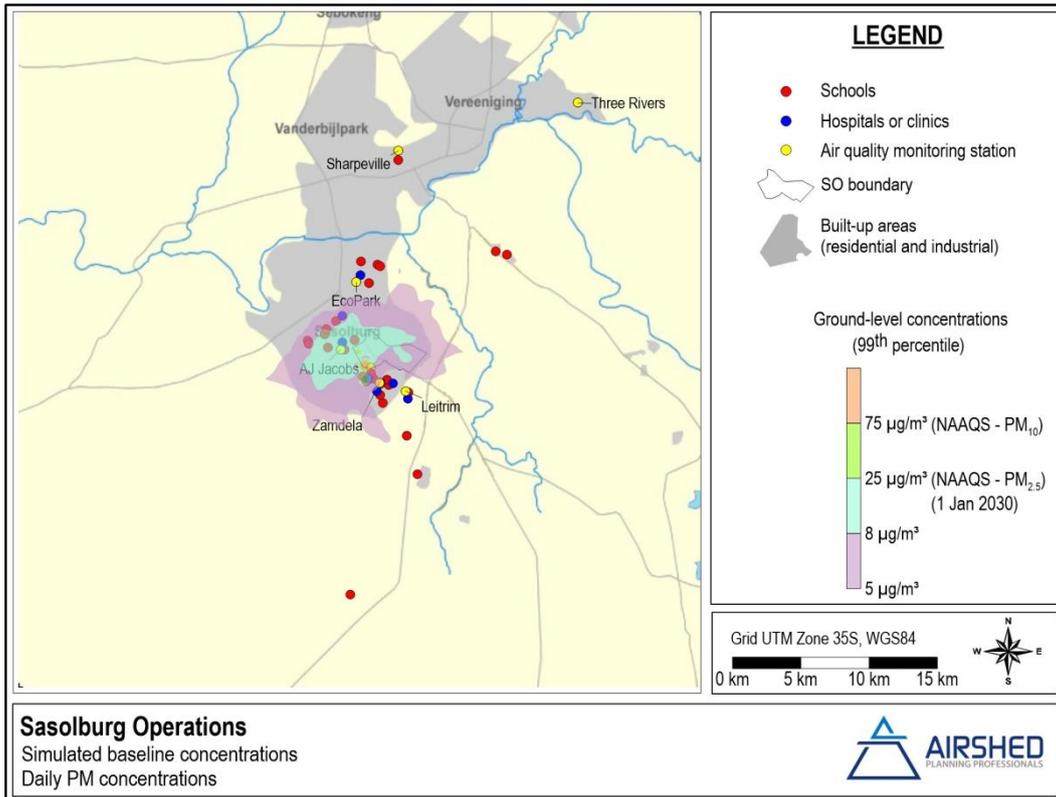


Figure 5-101: Simulated daily PM concentrations (99th percentile) as a result of baseline emissions

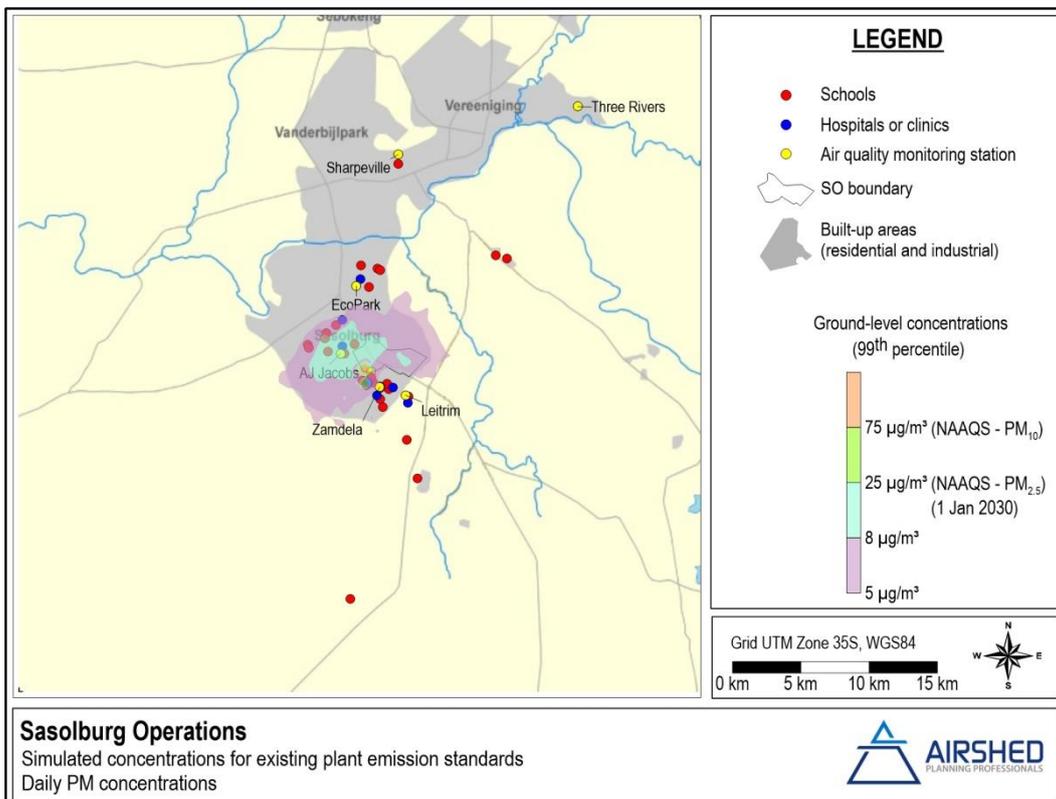


Figure 5-102: Simulated daily PM concentrations (99th percentile) as a result of theoretical compliance with existing plant emission standards

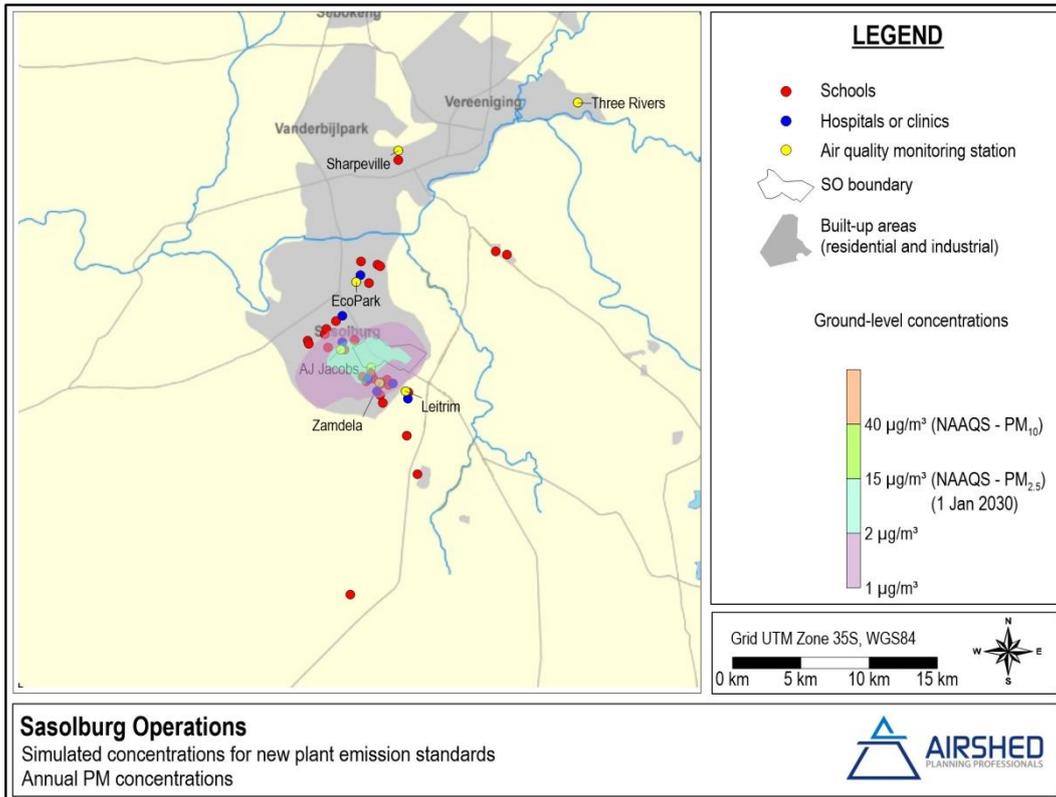


Figure 5-103: Simulated daily PM concentrations (99th percentile) as a result of theoretical compliance with new plant emission standards

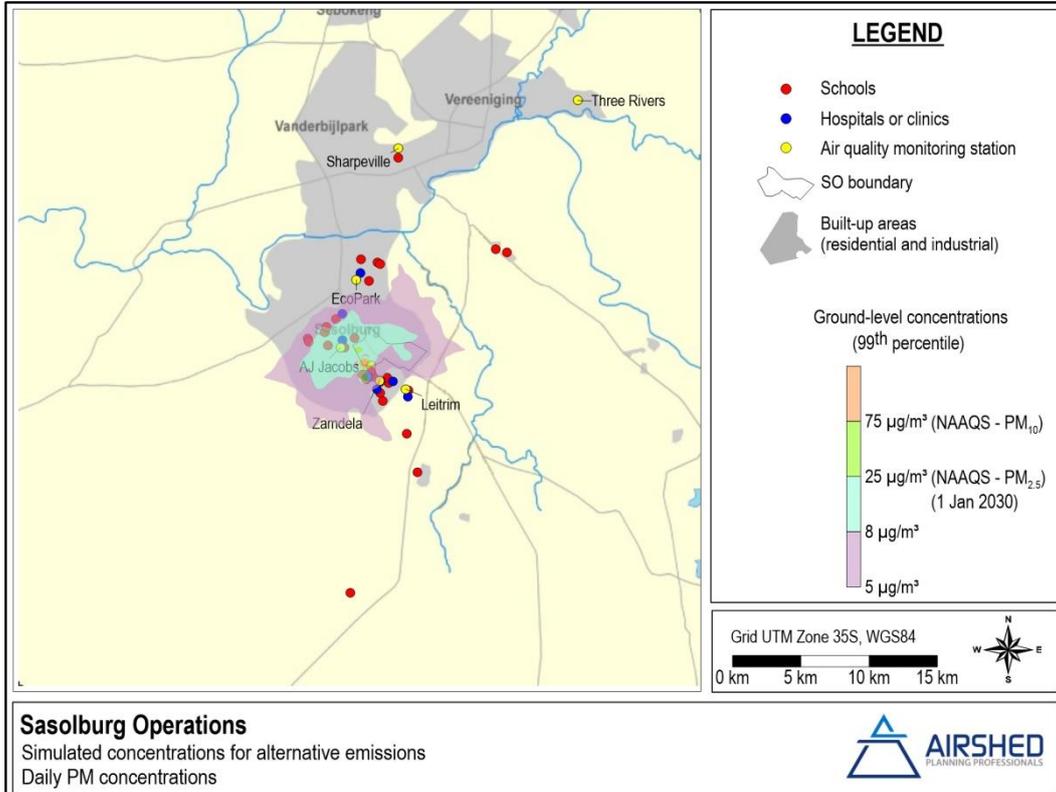


Figure 5-104: Simulated daily PM concentrations (99th percentile) as a result of alternative emissions

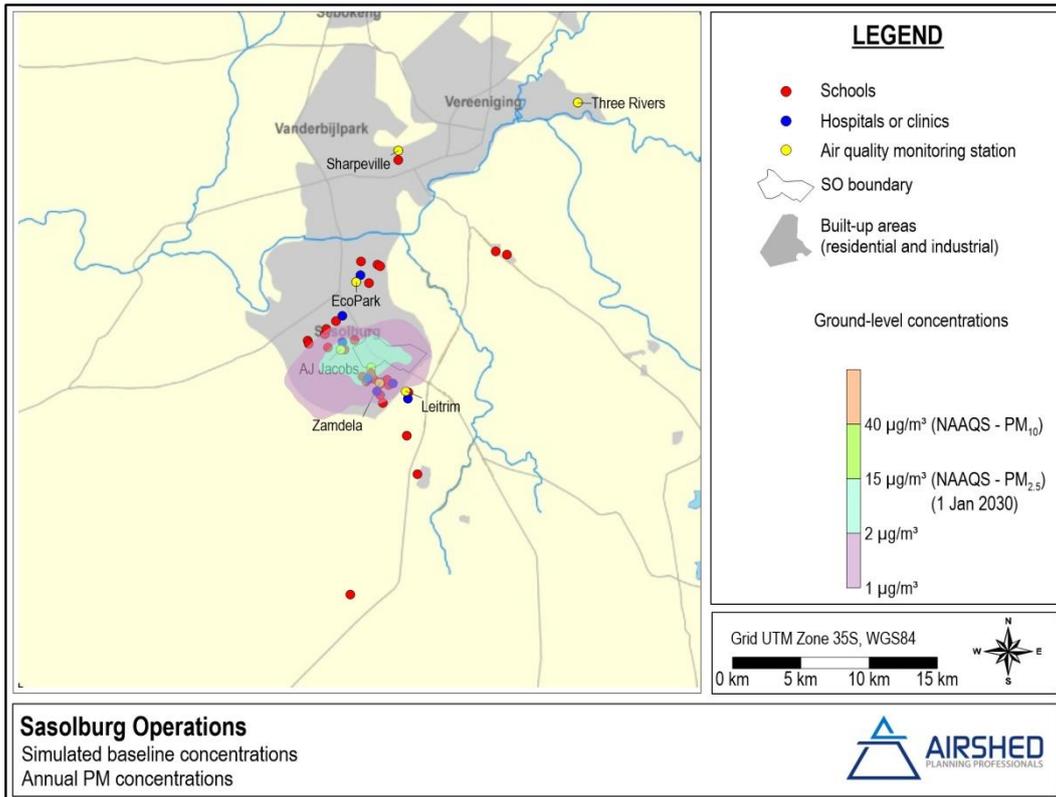


Figure 5-105: Simulated annual PM concentrations as a result of baseline emissions

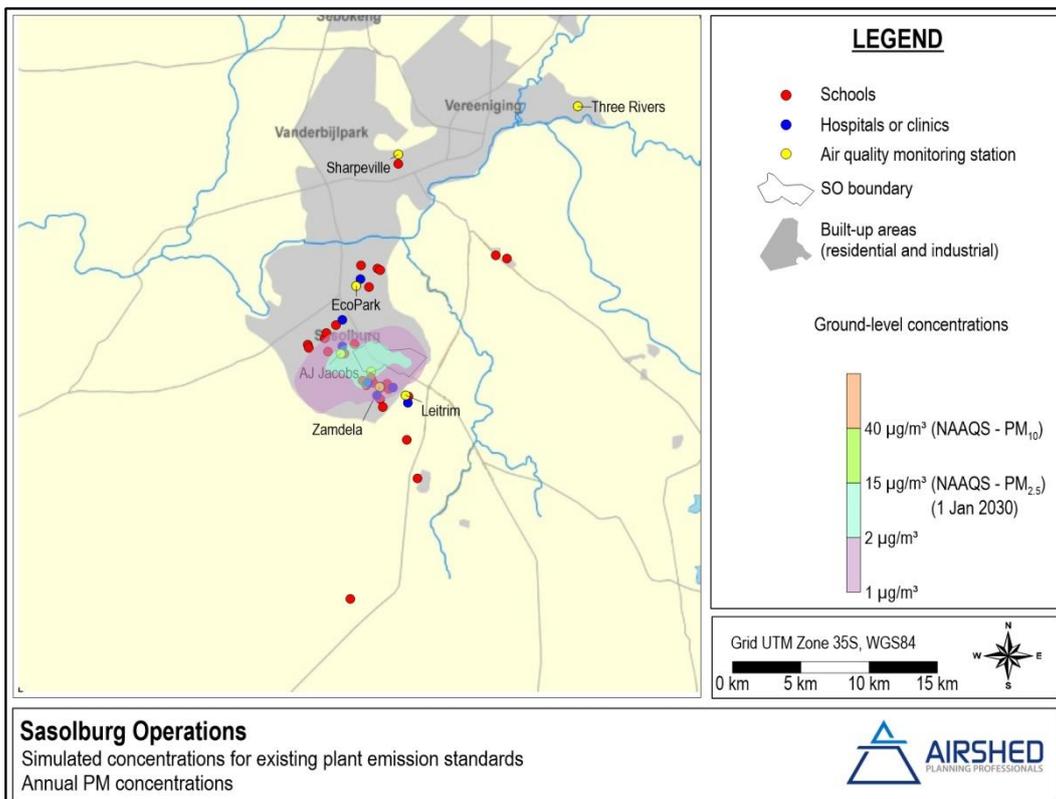


Figure 5-106: Simulated annual PM concentrations as a result of theoretical compliance with existing plant emission standards

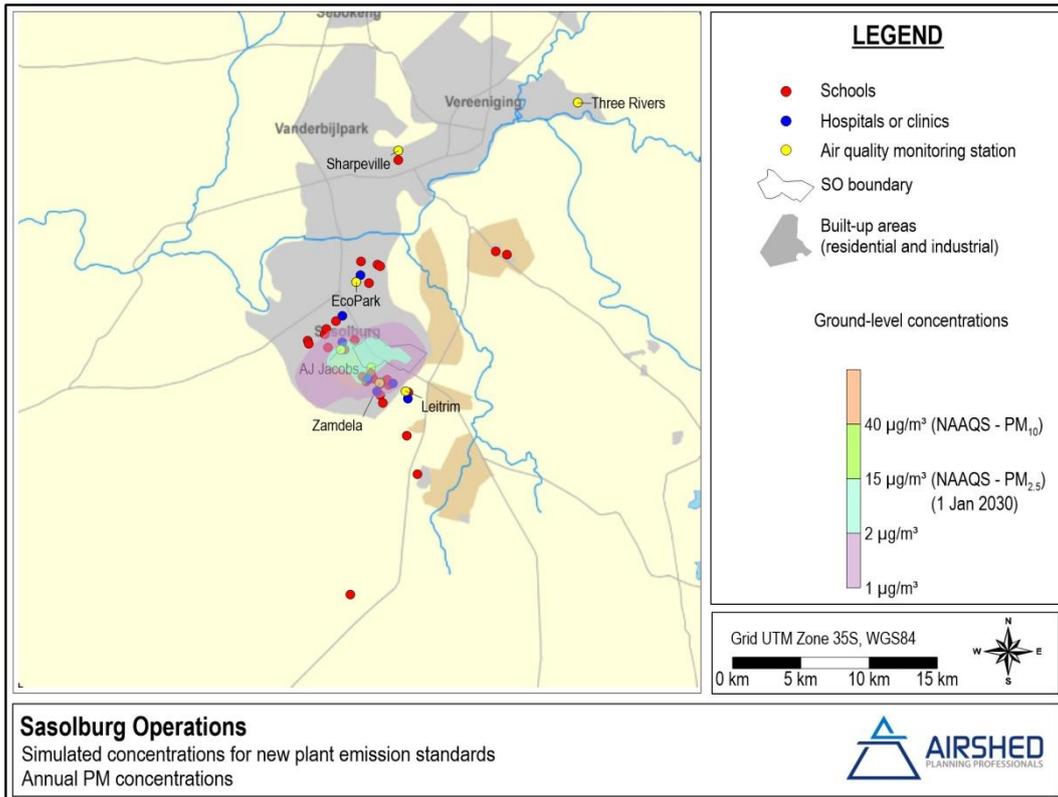


Figure 5-107: Simulated annual PM concentrations as a result of theoretical compliance with new plant emission standards

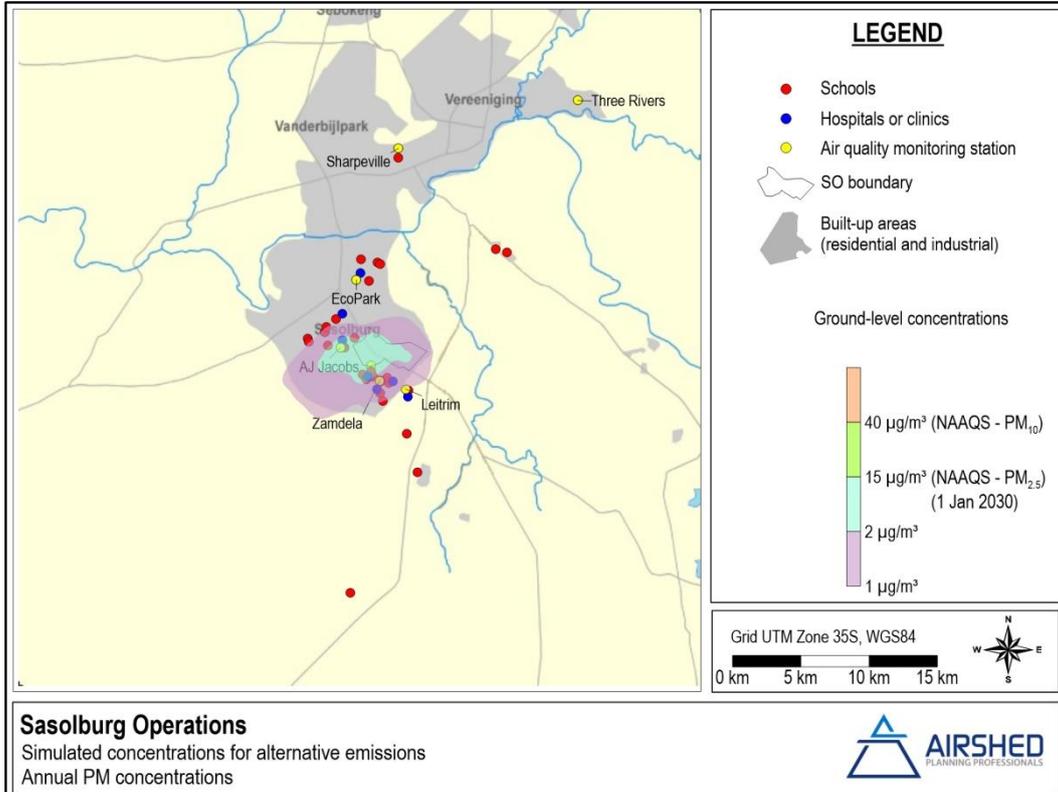


Figure 5-108: Simulated annual PM concentrations as a result of alternative emissions

5.1.8.1.4 Carbon Monoxide (CO)

Only CO sources included in the AEL, was simulated, i.e. the Subcategory 8.1 Thermal Oxidation sources (incinerators). Simulated hourly CO concentrations are in compliance with NAAQS at the AQMS (Figure 5-109) and receptors (Table 5-34) for all scenarios. Theoretical compliance with the existing and new plant emission standards will result in a reduction in ground-level concentrations by up to a maximum of 95% (Table 5-34). The alternative emission scenario will result in increases in hourly CO concentrations relative to the baseline (approximate 18%). The large variation between the ground-level CO concentrations at the AQMS and receptors is related to the small number of sources included for this pollutant with highly variable emission rates.

Isoleth plots are presented for all averaging periods ground-level CO concentrations as a result of all emission scenarios for SO, as per the figure numbers below:

Scenario	Hourly
Baseline concentrations	Figure 5-110
Existing Plant standards	Figure 5-111
New Plant standards	Figure 5-112
Alternative emissions	Figure 5-113

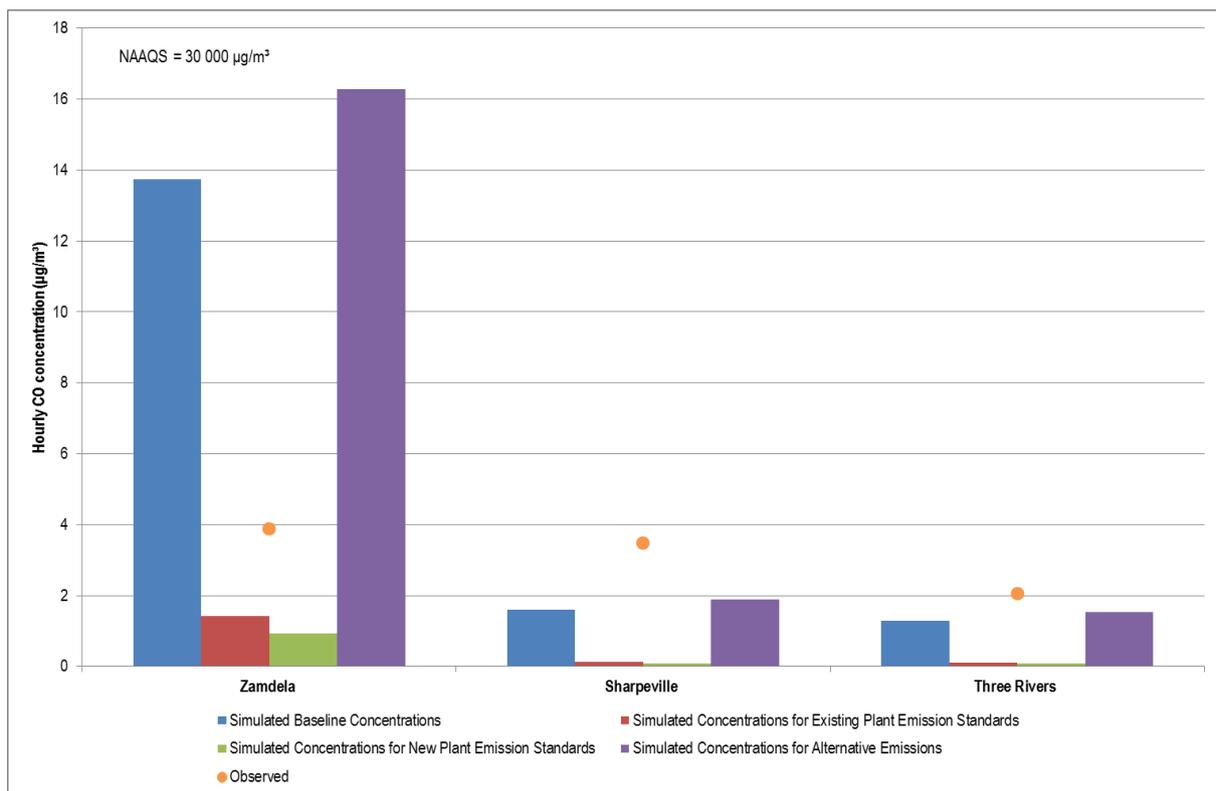


Figure 5-109: Simulated hourly CO concentrations (99th percentile) at AQMS for Sasolburg Operations

Table 5-34: Simulated baseline hourly CO concentrations and the theoretical change in concentrations relative to the baseline at the AQMs and 20 closest receptors

Receptor	Hourly CO						
	Baseline	Existing		New		Alternative	
	Concentration (µg/m ³)	Concentration (µg/m ³)	Relative change	Concentration (µg/m ³)	Relative change	Concentration (µg/m ³)	Relative change
Zamdela AQMS	12.6	1.2	-90.8%	0.8	-93.8%	14.9	18.6%
Leitrim AQMS	6.9	0.7	-90.4%	0.4	-93.6%	8.2	18.4%
AJ Jacobs AQMS	39.4	3.1	-92.1%	2.1	-94.7%	46.7	18.5%
Eco Park AQMS	1.5	0.1	-90.4%	0.1	-93.6%	1.7	18.1%
Sharpeville AQMS	1.1	0.1	-91.6%	0.1	-94.4%	1.3	18.4%
Three Rivers AQMS	1.3	0.1	-91.4%	0.1	-94.3%	1.6	18.4%
Malakabeng Primary School	19.0	1.7	-91.2%	1.1	-94.1%	22.5	18.5%
Cedar Secondary School	9.6	0.9	-90.6%	0.6	-93.7%	11.4	18.7%
Bofula- Tshepe Primary School	12.3	1.1	-90.8%	0.8	-93.9%	14.6	18.4%
Clinic A Zamdela	13.4	1.2	-91.2%	0.8	-94.1%	15.9	18.5%
Zamdela Hospital Zumayear	15.8	1.6	-90.1%	1.0	-93.4%	18.7	18.4%
Iketsetseng Secondary School	12.3	1.1	-90.8%	0.8	-93.9%	14.6	18.4%
Clinic B Zamdela	8.2	0.7	-91.0%	0.5	-94.0%	9.8	18.4%
Tsatsi Primary School	21.0	1.9	-90.8%	1.3	-93.9%	24.8	18.2%
Isaac Mhlambi Primary School	8.8	0.8	-90.4%	0.6	-93.6%	10.4	18.6%
Nkopoleng Secondary School	14.3	1.4	-90.2%	0.9	-93.5%	16.9	18.3%
HTS Secondary School	13.5	1.5	-89.3%	1.0	-92.9%	16.0	18.1%
Zamdela Community Clinic	9.2	0.9	-90.1%	0.6	-93.4%	10.9	18.9%
AJ Jacobs Primary School	38.1	3.1	-92.0%	2.0	-94.6%	45.1	18.5%
Theha Setjhaba Primary School	8.6	0.8	-90.4%	0.6	-93.6%	10.2	18.6%
Sasolburg Clinic	14.1	1.4	-90.1%	0.9	-93.4%	16.7	18.4%
Credo Primary School	7.1	0.7	-90.6%	0.4	-93.7%	8.4	18.4%
Lehutso Primary School	8.3	0.9	-89.7%	0.6	-93.1%	9.9	18.4%
Harry Gwala Clinic Creche	7.1	0.6	-91.1%	0.4	-94.1%	8.4	18.4%
Kahobotjha-Sakubusha Secondary School	15.1	1.3	-91.4%	0.9	-94.2%	17.8	18.2%
Sasolburg Provincial Hospital	3.0	0.3	-90.2%	0.2	-93.5%	3.5	18.4%

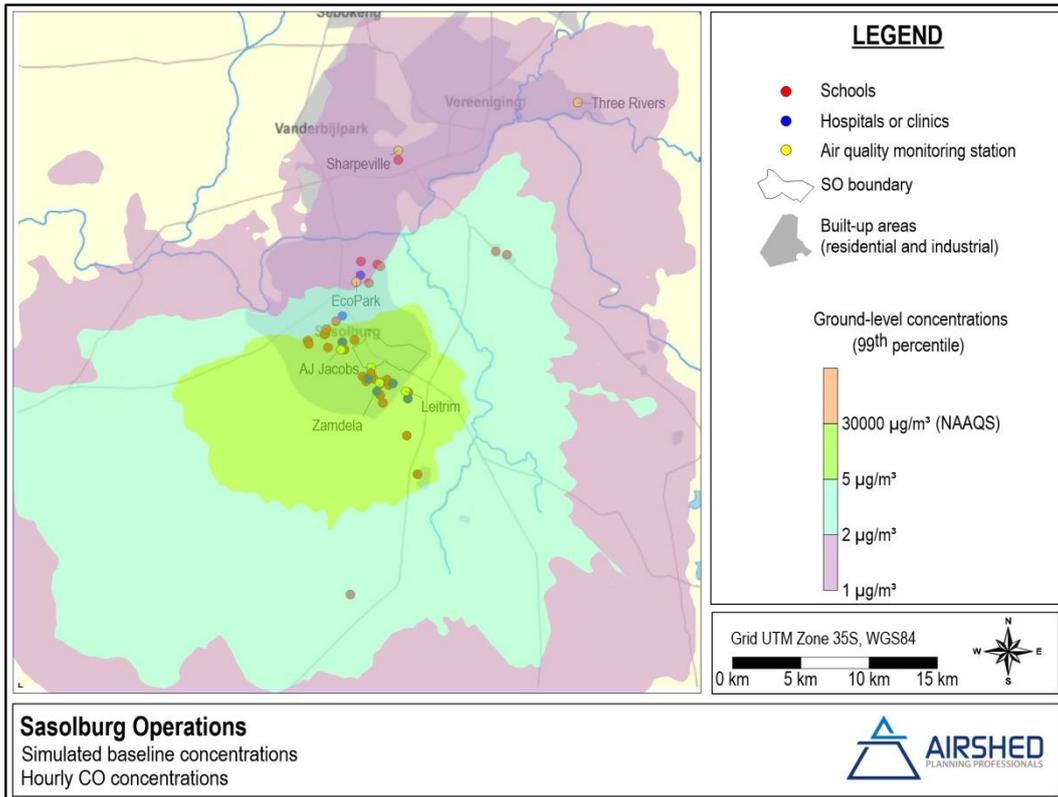


Figure 5-110: Simulated hourly CO concentrations (99th percentile) as a result of baseline emissions

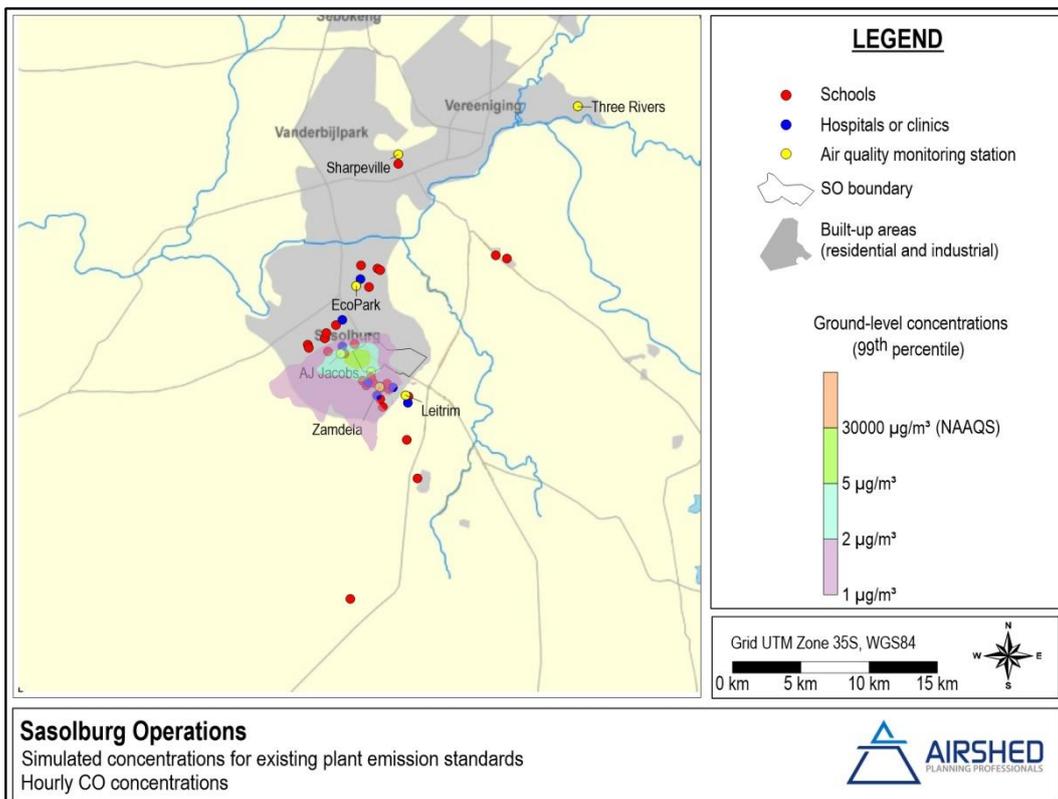


Figure 5-111: Simulated hourly CO concentrations (99th percentile) as a result of theoretical compliance with existing plant emission standards

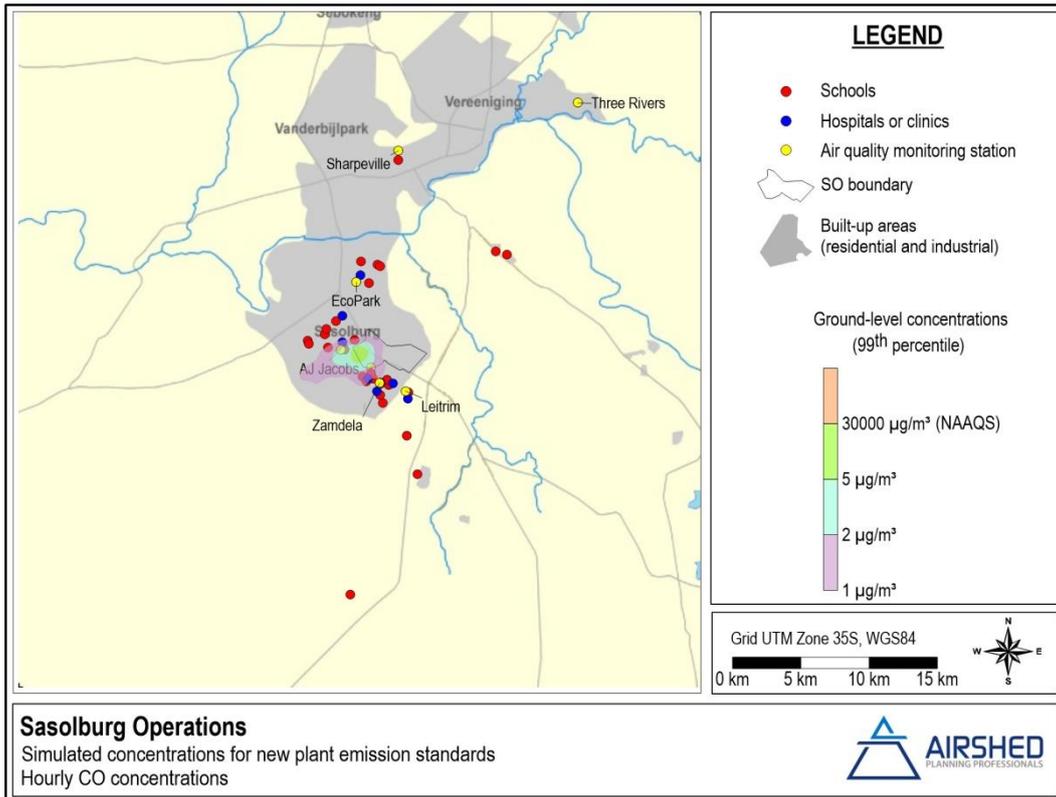


Figure 5-112: Simulated hourly CO concentrations (99th percentile) as a result of theoretical compliance with new plant emission standards

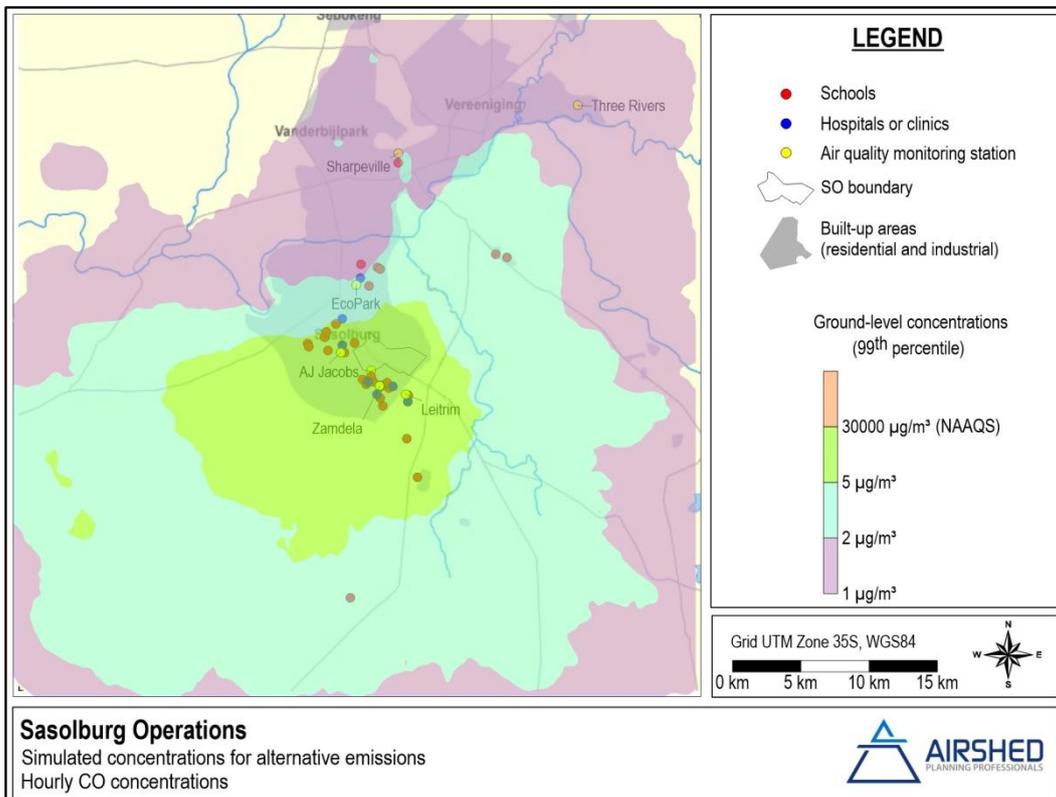


Figure 5-113: Simulated hourly CO concentrations (99th percentile) as a result of alternative emissions

5.1.8.2 Non-criteria pollutants

Ambient pollutant concentrations, either from the dispersion modelling or from direct physical measurements, are typically compared to defined standards or other thresholds to assess the health and/or environmental risk implications of the predicted or measured air quality. In South Africa, NAAQS have been set for criteria pollutants at limits deemed to uphold a permissible level of health risk and the assessment has accordingly been based on a comparison between the predicted concentrations and the NAAQS. The measured concentrations have been used to ascertain the representativeness of the modelling and to assess compliance with the NAAQS as a function of all sources of emissions.

Where NAAQS have not been set health-effect screening levels, appropriate for assessing the non-criteria pollutants emitted from SO, were identified from literature reviews and internationally recognised databases. These non-criteria pollutants for which screening levels were identified include, various emissions from the incinerators, namely lead (Pb), arsenic (As), antimony (Sb), chromium (Cr), cobalt (Co), copper (Cu), manganese (Mn), nickel (Ni) and vanadium (V). The health-effect screening levels used are listed in Table 5-35.

Table 5-35: Most stringent health-effect screening level identified for all non-criteria pollutants assessed

Compound	Acute exposure ^(a) [units: µg/m ³]	Chronic exposure ^(b) [units: µg/m ³]
Lead (Pb)	(c)	(d)
Arsenic (As)	0.2 (g)	0.015 (g)
Antimony (Sb)	(c)	(d)
Chromium (Cr)	(c)	0.1 (e)
Cobalt (Co)	(c)	0.1 (f)
Copper (Cu)	100 (g)	(d)
Manganese (Mn)	(c)	0.05 (e)
Nickel (Ni)	0.2 (g)	0.014 (g)
Vanadium (V)	0.8 (f)	0.1 (f)
Ammonia (NH ₃)	1 184 (f)	(d)
Hydrogen chloride (HCl)	2 100 (g)	(d)
Hydrogen fluoride (HF)	240 (g)	(d)
Volatile organic compounds (VOCs)	(c)	200 (h)

(a) Hourly concentrations compared with short-term / acute exposure health effect screening level
(b) Annual concentrations compared with long-term / chronic exposure health effect screening level
(c) No hourly health screening level
(d) No annual health screening level
(e) US-EPA IRIS Inhalation Reference Concentrations (µg/m³) – chronic
(f) US ATSDR Maximum Risk Levels (MRLs) (µg/m³) - acute
(g) Californian OEHHA (µg/m³)
(h) ECA (1992) – Chronic comfort level

A screening exercise of non-criteria pollutants emitted from the incinerators at SO, including all non-criteria pollutants listed in Table 5-25, was undertaken to identify pollutants that would be likely to exceed the most stringent health-effect screening levels identified (Table 5-35). The non-criteria pollutants that would possibly exceed the screening level concentrations included: As, Cr, Co, Mn, Ni, and V. Further analysis used the averaged normalised fraction of sum of metals represented by each metal element. This calculation was based on at least 15 sampling runs for the three sources for which postponement is applied. It should also be noted that one of the 15 sampling runs for the Caustic Incinerator (B6993) recorded a

substantially elevated Mn emission rate. This resulted in a normalised contribution of 94% of the 'sum of metals' from Mn. Excluding this outlier data point, the average contribution of Mn to the sum of metals was 52%. The use of the 94% contribution is therefore considered to be additionally conservative to Sasol's approach of emissions modelling. Where exceedances were simulated, results are presented for both calculated contributions (94% and 52% Mn in the sum of metals) to illustrate the potential range of impact.

The analysis of individual metal elements showed that simulated ground-level concentrations of these pollutants comply with the strictest health effect screening level concentrations across the modelling domain for all metals except Mn (Table 5-36). Potential Mn exceedances occur on-site for the baseline scenario (Figure 5-114). However, potential exceedances of the health effect screening level extend up to 800 m from the western site boundary under the alternative emission scenario when using a 94% contribution to the sum of metals (Figure 5-115). Potential exceedances under the alternative scenario extend up to 350 m from the SO boundary when a 52% contribution of Mn to the sum of metals is used (Figure 5-116) where maximum concentrations are likely to occur on-site, and the plume extends over the nearby Sasol Mining and Ash dump site to the west of the facility. Concentrations at receptors are unlikely to exceed the health effect screening level. Potential public exposure to the potentially elevated Mn concentrations would be limited to individuals travelling on the public road that separates the western boundary of the SO facility from the Mining and Ash dump site.

Table 5-36: Screening of non-criteria pollutants against health risk guidelines

Metallic element	Acute exposure ^(a) [units: µg/m ³]			Chronic exposure ^(b) [units: µg/m ³]		
	Minimum concentration ^(c)	Maximum concentration ^(d)	Strictest health effect screening level	Minimum concentration ^(c)	Maximum concentration ^(d)	Strictest health effect screening level
<i>Baseline Emissions</i>						
As	6.99x10 ⁻⁵	2.43x10 ⁻²	0.2 ^(g)	2.62x10 ⁻⁷	5.23 x10 ⁻⁴	0.015 ^(h)
Cr				2.98x10 ⁻⁶	7.25x10 ⁻³	0.1 ^(e)
Co				5.78x10 ⁻⁸	1.23x10 ⁻⁴	0.1 ^(f)
Mn				5.52x10 ⁻⁵	1.28x10⁻¹	0.05 ^(e)
Ni	2.34x10 ⁻⁴	7.11x10 ⁻²	0.2 ^(g)	8.73x10 ⁻⁷	1.84x10 ⁻³	0.014 ^(h)
V	4.51x10 ⁻⁵	1.61x10 ⁻²	0.8 ^(f)	1.59x10 ⁻⁷	3.68x10 ⁻⁴	0.1 ^(f)
<i>Existing Plant Standards and New Plant Standards</i>						
As	1.19x10 ⁻⁵	1.06x10 ⁻²	0.2 ^(g)			
Ni	3.95x10 ⁻⁵	3.53x10 ⁻²	0.2 ^(g)			
<i>Alternative Emissions</i>						
As	9.19x10 ⁻⁵	3.17x10 ⁻²	0.2 ^(g)	3.75x10 ⁻⁷	9.44x10 ⁻⁴	0.015 ^(h)
Cr				3.74x10 ⁻⁶	1.02x10 ⁻²	0.1 ^(e)
Co				1.34x10 ⁻⁷	3.98x10 ⁻⁴	0.1 ^(f)
Mn (94% of sum of metals)				1.41x10 ⁻⁴	4.37x10⁻¹	0.05 ^(e)
Mn (52% of sum of metals)				1.00 x10 ⁻⁴	2.92 x10⁻¹	0.05 ^(e)
Ni	4.63x10 ⁻⁴	1.52x10 ⁻¹	0.2 ^(g)	1.94x10 ⁻⁶	5.67x10 ⁻³	0.014 ^(h)
V	1.58x10 ⁻⁴	5.57x10 ⁻²	0.8 ^(f)	6.41x10 ⁻⁷	2.09x10 ⁻³	0.1 ^(f)
<p>(a) hourly concentrations compared with short-term / acute exposure health effect screening level (b) annual concentrations compared with long-term / chronic exposure health effect screening level (c) minimum concentration simulated across the domain (d) maximum concentration simulated across the domain (e) US-EPA IRIS Inhalation Reference Concentrations (µg/m³) – chronic (f) US ATSDR Maximum Risk Levels (MRLs) (µg/m³) - acute (g) Californian OEHHA (µg/m³) – acute (h) Californian OEHHA (µg/m³) – chronic Note: bold text indicates potential exceedance of the health effect screening level within domain</p>						

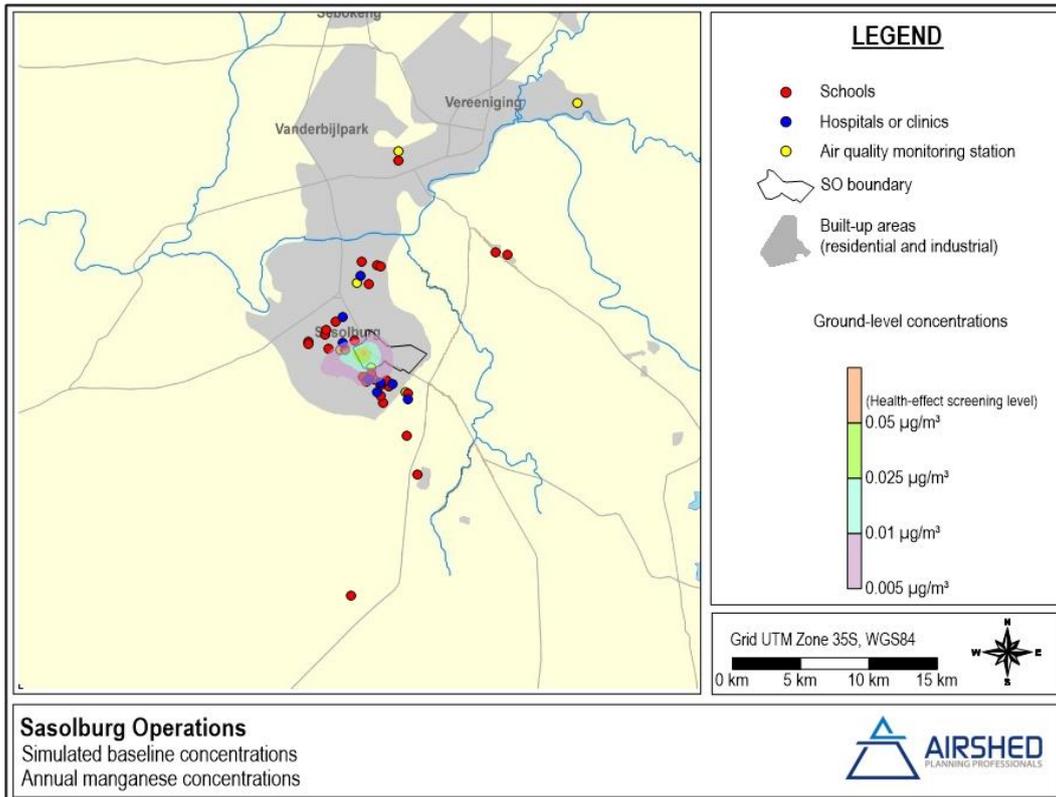


Figure 5-114: Simulated annual Mn concentrations as a result of baseline emissions

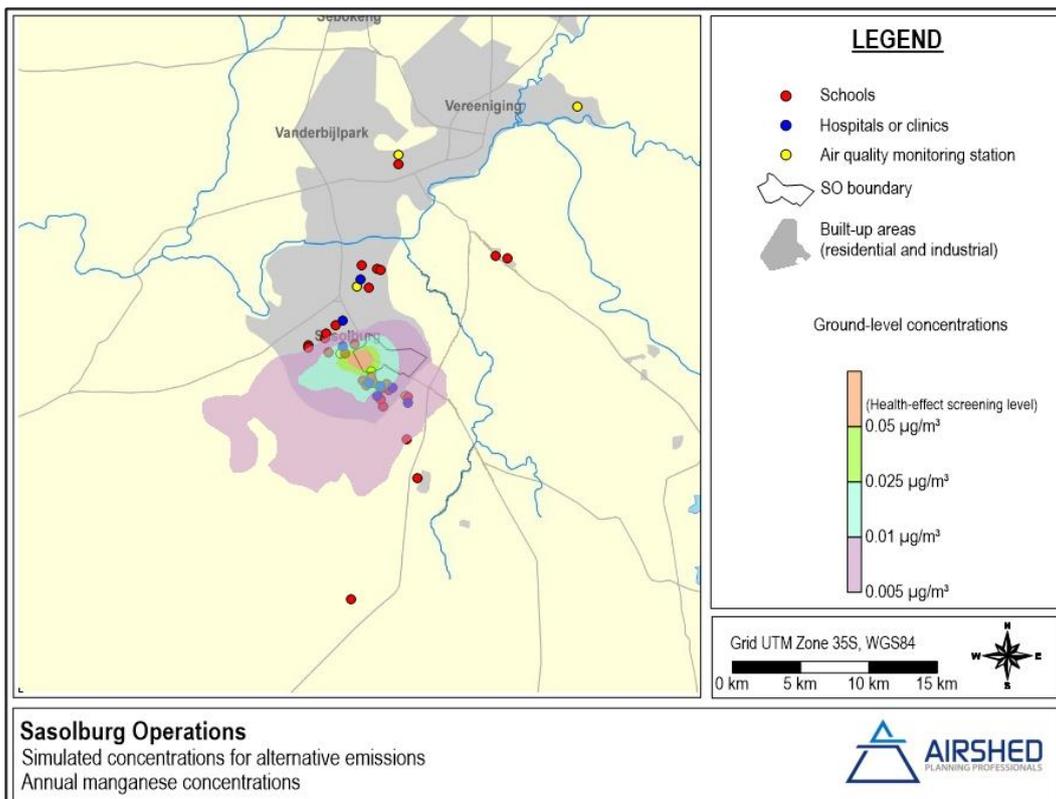


Figure 5-115: Simulated annual Mn concentrations as a result of alternative emissions (94% of sum of metals)

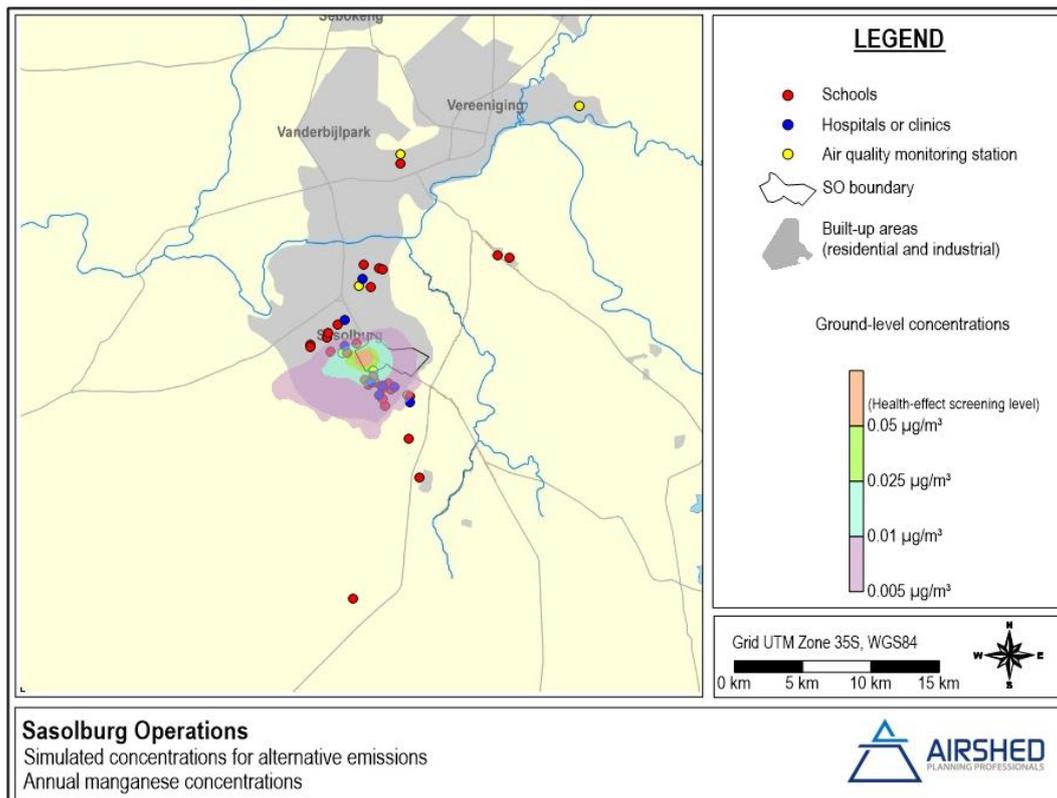


Figure 5-116: Simulated annual Mn concentrations as a result of alternative emissions (52% of sum of metals)

5.1.9 Uncertainty of Modelled Results

The main steps of uncertainty management are to:

- identify and understand uncertainties;
- understand whether uncertainties matter for decisions being made at the time;
- if they do matter, decide what to do about them; and,
- recommend a way forward.

Managing uncertainties attempts to eliminate the source of technical disagreements and failure to understand them often leads to a conclusion that all uncertainties need to be eliminated before project decisions can be made. The first decision about how to manage uncertainties relates to their significance given the decision being addressed. In the current context, the different parts of the investigation were grouped into similar uncertainty regimes, namely:

- dispersion model uncertainties;
- input data uncertainties;
- the methodology of validating model results; and,
- the methodology of expressing the modelled scenarios.

A comprehensive discussion on uncertainties is provided in Appendix H.

As discussed in Section 5.1.6, the baseline predictions with the inclusion of estimated background concentrations performed well within the generally accepted (U.S. EPA 2005) “factor of two” accuracy of dispersion models. Unless greater general

experience is gained or some further formal validation studies are conducted, it is not possible to say how much more confidence can be given to well-executed plume and puff models.

As discussed in Appendix H, it is estimated that the ambient monitoring has an uncertainty of 5% with a 95% confidence interval and the emissions monitoring an uncertainty of 10% with a 95% confidence interval. Based on these uncertainties, it is estimated that the concentration ratios of the different emission scenarios have an uncertainty of -36% and +58%, i.e. potential under-prediction of 36% and over-prediction of 58%.

The Intergovernmental Panel on Climate Change (IPCC) produced a qualitative method for consistent communication of uncertainties in the IPCC Fifth Assessment Report. This Guidance Note has been summarised in Appendix I. On application of this guide, the results from this investigation is considered to be of “high confidence” based on a “high agreement” of the baseline predictions with observations, albeit based only on one monitoring site for SO₂, i.e. “medium evidence”.

5.2 Analysis of Emissions’ Impact on the Environment

5.2.1 Critical Levels for Vegetation

The impact of SO emissions on surrounding vegetation was assessed by comparing the simulated annual SO₂ and NO₂ concentrations for each of the four emission scenarios against the critical levels for vegetation as defined by the United Nations Economic Commission for Europe (UNECE) Convention on Long Range Trans-boundary Air Pollution Limits (CLRTAP, 2015) (Table 5-37).

Table 5-37: Critical levels for SO₂ and NO₂ by vegetation type (CLRTAP, 2015)

Pollutant	Vegetation type	Critical Level (µg/m ³)	Time Period ^(a)
SO ₂	Cyanobacterial lichens	10	Annual average
	Forest ecosystems (including understorey vegetation)	20	Annual average and Half-year mean (winter)
	(Semi-)natural vegetation	20	Annual average and Half-year mean (winter)
	Agricultural crops	30	Annual average and Half-year mean (winter)
NO ₂	All	30	Annual average and Half-year mean (winter)
		75	Daily average
Notes:			
(a) For the purposes of mapping of critical levels and exceedances CLRTAP recommend using only the annual average, due to increased reliability of mapped and simulated data for the longer time period. It is also noted that long-term effects of NO _x are considered to be more significant than short-term effects (CLRTAP, 2015).			

The simulated off-site annual concentrations of SO₂ may exceed the critical levels for lichen (SO₂) for all emission scenarios (Figure 5-117 to Figure 5-120). However, off-site NO₂ concentrations are likely to be below the critical levels for all vegetation types (Figure 5-121 to Figure 5-124)

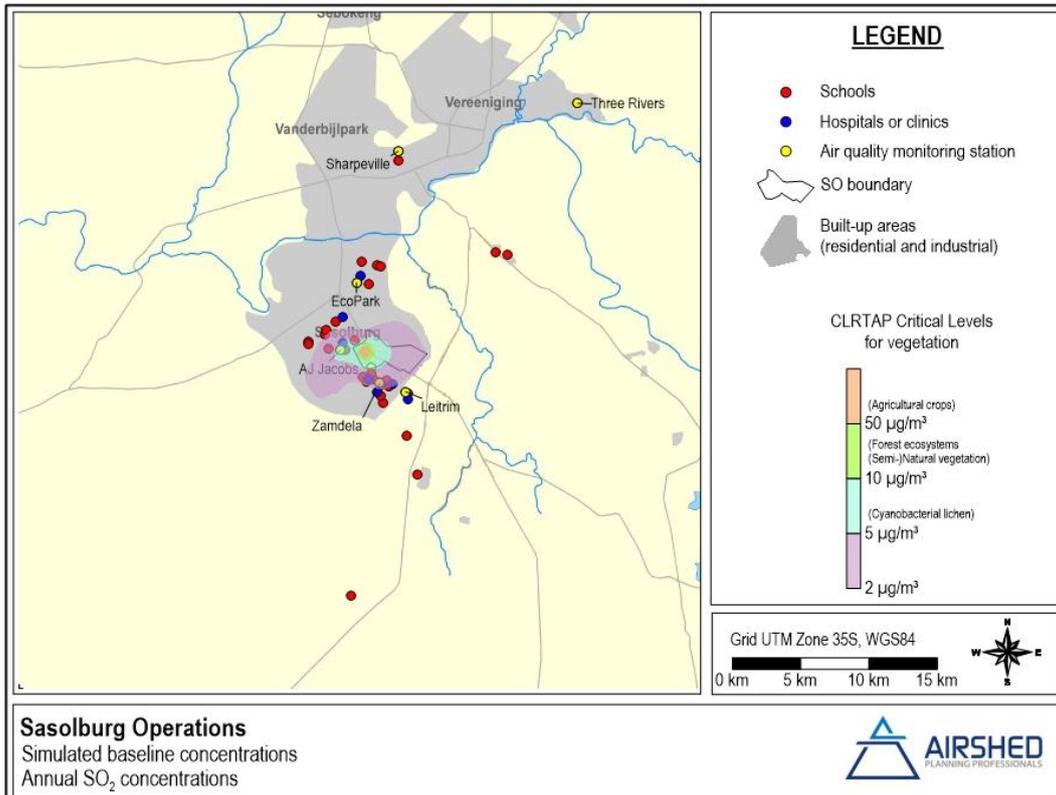


Figure 5-117: Annual SO₂ concentrations as a result of baseline emissions compared with CLRTAP critical levels

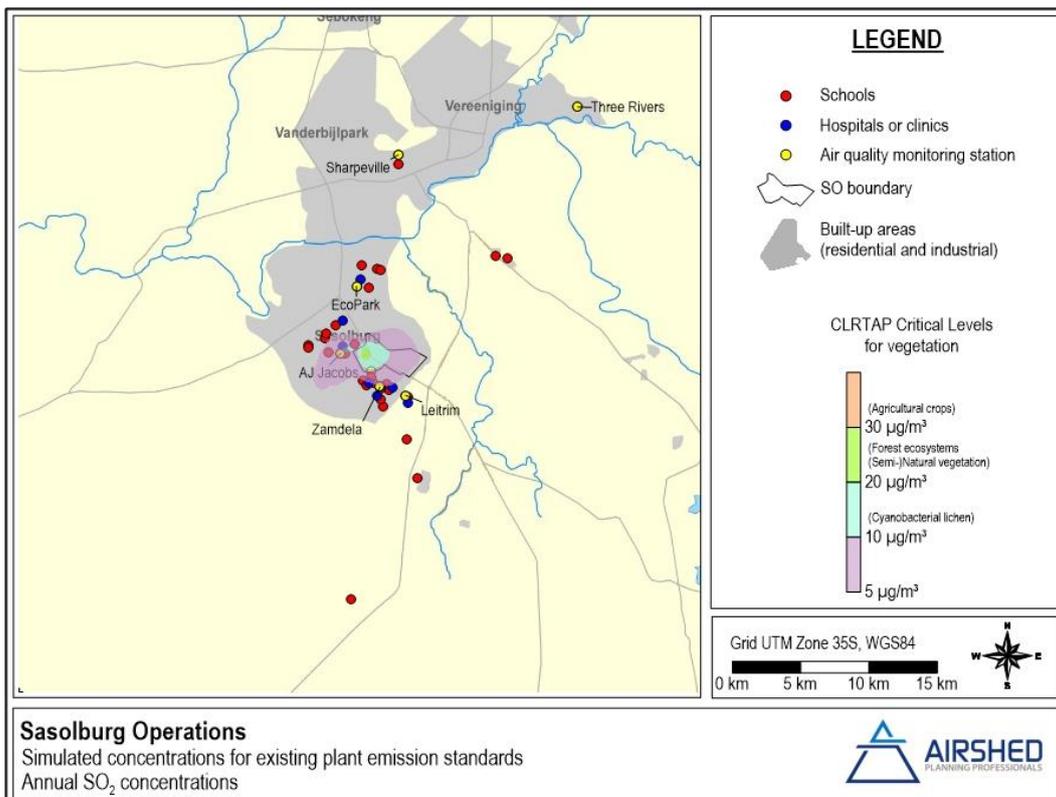


Figure 5-118: Annual SO₂ concentrations as a result of theoretical compliance with existing plant emission standards compared with CLRTAP critical levels

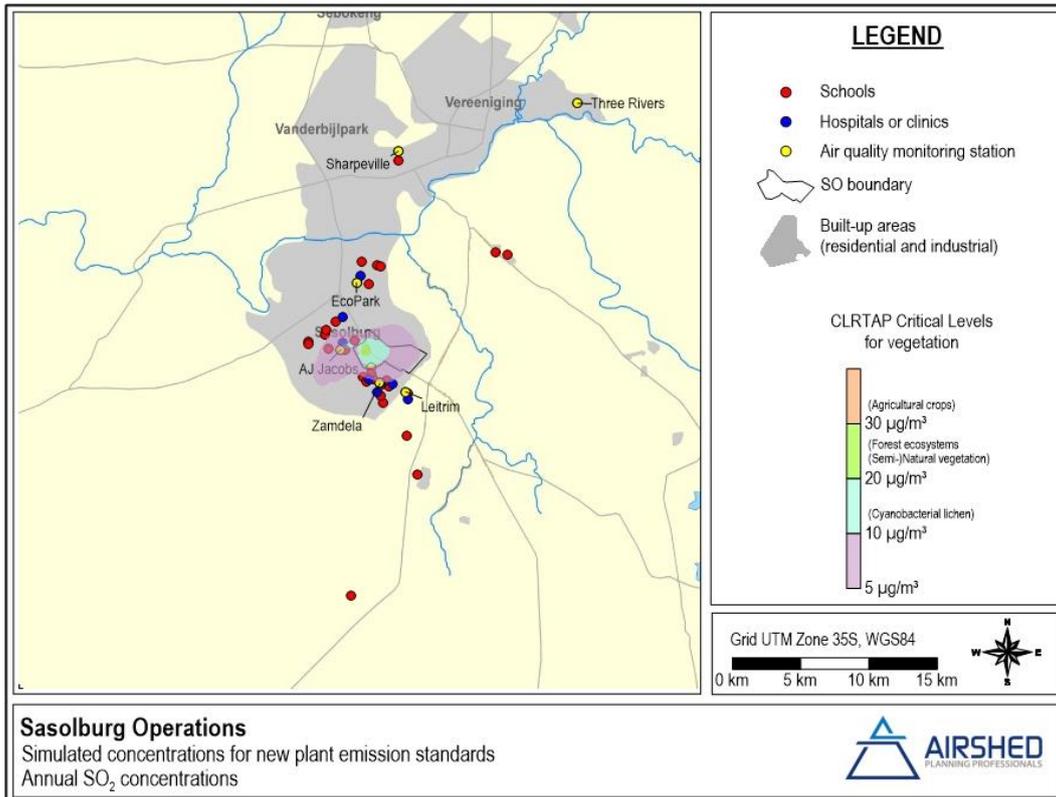


Figure 5-119: Annual SO₂ concentrations as a result of theoretical compliance with new plant emission standards compared with CLRTAP critical levels

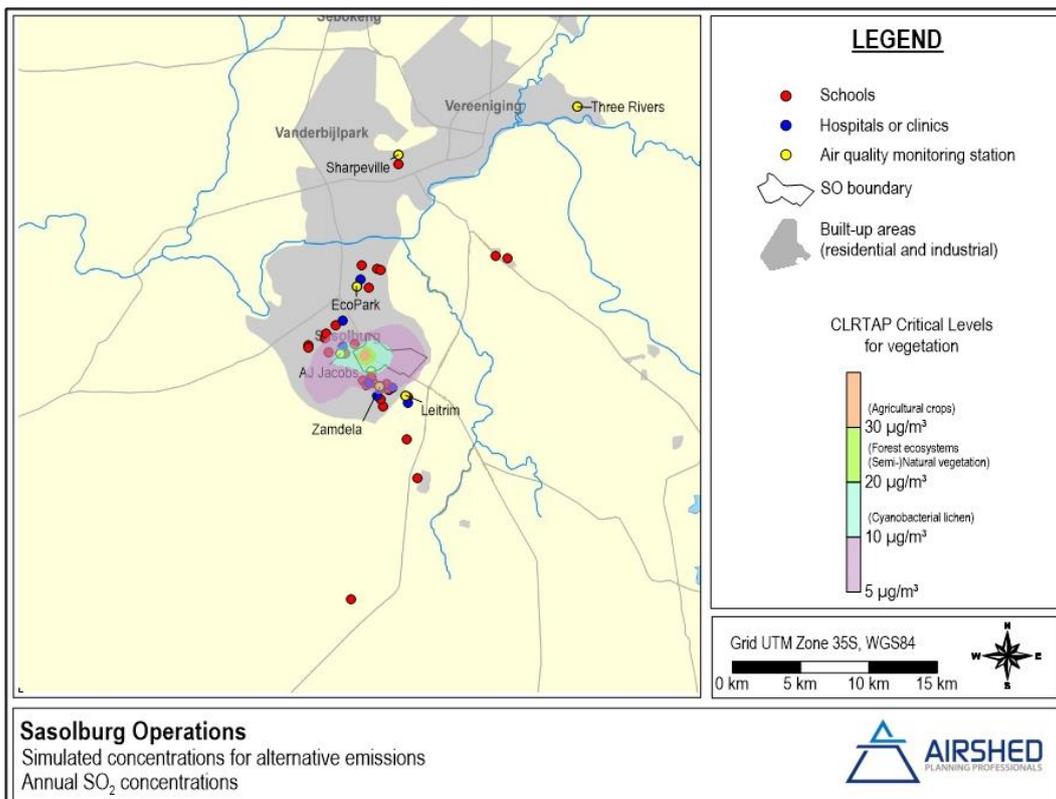


Figure 5-120: Annual SO₂ concentrations as a result alternative emissions compared with CLRTAP critical levels

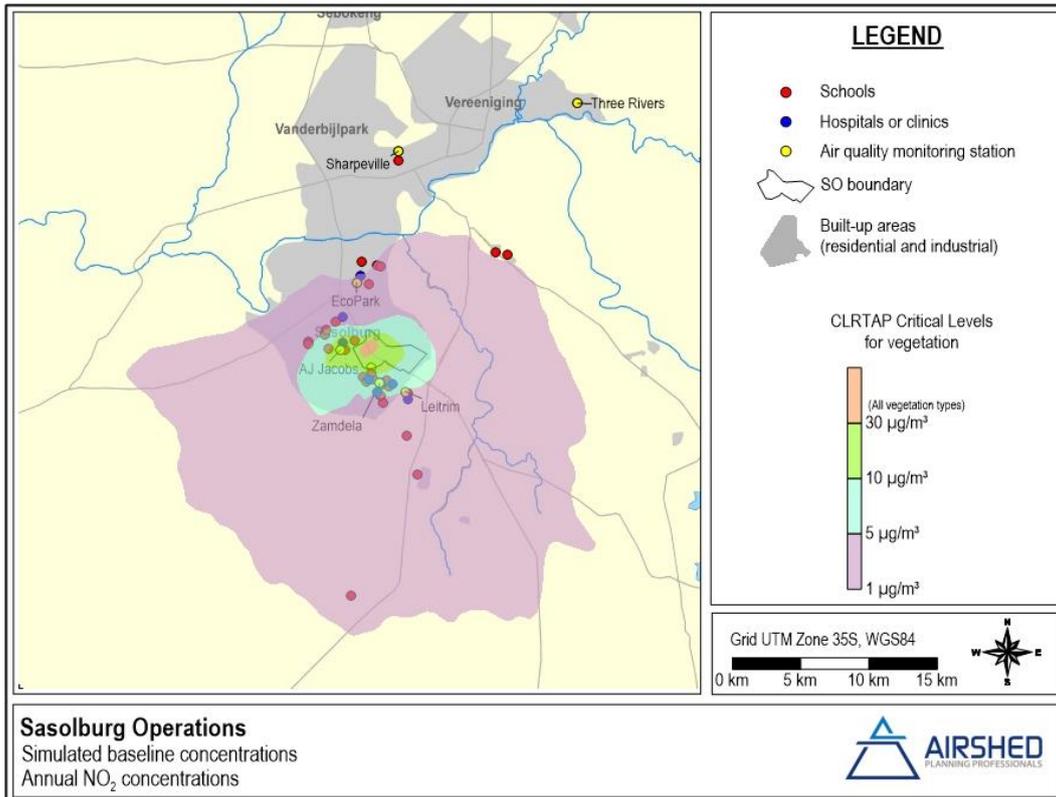


Figure 5-121: Annual NO₂ concentrations as a result of baseline emissions compared with CLRTAP critical levels

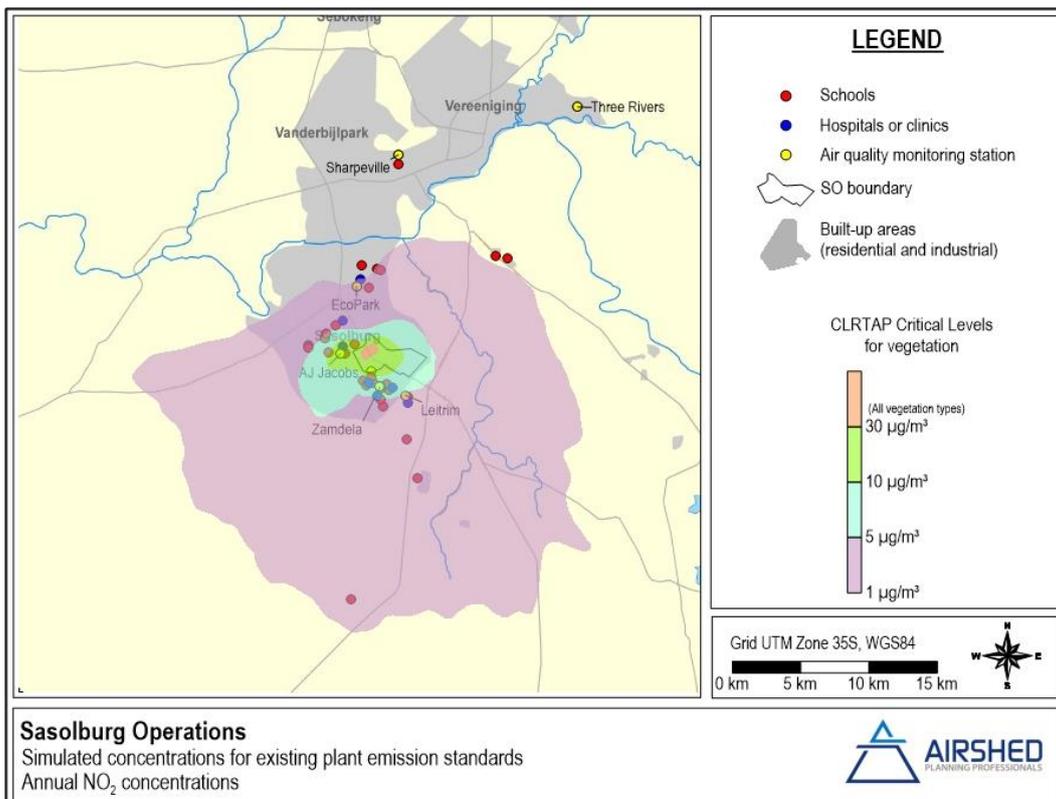


Figure 5-122: Annual NO₂ concentrations as a result of theoretical compliance with existing plant emission standards compared with CLRTAP critical levels

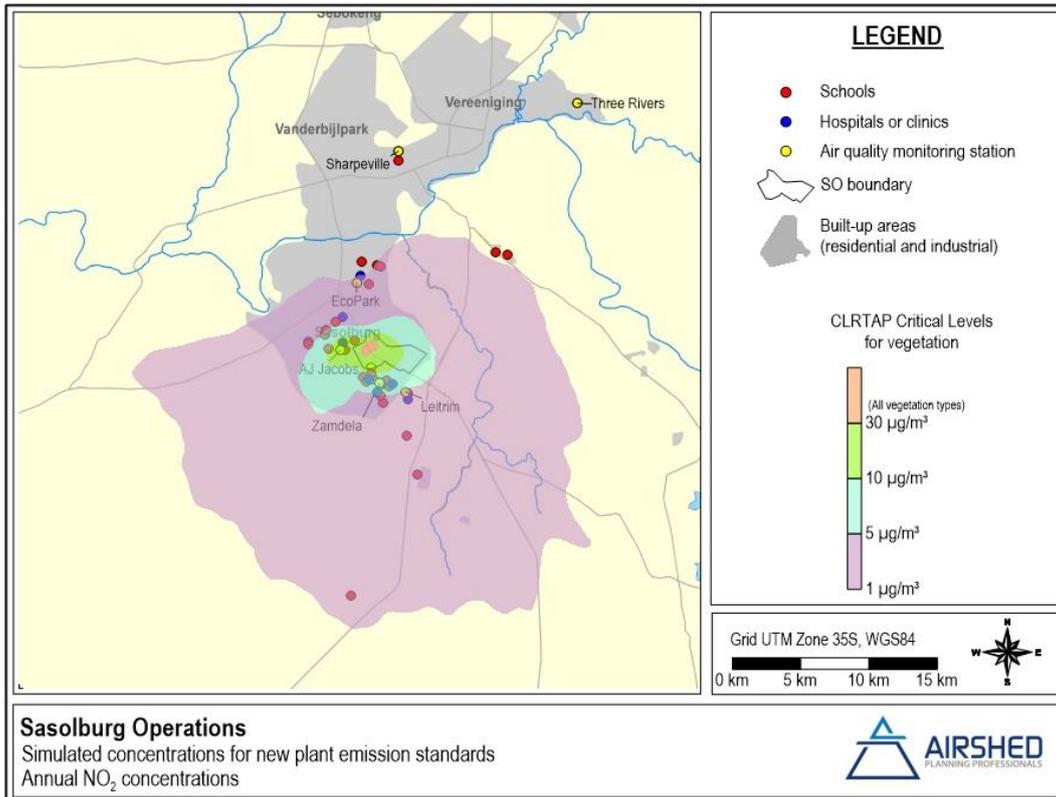


Figure 5-123: Annual NO₂ concentrations as a result of theoretical compliance with new plant emission standards compared with CLRTAP critical levels

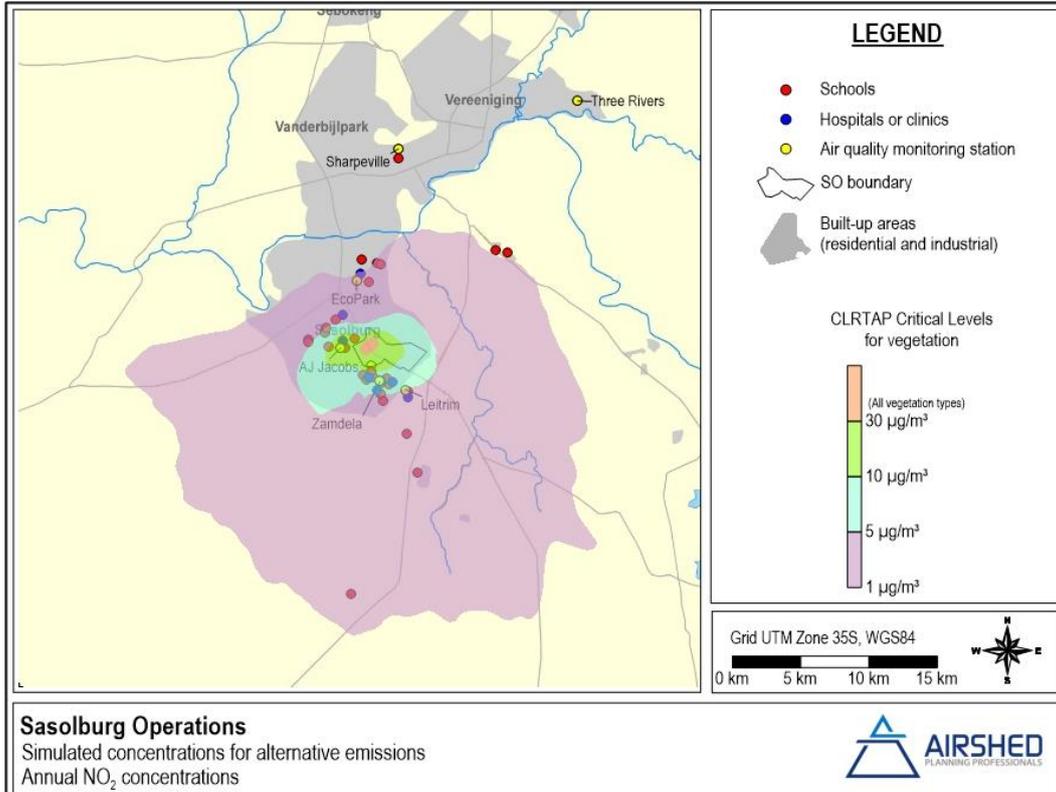


Figure 5-124: Annual NO₂ concentrations as a result of alternative emissions compared with CLRTAP critical levels

5.2.2 Dustfall

Dustfall deposition rates were estimated as a result of particulate emissions from the SO point sources. The simulated PM concentrations (Section 5.1.8.1.3) were converted to deposition rates by assuming a settling velocity of 6.43×10^{-3} m/s (based on a $10 \mu\text{m}$ particle with a density of 2.1 g/m^3). Estimated dustfall rates for the four simulation scenarios ranged between 0.12 and 1 319.8 $\text{mg/m}^2\cdot\text{day}$, where the theoretical compliance with existing and new plant standards would likely result in the lowest dustfall rates (Table 5-38). No exceedances of the NDCR residential standard were simulated off-site. Isoleth plots are presented for dustfall deposition rates for the four scenarios in Figure 5-125 to Figure 5-128. Simulated dustfall rates have been compared to the acceptable dustfall rate applicable to residential areas as defined by the NDCR (Table 5-3).

Table 5-38: Summary of dustfall deposition rates as a result of operations at SO

Criteria	Daily dustfall rate ($\text{mg/m}^2\cdot\text{day}$)			
	Simulated Baseline Concentrations	Simulated Concentrations for Existing Plant Emission Standards	Simulated Concentrations for New Plant Emission Standards	Simulated Concentrations for Alternative Emissions
Min	0.15	0.12	0.12	0.16
Max	1 320.1	1 319.8	1 319.8	1 320.2

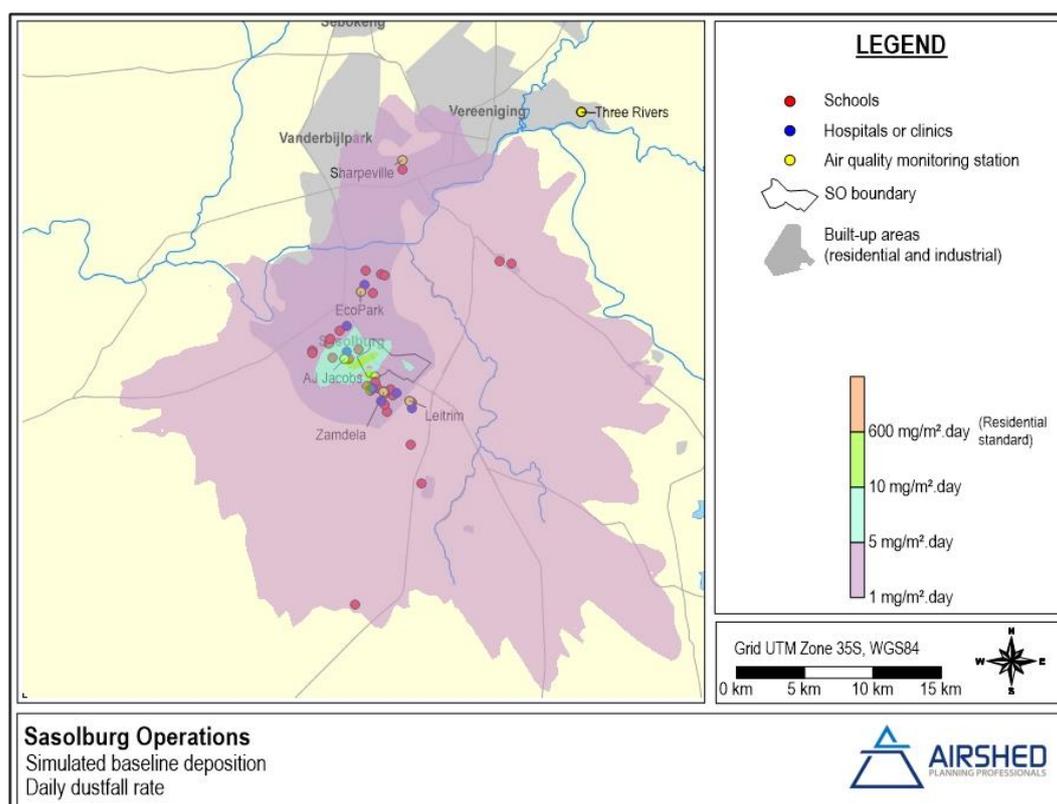


Figure 5-125: Simulated daily dustfall as a result of baseline emissions

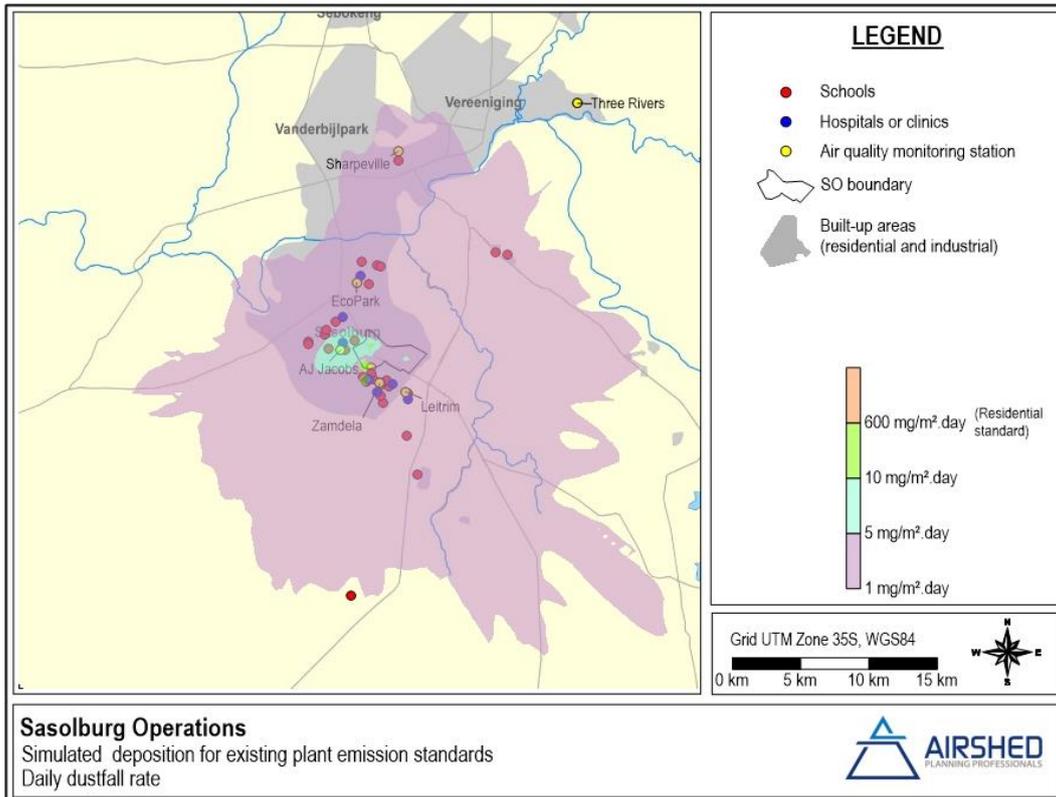


Figure 5-126: Simulated daily dustfall as a result of theoretical compliance with existing plant standards

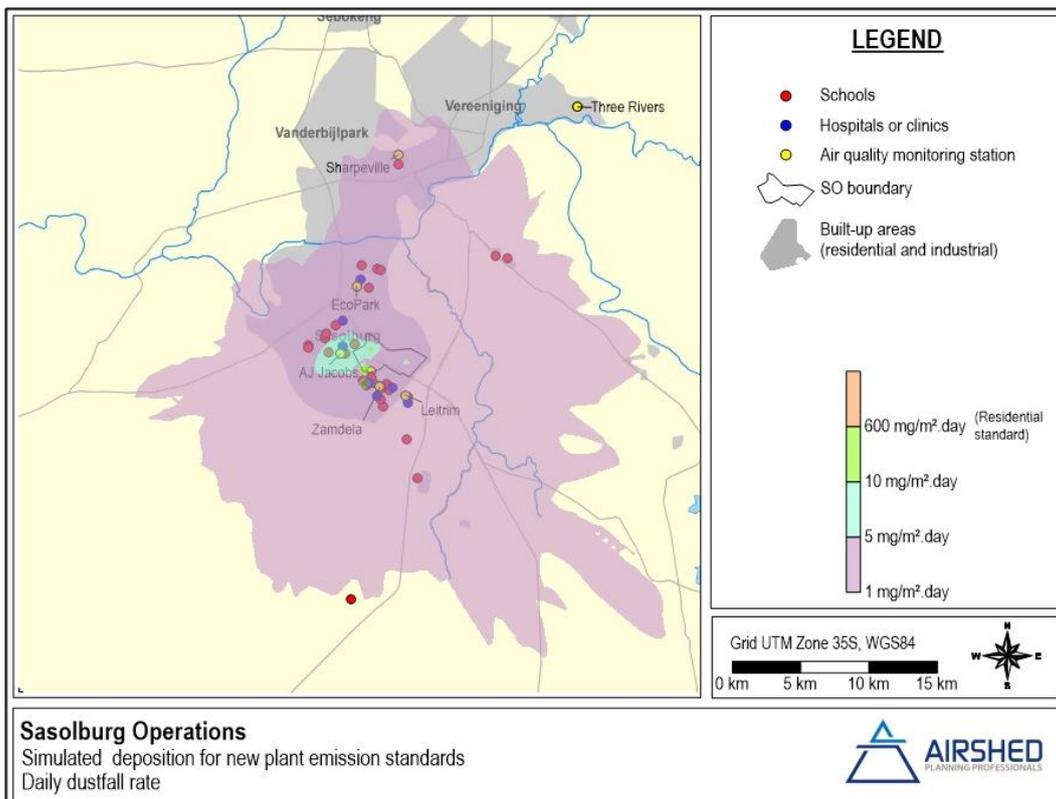


Figure 5-127: Simulated daily dustfall as a result of theoretical compliance with new plant standards

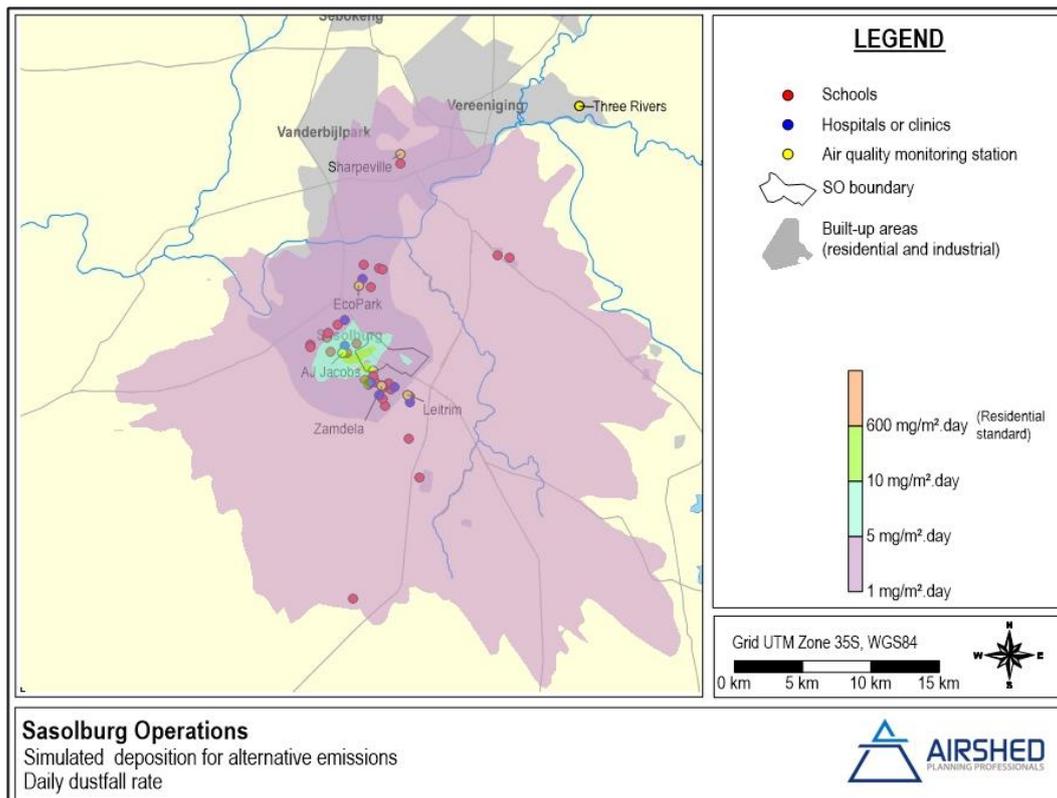


Figure 5-128: Simulated daily dustfall as a result of alternative emissions

5.2.3 Corrosion

5.2.3.1 Factors Affecting Corrosion

The most important corrosion stimulators are water (humidity) and air pollutants, such as SO₂, NH₃, and acids such as HCl and formic acid (HCOOH), as well as aerosols and particles containing chlorides (Cl⁻), nitrates (NO₃⁻), and sulfates (SO₄²⁻). The presence of a moisture film on the surface allows these pollutants to dissolve and dissociate into its respective positive and negative ions, and therefore constitutes the electrolyte for corrosion to take place. The thickness of this aqueous layer depends on the relative humidity and surface properties, and is typically a few to a few tens of nanometres (nm) at room temperature (Phipps and Rice 1979).

Dry deposition near emission sources in urban and industrial areas consists largely of the adsorption of criteria pollutants such as SO₂ and NO_x on surfaces, with the deposited amount proportional to the content in air. The deposition rate is high at elevated humidity, especially on some metals; e.g., steel and zinc (Sydberger and Vannerberg, 1972). Corrosion due to SO₂ exposure is perhaps the most significant. Although NO_x may also contribute to corrosion of metals, it is considerably less significant. Like SO₂, this pollutant is mainly emitted from combustion processes such as boilers, power stations, motor vehicle exhausts, etc. It is predominantly emitted as nitrogen oxide (NO) and oxidised in the atmosphere to nitrogen dioxide (NO₂). This oxidation process is a relatively fast process, but further oxidation of NO₂ to nitric acid (HNO₃), i.e. the form conducive for corrosion, occurs at a slow rate and therefore exposure is normally at comparatively low concentrations.

Very little work has been reported on the effect of HCl on the degradation of materials in the environment. This is probably because HCl, which is present outdoors in markedly reduced concentrations when compared with SO₂, has not been considered to contribute to significant degradation of materials. The first major study of atmospheric degradation of metals

by HCl was carried out by Feitnecht (1952) who exposed zinc, iron and copper to HCl vapours at varying humidity's between 50% and 95%. Feitnecht found that HCl reacted with metals only when a critical relative humidity was exceeded, which he linked to the vapour pressure of a saturated solution of the metal chloride formed during corrosion. He regards the mechanism as electrochemical, with the oxide-film as cathodes and small areas of metal exposed at breaks as anodes; the interaction between the hydroxide ions (OH⁻ ions), formed by the cathodic reduction of oxygen, and the metal ions, formed by the anodic reaction, leads to hydroxide or basic chloride. Barton and Bartonova (1969) carried out an extensive investigation of the corrosive effect of HCl gas at concentrations between 7 and 10 ppm on zinc, mild steel, and copper at temperatures between 20°C and 50°C and at relative humidity's of 70% and 95%. Two distinct stages were seen in the behaviour:

- Stage 1 was characterized by a non-linear increase in mass loss with time; termed the "indication period for steady-state corrosion".
- Stage 2, after about 16 days' exposure, showed steady-state corrosion with a linear increase in mass-loss with time.

The primary corrosion products found on iron were FeO(OH), Fe₃O₄ and FeCl₂, whilst those found on zinc were 4Zn (OH)₂, ZnCl₂, Zn (OH)₂ and ZnO. The amount of chloride in the corrosion product tended to decrease slowly with time. After the steady state corrosion stage had been reached, the composition of the corrosion product remained unchanged.

Barton and Bartonova (1969) measured the corrosion rate at different temperatures in the steady state region. For zinc, the corrosion rate decreased as the temperature increased; for iron, the corrosion rate increased with temperatures up to 40°C, but decreased at 50°C. The rate of the reactions did not appear to depend on the diffusion of HCl to the surface since the corrosion rate was similar in flowing and stationery atmospheres. The implication is that the corrosion rate is dependent on chemical reaction rate. The kinetics of corrosion is controlled by the transfer of HCl to the corrosion product atmosphere interface, its adsorption and the subsequent production of soluble ZnCl₂. The corrosion rate also depends on the hydroxide / chloride ratio in the corrosion product as the hydroxides are more protective than the chlorides.

No literature could be obtained on the combined corrosive effects of gaseous SO₂ and HCl pollutant. Furthermore, no dose-response relationships between hydrochloric acid concentrating or deposition rates and corrosion rates could be obtained. Most literature on chloride exposures discusses the corrosion rates associated with marine environments. Whilst the chemical reactions may be similar, it is not clear whether an assumption of equivalence may be made between hydrochloric acid and sodium chloride. Whilst both are donors of chloride ions, the former would also reduce the pH of the moisture layer on the metal surface. Given these limitations, and in an attempt to provide an indication of the corrosion potential that the proposed facility may have on the surrounding environment, it was decided to make reference to the International Standard Organisation (ISO) corrosion classification which considers SO₂ and chloride deposition rates to establish the rate of corrosion of a number of different metal types.

5.2.3.2 *International Standard Organisation*

The ISO provides a classification scheme that can directly be used for technical and economic analyses of corrosion damage due to atmospheric SO₂ and chlorides, and for the rational choice of protection measures. As such, the corrosivity of the atmosphere is divided into five categories (C1 to C5), ranging from very low to very high corrosivity. These corrosivity categories are estimated using a combination of the meteorological parameters, sulfate deposition and airborne salinity (chloride ion). These are discussed below.

5.2.3.2.1 Time of Wetness

Relative humidity, rain, dew, and temperature are determinants of the so-called *time of wetness* (TOW), defined (ISO 9223) as the fraction of time with relative humidity in excess of 80%, at temperatures above freezing ($>0^{\circ}\text{C}$). The TOW of a corroding surface is a key parameter, directly determining the duration of the electrochemical corrosion processes. This is a complex variable, since all the means of formation and evaporation of the surface electrolyte solution must be considered. The TOW refers to the period of time during which the atmospheric conditions are favourable for the formation of a surface layer of moisture on a metal or alloy. As pointed in the previous section, this moisture film is extremely important from the point of view of the chemical mechanisms of the corrosion process.

Meteorological data from the Eco Park and Sasol Fenceline (S1) were used to calculate the TOW. The average TOW at Eco Park is approximately 1 435 hours per year (16% of the year). The average TOW at the Fenceline AQMS is 2 410 hours per year (28% of the year). According to the ISO 9233 classification (Table 5-39), the TOW class represented by these weather conditions is **T3**.

Table 5-39: ISO 9223 Classification of the Time of Wetness

Category	Time of Wetness	Example of Occurrence	Comment
	Hours per Year	Percentage	
T1	$T \leq 10$	$T \leq 0.1$	Indoor
T2	$10 < T \leq 250$	$0.1 < T \leq 3$	Indoor without climate control
T3	$250 < T \leq 2500$	$3 < T \leq 30$	Outdoor atmospheres in dry, cold climates and part of temperate climates
T4	$2\ 500 < T \leq 5\ 500$	$30 < T \leq 60$	Outdoor atmospheres in all climates except for dry and cold climates
T5	$5\ 500 < T$	$60 < T$	Tropical outdoor or surf

5.2.3.2.2 Atmospheric pollutants

As indicated by the ISO standard, corrosion due to atmospheric pollution is dominated by sulfur dioxide (urban environments) and chlorides (marine environments). This is also evident from open literature where the focus of atmospheric corrosion of metals has predominantly been described through the impact of these two pollutants.

Sulfur Dioxide

Sulfate ions are formed in the surface moisture layer by the oxidation of sulfur dioxide and their formation is considered to be the main corrosion accelerating effect from sulfur dioxide. Sulfur dioxide may be expressed either in terms of a deposition rate or an airborne concentration. The method of determining the deposition rate in this instance followed the ISO 9223 Method, where the corrosion potential due to SO_2 is classified according to the long-term (annual) deposition rate or air concentration of SO_2 , as summarised in Table 5-40. Any concentration of SO_2 within category P_0 is considered to be the background concentration and is insignificant from the point of view of corrosive attack. Pollution by SO_2 within category P3 is considered extreme and is typical of operational microclimates beyond the scope of the International Standard. The ground-level SO_2 concentrations, as a result of emissions from SO, fall into the P2 category for all modelled scenarios (Table 5-41).

Table 5-40: ISO 9223 classification of pollution by sulfur-containing substances represented by SO_2

Category	Concentration of SO_2	Deposition Rate of SO_2
----------	--------------------------------	----------------------------------

	$\mu\text{g}/\text{m}^3$	$\text{mg}/(\text{m}^2 \cdot \text{day})$
P0	$P_c \leq 12$	$P_d \leq 10$
P1	$12 < P_c \leq 40$	$10 < P_d \leq 35$
P2	$40 < P_c \leq 90$	$35 < P_d \leq 80$
P3	$90 < P_c \leq 250$	$80 < P_d \leq 200$

Table 5-41: ISO 9223 classification of pollution by sulfur-containing substances represented by SO₂ as a result of SO

Criterion	Scenario			
	Baseline	Existing Plant Emission Standards	New Plant Emission Standards	Alternative Emissions
Maximum annual SO ₂ concentration ($\mu\text{g}/\text{m}^3$)	60.79	41.54	41.54	66.12
ISO corrosivity category for SO ₂	P2	P2	P2	P2

Airborne Chloride

The ISO 9223 classification of pollution by chloride containing substances is provided in Table 5-42. The predicted chloride deposition rates, based on the simulated concentrations of HCl (as a result of processes at SO) are classified as category S0 (Table 5-43). Other industrial sources may contribute to the HCl deposition load however the contribution is unknown. The contribution of marine chloride contribution at the site is also unknown, but likely to be very low.

Table 5-42: ISO 9223 classification of pollution by airborne chloride containing substances

Category	Deposition Rate of Chloride (mg/m ² .day)
S0	S ≤ 3
S1	3 < S ≤ 60
S2	60 < S ≤ 300
S3	300 < S ≤ 1500

Table 5-43: ISO 9223 classification of pollution by airborne chloride containing substances as a result of emissions from SO thermal oxidation units

Criterion	Scenario			
	Baseline	Existing Plant Emission Standards	New Plant Emission Standards	Alternative Emissions
Chloride deposition (mg/m ² .day)	0.06	0.16	0.16	0.07
ISO corrosivity category for Cl	S0	S0	S0	S0

5.2.3.2.3 Corrosivity Potential

Having calculated the TOW, the classification of pollution by sulfate and chloride containing substances, the corrosivity category (C1 to C5) for individual metals can be estimated according to ISO 9223, as shown in Table 5-44, and specific corrosivity categories associated with SO are summarised for the four scenarios in Table 5-45. Once the corrosivity category has been determined, the corrosion rate for carbon and weathered steel, zinc, copper and aluminium can be estimated using the rates given in Table 5-46.

Table 5-44: Estimated corrosivity categories of the atmosphere

Unalloyed carbon steel															
	T1			T2			T3			T4			T5		
	S ₀ -S ₁	S ₂	S ₃	S ₀ -S ₁	S ₂	S ₃	S ₀ -S ₁	S ₂	S ₃	S ₀ -S ₁	S ₂	S ₃	S ₀ -S ₁	S ₂	S ₃
P ₀ -P ₁	1	1	1/2	1	2	3/4	2/3	3/4	4	3	4	5	3/4	5	5
P ₂	1	1	1/2	1/2	2/3	3/4	3/4	3/4	4/5	4	4	5	4/5	5	5
P ₃	1/2	1/2	2	2	3	4	4	4/	5	5	5	5	5	5	5
Zinc and copper															
	T1			T2			T3			T4			T5		
	S ₀ -S ₁	S ₂	S ₃	S ₀ -S ₁	S ₂	S ₃	S ₀ -S ₁	S ₂	S ₃	S ₀ -S ₁	S ₂	S ₃	S ₀ -S ₁	S ₂	S ₃
P ₀ -P ₁	1	1	1	1	1/2	3	3	3	3/4	3	4	5	3/4	5	5
P ₂	1	1	1/2	1/2	2	3	3	3/4	4	3/4	4	5	4/5	5	5
P ₃	1	1/2	2	2	3	3/4	3	3/4	4	4/5	5	5	5	5	5
Aluminium															
	T1			T2			T3			T4			T5		
	S ₀ -S ₁	S ₂	S ₃	S ₀ -S ₁	S ₂	S ₃	S ₀ -S ₁	S ₂	S ₃	S ₀ -S ₁	S ₂	S ₃	S ₀ -S ₁	S ₂	S ₃
P ₀ -P ₁	1	2	2	1	2/3	4	3	3/4	4	3	3/4	5	4	5	5
P ₂	1	2	2/3	1/2	3/4	4	3	4	4/5	3/4	4	5	4/5	5	5
P ₃	1	2/3	3	3/4	4	4	3/4	4/5	5	4/5	5	5	5	5	5

Note: Corrosivity is expressed as the numerical part of the corrosivity category code (for example: 1 instead of C1).

Table 5-45: Estimated corrosivity categories of the atmosphere associated with SO

Metal type	Scenario			
	Baseline	Existing Plant Emission Standards	New Plant Emission Standards	Alternative Emissions
Unalloyed carbon steel	C3/4	C3/4	C3/4	C3/4
Zinc and copper	C3	C3	C3	C3
Aluminium	C3	C3	C3	C3

Table 5-46: Average and steady state corrosion rates for Different Metals and Corrosivity Categories

Metal	Average corrosion rate (r_{av}) during the first 10 years for the following corrosivity categories ($\mu\text{m/annum}$)				
	C1	C2	C3	C4	C5
Carbon steel	$r_{av} \leq 0.5$	$0.5 < r_{av} \leq 5$	$5 < r_{av} \leq 12$	$12 < r_{av} \leq 30$	$30 < r_{av} \leq 100$
Weathering steel	$r_{av} \leq 0.1$	$0.1 < r_{av} \leq 2$	$2 < r_{av} \leq 8$	$8 < r_{av} \leq 15$	$15 < r_{av} \leq 80$
Zinc	$r_{av} \leq 0.1$	$0.1 < r_{av} \leq 0.5$	$0.5 < r_{av} \leq 2$	$2 < r_{av} \leq 4$	$4 < r_{av} \leq 10$
Copper	$r_{av} \leq 0.01$	$0.01 < r_{av} \leq 0.1$	$0.1 < r_{av} \leq 1.5$	$1.5 < r_{av} \leq 3$	$3 < r_{av} \leq 5$
Aluminium	$r_{av} \approx 0.01$	$r_{av} \leq 0.025$	$0.01 < r_{av} \leq 0.1$	(5)	(5)
Metal	Steady state corrosion rate (r_{in}) for the following corrosivity categories ($\mu\text{m/annum}$)				
	C1	C2	C3	C4	C5
Carbon steel	$r_{av} \leq 0.1$	$0.1 < r_{av} \leq 1.5$	$1.5 < r_{av} \leq 8$	$8 < r_{av} \leq 20$	$20 < r_{av} \leq 90$
Weathering steel	$r_{av} \leq 0.1$	$0.1 < r_{av} \leq 1$	$1 < r_{av} \leq 5$	$5 < r_{av} \leq 10$	$10 < r_{av} \leq 80$
Zinc	$r_{av} \leq 0.05$	$0.1 < r_{av} \leq 0.5$	$0.5 < r_{av} \leq 2$	$2 < r_{av} \leq 4$	$4 < r_{av} \leq 10$
Copper	$r_{av} \leq 0.01$	$0.01 < r_{av} \leq 0.1$	$0.1 < r_{av} \leq 1$	$1 < r_{av} \leq 3$	$3 < r_{av} \leq 5$
Aluminium	negligible	$0.01 < r_{av} \leq 0.02$	$0.02 < r_{av} \leq 0.2$	(5)	(5)
Notes					
<ol style="list-style-type: none"> 1) The corrosion rate of carbon steel is not constant during the first 10 years. 2) The corrosion rate of weathering steel is strongly dependent on the combination of various influencing factors (alternation between wet and dry periods). In atmospheres with sulfur dioxide (SO₂) pollution, a more protective rust layer is formed. Rain protected surfaces in marine atmospheres heavily polluted with chlorides may have much higher corrosion rates than freely exposed surfaces. 3) Applies also to the copper-zinc, copper-tin and similar alloys with a copper content of at least 60 %. 4) The rates shown are based on commercially pure aluminium (purity > 99.5%) which, like most aluminium alloys, corrodes in the atmosphere at a rate that decreases with time. However, these rates are based on average mass loss results while the corrosion attack is usually manifested as pitting. Consequently, the rates shown do not represent rates of penetration. Penetration rates for pitting also decrease with exposure time. Commercially pure aluminium, aluminium alloys containing magnesium, manganese and/or silicon as the major alloying elements, and Alclad products generally have better corrosion resistance than aluminium alloys containing significant quantities of copper, zinc and/or iron. Alloys with significant quantities of magnesium, zinc, copper and/or iron may also be subject to other forms of localized corrosion such as stress corrosion cracking, exfoliation and intergranular attack. 5) In atmospheres defined by corrosivity categories C4 and C5, a marked increase in corrosion rate may be expected and local corrosion effects become important. For these two corrosivity categories, the data concerning general corrosion may be misleading. 					

5.2.3.3 ISOCORRAG Atmospheric Corrosion Model

The ISOCORRAG equation was developed to predict the annual corrosion rate resulting from atmospheric corrosion for several metals. The equation was created by the multiple linear regressions of corrosion data from several sites around the globe. With ISOCORRAG, the annual corrosion rate is expressed as (Knotkova *et al.*, 1995):

$$K = a + b_1[SO_2] + b_2[Cl^-] + b_3[TOW]$$

Equation 2

Where the constants a , b_1 , b_2 , and b_3 , differ according to the type of metal, shape of the specimen, and exposure conditions. Table 5-47 is a summary of constants for flat metal specimens. The deposition of SO₂ is expressed as an equivalent

concentration, i.e. $\mu\text{g}/\text{m}^3$; the deposition of chloride pollutants [Cl⁻] is expressed in $\text{mg}/\text{m}^2\cdot\text{day}$, and time of wetness [TOW] in hours per year.

Table 5-47: ISOCORRAG regression model constants (Knotkova *et al.*, 1995)

Metal	Regression Constants for ISOCORRAG model			
	a	b ₁	b ₂	b ₃
Steel	1.3269	0.4313	0.1384	0.0057
Zinc	0.2098	0.0232	0.0059	0.00027
Copper	0.9556	0.0065	0.00393	0.0000538
Aluminium	0.0069	0.00638	0.000558	0.0000650

Using simulated concentrations of SO₂ and HCl (as a result of emissions from SO) (as in Section 5.2.2.2 above) the rate of corrosion (K) was calculated (using Equation 2) across the dispersion modelling domain. TOW from both the Eco Park AQMS and the Sasol Fenceline AQMS was used. A summary of the findings is presented in Table 5-48. There is some agreement between the two methods for corrosion rate estimation, however corrosion rates calculated using the ISOCORRAG method are in the mid- to high-end of the ranges of corrosion rates presented for the ISO method (Table 5-46).

Table 5-48: Corrosion rate of metals associated with SO calculated according to the ISOCORRAG method

Scenario	Criteria	Corrosion rate (K) [$\mu\text{m}/\text{annum}$]			
		Steel	Zinc	Copper	Aluminium
Time of wetness at Eco Park AQMS [1 435 hours]					
Simulated Baseline Concentrations	Min	9.53	33.50	1.03	0.10
	Max	35.73	34.91	1.43	0.49
Simulated Concentrations for Existing Plant Emission Standards	Min	9.53	33.50	1.03	0.10
	Max	27.43	34.47	1.30	0.37
Simulated Concentrations for New Plant Emission Standards	Min	9.53	33.50	1.03	0.10
	Max	27.43	34.47	1.30	0.37
Simulated Concentrations for Alternative Emissions	Min	18.14	68.55	1.11	0.20
	Max	46.64	70.08	1.54	0.62
Time of wetness at Fenceline (S1) AQMS [2 410 hours]					
Simulated Baseline Concentrations	Min	1.35	0.21	0.96	0.01
	Max	27.55	1.62	1.35	0.39
Simulated Concentrations for Existing Plant Emission Standards	Min	1.35	0.21	0.96	0.01
	Max	19.25	1.17	1.23	0.27
Simulated Concentrations for New Plant Emission Standards	Min	1.35	0.21	0.96	0.01
	Max	19.25	1.17	1.23	0.27
Simulated Concentrations for Alternative Emissions	Min	1.35	0.21	0.96	0.01
	Max	29.85	1.74	1.39	0.43

5.2.4 Sulfur and Nitrogen Deposition Impacts

Understanding the impact of deposition of atmospheric sulfur (S) and nitrogen (N) on South African ecosystems has been on-going since the late 1980's (Tyson *et al.* 1988), with much of the earlier work focussing on the circulation over the sub-continent (Tyson *et al.* 1996). More recent research has focussed on quantifying S and N deposition (Galpin and Turner 1999, Zunckel *et al.* 1996, Scorgie and Kornelius 2009, Josipovic *et al.* 2010) and the subsequent impacts on ecosystems (Fey and Guy 1993, Van Tienhoven *et al.* 1995, Reid 2007, Bird 2011, Josipovic *et al.* 2011).

These studies estimating deposition of S and or N compounds to ecosystems present ranges of deposition rates where the differences are related to the distance from major industrial sources; the method of estimation (field work and/or calculation based on deposition velocities or dispersion modelling). As an indication, total S deposition over the industrialised Highveld of South Africa was modelled to range between 8 and 35 kg/ha/year with background levels of approximately 1 kg/ha/year (Scorgie and Kornelius 2009). In contrast, using ambient SO₂ concentrations and an inferential deposition model to calculate S deposition, Zunckel *et al.*(1996) estimated total S deposition of 13.9 kg/ha/year as maximum deposition rate on the Highveld. Estimates of nitrogen deposition range between 6.7 kg/ha/year (Collett *et al.* 2010) and 15 kg/ha/year (Scorgie and Kornelius 2009). Considering total acidic input from atmospheric sources, Josipovic and colleagues (2011) calculated a range of deposition rates between 15.8 and 23.2 kg/ha/year. All estimates are within the range of deposition rates for S and N as for some of the industrialised regions of Europe and North America (compared in Scorgie and Kornelius 2009, and Bird 2011) raising concern that the acidic loading of sulfur and nitrogen on the ecosystems of the Highveld – South Africa’s most heavily industrialised region – could have implications for ecosystem functioning.

Establishing clear cause-effect relationships in complex ecosystem studies can be difficult, especially where the extent of visible damage is large and local emissions are low (Matzner and Murach 1995). Reasons include: time lags between stressor (high concentration of atmospheric pollutants) and visible symptomatic response of biota; interaction of natural factors (e.g. climate, soil and pests) and human activities (such as management, site history and air pollution); local ecosystem uniqueness and difficulty of extrapolating to larger scales; or, symptomatic responses that are not unique to the cause (e.g. defoliation) (Matzner and Murach 1995). The synergistic effect of pollutant cocktails can also add complexity to identifying causative pollutants (Emberson 2003).

Mobilisation of active forms of S and N into the atmosphere, and later as deposition onto ecosystems, can result in acidification of soils and freshwater systems, soil nutrient depletion, fertilization of naturally (usually nitrogen) limited systems and increased availability of metal ions (e.g. Al) disrupting ecosystem functioning (Rodhe *et al.* 1995) and changing plant and/or freshwater species diversity (Stevens *et al.* 2004). Many of these impacts occur over a decade or longer where attributing source contributions can be complex within a regional setting. Sasol have, however, supported the long-term deposition quantification studies in South African under the DEBITS (Deposition of Biogeochemically Important Trace Species) programme, as part of the International Global Atmospheric Chemistry Project. Three DEBITS sites are maintained within South Africa, one located near Amersfoort, on the Mpumalanga Highveld, downwind from major industrial sources, including SO. Investigating deposition and its impacts on the Highveld grasslands as a result of SO operations was beyond the time-frame of the accompanying postponement application especially since long-term impact studies are not yet available for South Africa.

6 COMPLAINTS

Year	Nature of complaints	Actions taken to investigate complaints	Causes of complaints identified	Measures taken to avoid reoccurrences in instances where the plant's operations were found to be the cause
FY14/15	<p>A total of 5 external Sasolburg Operations air related complaints were received during SO's 2014/2015 financial year. The mentioned incidents varied from minor to moderate incidents.</p> <p>1 visible emission complaint was received associated with the start-up of the SO's nitric acid plant</p> <p>1 Noise complaint was received during this period and</p> <p>3 odour related complaints were received during the financial year</p>	<p>Sasol operates a complaint line where any environmental complaint can be registered. The environmental standby will investigate the complaint and ensure that the necessary steps are taken to reduce and manage the impact and to reduce the time of the incident. Subsequent to an investigation, corrective action measures are implemented</p>	<p>Process start-ups, upsets and plant related trips</p>	<p>Root cause investigations, followed by the implementation of corrective and preventative measures where possible.</p>
FY15/16	<p>A total of 6 external Sasolburg Operations related complaints were received during SO's 2015/2016 financial year. The mentioned incidents varied from minor to moderate incidents.</p> <p>4 odour complaints related to acrylate and gaseous odours</p> <p>2 visual smoke complaints, one related to planned fire break burning and another of windblown dust</p>	<p>Sasol operates a complaint line where any environmental complaint can be registered. The environmental standby will investigate the complaint and ensure that the necessary steps are taken to reduce and manage the impact and to reduce the time of the incident. Subsequent to an investigation, corrective action measures are implemented</p>	<p>Process related upsets including shut downs; Fire break burning; Elevated wind speeds under drought conditions entraining dust</p>	<p>Root cause investigations, followed by the implementation of corrective and preventative measures where possible.</p>

7 CURRENT OR PLANNED AIR QUALITY MANAGEMENT INTERVENTIONS

An overview of approved air quality management improvement interventions, currently implemented and scheduled over the next 5 to 10 years, is detailed in the accompanying Motivation Report.

8 COMPLIANCE AND ENFORCEMENT ACTIONS

No final directives or compliance notices have been issued to SO in the last five years.

9 ADDITIONAL INFORMATION

Beyond the requirements stipulated in the AIR Regulations and Dispersion Modelling Regulations, the following additional information is considered useful for better understanding the impacts of Sasol's activities and the implications of the requested postponements on ambient air quality. A brief description of each of these analyses is provided below, and referenced to where in the applications the information may be found.

a) Polar plots

Polar plots have been provided in Section 5.1.6.1 to visually demonstrate directional contribution as well as the dependence of concentrations on wind speed, in much the same way as a pollution rose does. The polar plots identify major contributing emissions sources impacting on a monitoring station and the direction of the impact. These polar plots do not replace isopleth plots, but rather provide additional information on the measured air quality in the region of the facility.

b) Peer review of dispersion model

To provide increased certainty to both the DEA and the public that the dispersion modelling approach of Airshed is accurate, valid and representative, Sasol decided to take an additional step to appoint an independent international expert to peer review the modelling methodology, Exponent Incorporated. Exponent Inc. is a world-renowned expert assisting the US-EPA with compliance modelling in similar instances in the United States

c) Delta approach to assessing implications of postponements for ambient air quality

In assessing the impacts of Sasol's postponement applications on ambient air quality, a fit-for-purpose approach, as requested for by the Dispersion modelling Regulations, was taken to assess the results from the dispersion modelling, which we have referred to as the "delta approach". The delta approach is premised on recognising that the difference between the current or "before additional compliance is implemented" emission scenario (i.e. the baseline scenario) and "after additional compliance is implemented" scenario (i.e. the 2020 MES compliance scenario) relates to the change in emissions from the point sources in question.

Therefore, the delta approach focuses on demonstrating the change in predicted ambient impacts of the various compliance scenarios, to guide decision makers toward better understanding the implications of the approval of postponements on air quality, and how compliance with the existing and new plant standards would impact on prevailing ambient air quality.

A detailed explanation of the scenarios modelled to highlight the delta changes in ambient air quality arising from retrofit of abatement technology is provided in Section 5.1.1.2. In summary, the four scenarios modelled include:

- Baseline Emissions – modelling conducted based on the current inventory and impacts
- Minimum Emissions Standards – modelling conducted based on plants theoretically complying with:
 - Existing Plant Standards, and
 - New Plant Standards
- Alternative Emission Limits – the proposed maximum emission concentrations, where applicable and different from the other three emission scenarios.

d) Estimating background ambient air pollutant concentrations

A background air concentration is normally defined as that concentration which would result from air emission sources outside the chosen modelling domain. This concentration can, for instance, be estimated by analysing observed air concentrations for those wind directions when it is blowing towards the sources included in the modelling domain. In other words, the observation point would be upwind from the sources being simulated by the dispersion modelling.

However, as used in the current investigation, background concentrations could also incorporate the contributions from air emission sources present in the modelling domain, but which were not included in the dispersion simulations. For example, air emissions from vehicle tailpipes can significantly contribute to the local ambient NO₂ concentrations. Although most of the sources of air emissions within the Sasol operations were included in the simulations, there remains some that were excluded, for instance fugitive emissions, but would add to the background concentration level.

Since these sources are not neatly located for easy analysis of upwind contributions, the procedure normally adopted to estimate background air concentrations could not be followed. Instead, the "background" concentration was established by comparing the predicted air concentrations with the observed air concentrations. The background concentration as used in this application therefore corresponds to the observed concentration value at a monitoring site when the simulated value at this site reached a near zero value. In other words, the observed residual air concentration was assumed to arise from other sources in the modelling domain.

With this method, the assumption is made that the model performs realistically and that the residual concentration determined this way is a good reflection of the emissions not included in the simulations. In an attempt to illustrate the model accuracy, the fractional bias was calculated for each monitoring station as described in Section 5.1.6.2 of the AIRs. This methodology has been prescribed by the US EPA (U.S. EPA 1992) as an acceptable manner to illustrate the validity of atmospheric dispersion model. Given the good model performance, as measure by the fractional bias, it is assumed that the background concentration obtained using this methodology is reasonable estimates.

e) Ambient impacts of secondary particulates arising from Sasol emissions

As detailed in Section 5.1.4.4, one of the reasons for selection of the CALPUFF modelling suite is the fact this this enabled inclusion of the impact of the chemical conversion of sulfur dioxide and nitrogen oxides to secondary particulates within the dispersion model results. Thus, the predicted PM₁₀ concentrations reflected in Section 5.1.8.1.3 include direct emissions of PM plus secondary particulates formed from Sasol's emissions.

10 ANNEXURE A

Name of Enterprise: Sasol Sasolburg Operations

Declaration of accuracy of information provided:

Atmospheric Impact Report in terms of section 30 of the Act.

I, Ristoff van Zyl [*duly authorised*], declare that the information provided in this atmospheric impact report is, to the best of my knowledge, in all respects factually true and correct. I am aware that the supply of false or misleading information to an air quality officer is a criminal offence in terms of section 51(1)(g) of the National Environmental Management : Air Quality Act (Act No. 39 of 2004).

Signed at Sasolburg on this 2nd day of February 2017



SIGNATURE

Manager SHE: Air Quality & Greenhouse Gasses
CAPACITY OF SIGNATORY

11 ANNEXURE B

DECLARATION OF INDEPENDENCE - PRACTITIONER

Name of Practitioner: Reneé von Gruenewaldt

Name of Registration Body: South African Council for Natural Scientific Professions

Professional Registration No.: 400304/07

Declaration of independence and accuracy of information provided:

Atmospheric Impact Report in terms of section 30 of the Act.

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

Signed at Midrand on this 19th day of January 2017


SIGNATURE

Principal Air Quality Scientist

CAPACITY OF SIGNATORY

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APPENDIX A: COMPETENCIES FOR PERFORMING AIR DISPERSION MODELLING

All modelling tasks were performed by competent personnel. Table A-1 is a summary of competency requirements. Apart from the necessary technical skills required for the calculations, personnel competency also include the correct attitude, behaviour, motive and other personal characteristic that are essential to perform the assigned job on time and with the required diligence as deemed necessary for the successful completion of the project.

The project team included a principal engineer, with relevant experience of more than 25 years and two principal scientists with 5 years and 15 years relevant experience. One of the principal scientists managed and directed the project.

The principal engineer also conducted verification of modelling results. The latter function requires a thorough knowledge of the

- meteorological parameters that influence the atmospheric dispersion processes and
- atmospheric chemical transformations that some pollutants may undergo during the dispersion process.

Table A-1: Competencies for Performing Air Dispersion Modelling

Competency	Task, Knowledge and Experience
Context	Communication with field workers, technicians, laboratories, engineers and scientists and project managers during the process is important to the success of the model
	Familiar with terminology, principles and interactions
	Record keeping is important to support the accountability of the model - Understanding of data collection methods and technologies
Knowledge	Meteorology: <ul style="list-style-type: none"> • Obtain, review and interpret meteorological data • Understanding of meteorological impacts on pollutants • Ability to identify and describe soil, water, drainage and terrain conditions <ul style="list-style-type: none"> ○ Understanding of their interaction ○ Familiarity with surface roughness` • Ability to identify good and bad data points/sets • Understanding of how to deal with incomplete/missing meteorological data
	Atmospheric Dispersion models <ul style="list-style-type: none"> • Select appropriate dispersion model • Prepare and execute dispersion model • Understanding of model input parameters • Interpret results of model
	Chemical and physical interactions of atmospheric pollutants <ul style="list-style-type: none"> • Familiarity with fate and transport of pollutants in air • Interaction of primary pollutants with other substances (natural or industrial) to form secondary pollutants
	Information relevant to the model <ul style="list-style-type: none"> • Identify potential pollution (emission) sources and rates • Gather physical information on sources such as location, stack height and diameter • Gather operating information on sources such as mass flow rates, stack top temperature, velocity or volumetric flow rate • Calculate emission rates based on collected information • Identify land use (urban/rural) • Identify land cover/terrain characteristics • Identify the receptor grid/site
	Legislation, regulations and guidelines in regards to National Environment Management: Air Quality Act (Act No 39 of 2004), including <ul style="list-style-type: none"> • Minimum Emissions Standards (Section 21 of Act) • National Ambient Air Quality Standards • Regulations Regarding Air Dispersion Modelling • Atmospheric Impact Report (AIR)
Abilities	Ability to read and understand map information

Competency	Task, Knowledge and Experience
	Ability to prepare reports and documents as necessary
	Ability to review reports to ensure accuracy, clarity and completeness
	Communication skills
	Team skills