

ANALYSIS OF AIR QUALITY IMPACTS AND HEALTH EFFECTS DUE TO KENDAL POWER STATION'S EMISSIONS BETWEEN JANUARY 2018 AND OCTOBER 2019

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SUMMARY

This report augments my June 2019 report on air pollution dispersion modeling and health effects risk assessment for 14 industrial facilities located in and around the Mpumalanga Highveld Priority Area (HPA) in South Africa, based on 2016 emissions.¹ More recent emissions data from Eskom's Kendal coal-fired power station show major increases in emissions of sulphur dioxide (SO₂), oxides of nitrogen (NO_x), and particulate matter (PM). I analyzed Kendal's emissions data for the period January 2018 to October 2019 to model air quality and health impacts from this power station alone.

My main findings are:

- Emissions from Kendal power station were responsible for between 67 and 144 early deaths in and around the HPA during 2018 (95 percent confidence interval), and between 61 and 130 early deaths between November 2018 and October 2019.
- In 2018, Kendal power station caused SO₂ (10 minute average) levels over four times the World Health Organization recommended maximum at Hlanga Phala primary school, 11 km away. The power station also created ambient SO₂ (10 minute average) over two times the WHO recommended maximum in the township of Ogies.
- In 2018, Kendal power station caused SO₂ daily averages over five times the WHO recommended maximum at Ogies and Phola, and exceeded the WHO maximum at numerous other locations throughout the HPA area.
- In 2018, Kendal power station caused PM_{2.5} daily averages to reach half of the WHO recommended maximum at Laerskool Panorama, Leandra, Ogies, and Phola.

¹ Gray, H.A., "Air Quality Impacts and Health Effects Due to Large Stationary Source Emissions in and Around South Africa's Mpumalanga Highveld Priority Area (HPA), June 3, 2019.

- In 2019, Kendal power station caused NO_x 1-hour averages to reach two times the WHO recommended maximum at Ogies and Phola, and more than half the recommended maximum at 21 sensitive receptor locations across the HPA, including at Witbank, Secunda, Delmas, and Kinross.

EMISSIONS DATA

Monthly average rates of SO₂, NO_x, and PM emissions from the Kendal power station were obtained from monthly emissions reports for 2018 and 2019 published by Eskom.² These monthly data are shown in Table 1 below:

Table 1. Monthly Average Emission Data for Kendal Power Station, 2018-2019

SO₂ (tonnes/month) 2018					
Jan-2018	Feb-2018	Mar-2018	Apr-2018	May-2018	Jun-2018
21,894	15,643	23,691	22,523	23,764	21,276
Jul-2018	Aug-2018	Sep-2018	Oct-2018	Nov-2018	Dec-2018
19,881	17,101	18,167	23,078	17,351	13,718
SO₂ (tonnes/month) 2019					
Jan-2019	Feb-2019	Mar-2019	Apr-2019	May-2019	Jun-2019
16,617	16,844	19,182	18,838	16,362	20,211
Jul-2019	Aug-2019	Sep-2019	Oct-2019		
20,354	11,133	11,369	11,091		
NO_x (tonnes/month) 2018					
Jan-2018	Feb-2018	Mar-2018	Apr-2018	May-2018	Jun-2018
6,770	5,144	7,745	7,116	8,305	7,826
Jul-2018	Aug-2018	Sep-2018	Oct-2018	Nov-2018	Dec-2018
7,121	6,005	6,921	7,535	5,555	4,227
NO_x (tonnes/month) 2019					
Jan-2019	Feb-2019	Mar-2019	Apr-2019	May-2019	Jun-2019
5,897	5,236	7,462	6,707	5,576	6,484
Jul-2019	Aug-2019	Sep-2019	Oct-2019		
6,126	3,970	4,020	4,234		

² Monthly emissions reports are required in the terms of Section 7.4 of Kendal Power Station's Atmospheric Emission License (17/4/AEL/MP312/11/15). The monthly reports for January 2018 through October 2019 are available at <http://www.eskom.co.za/Whatweredoing/AirQuality/Pages/Kendal-Power-Station.aspx>. (At the time of this analysis, monthly emissions reports for November and December 2019 were not yet available.)

PM (tonnes/month) 2018					
Jan-2018	Feb-2018	Mar-2018	Apr-2018	May-2018	Jun-2018
707.95	620.27	967.05	1,449.10	1,761.48	3,770.15
Jul-2018	Aug-2018	Sep-2018	Oct-2018	Nov-2018	Dec-2018
3,230.96	3,742.48	1,077.07	7,120.15	2,344.05	1,833.39
PM (tonnes/month) 2019					
Jan-2019	Feb-2019	Mar-2019	Apr-2019	May-2019	Jun-2019
3,120.76	2,252.27	3,007.46	4,932.94	3,533.30	2,863.70
Jul-2019	Aug-2019	Sep-2019	Oct-2019		
2,750.27	1,941.39	1,514.31	1,455.98		

DISPERSION MODELING

The concentration impacts due to emissions from Kendal power station were modeled using the CALPUFF dispersion modeling system detailed in my June 2019 report. The model simulated emissions and regional transport of sulfur dioxide (SO₂), oxides of nitrogen (NO_x), particulate matter smaller than 10 microns (micrometers) in diameter (PM₁₀), and particulate matter smaller than 2.5 microns in diameter (PM_{2.5}) originating from the Kendal power plant stacks. The model considers the formation of “secondary” PM_{2.5} (sulfate and nitrate) caused by reactions of SO₂ and NO_x emissions in the atmosphere, which accounts for the majority of the PM_{2.5} attributable to the Kendal power station.

Meteorological data for every hour of 2016³, including 3-dimensional wind fields, temperatures, and other atmospheric parameters, were combined with hourly surface data collected at 32 weather stations (typically located at regional airports) in and near the HPA. In addition to meteorological data, geophysical data were obtained in order to characterize the modeling domain, including terrain (elevation data), and other parameters related to the land surface. Further details regarding the meteorological and geophysical data that were used in the modeling can be found in Appendix A of my June 2019 report.

The CALPUFF model is designed to estimate pollutant concentrations at a specified set of locations within the modeling domain, which are referred to as the modeled “receptors”. For the current CALPUFF application, a large set of gridded receptors were defined, to cover the entire modeling domain, using 4 km grid spacing, accounting for 9,207 virtual

³ In my previous report, meteorological data was assembled for 2016 and 2017. For the current modeling analysis, data for 2016 were used to represent a typical annual cycle of meteorology.

receptors (99 E/W x 93 N/S). The modeled concentrations at the set of gridded receptors were used to establish pollutant exposure levels across the modeling domain for the health effects analysis. In addition to the gridded receptors, a set of 120 sensitive receptor locations were identified, which includes a number of schools, hospitals and other locations where children, the elderly, and other sensitive segments of the population may be exposed.

Two emission scenarios were modeled using the CALPUFF model: (1) using the emissions data for the calendar year 2018 (January 2018 through December 2018), and (2) using the emissions data for the 12-month period November 2018 through October 2019 (as shown In Table 1, above).

MODEL RESULTS: HEALTH EFFECTS

The CALPUFF model was used to estimate the concentration impacts due to the actual reported Kendal power station emissions using 2016 meteorology. I then computed the health impacts across the entire modeling domain due to the modeled fine particle concentrations (consisting of directly-emitted PM_{2.5}, sulfate and nitrate) -- using the same health effects program as described in my June 2019 report (Appendix B). There were 29,772 separate demographic units processed, accounting for an area of 144,787 km². The population-weighted average fine particle concentration in 2018 was 0.32 µg/m³. For the 2019 modeling period (actually Nov 2018 through Oct 2019), the population-weighted average fine particle concentration was 0.29 µg/m³.

The estimated health effects (annual mortality rates) due to the Kendal power station's emissions are shown below, in Table 2, broken down into the five computed causes of death. In addition, the 95% confidence intervals are also shown for each cause of death and for total mortality.

Table 2. Estimated Annual Mortality (Additional Deaths/Year), by Cause due to Kendal Power Station's Emissions

	2018			2019		
	MEAN	CI LOW	CI HIGH	MEAN	CI LOW	CI HIGH
Ischemic Heart Disease	42.4	25.8	67.3	38.5	23.4	61.1
Lung Cancer	4.7	1.1	8.0	4.3	1.0	7.3
Stroke	40.5	12.4	75.2	36.8	11.2	68.3
COPD	6.5	2.5	11.1	5.9	2.3	10.1
Lower Respiratory Infections (children under 5)	6.3	3.9	9.0	5.7	3.5	8.2
TOTAL	100.3	67.2	143.5	91.1	61.0	130.4

As shown in Table 2, emissions from the Kendal power station were responsible for between 67 and 144 early deaths in and around the HPA region during 2018 (95 percent confidence interval), and between 61 and 130 early deaths during the period November 2018 through October 2019.

MODEL RESULTS: SENSITIVE RECEPTORS

I also computed the concentration impacts at the 120 sensitive receptors due to Kendal power station's emissions for each modeled year (2018 and 2019) using the same metrics that were reported in my June 2019 report, as shown in Table 3 and Table 4.

As can be seen in Tables 3 and 4, the 10-minute mean WHO SO₂ guideline level (500 µg/m³) was exceeded due solely to Kendal's emissions by more than four times during the peak hourly period in 2018 at Hlangu Phala Primary School in Phola Township, located about 11 km northeast of the Kendal power station (see Figure 1, below), and by more than two times in the nearby township of Ogies. The maximum 24-hour SO₂ level in 2018 due to Kendal's emissions also was more than five times the WHO guideline level (20 µg/m³) at Ogies and Phola, and exceeded the WHO level at numerous other locations throughout the HPA region

The peak 24-hour average PM_{2.5} concentration level also was more than half of the acceptable WHO guideline level (25 µg/m³) at Laerskool Panorama, Leandra, Ogies, and Phola. The acceptable 1-hour WHO level for NO₂ (200 µg/m³) was exceeded by more than two times at Ogies and Phola in 2018, and was more than half the WHO guideline level at 21 sensitive receptor locations across the HPA, including at Witbank, Secunda, Delmas, and Kinross (see Figure 2, below).

Table 3. CALPUFF RESULTS: Modeled Concentrations ($\mu\text{g}/\text{m}^3$) at Sensitive Receptor Locations, Jan 2018 – Dec 2018⁴

Hotspot	Location	2018 Kendal emissions					
		SO2 1 hr 1st high	SO2 1 hr 4th high	SO2 1 hr 89th high	SO2 24 hr 1st high	SO2 24 hr 5th high	SO2 annual
HOTSPOT AREAS							
Emalahleni	Witbank High School	369.45	249.61	65.63	46.07	31.56	2.90
	Duvha Primary School	203.41	184.92	53.45	42.64	25.60	2.60
	Laerskool Taalfees	361.65	244.08	65.69	45.57	31.11	2.88
	Witbank Hospital	338.37	234.05	64.24	44.90	30.22	2.85
	Witbank TB Specialised Hospital	224.66	177.24	68.13	38.08	30.36	2.75
	Nancy Shiba Primary School (Vosman)	259.39	202.74	69.78	40.75	29.56	2.73
	Empumeleleni	324.05	304.08	66.50	38.97	32.50	2.90
	W.H. De Klerk Skool	303.32	240.46	61.32	47.07	28.11	2.68
	Laerskool Panorama	258.68	228.93	61.06	45.93	26.02	2.51
	Laerskool Duvhapark	347.57	256.04	64.13	38.69	30.57	2.87
	Damelin-Witbank University	368.68	279.65	64.23	47.26	31.08	3.00
Kriel	Kwanala Primary School	321.60	231.77	111.95	42.67	34.44	5.59
	Merlin Park Primary School	201.05	173.22	86.59	39.63	27.37	4.39
	Sibongamandla Secondary School	251.36	213.68	91.12	39.00	28.31	4.35
	Kriel Medical Centre	213.19	160.17	86.77	38.77	27.21	4.43
	Ga-Nala Clinic	219.55	181.80	91.10	41.82	29.35	4.43
	Laerskool Krielpark	240.82	181.96	95.69	38.90	28.54	4.91
Steve Tshwete	Makhathini Primary School	124.84	100.15	33.62	24.72	16.52	1.59
	Middelburg Preparatory School	116.16	102.42	31.09	24.71	14.55	1.56
	Middelburg Combined School	138.13	100.61	33.17	24.42	14.45	1.61
	Life Midmed Hospital	122.35	105.27	33.03	25.21	14.84	1.60
	Laerskool Dennesig	120.15	99.19	29.27	23.68	14.51	1.53
	Middelburg Hospital	121.45	111.41	35.50	26.04	15.60	1.66
	Hoerskool Kanonkop	115.55	103.37	30.56	24.00	14.21	1.54
	Laerskool Kanonkop	118.59	100.37	31.03	24.48	15.01	1.56
	Steelcrest High School	117.61	102.69	31.72	24.75	14.67	1.57
Ermelo	Ermelo Christian School	125.92	71.58	31.54	15.21	11.46	1.85
	Lindile Secondary School	122.63	71.22	30.94	15.97	11.60	1.80
	Camden Combined School	83.98	64.98	27.91	16.99	10.91	1.57
	Mediclinic Ermelo	133.62	73.89	30.84	14.92	11.50	1.83
	Ermelo Hospital	125.72	70.61	31.67	15.77	11.73	1.83
	Hoerskool Ermelo	128.76	70.18	31.40	15.56	11.68	1.83
	Davel Combined School	136.24	107.55	45.23	19.74	14.95	2.67
	Camden School	91.52	67.60	28.33	16.27	10.75	1.62
	Ermelo Indian Combined School	132.28	69.86	31.81	15.76	11.92	1.83
	Lungelo Combined School	82.93	65.27	32.99	13.72	10.65	1.86
	Morgenzon Landbou Akademie	151.16	97.78	35.79	20.78	12.43	2.13
	Nqobangolwazi Secondary School	151.45	99.81	35.58	19.99	12.60	2.08
	New Ermelo Primary School	101.44	71.49	30.82	14.87	10.92	1.76
	Umzimvelo Secondary School	68.93	62.89	24.57	12.55	8.60	1.42
SOUTH AFRICA NAAQS				350		125	50
US NAAQS			196				
WHO GUIDELINES³		500			20		

⁴ The WHO guideline level for short-term SO₂ concentrations (500 $\mu\text{g}/\text{m}^3$) is based on a 10-minute averaging period.

Hotspot	Location	2018 Kendal emissions					
		SO2 1 hr 1st high	SO2 1 hr 4th high	SO2 1 hr 89th high	SO2 24 hr 1st high	SO2 24 hr 5th high	SO2 annual
Secunda	Laerskool Kruinpark	497.29	181.83	67.69	34.33	19.63	3.48
	Laerskool Secunda	557.20	190.12	66.21	36.98	21.14	3.43
	Evander Hospital - Arv Clinic	361.88	150.90	70.67	32.62	22.72	3.52
	Highveld Mediclinic Pediatric Ward	439.11	199.69	68.58	31.88	19.92	3.67
	Mediclinic Secunda	566.12	185.62	62.43	37.37	21.64	3.37
	Sasol Recreation Club	579.18	176.42	59.93	36.42	21.29	3.20
	Highveld Park High School	529.56	178.33	65.35	35.83	19.70	3.44
	Hoerskool Secunda	562.40	185.99	64.31	36.88	20.70	3.36
	Hoerskool Oosterland	524.75	182.13	64.66	35.42	19.33	3.41
	Thomas Nhlabathi Secondary School	211.94	140.26	57.31	29.43	17.37	2.84
	Vukuzithathe Primary School	197.07	136.43	58.35	26.54	18.00	2.75
	Ki Twala Secondary School	218.39	144.92	59.05	29.70	17.90	2.76
	Allan Makunga Primary School	205.26	114.10	59.80	25.26	15.57	2.86
	Kinross	584.12	204.65	77.67	36.20	25.92	3.95
Leandra	287.38	198.70	78.61	49.51	30.35	3.54	
Ekurhuleni	Ekurhuleni School For The Deaf	142.45	86.28	30.70	19.95	11.87	1.29
	Alberton High School	176.63	114.39	30.71	26.62	11.57	1.40
	Laerskool Eloff	307.68	186.35	68.38	44.02	26.83	2.74
	Life Springs Parkland Hospital	233.93	160.75	42.41	33.47	18.06	1.83
	LifeLine Ekurhuleni	314.95	173.71	41.10	24.69	16.38	1.76
	Tambo Memorial Hospital	228.85	142.38	34.73	24.92	16.29	1.58
	Thelle Mogoerane Hospital	133.34	100.19	29.39	20.34	10.21	1.31
	Tembisa Hospital	158.31	99.51	32.96	28.18	13.91	1.34
	Sasolburg High School	107.98	78.14	18.31	12.44	9.23	0.83
	Theha Setjhaba Primary School (Zamdela)	121.35	73.41	20.59	13.14	10.22	0.89
	Credo Primary School (Zamdela)	117.85	70.22	21.68	13.69	9.42	0.92
	Vaalpark Hospital	112.88	87.22	19.20	12.51	8.86	0.84
	Mediclinic Emfuleni	121.41	72.08	18.87	11.69	9.28	0.88
	Mediclinic Vereeniging	113.58	87.05	20.22	11.88	9.38	0.90
	Riverside High School (Three Rivers)	149.56	78.34	21.65	13.72	10.55	0.96
	Hoerskool DR Malan (Meyerton)	127.51	89.21	22.78	14.78	9.87	1.00
	Ratanda Secondary School	137.95	107.87	31.48	19.72	12.80	1.42
	Heidelberg Day Hospital	208.72	104.51	34.31	24.41	15.62	1.51
	Hoërskool John Vorster (Nigel)	226.58	107.73	37.76	22.89	17.65	1.73
	Pholosong Hospital (Tsakane)	183.75	136.21	36.40	18.80	12.16	1.63
	Brakpan Primary School	273.05	127.46	45.29	28.58	18.88	1.89
	Brandwag Hoerskool (Airfield)	355.78	179.45	42.36	27.57	16.49	1.78
	Sibonelo Primary School (Daveyton)	237.04	155.81	46.19	34.22	18.55	1.90
	Thembelihle Primary School (Emaphupheni)	326.21	127.13	49.68	38.31	18.62	2.02
	South Rand Hospital (Johannesburg South)	243.46	133.84	38.51	26.93	17.74	1.58
	Afrikaanse Hoerskool Germiston	224.02	127.07	37.82	31.29	14.09	1.55
	Milpark Hospital (Johannesburg)	265.17	175.69	32.96	25.71	17.71	1.36
	Thulani Primary School (Soweto)	241.25	137.29	24.93	21.47	12.19	1.04
	Arwyp Medical Centre (Kempton Park)	216.07	125.24	38.05	24.14	16.97	1.54
	Hoerskool Birchleigh	272.21	125.36	33.58	26.11	14.56	1.41
Tembisa West Secondary School	216.42	106.47	28.84	18.81	12.91	1.22	
Pretoria Heart Hospital	398.33	123.69	18.94	23.73	13.45	0.86	
SOUTH AFRICA NAAQS				350		125	50
US NAAQS		7	196				
WHO GUIDELINES³		500			20		

Hotspot	Location	2018 Kendal emissions					
		SO2 1 hr 1st high	SO2 1 hr 4th high	SO2 1 hr 89th high	SO2 24 hr 1st high	SO2 24 hr 5th high	SO2 annual
Lekwa	Laerskool Jeugkrag	104.18	83.19	36.39	17.74	14.55	1.87
	Standerton Primary School	100.75	83.22	36.24	17.54	14.11	1.86
	Thobelani Secondary School	121.58	89.61	36.24	18.78	13.80	1.84
	Standerton Provincial Government Hospital	103.44	83.42	35.37	17.68	14.59	1.84
	Thuthukani	101.55	95.69	43.98	19.94	12.97	2.22
	Ulwazi Primary School	100.03	96.23	44.00	20.11	13.02	2.22
	Standerton Tb Hospital	111.56	91.04	34.10	18.08	13.44	1.74
	Jandrell Secondary School	119.08	89.79	35.09	18.59	13.63	1.81
Balfour	Gekombineerde Skool Balfour	125.29	109.34	37.60	28.10	12.38	1.82
	Bonukukhanya Primary	137.65	121.75	40.38	30.57	14.36	1.93
	Dr Nieuwoudt and Dr Kok	126.98	109.51	38.71	28.46	12.54	1.86
	The Stone Cellar	162.75	98.23	35.19	15.85	10.46	1.59
Delmas	Bazani Primary School	339.91	202.40	81.14	38.73	34.94	2.93
	Kangela Primary School	278.03	215.29	80.91	36.32	30.46	3.00
	Bernice Samuel Hospital	357.03	200.15	77.56	37.59	29.96	2.83
Hendrina	Tsiki Naledi Secondary School	143.39	91.43	40.56	19.63	16.07	2.16
	Maziya Combined School	131.61	99.58	39.52	22.92	15.17	2.10
Grootvlei	Grootvlei	150.78	103.05	32.83	17.40	10.71	1.54
	Laerskool Grootvlei	181.07	106.49	33.65	23.04	10.66	1.58
	Nthoroane Secondary School	118.14	96.11	36.30	21.65	13.31	1.82
OTHER AREAS							
Ogies	Ogies Police Station	1,340.40	636.16	198.78	104.15	61.40	7.05
Phola	Hlangu Phala Primary School	2,170.90	484.78	129.71	103.70	60.79	4.95
	Sibongindawo Primary School	981.74	623.11	138.39	104.19	60.06	5.02
Komati	Blinkpan Primary School	201.62	168.99	57.28	37.78	20.88	2.86
Pullens Hope	Pullens Hope (1)	206.01	124.10	40.54	22.19	17.58	2.12
	Pullens Hope (2)	223.76	126.68	39.75	22.53	18.16	2.10
Rietkuil	Rietkuil	216.62	103.13	28.20	19.75	13.39	1.57
Lothair	Ubuhle Bolwazi Secondary School	94.05	76.59	23.90	13.42	12.11	1.26
Warburton	Warburton Combined School	70.99	56.43	22.56	14.54	10.85	1.15
Volkstrust	Volkstrust High School	110.50	59.94	21.53	9.81	7.71	1.15
Bethal	Life Bethal Hospital	191.69	132.36	56.91	20.69	16.38	3.09
Amersfoort	Elsie Ballot Hospital	111.83	73.28	28.36	13.47	10.37	1.49
Belfast	Town of Belfast	116.83	97.04	26.48	24.58	13.49	1.28
SOUTH AFRICA NAAQS				350		125	50
US NAAQS			196				
WHO GUIDELINES³		500			20		

Hotspot	Location	2018 Kendal emissions							
		PM10 24 hr	PM10 24 hr	PM10 24 hr	PM10	PM2.5 24 hr	PM2.5 24 hr	PM2.5 24 hr	PM2.5
		1st high	2nd high	5th high	annual	1st high	5th high	8th high	annual
HOTSPOT AREAS									
Emalaheni	Witbank High School	15.17	13.71	10.90	1.02	12.16	9.35	7.03	0.82
	Duvha Primary School	12.50	10.81	9.20	0.93	10.18	6.97	6.34	0.75
	Laerskool Taalfees	15.25	13.66	10.91	1.01	12.22	9.40	6.98	0.82
	Witbank Hospital	15.49	13.65	11.01	1.01	12.40	9.41	6.87	0.81
	Witbank TB Specialised Hospital	14.73	13.23	10.92	1.00	11.79	9.22	7.07	0.81
	Nancy Shiba Primary School (Vosman)	14.08	13.16	10.52	0.99	12.06	9.39	8.16	0.80
	Empumelweni	17.49	13.68	11.02	1.03	13.61	9.36	7.48	0.83
	W.H. De Klerk Skool	15.59	14.27	11.21	0.98	12.48	8.93	6.73	0.79
	Laerskool Panorama	15.83	14.33	11.15	0.95	12.64	9.11	6.39	0.77
	Laerskool Duvhapark	13.38	12.59	10.14	1.00	11.08	8.44	7.11	0.80
Damelin-Witbank University	14.56	13.80	10.78	1.03	12.12	8.85	7.50	0.82	
Kriel	Kwanala Primary School	12.77	10.45	8.94	1.32	9.18	7.34	6.13	0.99
	Merlin Park Primary School	10.25	10.04	8.44	1.13	8.92	6.24	5.89	0.87
	Sibongamandla Secondary School	10.70	10.58	8.96	1.17	9.39	6.45	5.96	0.89
	Kriel Medical Centre	10.58	9.90	8.46	1.14	8.81	6.21	5.83	0.87
	Ga-Nala Clinic	10.52	9.79	8.45	1.15	9.34	6.38	5.82	0.88
	Laerskool Krielpark	11.41	10.09	9.14	1.22	8.97	6.47	5.89	0.92
Steve Tshwete	Makhathini Primary School	13.38	11.46	7.64	0.75	12.01	7.07	5.82	0.63
	Middelburg Preparatory School	13.41	10.87	7.65	0.74	12.04	7.08	5.80	0.62
	Middelburg Combined School	13.32	10.47	7.53	0.75	11.96	6.98	5.90	0.62
	Life Midmed Hospital	13.50	11.37	7.61	0.75	12.11	7.05	5.87	0.63
	Laerskool Dennesig	13.19	10.40	7.78	0.73	11.86	7.21	5.54	0.62
	Middelburg Hospital	13.67	11.80	7.54	0.76	12.24	6.98	5.99	0.64
	Hoerskool Kanonkop	13.27	10.43	7.75	0.73	11.92	7.17	5.62	0.62
	Laerskool Kanonkop	13.36	10.75	7.69	0.74	11.99	7.12	5.73	0.62
	Steelcrest High School	13.42	10.95	7.65	0.74	12.04	7.08	5.80	0.62
Ermelo	Ermelo Christian School	6.27	5.93	5.32	0.67	5.19	3.92	3.60	0.54
	Lindile Secondary School	6.26	6.02	5.02	0.67	5.25	3.86	3.58	0.54
	Camden Combined School	7.44	5.44	4.59	0.60	4.81	3.77	3.35	0.49
	Mediclinic Ermelo	6.03	5.94	5.26	0.67	5.20	3.90	3.59	0.54
	Ermelo Hospital	6.06	6.01	5.17	0.68	5.24	3.89	3.62	0.55
	Hoerskool Ermelo	5.99	5.93	5.18	0.67	5.23	3.89	3.60	0.55
	Davel Combined School	7.88	6.69	5.79	0.86	5.84	4.91	3.89	0.68
	Camden School	7.13	5.52	4.46	0.61	4.87	3.89	3.40	0.50
	Ermelo Indian Combined School	6.07	6.03	5.14	0.68	5.26	3.87	3.59	0.55
	Lungelo Combined School	5.64	5.61	4.57	0.68	5.01	3.93	3.58	0.55
	Morgenzon Landbou Akademie	9.89	7.96	6.16	0.75	8.01	4.76	4.51	0.59
	Nqobangolwazi Secondary School	10.04	7.22	6.13	0.74	8.12	4.76	4.18	0.59
	New Ermelo Primary School	5.82	5.75	5.10	0.66	5.09	3.94	3.57	0.53
Umzimvelo Secondary School	5.21	4.76	4.23	0.56	4.57	3.44	2.86	0.46	
SOUTH AFRICA NAAQS				75	40		40		20
US NAAQS			150					35	
WHO GUIDELINES³		50			20	25			10

Hotspot	Location	2018 Kendal emissions							
		PM10 24 hr	PM10 24 hr	PM10 24 hr	PM10	PM2.5 24 hr	PM2.5 24 hr	PM2.5 24 hr	PM2.5
		1st high	2nd high	5th high	annual	1st high	5th high	8th high	annual
Secunda	Laerskool Kruinpark	10.66	10.54	9.04	1.00	8.42	5.53	5.06	0.76
	Laerskool Secunda	11.05	10.57	9.24	0.98	8.56	5.64	4.75	0.74
	Evander Hospital - Arv Clinic	11.66	10.01	8.25	0.98	9.06	6.03	4.75	0.74
	Highveld Mediclinic Pediatric Ward	10.67	10.35	8.25	1.04	8.44	5.62	4.58	0.78
	Mediclinic Secunda	11.24	10.49	9.29	0.96	8.67	5.44	4.86	0.73
	Sasol Recreation Club	11.19	10.40	8.48	0.93	8.64	5.31	4.66	0.71
	Highveld Park High School	10.78	10.62	9.18	0.98	8.46	5.39	4.82	0.75
	Hoerskool Secunda	11.02	10.54	9.20	0.96	8.54	5.51	4.71	0.73
	Hoerskool Oosterland	10.69	10.63	9.10	0.98	8.41	5.31	4.86	0.74
	Thomas Nhlabathi Secondary School	9.57	8.97	7.57	0.84	8.85	6.23	4.48	0.65
	Vukuzithathe Primary School	9.31	9.30	7.31	0.82	8.62	5.83	4.52	0.64
	Ki Twala Secondary School	9.33	8.93	7.06	0.82	8.64	5.89	4.53	0.64
	Allan Makunga Primary School	9.93	9.53	8.19	0.85	8.81	6.09	4.55	0.66
	Kinross	11.76	10.18	9.45	1.05	9.38	6.80	5.07	0.79
	Leandra	16.82	16.75	11.43	1.04	13.01	9.04	6.12	0.78
Ekurhuleni	Ekurhuleni School For The Deaf	11.07	7.84	4.23	0.44	9.52	3.40	2.63	0.36
	Alberton High School	10.86	6.65	4.75	0.44	9.31	3.68	2.75	0.36
	Laerskool Eloff	18.65	9.68	8.10	0.79	11.31	6.84	4.82	0.61
	Life Springs Parkland Hospital	10.38	9.92	6.02	0.58	8.89	5.06	3.85	0.46
	LifeLine Ekurhuleni	10.26	9.52	5.26	0.54	8.22	4.84	3.21	0.43
	Tambo Memorial Hospital	9.79	7.27	4.68	0.49	8.45	3.92	3.14	0.40
	Thelle Mogoerane Hospital	10.77	8.20	4.00	0.45	9.29	2.73	2.67	0.37
	Tembisa Hospital	8.14	6.87	4.62	0.46	6.47	3.76	3.38	0.38
	Sasolburg High School	9.97	5.61	3.32	0.30	8.63	2.56	2.36	0.25
	Theha Setjhaba Primary School (Zamdela)	9.42	4.71	3.07	0.31	8.17	2.41	2.10	0.25
	Credo Primary School (Zamdela)	9.39	4.37	3.31	0.32	8.15	2.46	2.20	0.26
	Vaalpark Hospital	10.33	5.61	3.35	0.31	8.93	2.65	2.31	0.25
	Mediclinic Emfuleni	11.11	5.57	3.67	0.32	9.59	2.96	2.43	0.26
	Mediclinic Vereeniging	11.27	5.44	3.93	0.33	9.73	2.78	1.91	0.27
	Riverside High School (Three Rivers)	11.09	5.23	3.55	0.35	9.60	2.73	2.18	0.29
	Hoerskool DR Malan (Meyerton)	11.86	6.34	3.15	0.36	10.22	2.74	2.23	0.30
	Ratanda Secondary School	10.04	7.31	4.41	0.49	8.67	3.63	3.00	0.40
	Heidelberg Day Hospital	10.38	7.71	4.48	0.51	8.92	3.53	3.16	0.41
	Hoërskool John Vorster (Nigel)	11.26	8.48	4.56	0.58	9.52	3.56	3.19	0.46
	Pholosong Hospital (Tsakane)	10.58	8.32	4.48	0.53	9.08	3.22	2.87	0.43
	Brakpan Primary School	10.06	9.93	5.69	0.58	8.65	4.85	3.64	0.46
	Brandwag Hoerskool (Airfield)	11.86	9.40	5.36	0.55	8.12	4.93	3.14	0.44
	Sibonelo Primary School (Daveyton)	12.38	9.02	5.46	0.60	7.77	4.98	3.57	0.48
	Thembelihle Primary School (Emaphupheni)	8.86	8.65	6.32	0.63	7.43	5.45	3.70	0.51
	South Rand Hospital (Johannesburg South)	10.88	6.58	4.80	0.46	9.29	3.59	2.90	0.37
	Afrikaanse Hoerskool Germiston	10.17	6.98	4.86	0.47	8.76	3.53	2.77	0.39
	Milpark Hospital (Johannesburg)	10.04	5.85	5.09	0.42	8.60	3.71	3.09	0.35
Thulani Primary School (Soweto)	11.30	5.67	4.27	0.35	9.56	3.13	2.59	0.29	
Arwyp Medical Centre (Kempton Park)	8.60	6.72	5.77	0.50	7.46	3.55	3.24	0.40	
Hoerskool Birchleigh	7.95	7.07	4.55	0.48	6.90	3.78	2.78	0.39	
Tembisa West Secondary School	7.48	7.12	4.03	0.43	6.50	3.54	2.88	0.36	
Pretoria Heart Hospital	6.80	6.49	4.42	0.36	6.33	4.17	3.07	0.30	
SOUTH AFRICA NAAQS				75	40		40		20
US NAAQS			150					35	
WHO GUIDELINES³		50			20	25			10

Hotspot	Location	2018 Kendal emissions							
		PM10 24 hr	PM10 24 hr	PM10 24 hr	PM10	PM2.5 24 hr	PM2.5 24 hr	PM2.5 24 hr	PM2.5
		1st high	2nd high	5th high	annual	1st high	5th high	8th high	annual
Lekwa	Laerskool Jeugkrug	9.39	8.32	5.17	0.64	7.81	4.60	4.08	0.52
	Standerton Primary School	9.35	8.24	5.18	0.64	7.78	4.56	4.06	0.51
	Thobelani Secondary School	9.00	8.05	5.10	0.64	7.54	4.50	3.90	0.51
	Standerton Provincial Government Hospital	9.27	8.17	5.17	0.64	7.72	4.51	4.02	0.51
	Thuthukani	12.24	8.88	5.89	0.73	9.81	5.03	4.42	0.58
	Ulwazi Primary School	12.25	8.90	5.88	0.73	9.82	5.00	4.41	0.58
	Standerton Tb Hospital	8.94	7.89	5.06	0.62	7.49	4.48	3.84	0.50
	Jandrell Secondary School	8.96	7.99	5.09	0.63	7.51	4.50	3.87	0.51
Balfour	Gekombineerde Skool Balfour	13.97	8.48	5.62	0.63	10.93	3.94	3.74	0.49
	Bonukukhanya Primary	14.34	8.70	5.92	0.66	11.18	4.03	3.63	0.51
	Dr Nieuwoudt and Dr Kok	14.04	8.46	5.62	0.64	10.95	3.95	3.79	0.50
	The Stone Cellar	11.89	8.03	4.96	0.55	9.81	4.02	3.51	0.44
Delmas	Bazani Primary School	13.63	12.70	8.51	0.84	10.53	7.29	5.97	0.66
	Kangela Primary School	15.67	11.60	8.95	0.85	9.67	7.33	5.51	0.67
	Bernice Samuel Hospital	16.15	10.36	8.53	0.82	9.87	7.15	5.43	0.64
Hendrina	Tsiki Naledi Secondary School	7.47	7.29	5.56	0.80	6.71	4.58	4.23	0.65
	Maziya Combined School	7.07	6.70	5.68	0.79	6.49	4.65	4.12	0.64
Grootvlei	Grootvlei	8.57	7.86	5.18	0.54	7.31	4.21	3.58	0.43
	Laerskool Grootvlei	8.26	7.83	5.97	0.55	6.98	4.33	3.60	0.44
	Nthoroane Secondary School	9.04	8.71	6.15	0.64	7.77	4.67	4.10	0.51
OTHER AREAS									
Ogies	Ogies Police Station	21.72	21.48	15.48	1.60	12.96	12.11	9.74	1.18
Phola	Hlangu Phala Primary School	16.44	16.36	14.23	1.26	14.19	9.56	8.72	0.98
	Sibongindawo Primary School	21.27	21.04	16.36	1.38	15.53	13.20	10.75	1.06
Komati	Blinkpan Primary School	9.91	8.57	6.69	0.93	8.93	5.47	4.71	0.74
Pullens Hope	Pullens Hope (1)	9.67	8.06	7.01	0.80	8.81	5.93	4.94	0.65
	Pullens Hope (2)	9.68	8.14	7.09	0.80	8.82	5.94	4.98	0.65
Rietkuil	Rietkuil	9.84	8.16	5.54	0.70	9.03	4.72	4.21	0.58
Lothair	Ubuhle Bolwazi Secondary School	6.49	5.37	4.42	0.51	4.99	3.67	3.11	0.42
Warburton	Warburton Combined School	5.82	5.80	4.60	0.50	4.67	3.63	3.34	0.41
Volksrust	Volksrust High School	7.33	5.46	4.26	0.46	6.00	3.05	2.70	0.37
Bethal	Life Bethal Hospital	11.40	7.08	5.88	0.93	8.91	5.02	4.29	0.73
Amersfoort	Elsie Ballot Hospital	7.96	5.85	5.64	0.59	6.50	4.14	3.27	0.47
Belfast	Town of Belfast	8.75	8.15	6.32	0.64	8.11	5.14	4.75	0.53
SOUTH AFRICA NAAQS				75	40		40		20
US NAAQS			150					35	
WHO GUIDELINES³		50			20	25			10

Hotspot	Location	2018 Kendal emissions			
		NO2 1 hr 1st high	NO2 1 hr 8th high	NO2 1 hr 89th high	NO2 annual
HOTSPOT AREAS					
Emalaheni	Witbank High School	108.98	58.37	16.63	0.65
	Duvha Primary School	67.24	47.97	14.75	0.58
	Laerskool Taalfees	106.57	54.54	16.15	0.64
	Witbank Hospital	99.36	51.15	15.99	0.63
	Witbank TB Specialised Hospital	66.31	40.65	16.39	0.58
	Nancy Shiba Primary School (Vosman)	85.24	47.31	16.33	0.58
	Empumelweni	113.61	68.05	17.15	0.65
	W.H. De Klerk Skool	88.06	51.34	14.85	0.58
	Laerskool Panorama	74.70	52.03	13.61	0.52
	Laerskool Duvhapark	100.87	65.96	17.30	0.66
	Damelin-Witbank University	109.48	75.04	16.51	0.68
Kriel	Kwanala Primary School	99.70	65.87	34.27	1.54
	Merlin Park Primary School	58.97	50.36	26.44	1.15
	Sibongamandla Secondary School	82.11	60.15	27.56	1.14
	Kriel Medical Centre	62.66	49.64	26.00	1.16
	Ga-Nala Clinic	71.56	53.44	27.34	1.16
	Laerskool Krielpark	75.03	53.56	28.84	1.32
Steve Tshwete	Makhathini Primary School	36.32	22.39	6.55	0.26
	Middelburg Preparatory School	36.36	24.71	6.44	0.26
	Middelburg Combined School	47.01	24.88	6.99	0.28
	Life Midmed Hospital	37.37	24.68	6.96	0.27
	Laerskool Dennesig	40.89	24.42	6.09	0.25
	Middelburg Hospital	39.56	27.16	7.54	0.29
	Hoerskool Kanonkop	36.86	25.86	5.98	0.25
	Laerskool Kanonkop	37.19	26.74	6.37	0.26
	Steelcrest High School	36.46	24.24	6.52	0.26
Ermelo	Ermelo Christian School	34.66	21.88	8.60	0.40
	Lindile Secondary School	34.30	20.59	7.90	0.38
	Camden Combined School	24.97	17.62	7.68	0.33
	Mediclinic Ermelo	36.93	21.59	8.42	0.39
	Ermelo Hospital	34.97	20.87	8.24	0.39
	Hoerskool Ermelo	35.78	21.04	8.20	0.39
	Davel Combined School	42.58	30.54	12.49	0.62
	Camden School	27.30	17.73	7.69	0.34
	Ermelo Indian Combined School	36.96	21.08	8.17	0.39
	Lungelo Combined School	24.30	18.47	8.78	0.40
	Morgenzon Landbou Akademie	34.70	25.14	9.89	0.49
	Nqobangolwazi Secondary School	37.01	26.45	9.83	0.47
	New Ermelo Primary School	27.70	21.02	7.77	0.38
	Umzimvelo Secondary School	22.64	14.74	6.03	0.29
SOUTH AFRICA NAAQS				200	40
US NAAQS			188		
WHO GUIDELINES³		200		40	

Hotspot	Location	2018 Kendal emissions			
		NO2 1 hr 1st high	NO2 1 hr 8th high	NO2 1 hr 89th high	NO2 annual
Secunda	Laerskool Kruinpark	153.58	48.40	20.01	0.93
	Laerskool Secunda	180.67	49.63	19.86	0.92
	Evander Hospital - Arv Clinic	126.86	43.25	22.48	0.96
	Highveld Mediclinic Pediatric Ward	130.18	49.89	21.68	0.98
	Mediclinic Secunda	186.35	50.94	19.19	0.90
	Sasol Recreation Club	190.83	48.62	17.79	0.85
	Highveld Park High School	167.81	52.83	20.41	0.92
	Hoerskool Secunda	182.38	46.76	19.60	0.90
	Hoerskool Oosterland	165.24	50.77	20.05	0.91
	Thomas Nhlabathi Secondary School	60.70	39.69	17.89	0.75
	Vukuzithathe Primary School	53.32	39.75	17.48	0.73
	Ki Twala Secondary School	57.01	40.41	17.77	0.73
	Allan Makunga Primary School	58.80	35.49	18.86	0.76
	Kinross	207.40	51.22	24.83	1.10
	Leandra	90.43	52.40	24.53	0.96
Ekurhuleni	Ekurhuleni School For The Deaf	43.93	23.87	9.33	0.32
	Alberton High School	60.79	30.51	10.11	0.37
	Laerskool Eloff	91.21	53.00	20.19	0.71
	Life Springs Parkland Hospital	74.10	37.97	12.72	0.47
	LifeLine Ekurhuleni	97.07	45.66	12.96	0.46
	Tambo Memorial Hospital	71.56	38.87	11.03	0.41
	Thelle Mogoerane Hospital	40.16	27.09	9.22	0.33
	Tembisa Hospital	53.53	29.60	9.47	0.31
	Sasolburg High School	30.32	17.35	5.46	0.21
	Theha Setjhaba Primary School (Zamdela)	34.11	21.06	6.47	0.23
	Credo Primary School (Zamdela)	33.03	21.14	6.92	0.24
	Vaalpark Hospital	33.19	21.03	5.71	0.21
	Mediclinic Emfuleni	34.37	21.19	5.94	0.22
	Mediclinic Vereeniging	33.32	19.78	5.95	0.22
	Riverside High School (Three Rivers)	42.99	20.22	6.70	0.24
	Hoerskool DR Malan (Meyerton)	37.69	22.33	6.96	0.24
	Ratanda Secondary School	54.85	27.27	9.87	0.37
	Heidelberg Day Hospital	79.64	24.46	10.97	0.39
	Hoërskool John Vorster (Nigel)	81.89	29.87	12.07	0.45
	Pholosong Hospital (Tsakane)	55.12	33.18	10.96	0.42
	Brakpan Primary School	68.04	34.90	14.21	0.49
	Brandwag Hoerskool (Airfield)	91.00	43.47	13.39	0.46
	Sibonelo Primary School (Daveyton)	95.53	32.94	13.00	0.46
	Thembelihle Primary School (Emaphupheni)	132.11	36.57	13.97	0.49
	South Rand Hospital (Johannesburg South)	81.73	38.52	12.04	0.43
	Afrikaanse Hoerskool Germiston	69.49	35.42	11.39	0.41
	Milpark Hospital (Johannesburg)	84.07	32.59	11.05	0.35
	Thulani Primary School (Soweto)	65.90	27.51	7.50	0.25
	Arwyp Medical Centre (Kempton Park)	73.54	33.74	10.81	0.38
	Hoerskool Birchleigh	92.36	30.96	10.07	0.33
Tembisa West Secondary School	72.89	25.58	8.80	0.28	
Pretoria Heart Hospital	127.83	24.76	3.85	0.16	
SOUTH AFRICA NAAQS				200	40
US NAAQS			188		
WHO GUIDELINES³		200			40

Hotspot	Location	2018 Kendal emissions			
		NO2 1 hr 1st high	NO2 1 hr 8th high	NO2 1 hr 89th high	NO2 annual
Lekwa	Laerskool Jeugkrag	38.07	25.93	10.77	0.45
	Standerton Primary School	36.78	25.31	11.13	0.44
	Thobelani Secondary School	39.66	23.25	10.81	0.44
	Standerton Provincial Government Hospital	37.72	26.44	10.95	0.44
	Thuthukani	33.97	26.15	12.51	0.53
	Ulwazi Primary School	33.88	26.78	12.47	0.53
	Standerton Tb Hospital	36.32	22.96	10.15	0.41
	Jandrell Secondary School	38.83	23.14	10.68	0.43
Balfour	Gekombineerde Skool Balfour	40.46	30.84	12.99	0.47
	Bonukukhanya Primary	44.65	33.92	13.13	0.50
	Dr Nieuwoudt and Dr Kok	41.03	32.34	13.21	0.48
	The Stone Cellar	46.86	29.61	11.29	0.41
Delmas	Bazani Primary School	95.99	51.11	22.02	0.74
	Kangela Primary School	86.03	55.56	22.58	0.77
	Bernice Samuel Hospital	108.53	52.57	20.16	0.72
Hendrina	Tsiki Naledi Secondary School	38.89	27.68	11.39	0.46
	Maziya Combined School	35.52	29.11	11.19	0.45
Grootvlei	Grootvlei	62.42	25.02	10.71	0.39
	Laerskool Grootvlei	61.58	31.95	10.55	0.40
	Nthoroane Secondary School	45.83	29.29	11.85	0.46
OTHER AREAS					
Ogies	Ogies Police Station	407.92	166.06	59.05	2.00
Phola	Hlangu Phala Primary School	689.90	115.27	37.13	1.28
	Sibongindawo Primary School	329.24	127.86	35.39	1.30
Komati	Blinkpan Primary School	64.05	47.37	16.03	0.67
Pullens Hope	Pullens Hope (1)	49.25	30.36	10.46	0.44
	Pullens Hope (2)	53.69	28.81	10.47	0.43
Rietkuil	Rietkuil	62.59	22.08	7.14	0.30
Lothair	Ubuhle Bolwazi Secondary School	24.32	15.79	5.81	0.24
Warburton	Warburton Combined School	22.05	13.20	5.22	0.21
Volksrust	Volksrust High School	28.91	15.51	6.09	0.24
Bethal	Life Bethal Hospital	62.01	33.33	15.96	0.74
Amersfoort	Elsie Ballot Hospital	24.34	17.66	7.67	0.32
Belfast	Town of Belfast	37.32	24.01	6.70	0.25
SOUTH AFRICA NAAQS				200	40
US NAAQS				188	
WHO GUIDELINES³				200	40

Table 4. CALPUFF RESULTS: Modeled Concentrations ($\mu\text{g}/\text{m}^3$) at Sensitive Receptor Locations, Nov 2018 – Oct 2019

Hotspot	Location	2019 Kendal emissions					
		SO2 1 hr 1st high	SO2 1 hr 4th high	SO2 1 hr 89th high	SO2 24 hr 1st high	SO2 24 hr 5th high	SO2 annual
HOTSPOT AREAS							
Emalahleni	Witbank High School	280.40	187.59	54.12	32.59	25.55	2.42
	Duvha Primary School	198.60	159.58	43.84	29.36	23.15	2.13
	Laerskool Taalfees	274.49	191.66	53.54	32.06	25.19	2.40
	Witbank Hospital	256.82	194.92	51.39	30.94	24.56	2.37
	Witbank TB Specialised Hospital	241.91	138.59	56.58	30.83	24.78	2.30
	Nancy Shiba Primary School (Vosman)	218.31	168.38	55.57	33.00	24.72	2.28
	Empumelelweni	311.31	273.57	55.89	35.72	26.83	2.44
	W.H. De Klerk Skool	230.21	171.16	48.37	32.41	24.21	2.23
	Laerskool Panorama	198.01	182.42	46.92	31.62	23.58	2.09
	Laerskool Duvhapark	281.42	242.75	51.89	36.75	24.95	2.39
	Damelin-Witbank University	279.82	233.90	53.84	35.88	25.47	2.50
	Kriel	Kwanala Primary School	260.39	211.19	90.90	40.51	25.68
Merlin Park Primary School		186.52	149.66	73.57	31.99	22.16	3.60
Sibongamandla Secondary School		187.53	175.86	73.18	30.41	23.68	3.55
Kriel Medical Centre		184.86	149.59	73.17	31.88	22.04	3.63
Ga-Nala Clinic		179.63	157.98	71.93	31.95	24.76	3.64
Laerskool Krielpark		194.99	175.85	78.81	33.94	23.11	4.00
Steve Tshwete	Makhathini Primary School	113.09	94.55	26.19	17.02	13.38	1.32
	Middelburg Preparatory School	109.61	101.20	24.82	17.02	11.96	1.30
	Middelburg Combined School	131.22	85.07	26.41	20.39	13.73	1.32
	Life Midmed Hospital	111.86	106.85	26.26	17.36	12.36	1.33
	Laerskool Dennesig	114.13	93.95	24.27	16.30	12.13	1.27
	Middelburg Hospital	123.46	99.99	26.78	17.93	12.23	1.38
	Hoerskool Kanonkop	106.43	96.29	25.03	16.53	12.01	1.28
	Laerskool Kanonkop	107.35	100.94	25.08	16.86	12.15	1.30
	Steelcrest High School	109.07	102.08	25.02	17.04	12.06	1.30
Ermelo	Ermelo Christian School	135.58	63.40	25.31	14.45	10.66	1.47
	Lindile Secondary School	132.04	63.86	24.68	13.41	11.00	1.45
	Camden Combined School	72.84	55.33	21.20	11.62	8.16	1.23
	Mediclinic Ermelo	143.87	63.38	25.13	13.99	10.82	1.46
	Ermelo Hospital	135.38	65.91	24.88	13.69	10.86	1.47
	Hoerskool Ermelo	138.64	64.69	24.52	13.69	10.71	1.47
	Davel Combined School	146.70	91.49	37.32	18.73	13.64	2.16
	Camden School	74.10	63.85	22.34	12.38	8.56	1.27
	Ermelo Indian Combined School	142.43	65.86	25.06	13.49	10.85	1.47
	Lungelo Combined School	68.50	62.00	25.71	9.20	8.18	1.45
	Morgenzon Landbou Akademie	143.59	88.29	27.08	17.13	10.60	1.65
	Nqobangolwazi Secondary School	143.86	93.36	26.61	16.72	9.92	1.62
	New Ermelo Primary School	109.23	65.81	23.51	13.38	10.24	1.41
	Umzimvelo Secondary School	69.14	47.98	19.60	9.88	7.69	1.14
SOUTH AFRICA NAAQS				350		125	50
US NAAQS			196				
WHO GUIDELINES³		500			20		

Hotspot	Location	2019 Kendal emissions					
		SO2 1 hr 1st high	SO2 1 hr 4th high	SO2 1 hr 89th high	SO2 24 hr 1st high	SO2 24 hr 5th high	SO2 annual
Secunda	Laerskool Kruinpark	472.40	167.14	50.71	32.61	17.63	2.76
	Laerskool Secunda	529.31	157.50	49.82	35.12	15.88	2.73
	Evander Hospital - Arv Clinic	343.76	129.25	54.69	30.98	17.02	2.81
	Highveld Mediclinic Pediatric Ward	417.13	171.68	54.85	30.28	17.23	2.92
	Mediclinic Secunda	537.79	157.63	49.57	35.50	15.84	2.68
	Sasol Recreation Club	550.19	148.69	46.01	34.60	14.45	2.55
	Highveld Park High School	503.05	150.81	49.71	34.03	18.20	2.74
	Hoerskool Secunda	534.25	157.58	49.35	35.03	15.64	2.68
	Hoerskool Oosterland	498.48	153.37	49.73	33.64	18.13	2.71
	Thomas Nhlabathi Secondary School	160.86	140.26	44.60	24.61	11.35	2.25
	Vukuzithathe Primary School	149.57	136.43	44.10	22.20	11.99	2.18
	Ki Twala Secondary School	165.75	135.53	42.94	24.84	11.77	2.19
	Allan Makunga Primary School	155.79	110.45	46.05	19.53	12.85	2.27
	Kinross	554.88	165.70	57.33	34.39	18.45	3.15
	Leandra	187.09	141.34	59.22	36.69	23.79	2.81
	Ekurhuleni	Ekurhuleni School For The Deaf	143.04	75.22	24.89	18.01	9.65
Alberton High School		167.39	91.40	25.85	20.20	10.86	1.16
Laerskool Eloff		262.14	154.93	53.61	33.68	21.16	2.21
Life Springs Parkland Hospital		161.06	118.99	35.19	27.12	12.34	1.49
Lifeline Ekurhuleni		253.12	151.36	31.14	19.99	12.52	1.41
Tambo Memorial Hospital		185.29	117.52	27.64	19.67	12.91	1.29
Thelle Mogoerane Hospital		103.49	82.80	25.29	18.25	9.07	1.09
Tembisa Hospital		150.39	83.47	25.12	22.82	10.87	1.07
Sasolburg High School		87.43	65.78	14.75	12.88	7.14	0.68
Theha Setjhaba Primary School (Zamdela)		98.26	63.13	17.28	13.26	7.66	0.75
Credo Primary School (Zamdela)		95.42	60.02	18.82	14.02	8.62	0.77
Vaalpark Hospital		82.85	67.96	15.33	12.98	7.37	0.69
Mediclinic Emfuleni		115.34	58.06	16.66	10.00	8.11	0.73
Mediclinic Vereeniging		85.02	60.64	16.80	12.80	7.69	0.75
Riverside High School (Three Rivers)		121.10	69.93	18.23	14.05	7.65	0.80
Hoerskool DR Malan (Meyerton)		96.78	67.71	19.31	12.56	8.19	0.83
Ratanda Secondary School		102.66	81.04	25.94	20.19	10.31	1.17
Heidelberg Day Hospital		143.71	75.78	28.77	24.99	11.53	1.24
Hoërskool John Vorster (Nigel)		156.01	85.36	31.54	23.44	13.55	1.43
Pholosong Hospital (Tsakane)		113.92	96.95	30.15	19.24	10.23	1.32
Brakpan Primary School		167.96	115.37	37.93	23.14	14.06	1.54
Brandwag Hoerskool (Airfield)		237.61	128.14	31.91	20.92	12.86	1.42
Sibonelo Primary School (Daveyton)		163.21	97.78	36.07	25.97	13.44	1.51
Thembelihle Primary School (Emaphupheni)		224.61	103.72	39.25	29.08	16.94	1.61
South Rand Hospital (Johannesburg South)		231.27	108.37	30.81	20.44	12.35	1.27
Afrikaanse Hoerskool Germiston		181.38	109.35	29.31	23.75	11.75	1.27
Milpark Hospital (Johannesburg)		240.75	142.25	26.53	20.49	15.95	1.10
Thulani Primary School (Soweto)		195.33	107.48	20.78	17.38	9.70	0.84
Arwyp Medical Centre (Kempton Park)		205.26	106.37	29.45	19.43	14.27	1.23
Hoerskool Birchleigh		258.59	101.50	25.56	21.14	12.17	1.13
Tembisa West Secondary School		205.59	73.31	22.92	12.95	11.47	0.98
Pretoria Heart Hospital		274.26	92.93	14.23	18.42	9.26	0.67
SOUTH AFRICA NAAQS				350		125	50
US NAAQS			196				
WHO GUIDELINES³		500			20		

Hotspot	Location	2019 Kendal emissions					
		SO2 1 hr 1st high	SO2 1 hr 4th high	SO2 1 hr 89th high	SO2 24 hr 1st high	SO2 24 hr 5th high	SO2 annual
Lekwa	Laerskool Jeugkrag	80.57	67.38	29.09	15.97	11.90	1.47
	Standerton Primary School	83.61	66.64	28.94	16.48	11.67	1.46
	Thobelani Secondary School	108.04	73.11	28.47	15.21	11.97	1.45
	Standerton Provincial Government Hospital	77.38	69.03	28.72	16.53	11.58	1.45
	Thuthukani	91.50	80.47	33.74	17.63	11.48	1.76
	Ulwazi Primary School	93.46	78.90	33.62	17.69	11.57	1.76
	Standerton Tb Hospital	95.59	72.72	26.70	14.89	11.37	1.37
	Jandrell Secondary School	106.78	73.17	27.90	15.05	11.79	1.43
Balfour	Gekombineerde Skool Balfour	119.02	91.71	29.21	25.41	9.40	1.44
	Bonukukhanya Primary	130.76	93.16	29.27	26.55	9.02	1.52
	Dr Nieuwoudt and Dr Kok	120.62	98.58	29.12	25.94	9.51	1.47
	The Stone Cellar	125.11	88.80	28.40	15.05	8.47	1.30
Delmas	Bazani Primary School	284.30	140.88	62.07	32.20	26.32	2.34
	Kangela Primary School	278.03	163.60	63.96	27.38	23.37	2.40
	Bernice Samuel Hospital	357.03	163.25	60.50	36.20	22.94	2.28
Hendrina	Tsiki Naledi Secondary School	119.93	86.86	34.65	16.84	13.14	1.75
	Maziya Combined School	110.07	91.75	32.86	16.04	13.39	1.71
Grootvlei	Grootvlei	125.71	107.76	24.74	10.89	7.70	1.24
	Laerskool Grootvlei	152.37	103.00	25.90	14.42	7.70	1.25
	Nthoroane Secondary School	85.20	76.10	28.36	12.82	11.16	1.44
OTHER AREAS							
Ogies	Ogies Police Station	1,085.30	515.08	168.02	98.94	55.06	6.00
Phola	Hlangu Phala Primary School	1,757.80	400.83	113.99	83.97	57.75	4.20
	Sibongindawo Primary School	794.89	535.27	126.73	84.36	50.23	4.26
Komati	Blinkpan Primary School	171.61	139.03	49.05	26.12	18.45	2.34
Pullens Hope	Pullens Hope (1)	166.81	102.31	32.55	17.97	14.02	1.71
	Pullens Hope (2)	181.19	103.73	32.10	18.24	13.68	1.70
Rietkuil	Rietkuil	221.77	87.15	23.84	18.76	12.63	1.29
Lothair	Ubhle Bolwazi Secondary School	65.44	55.14	20.08	11.79	10.22	1.03
Warburton	Warburton Combined School	52.38	46.35	19.71	11.77	10.37	0.95
Volkstrust	Volkstrust High School	89.47	49.91	16.84	7.65	5.86	0.90
Bethal	Life Bethal Hospital	206.40	121.22	43.16	18.55	12.95	2.45
Amersfoort	Elsie Ballot Hospital	106.23	65.59	19.33	12.79	7.07	1.14
Belfast	Town of Belfast	119.61	74.07	23.02	16.93	12.20	1.05
SOUTH AFRICA NAAQS				350		125	50
US NAAQS			196				
WHO GUIDELINES³		500			20		

Hotspot	Location	2019 Kendal emissions							
		PM10 24 hr	PM10 24 hr	PM10 24 hr	PM10	PM2.5 24 hr	PM2.5 24 hr	PM2.5 24 hr	PM2.5
		1st high	2nd high	5th high	annual	1st high	5th high	8th high	annual
HOTSPOT AREAS									
Emalaheni	Witbank High School	19.48	15.11	11.62	1.02	14.17	9.40	6.73	0.77
	Duvha Primary School	14.69	12.61	10.48	0.92	10.94	8.02	6.26	0.70
	Laerskool Taalfees	19.32	15.09	11.69	1.02	14.08	9.45	6.70	0.77
	Witbank Hospital	18.88	15.14	11.67	1.01	13.82	9.45	6.79	0.76
	Witbank TB Specialised Hospital	18.86	15.01	11.61	1.01	13.82	8.64	7.79	0.76
	Nancy Shiba Primary School (Vosman)	18.62	15.63	12.27	1.00	13.66	9.27	7.58	0.76
	Empumelweni	18.20	15.07	12.37	1.03	13.34	9.75	7.93	0.77
	W.H. De Klerk Skool	18.11	15.32	10.99	0.98	13.37	8.92	6.66	0.74
	Laerskool Panorama	17.40	15.29	11.14	0.94	12.96	9.09	6.67	0.72
	Laerskool Duvhapark	18.47	14.03	11.08	0.99	13.34	8.03	7.77	0.74
Damelin-Witbank University	20.38	14.89	11.01	1.03	14.66	8.91	7.18	0.77	
Kriel	Kwanala Primary School	14.39	10.90	8.91	1.32	10.65	6.84	5.45	0.93
	Merlin Park Primary School	14.22	11.23	7.41	1.13	10.43	5.60	5.00	0.81
	Sibongamanda Secondary School	15.06	10.73	7.55	1.14	11.01	5.52	5.20	0.82
	Kriel Medical Centre	14.01	11.07	7.40	1.13	10.28	5.58	4.96	0.82
	Ga-Nala Clinic	14.95	11.57	7.35	1.14	10.94	5.74	5.11	0.82
	Laerskool Krielpark	14.29	11.02	7.43	1.21	10.49	5.81	4.96	0.86
Steve Tshwete	Makhathini Primary School	13.43	13.34	8.81	0.72	10.59	6.88	5.56	0.57
	Middelburg Preparatory School	13.45	13.40	8.74	0.71	10.64	6.71	5.53	0.56
	Middelburg Combined School	13.60	13.35	8.60	0.72	10.62	6.60	5.69	0.57
	Life Midmed Hospital	13.55	13.49	8.81	0.72	10.69	6.76	5.60	0.57
	Laerskool Dennesig	13.21	13.14	8.90	0.71	10.47	6.99	5.28	0.56
	Middelburg Hospital	13.70	13.69	8.89	0.74	10.82	6.81	5.67	0.58
	Hoerskool Kanonkop	13.29	13.23	8.69	0.71	10.54	6.88	5.36	0.56
	Laerskool Kanonkop	13.38	13.34	8.73	0.71	10.60	6.76	5.46	0.56
	Steelcrest High School	13.45	13.40	8.75	0.71	10.64	6.71	5.54	0.57
Ermelo	Ermelo Christian School	6.11	4.73	4.25	0.61	4.62	3.45	3.20	0.47
	Lindile Secondary School	6.28	5.36	4.19	0.61	4.72	3.40	3.22	0.48
	Camden Combined School	5.47	4.31	4.05	0.54	4.21	3.30	2.67	0.42
	Mediclinic Ermelo	6.11	4.77	4.20	0.61	4.63	3.41	3.21	0.47
	Ermelo Hospital	6.24	5.19	4.22	0.62	4.70	3.44	3.23	0.48
	Hoerskool Ermelo	6.21	5.08	4.22	0.62	4.68	3.40	3.23	0.48
	Davel Combined School	7.16	6.83	4.72	0.81	5.68	3.83	3.37	0.61
	Camden School	5.57	4.26	4.07	0.55	4.27	3.34	2.82	0.43
	Ermelo Indian Combined School	6.26	5.20	4.22	0.62	4.72	3.42	3.23	0.48
	Lungelo Combined School	5.64	4.94	4.11	0.60	4.36	3.32	3.12	0.46
	Morgenzon Landbou Akademie	8.55	7.97	5.41	0.64	7.12	4.19	3.40	0.50
	Nqobangolwazi Secondary School	8.68	7.94	5.28	0.63	7.21	4.20	3.31	0.49
	New Ermelo Primary School	6.01	4.81	4.18	0.60	4.55	3.41	3.19	0.46
	Umzimvelo Secondary School	5.34	4.75	3.91	0.51	4.06	3.18	2.43	0.40
SOUTH AFRICA NAAQS				75	40		40		20
US NAAQS			150					35	
WHO GUIDELINES³		50			20	25			10

Hotspot	Location	2019 Kendal emissions							
		PM10 24 hr	PM10 24 hr	PM10 24 hr	PM10	PM2.5 24 hr	PM2.5 24 hr	PM2.5 24 hr	PM2.5
		1st high	2nd high	5th high	annual	1st high	5th high	8th high	annual
Secunda	Laerskool Kruinpark	11.60	9.14	8.07	0.89	9.16	5.50	4.02	0.66
	Laerskool Secunda	11.77	9.43	7.42	0.87	9.33	5.64	3.98	0.65
	Evander Hospital - Arv Clinic	12.61	9.84	6.94	0.89	10.03	5.70	4.14	0.66
	Highveld Mediclinic Pediatric Ward	11.71	9.13	7.55	0.92	9.23	5.18	4.26	0.68
	Mediclinic Secunda	11.82	9.58	7.06	0.86	9.39	5.45	3.90	0.64
	Sasol Recreation Club	11.60	9.54	6.95	0.83	9.25	5.40	3.69	0.62
	Highveld Park High School	11.69	9.22	7.89	0.88	9.25	5.59	4.06	0.65
	Hoerskool Secunda	11.69	9.41	7.37	0.86	9.28	5.64	3.92	0.64
	Hoerskool Oosterland	11.58	9.14	8.00	0.87	9.17	5.58	4.00	0.64
	Thomas Nhlabathi Secondary School	12.25	8.86	6.60	0.77	9.78	5.44	4.06	0.57
	Vukuzithathe Primary School	11.83	8.08	6.09	0.75	9.47	4.99	3.92	0.56
	Ki Twala Secondary School	11.86	9.04	6.16	0.75	9.49	5.36	3.96	0.56
	Allan Makunga Primary School	12.19	8.38	6.46	0.77	9.73	4.73	4.01	0.57
	Kinross	13.13	9.87	8.48	0.97	10.41	6.91	4.36	0.71
Leandra	15.06	14.42	7.60	0.90	11.78	5.42	4.06	0.66	
Ekurhuleni	Ekurhuleni School For The Deaf	9.81	8.11	3.72	0.43	8.63	3.26	2.17	0.33
	Albertyn High School	9.63	7.74	3.87	0.45	8.45	3.32	2.37	0.34
	Laerskool Eloff	9.63	8.71	7.74	0.76	7.82	5.61	4.24	0.56
	Life Springs Parkland Hospital	9.62	9.09	5.75	0.56	7.96	4.56	3.31	0.43
	Lifeline Ekurhuleni	8.61	8.39	5.07	0.54	7.40	4.33	3.18	0.40
	Tambo Memorial Hospital	8.64	8.46	4.96	0.50	7.62	3.85	2.90	0.38
	Thelle Mogoerane Hospital	9.51	8.60	3.89	0.44	8.38	3.10	2.08	0.34
	Tembisa Hospital	7.07	6.91	5.15	0.46	5.80	4.00	3.22	0.35
	Sasolburg High School	8.77	4.03	2.80	0.28	7.75	2.30	1.74	0.22
	Theha Setjhaba Primary School (Zamdela)	8.29	3.50	2.79	0.29	7.34	2.13	1.88	0.23
	Credo Primary School (Zamdela)	8.27	3.61	2.93	0.30	7.32	2.08	1.90	0.23
	Vaalpark Hospital	9.08	4.28	2.77	0.29	8.02	2.36	1.68	0.23
	Mediclinic Emfuleni	9.76	5.13	3.06	0.30	8.61	2.37	1.70	0.24
	Mediclinic Vereeniging	9.91	4.99	2.81	0.32	8.74	2.41	1.67	0.25
	Riverside High School (Three Rivers)	9.75	5.41	2.89	0.33	8.62	2.16	1.91	0.26
	Hoerskool DR Malan (Meyerton)	10.47	6.08	3.55	0.35	9.22	2.49	2.15	0.28
	Ratanda Secondary School	8.81	8.60	3.88	0.46	7.77	3.23	2.79	0.35
	Heidelberg Day Hospital	9.10	9.09	4.06	0.48	7.99	3.29	2.83	0.37
	Hoërskool John Vorster (Nigel)	10.09	9.82	4.93	0.54	8.49	3.23	3.06	0.41
	Pholosong Hospital (Tsakane)	9.61	9.28	4.61	0.52	8.15	3.34	2.42	0.39
	Brakpan Primary School	9.22	8.84	5.57	0.57	7.77	4.35	3.33	0.43
	Brandwag Hoerskool (Airfield)	8.61	8.28	5.25	0.54	7.31	4.36	3.18	0.41
	Sibonelo Primary School (Daveyton)	8.73	7.91	6.21	0.59	7.16	4.32	3.78	0.44
	Thembelihle Primary School (Emaphupheni)	8.63	8.10	6.87	0.63	7.09	5.02	3.95	0.47
	South Rand Hospital (Johannesburg South)	9.66	7.78	4.69	0.47	8.45	3.27	2.68	0.35
	Afrikaanse Hoerskool Germiston	8.99	8.62	4.35	0.48	7.92	3.29	2.52	0.36
	Milpark Hospital (Johannesburg)	8.88	6.78	5.05	0.43	7.79	3.38	3.12	0.33
	Thulani Primary School (Soweto)	10.07	5.68	4.15	0.36	8.74	2.64	2.48	0.27
	Arwyp Medical Centre (Kempton Park)	7.85	7.78	4.98	0.50	6.71	3.64	2.98	0.38
	Hoerskool Birchleigh	7.45	7.00	5.36	0.47	6.21	3.87	3.13	0.36
Tembisa West Secondary School	7.00	6.59	4.78	0.43	5.84	3.70	2.77	0.33	
Pretoria Heart Hospital	7.67	6.59	5.02	0.36	6.22	4.17	3.02	0.28	
SOUTH AFRICA NAAQS				75	40		40		20
US NAAQS			150					35	
WHO GUIDELINES³		50			20	25			10

Hotspot	Location	2019 Kendal emissions							
		PM10 24 hr	PM10 24 hr	PM10 24 hr	PM10	PM2.5 24 hr	PM2.5 24 hr	PM2.5 24 hr	PM2.5
		1st high	2nd high	5th high	annual	1st high	5th high	8th high	annual
Lekwa	Laerskool Jeugkrug	8.19	7.16	5.47	0.57	6.99	3.87	3.37	0.44
	Standerton Primary School	8.17	7.09	5.32	0.57	6.97	3.97	3.33	0.44
	Thobelani Secondary School	7.87	6.92	5.86	0.57	6.76	4.40	3.38	0.44
	Standerton Provincial Government Hospital	8.09	7.03	5.46	0.57	6.91	3.95	3.32	0.44
	Thuthukani	10.57	7.65	4.50	0.65	8.73	3.62	3.30	0.50
	Ulwazi Primary School	10.58	7.66	4.48	0.65	8.74	3.61	3.30	0.50
	Standerton Tb Hospital	7.82	6.78	5.73	0.55	6.71	4.19	3.30	0.43
	Jandrell Secondary School	7.84	6.86	5.82	0.57	6.73	4.38	3.36	0.44
Balfour	Gekombineerde Skool Balfour	12.06	10.38	4.80	0.55	9.76	3.83	2.55	0.42
	Bonukukhanya Primary	12.37	10.71	5.00	0.57	9.97	3.87	2.58	0.43
	Dr Nieuwoudt and Dr Kok	12.12	10.36	4.82	0.56	9.77	3.82	2.55	0.42
	The Stone Cellar	10.30	9.59	4.22	0.50	8.72	3.50	2.71	0.39
Delmas	Bazani Primary School	13.36	11.65	9.83	0.86	9.29	6.73	5.64	0.62
	Kangela Primary School	10.57	10.52	8.29	0.85	8.40	5.88	5.33	0.62
	Bernice Samuel Hospital	10.38	9.51	8.43	0.81	8.33	6.59	4.75	0.59
Hendrina	Tsiki Naledi Secondary School	9.14	7.20	5.97	0.75	7.17	4.71	4.16	0.58
	Maziya Combined School	8.30	7.19	6.16	0.74	6.55	4.66	4.24	0.57
Grootvlei	Grootvlei	8.32	7.48	4.59	0.48	6.73	3.72	2.59	0.37
	Laerskool Grootvlei	8.15	7.16	4.90	0.49	6.59	3.81	2.39	0.37
	Nthoroane Secondary School	10.65	7.79	5.29	0.56	8.46	4.52	2.96	0.43
OTHER AREAS									
Ogies	Ogies Police Station	19.10	18.94	15.60	1.70	14.21	11.08	8.99	1.17
Phola	Hlangu Phala Primary School	24.57	23.87	18.86	1.39	16.87	12.08	9.93	0.99
	Sibongindawo Primary School	25.26	23.10	18.20	1.43	17.22	13.65	11.20	1.03
Komati	Blinkpan Primary School	13.39	8.47	7.44	0.91	10.07	5.42	5.23	0.68
Pullens Hope	Pullens Hope (1)	9.73	9.15	6.64	0.78	7.51	5.74	4.97	0.60
	Pullens Hope (2)	9.74	9.18	6.70	0.78	7.52	5.79	5.02	0.60
Rietkuil	Rietkuil	10.62	9.12	6.71	0.66	8.22	5.16	3.95	0.52
Lothair	Ubuhle Bolwazi Secondary School	5.48	4.95	4.16	0.47	4.34	3.41	2.66	0.37
Warburton	Warburton Combined School	5.38	5.32	4.35	0.46	4.40	3.40	3.03	0.37
Volksrust	Volksrust High School	6.29	4.48	2.95	0.39	5.19	2.59	2.20	0.31
Bethal	Life Bethal Hospital	9.73	7.97	5.65	0.86	7.84	4.42	3.90	0.64
Amersfoort	Elsie Ballot Hospital	7.17	5.58	4.76	0.49	5.72	3.62	2.59	0.39
Belfast	Town of Belfast	8.31	7.98	6.76	0.59	6.70	5.74	4.56	0.47
SOUTH AFRICA NAAQS				75	40		40		20
US NAAQS			150					35	
WHO GUIDELINES³		50			20	25			10

Hotspot	Location	2019 Kendal emissions			
		NO2 1 hr 1st high	NO2 1 hr 8th high	NO2 1 hr 89th high	NO2 annual
HOTSPOT AREAS					
Emalaheni	Witbank High School	94.62	51.42	13.61	0.54
	Duvha Primary School	52.99	39.05	11.42	0.47
	Laerskool Taalfees	92.52	48.67	13.31	0.53
	Witbank Hospital	86.26	44.72	12.94	0.53
	Witbank TB Specialised Hospital	62.25	34.80	13.99	0.49
	Nancy Shiba Primary School (Vosman)	64.60	41.44	13.13	0.48
	Empumelweni	93.71	52.16	13.99	0.54
	W.H. De Klerk Skool	76.42	47.07	12.16	0.48
	Laerskool Panorama	64.81	40.09	11.12	0.43
	Laerskool Duvhapark	91.46	48.82	14.11	0.54
	Damelin-Witbank University	95.07	64.53	13.34	0.57
	Kriel	Kwanala Primary School	95.96	53.05	28.40
Merlin Park Primary School		56.63	39.79	21.96	0.94
Sibongamandla Secondary School		63.21	52.82	21.83	0.93
Kriel Medical Centre		60.27	40.43	22.22	0.95
Ga-Nala Clinic		53.99	38.61	22.04	0.96
Laerskool Krielpark		68.95	45.48	23.80	1.07
Steve Tshwete	Makhathini Primary School	34.97	18.22	5.12	0.22
	Middelburg Preparatory School	31.23	21.85	5.13	0.21
	Middelburg Combined School	38.68	21.49	5.24	0.23
	Life Midmed Hospital	32.11	22.54	5.15	0.22
	Laerskool Dennesig	33.71	21.05	4.68	0.21
	Middelburg Hospital	33.99	23.17	6.10	0.24
	Hoerskool Kanonkop	31.68	23.38	4.63	0.21
	Laerskool Kanonkop	31.96	23.29	4.88	0.21
	Steelcrest High School	31.32	22.52	5.11	0.21
Ermelo	Ermelo Christian School	35.32	18.77	6.69	0.32
	Lindile Secondary School	34.95	18.39	6.19	0.30
	Camden Combined School	24.02	14.95	5.66	0.25
	Mediclinic Ermelo	37.63	18.76	6.53	0.31
	Ermelo Hospital	35.64	18.13	6.48	0.31
	Hoerskool Ermelo	36.46	18.73	6.61	0.31
	Davel Combined School	43.39	26.30	10.20	0.50
	Camden School	26.27	15.30	5.78	0.26
	Ermelo Indian Combined School	37.67	18.20	6.56	0.31
	Lungelo Combined School	21.54	15.54	6.95	0.31
	Morgenzon Landbou Akademie	30.18	20.87	7.34	0.37
	Nqobangolwazi Secondary School	32.19	20.81	7.19	0.36
	New Ermelo Primary School	28.23	19.07	6.04	0.30
	Umzimvelo Secondary School	18.36	12.42	4.80	0.22
SOUTH AFRICA NAAQS				200	40
US NAAQS			188		
WHO GUIDELINES³		200		40	

Hotspot	Location	2019 Kendal emissions			
		NO2 1 hr 1st high	NO2 1 hr 8th high	NO2 1 hr 89th high	NO2 annual
Secunda	Laerskool Kruinpark	125.56	39.92	15.52	0.73
	Laerskool Secunda	148.15	42.63	15.53	0.73
	Evander Hospital - Arv Clinic	104.59	33.32	17.59	0.77
	Highveld Mediclinic Pediatric Ward	106.18	39.03	16.92	0.78
	Mediclinic Secunda	152.94	40.40	15.11	0.71
	Sasol Recreation Club	156.62	35.60	14.16	0.67
	Highveld Park High School	137.41	40.62	15.84	0.73
	Hoerskool Secunda	149.54	43.16	15.30	0.71
	Hoerskool Oosterland	135.25	41.11	15.99	0.72
	Thomas Nhlabathi Secondary School	52.66	31.80	14.63	0.60
	Vukuzithathe Primary School	46.24	31.49	13.91	0.58
	Ki Twala Secondary School	52.56	30.96	13.74	0.58
	Allan Makunga Primary School	51.02	31.07	14.46	0.61
	Kinross	171.20	42.44	18.33	0.88
	Leandra	58.54	41.99	18.43	0.76
Ekurhuleni	Ekurhuleni School For The Deaf	37.71	21.56	8.01	0.28
	Alberton High School	50.17	27.09	9.18	0.31
	Laerskool Eloff	78.43	45.12	16.46	0.59
	Life Springs Parkland Hospital	54.18	33.60	11.23	0.39
	LifeLine Ekurhuleni	93.50	38.48	10.25	0.38
	Tambo Memorial Hospital	68.91	32.13	9.50	0.35
	Thelle Mogoerane Hospital	30.75	24.20	7.93	0.28
	Tembisa Hospital	44.33	25.84	7.09	0.25
	Sasolburg High School	29.38	16.72	4.95	0.17
	Theha Setjhaba Primary School (Zamdela)	32.86	19.66	5.53	0.20
	Credo Primary School (Zamdela)	31.81	19.85	5.90	0.21
	Vaalpark Hospital	30.44	17.05	5.08	0.18
	Mediclinic Emfuleni	33.11	17.99	5.15	0.18
	Mediclinic Vereeniging	22.77	18.72	5.21	0.19
	Riverside High School (Three Rivers)	40.77	18.34	5.92	0.20
	Hoerskool DR Malan (Meyerton)	32.21	20.03	6.16	0.21
	Ratanda Secondary School	36.83	23.24	8.46	0.30
	Heidelberg Day Hospital	53.47	21.93	9.11	0.32
	Hoërskool John Vorster (Nigel)	54.98	22.62	9.92	0.37
	Pholosong Hospital (Tsakane)	38.55	27.24	9.80	0.35
	Brakpan Primary School	62.40	32.36	12.59	0.41
	Brandwag Hoerskool (Airfield)	87.66	37.01	10.55	0.38
	Sibonelo Primary School (Daveyton)	63.59	30.08	10.80	0.38
	Thembelihle Primary School (Emaphupheni)	88.15	28.48	11.14	0.40
	South Rand Hospital (Johannesburg South)	67.41	30.31	10.19	0.36
	Afrikaanse Hoerskool Germiston	66.92	32.61	9.94	0.35
	Milpark Hospital (Johannesburg)	76.49	30.76	8.65	0.29
	Thulani Primary School (Soweto)	63.34	23.20	6.26	0.21
	Arwyp Medical Centre (Kempton Park)	60.88	27.46	9.16	0.32
	Hoerskool Birchleigh	76.46	24.30	8.14	0.27
Tembisa West Secondary School	60.34	22.67	6.91	0.23	
Pretoria Heart Hospital	85.24	18.67	3.00	0.13	
SOUTH AFRICA NAAQS				200	40
US NAAQS			188		
WHO GUIDELINES³		200			40

Hotspot	Location	2019 Kendal emissions			
		NO2 1 hr 1st high	NO2 1 hr 8th high	NO2 1 hr 89th high	NO2 annual
Lekwa	Laerskool Jeugkrug	24.92	21.20	8.37	0.35
	Standerton Primary School	24.46	21.16	8.25	0.35
	Thobelani Secondary School	26.63	19.67	8.36	0.35
	Standerton Provincial Government Hospital	23.88	21.54	8.40	0.35
	Thuthukani	30.32	21.93	9.97	0.42
	Ulwazi Primary School	29.88	21.80	9.83	0.42
	Standerton Tb Hospital	26.12	19.22	7.75	0.32
	Jandrell Secondary School	26.24	19.27	8.10	0.34
Balfour	Gekombineerde Skool Balfour	33.98	23.41	9.60	0.37
	Bonukukhanya Primary	37.61	24.25	9.93	0.40
	Dr Nieuwoudt and Dr Kok	33.99	24.41	9.71	0.38
	The Stone Cellar	38.83	23.33	9.38	0.34
Delmas	Bazani Primary School	90.26	42.26	17.70	0.60
	Kangela Primary School	85.17	44.63	18.85	0.63
	Bernice Samuel Hospital	108.53	45.14	15.87	0.60
Hendrina	Tsiki Naledi Secondary School	36.56	22.22	8.99	0.37
	Maziya Combined School	33.39	23.18	9.12	0.36
Grootvlei	Grootvlei	54.37	21.08	8.10	0.31
	Laerskool Grootvlei	53.64	22.33	8.32	0.32
	Nthoroane Secondary School	45.83	23.78	9.61	0.37
OTHER AREAS					
Ogies	Ogies Police Station	392.57	145.29	53.10	1.72
Phola	Hlangu Phala Primary School	664.32	100.32	33.51	1.12
	Sibongindawo Primary School	317.20	109.72	32.01	1.09
Komati	Blinkpan Primary School	58.93	38.18	13.73	0.54
Pullens Hope	Pullens Hope (1)	47.27	26.05	7.78	0.35
	Pullens Hope (2)	51.54	26.11	8.04	0.35
Rietkuil	Rietkuil	53.31	18.88	5.63	0.24
Lothair	Ubuhle Bolwazi Secondary School	22.02	12.27	4.70	0.19
Warburton	Warburton Combined School	14.80	10.94	4.20	0.17
Volksrust	Volksrust High School	19.67	13.47	4.95	0.19
Bethal	Life Bethal Hospital	63.16	28.69	12.33	0.59
Amersfoort	Elsie Ballot Hospital	20.59	15.28	5.70	0.24
Belfast	Town of Belfast	32.10	18.18	5.18	0.19
SOUTH AFRICA NAAQS				200	40
US NAAQS			188		
WHO GUIDELINES³		200			40

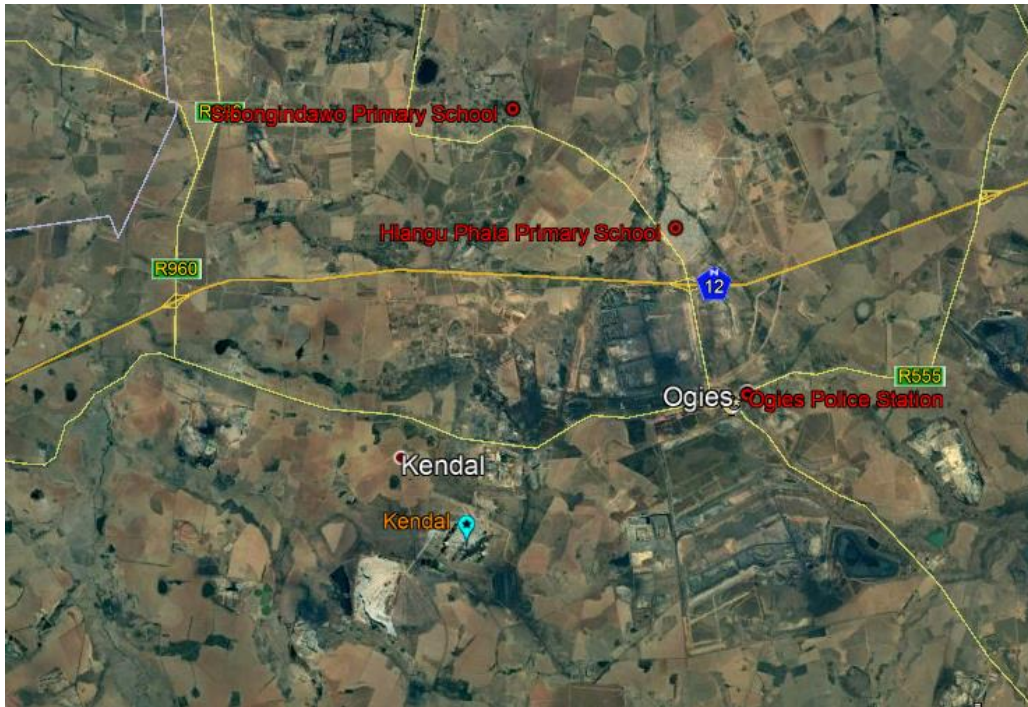


Figure 1. Sensitive Receptors Near Kendal Power Station

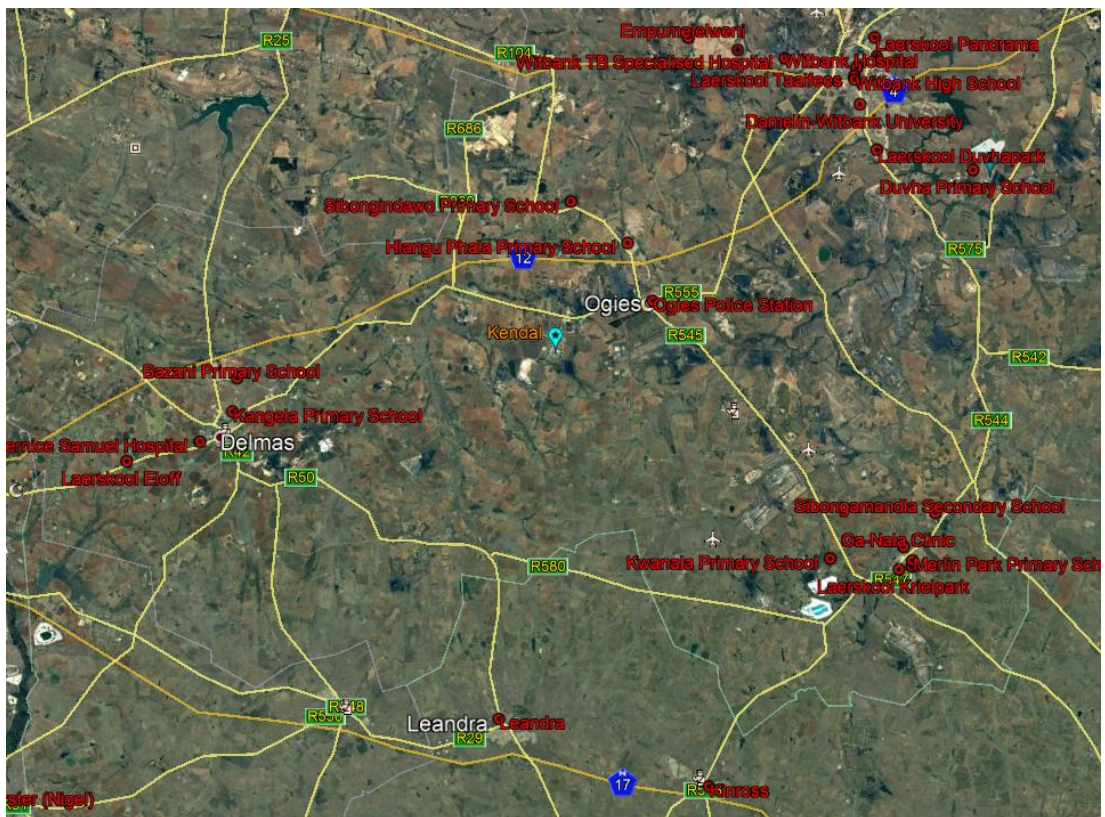



Figure 2. Sensitive Receptors Impacted by the Kendal Power Station



Dr. H. Andrew Gray

22 April 2020

Date