Eskom

RESEARCH, TESTING AND DEVELOPMENT

SUSTAINABILITY DEPARTMENT

EZAMOKUHLE AIR QUALITY MONTHLY REPORT

SEPTEMBER 2016

EXECUTIVE SUMMARY

This monthly report covers the ambient air quality data as monitored at Ezamokuhle monitoring site in September 2016.

There was one exceedance of the $PM_{2.5}$ daily limit of 40 µg/m^3, two hundred and fifty one (251) exceedances of O_3 8-hour moving average limit of 61ppb and no exceedances recorded for other parameters monitored (Table 3) at Ezamokuhle during the September 2016 monitoring period. There is already non-compliance with the daily PM_{10}, daily $PM_{2.5}$ and 8-hourly ozone ambient standards at this site for 2016.

PM_{10} and $PM_{2.5}$ ambient concentrations are influenced by low level sources while NO_2 ambient concentrations are also influenced predominantly by low level sources, as depicted in the diurnal variation graphs.

The dominant wind directions during the day time were east-north-east, east, west, west-north-west and north-west. During the night, the most frequent directions were east, south-south-west, north-west and north-north-west.

The overall percentage data recovered from the monitoring station was 99.5% and the overall station availability was 99.6%. The data losses for September were due to zero/span checks during routine site servicing.

DISCLAIMER

1. INTRODUCTION

At the request of Environmental Management's Offset project team, the Research, Testing and Development (RT&D) air quality monitoring team, commissioned an ambient air quality monitoring station at Ezamokuhle Township (Amersfoort). Ambient monitoring results measured at Ezamokuhle are presented in this report and are compared to the National Ambient Air Quality Standards.

The Ezamokuhle monitoring station is equipped to continuously monitor ambient concentrations of sulphur dioxide, oxides of nitrogen, ozone and fine particulate matter of particulate size <10µm and 2.5µm in diameter (PM_{10} and $PM_{2.5}$). In addition, meteorological parameters of wind

velocity, wind direction, ambient temperature, humidity, rainfall and solar radiation are also recorded.

Standard Specifications, Equipment/Techniques used for the measurement of SO_2, O_3 and NOx conform to US-EPA equivalent method No EQSA-0486-060, EQOA-0880-047 and RFNA-1289-074 respectively.

2. SITE LOCATION

The Ezamokuhle monitoring site is located ±13.7km north-north-east of Majuba power station (Figure 1). It is situated centrally in Ezamokuhle Township, at Hlelimfundo High School at co-ordinates -26.997571, 29.850086. The monitoring site's main objective is to determine the background concentrations of pollutants measured at the site for Offsets intervention project.

Figure 1: Ezamokuhle air quality monitoring site (Amersfoort) in relation to Majuba power station

3. DATA RECOVERY

The South African National Accreditation System (SANAS) guideline figure of 90% data availability per parameter monitored is used as a standard for representative data capture. This describes the required completeness of data set for the reporting of averages and is based on standard arithmetic calculations. The completeness calculations for data sets exclude zero and span data and times where service and/or maintenance is being conducted on the instruments in question.

Availability is a management definition related to system reliability. The availability target is not set in terms of data quality criteria and has no associated quality objectives. A target of 100% availability has been set for performance evaluation. Availability is reported as a measure of the percentage of time that electrical power was available to the monitoring station.

Table 1 shows the percentage data recovered, for each parameter monitored, during the reporting period.

Table 1: Percentage data recovered per parameter for September 2016

NO_1	NO_2	NO_X	OZN	PRS	RAD	RFL	SGT	SO2	TMP	WDR	WSP	WVL	PM2.5	PM10	HUM	Data Rec	Station Avail
98.9	98.9	98.9	99.0	100	100	100	100	98.9	100	99.7	100	99.7	99.3	99.3	100	99.5	99.6

The overall percentage data recovered from the monitoring station during the period was 99.5% (Table 1) and the overall monitoring station availability was 99.6%.

4. SUMMARY OF RESULTS FOR REPORTED PERIOD

Table 3 is a summary report presenting highest mean concentrations and the number of exceedances above the respective National Ambient Air Quality Standards limits as presented in Table 2.

Note: PM_{10} and $PM_{2.5}$ are monitored, using Beta gauge (Beta-attenuation using a C-14 source).

Table 2: National Ambient Air Quality Standards.

Pollutant	Unit	Period	Limit	Number of annual exceedances allowed	Source
Carbon Monoxide	ppm	1hr	26	88	DEA
Carbon Monoxide	ppm	8hr	8.7	11	DEA
($PM\text{-}_{10}$) by Beta gauge	$\mu g/m^3$	24hr	75	4	DEA
($PM\text{-}_{10}$) by Beta gauge	$\mu g/m^3$	1year	40	0	DEA
($PM\text{-}_{2.5}$) by Beta gauge	$\mu g/m^3$	24hr	40	4	DEA
($PM\text{-}_{2.5}$) by Beta gauge	$\mu g/m^3$	1year	20	0	DEA
Nitrogen dioxide	ppb	1year	21	0	DEA
Nitrogen dioxide	ppb	1hr	106	88	DEA
Ozone	ppb	8hr	61	11.	DEA
Sulphur dioxide	ppb	1hr	134	88	DEA
Sulphur dioxide	ppb	10min	191	526	DEA
Sulphur dioxide	ppb	24hr	48	4	DEA
Sulphur dioxide	ppb	1year	19	0	DEA

Table 3: Summary report of parameters monitored at Ezamokuhle in September 2016

Pollutant	Highest Hourly Mean	No of Hourly National Limit Exceedances	Highest Daily Mean	No of Daily National Limit Exceedances	No of 8hr Moving Average Limit	Highest 10min Mean	No of 10min National Limit Exceedances
FPM (PM-2.5) by Beta gauge [ug/m^3]	283.4		50.8	1		536.6	
FPM (PM-10) by Beta gauge [ug/m^3]	136.2		28.1	0		229.9	
Nitric oxide [ppb]	45.		4.6			77.	
Nitrogen dioxide [ppb]	54.1	0	14.2			59.6	
Nitrogen oxide [ppb]	98.7		17.2			127.7	
Ozone [ppb]	138.8		80.7		251	142.8	
Sigma theta [deg]	46.5		21.9			75.8	
Sulphur dioxide [ppb]	74.8	0	13.8	0		114.2	0
Ambient temperature [deg C]	30.5		20.7			30.7	
Wind speed [m/s]	9.6		6.4			11.3	
Wind velocity [m/s]	9.2		6.3			11.2	

There was one exceedance of the $PM_{2.5}$ daily limit of 40 µg/m^3, two hundred and fifty one (251) exceedances of O_3 8-hour moving average limit of 61ppb and no exceedances recorded for other parameters monitored (Table 3) at Ezamokuhle during the September 2016 monitoring period.

Table 4: Exceedances above the national ambient air quality limits

$PM_{2.5}$ daily exceedances					
Pollutant	**Limit**	**Year**	**Month**	**Day**	**Conc. (µg/m^3)**
$PM_{2.5}$	40	2016	09	01	50.8

5. METEOROLOGICAL OBSERVATIONS

Figure 2 shows the daytime and night-time wind roses for the reporting period. The centre of the wind rose depicts the position of the air quality monitoring station. The positions of the spokes in the polar diagram represent directions from which the wind was blowing. The length of the segment indicates the percentage of the time the wind blew from that direction and the speed in the various categories are denoted by colours and width.

The dominant wind directions during the day time were east-north-east, east, west, west-north-west and north-west. During the night, the most frequent directions were east, south-south-west, north-west and north-north-west.

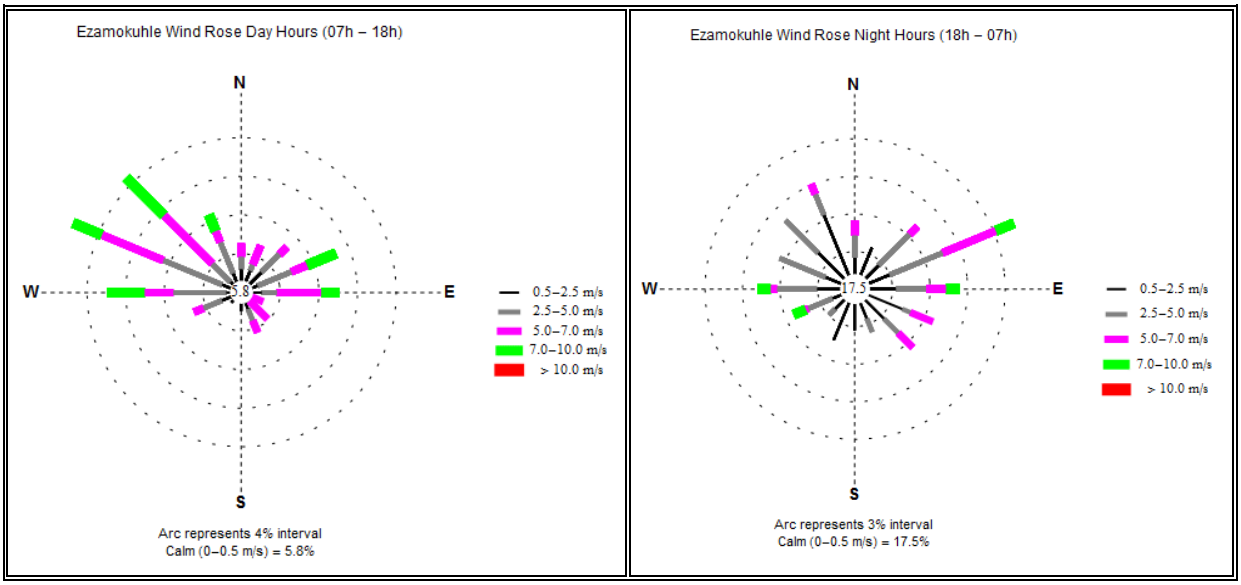

Figure 2: Day and night time wind roses at Kriel village monitoring site

6. DISCUSSION OF POLLUTANTS

Emissions of primary pollutants such as PM_{10}, SO_2, and NO_X from typical low level sources such as domestic combustion and motor vehicles are expected to impact at ground level more significantly during the evening and morning hours as a result of temperature inversion. Emissions of such pollutants from tall stacks (power stations and other industries), are expected to have more significant impacts at ground level during the day, due to atmospheric turbulence influences. O_3 and other oxidants are formed in polluted atmospheres as a result of a wide variety of photochemical reactions as a result a gradual increase of O_3 throughout the day is expected, peaking at mid-afternoon and then decaying once more during the night.

6.1. Fine Particulate Matter (PM_{10}).

6.1.1. Source identification by PM_{10} diurnal variations.

Figure 3 shows the diurnal variation of PM_{10} concentrations. Hourly average PM_{10} concentrations show a major peak at 13:00 during the day. The concentrations are lower in the early morning hours and late evening hours. The high concentration peak at 13:00 during the day is typically expected as a result of contributions from tall stack emitters. Concentration peaks observed at 09:00 in the morning and 20:00 in the evening are as a result from emissions from low level sources.

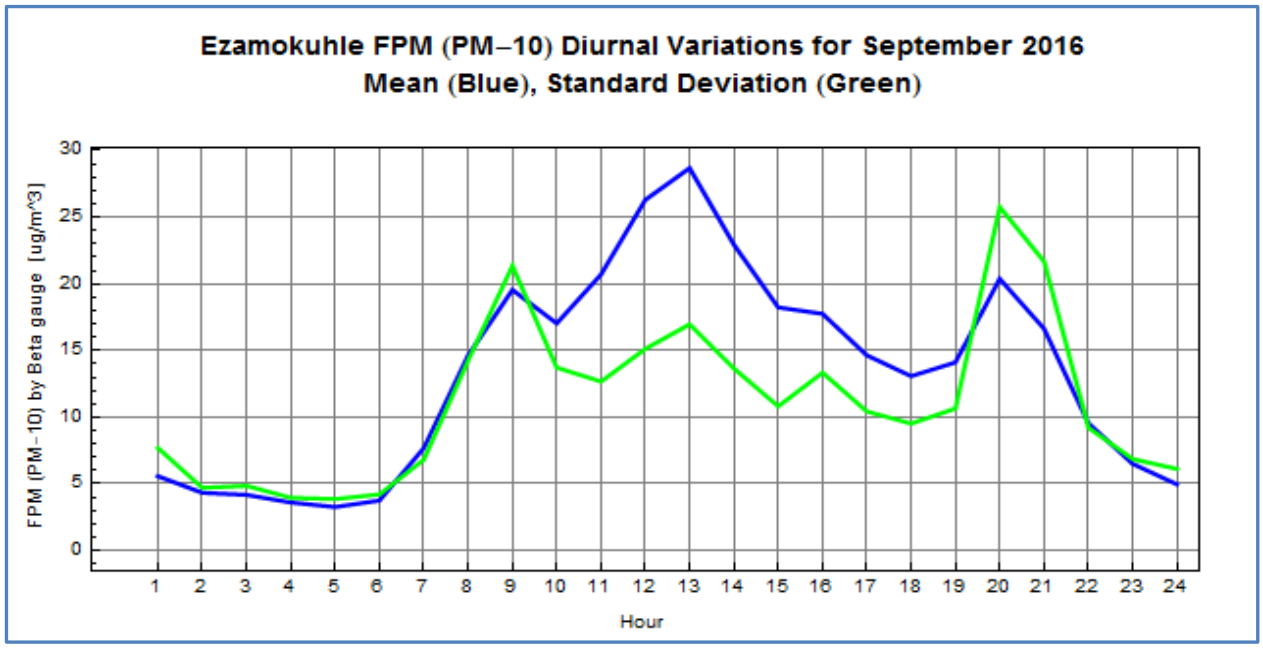

Figure 3: PM_{10} Diurnal variations (Mean concentrations = Blue line, Standard Deviation = Green line).

6.1.2. PM_{10} hourly mean event roses and tables.

Since there is no national hourly limit for PM_{10}; the hourly 98th percentile daytime and night-time event roses are presented in Figure 4 to identify the wind sectors from which the highest concentrations are derived.

The most dominant hourly mean concentrations during daytime period were recorded from east-north-east, south-east, west, west-north-west and north-west sectors. The most dominant hourly mean concentrations during night time period were recorded from north-east, east, south-east, south-south-west, south-west, west-south-west and west sectors. Major roads and other activities at Ezamokuhle Township around the monitoring site might be impacting the PM_{10} ambient concentrations.

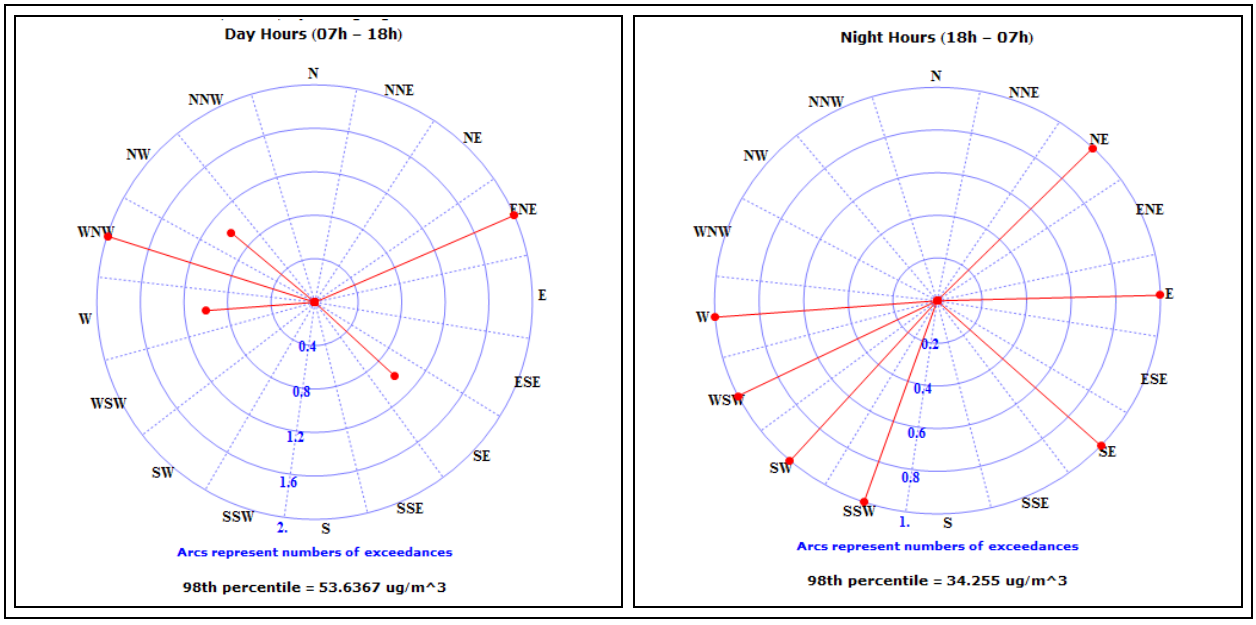

Figure 4: PM_{10} hourly mean 98th percentile event roses during day and night times

Table 5: PM_{10} daytime hourly mean 98th percentile event table

Dir.	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Eve.	0	0	0	2	0	0	1	0	0	0	0	0	1	2	1	0
%	0	0	0	28.57	0	0	14.29	0	0	0	0	0	14.29	28.57	14.29	0

Table 6: PM_{10} night-time hourly mean 98th percentile event table

Dir.	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Eve.	0	0	1	0	1	0	1	0	0	1	1	1	1	0	0	0
%	0	0	14.29	0	14.29	0	14.29	0	0	14.29	14.29	14.29	14.29	0	0	0

6.2. Fine Particulate Matter ($PM_{2.5}$).

6.2.1. Source identification by $PM_{2.5}$ diurnal variations

Figure 5 shows the diurnal variation of $PM_{2.5}$ concentrations with elevated concentrations during the early hours of the morning and higher concentrations during the evening hours. The concentrations depict decreasing levels from 09:00 in the morning till 17:00 and begin to increase from 18:00 until evening peak is reached at 20:00. Elevated concentrations in the mornings and evenings indicate typical contribution by low level sources.

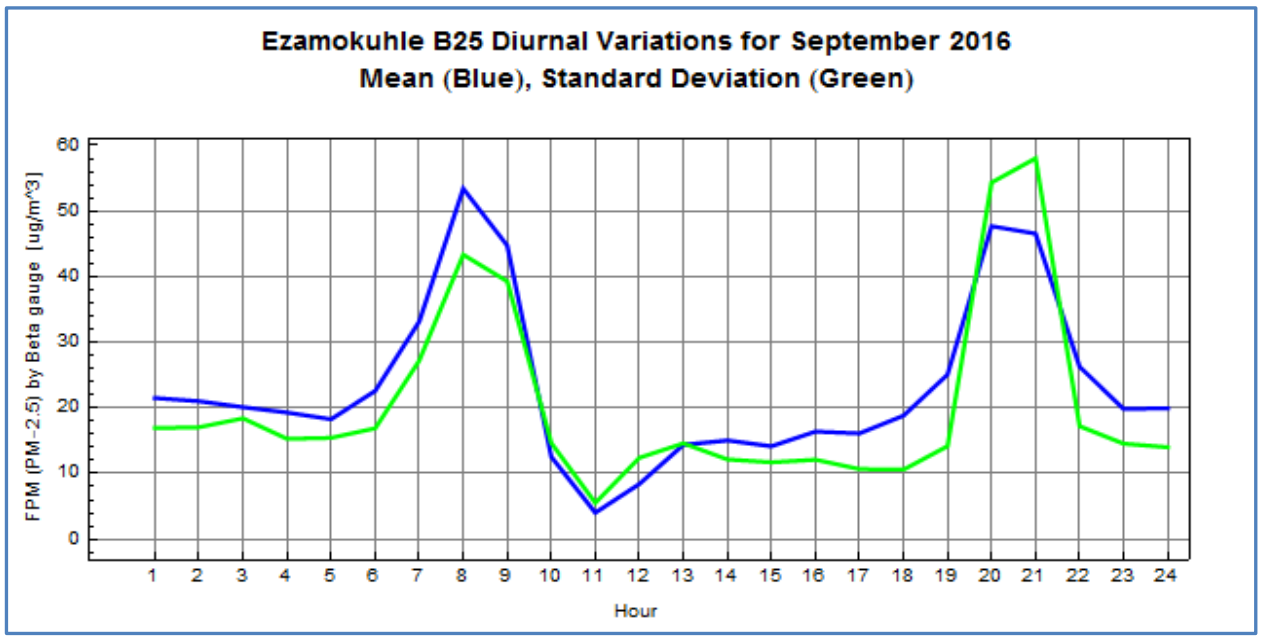

Figure 5: $PM_{2.5}$ Diurnal variations (Mean concentrations = Blue line, Standard Deviation = Green line).

6.2.2. $PM_{2.5}$ hourly mean event roses and tables.

Since there is no national hourly limit for $PM_{2.5}$; the hourly 98th percentile daytime and night-time event roses are presented in Figure 6 to identify the wind sectors from which the highest concentrations are derived.

The most dominant hourly mean concentrations during daytime period were recorded from north, east-north-east, south, west-north-west and north-north-west sectors. The most dominant hourly mean concentrations during night time period were north-east, east, south-east, south-west, west and north-north-west sectors.

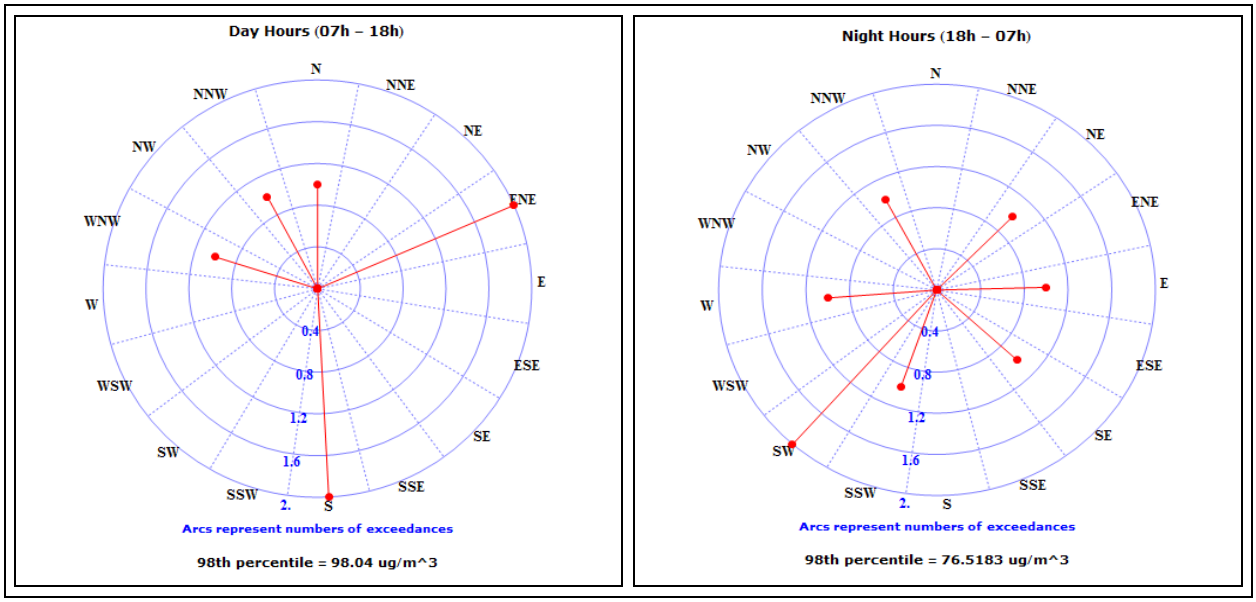

Figure 6: $PM_{2.5}$ hourly mean 98th percentile event roses during day and night times

Table 7: $PM_{2.5}$ daytime hourly mean 98th percentile event table

Dir.	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Eve.	1	0	0	2	0	0	0	0	2	0	0	0	0	1	0	1
%	14.29	0	0	28.57	0	0	0	0	28.57	0	0	0	0	14.29	0	14.29

Table 8: $PM_{2.5}$ night-time hourly mean 98th percentile event table

Dir.	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Eve.	0	0	1	0	1	0	1	0	0	1	2	0	1	0	0	1
%	0	0	12.5	0	12.5	0	12.5	0	0	12.5	25	0	12.5	0	0	12.5

6.2. Sulphur Dioxide (SO_2)

6.2.1. Source identification by SO_2 diurnal variations.

The SO_2 hourly mean diurnal variation is presented in Figure 7. The diurnal variation shows an increase in SO_2 concentrations during the daytime hours with maximum peak observed at 11:00. This diurnal variation indicates emissions from tall stack sources that probably have influence on the concentrations observed throughout the day.

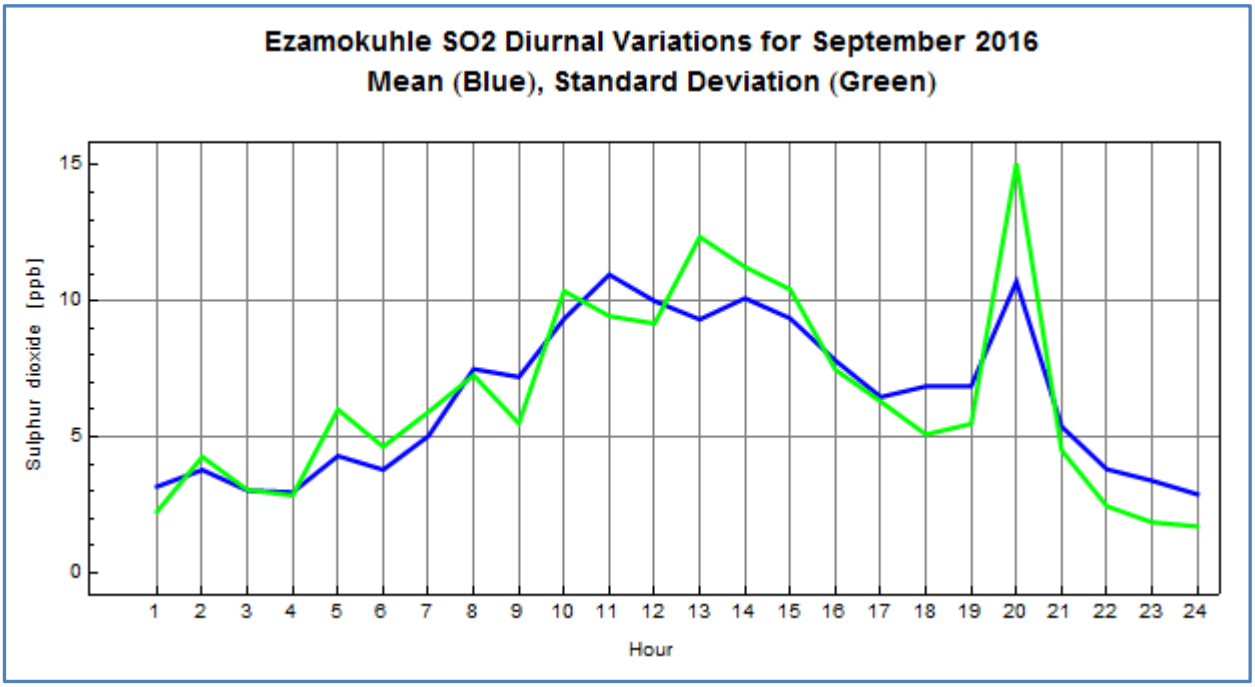

Figure 7: SO_2 diurnal variations (.Mean concentrations = Blue line, Standard Deviation = Green line).

6.2.2. SO_2 hourly mean event roses and tables.

Figure 8 presents the SO_2 98th percentile SO_2 event roses during the day and night-time. The most dominant hourly mean concentrations above 37.26ppb (98th percentile value) during the day time period were recorded from north, west-south-west, west-north-west, north-west and north-north-west sectors. Tutuka power station is located 55km north-west of the monitoring station. It is probable that this source could have an impact on the recorded SO_2 ambient concentrations. The most dominant hourly mean concentrations above 21.40ppb (98th percentile value) during night time period were recorded from north, north-east, east-north-east, east-south-east, south-east, south-south-west and north-west sector.

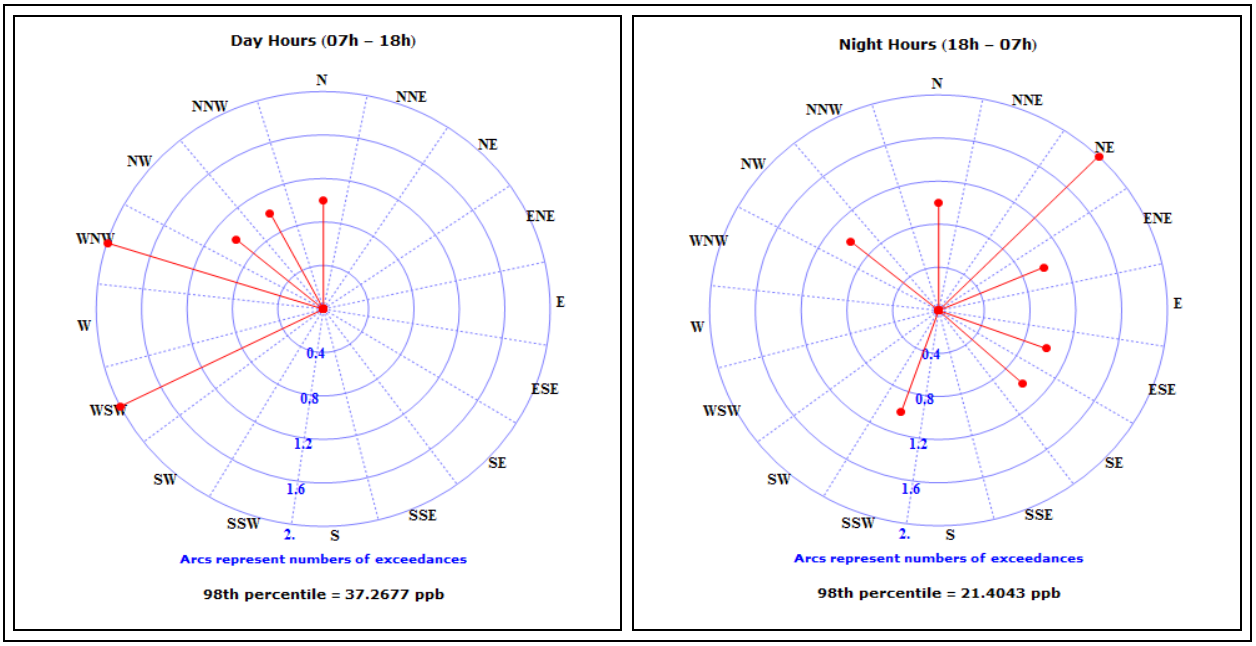

Figure 8: SO_2 exceedance rose for daytime and hourly mean 98th percentile night time event roses.

Table 9: SO_2 day-time hourly mean exceedance table

Dir.	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Eve.	1	0	0	0	0	0	0	0	0	0	0	2	0	2	1	1
%	14.29	0	0	0	0	0	0	0	0	0	0	28.57	0	28.57	14.27	14.27

Table 10: SO_2 night-time hourly mean 98th percentile event table

Dir.	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Eve.	1	0	2	1	0	1	1	0	0	1	0	0	0	0	1	0
%	12.5	0	25	12.5	0	12.5	12.5	0	0	12.5	0	0	0	0	12.5	0

6.3. Nitrogen Dioxide (NO_2)

6.3.1 Source identification by NO_2 variations

The NO_2 hourly mean diurnal variation show increasing NO_2 concentrations during morning hours. The concentrations also show increasing levels from 17:00 until the evening peak is observed at 20:00. This indicates the influence of both tall stack emitters and low level sources on the ambient concentrations at site.

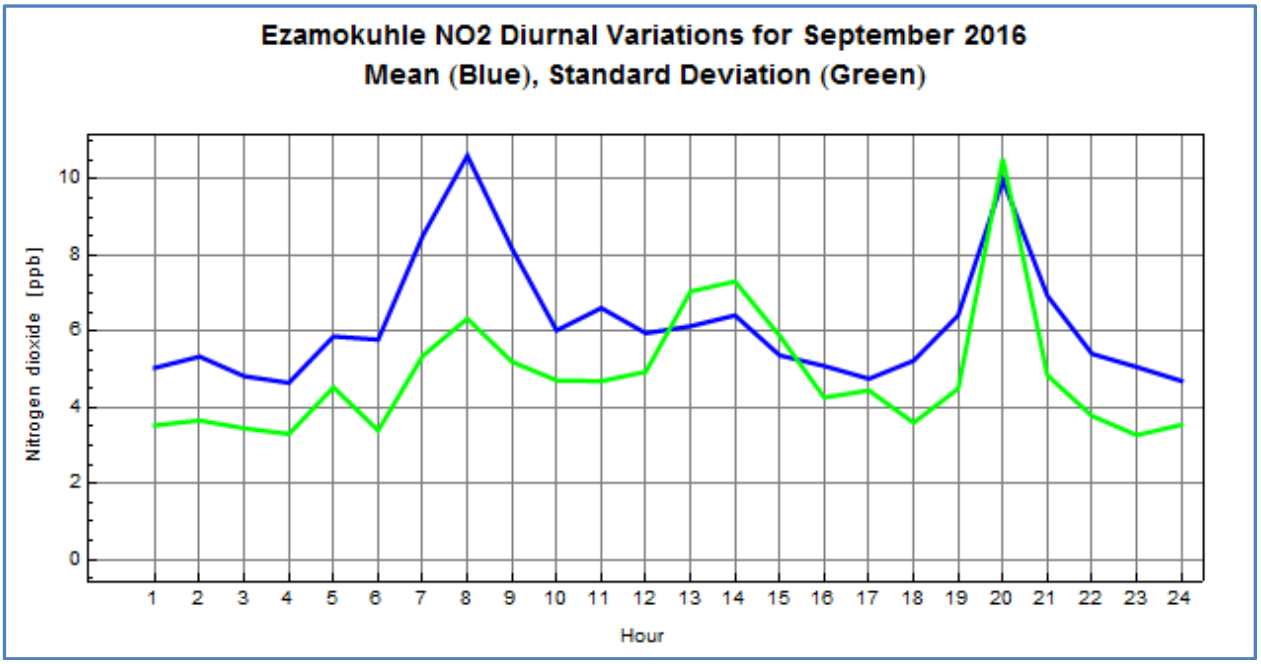

Figure 9: NO_2 diurnal variations (Mean concentrations = Blue line, Standard Deviation = Green line)

6.3.2 NO_2 hourly mean event roses and tables

The 98th percentile daytime and night-time event roses are presented in Figure 10 to identify the wind sectors from which the highest concentrations are derived.

The most dominant daytime concentrations above 22.12ppb (98th percentile value) were from north, east, south, west-south-west, west-north-west and north-west sectors (Table 11). The most dominant night-time concentrations above 17.03ppb (98th percentile value) were from the north, east-north-east, east-south-east, south-east and south-south-west sector (Table 12). The Vehicles operating in the vicinity of monitoring station might have an impact on the NO_2 ambient concentrations.

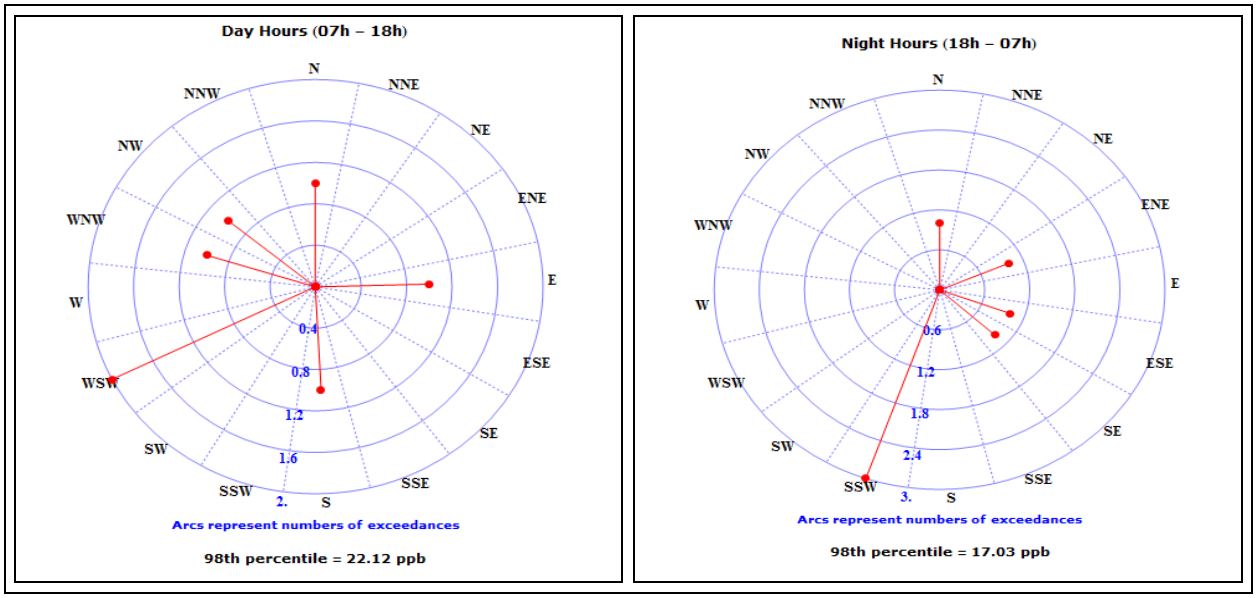

Figure 10: NO_2 hourly mean sector 98th percentile event roses

Table 11: NO_2 day-time hourly mean 98th percentile event table

Dir.	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Eve.	1	0	0	0	1	0	0	0	1	0	0	2	0	1	1	0
%	14.29	0	0	0	14.29	0	0	0	14.29	0	0	28.57	0	14.29	14.29	0

Table 12: NO_2 night-time hourly mean 98th percentile event table

Dir.	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Eve.	1	0	0	1	0	1	1	0	0	3	0	0	0	0	0	0
%	14.29	0	0	14.29	0	14.29	14.29	0	0	42.86	0	0	0	0	0	0

6.4. OZONE (O_3)

Figure 11 shows the O_3 hourly mean diurnal variation with increase in ozone concentrations occurring from 08h00 and maximum peak recorded at 16h00 in the afternoon. The increase in concentrations in the morning can be associated with the formation of NO_2 and the photochemical reaction in the presence of sunlight during the day. Figure 12 event roses indicate from which direction during day and night the exceedances where coming from and Figure 13 shows the 8 hour moving average of ozone concentrations with no exceedances above 61ppb national limit recorded during the month.

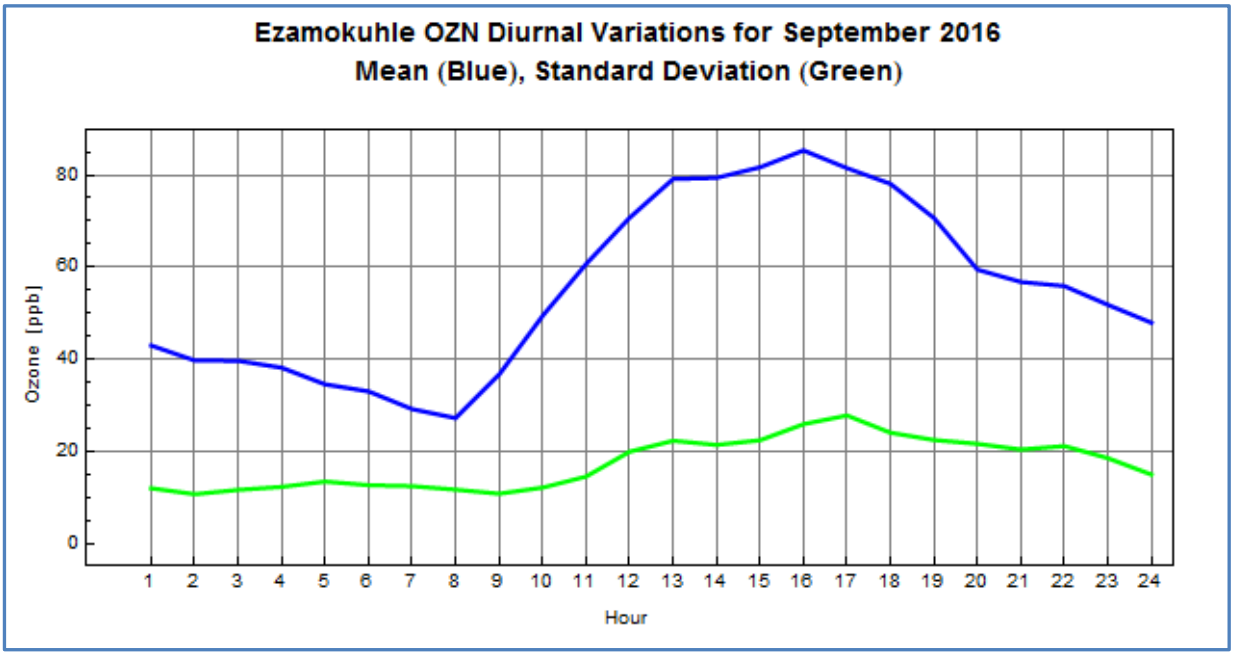

Figure 11: O_3 diurnal variations (.Mean concentrations = Blue line, Standard Deviation = Green line)

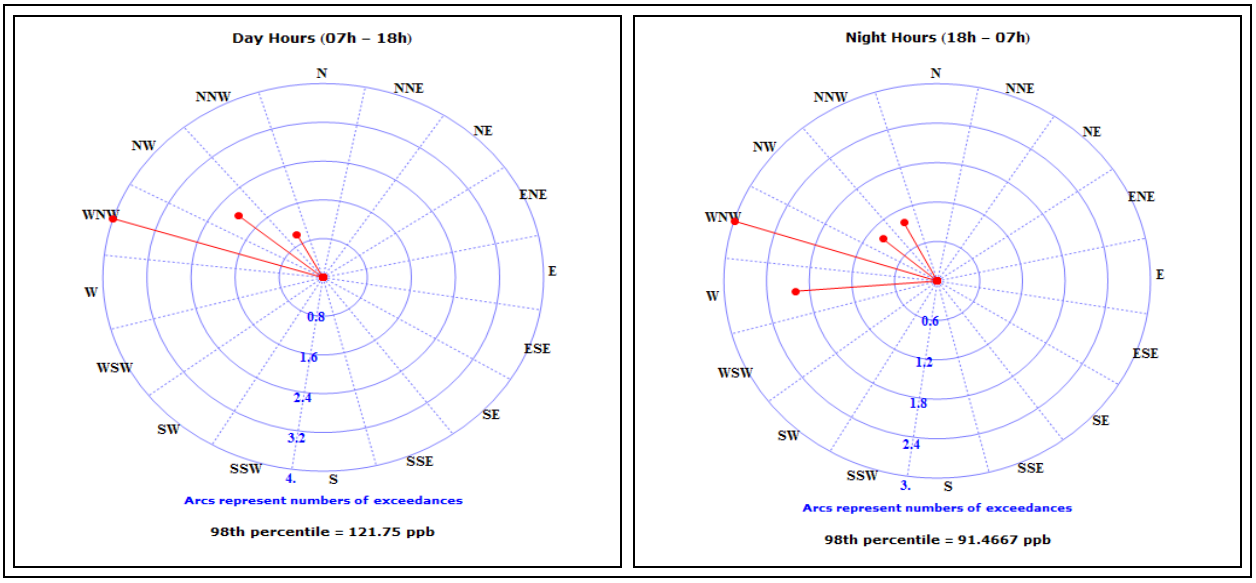

Figure 12: O_3 hourly mean sector 98th percentile event roses

Table 13: O_3 day-time hourly mean 98th percentile event table

Dir.	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Eve.	0	0	0	0	0	0	0	0	0	0	0	0	0	4	2	1
%	0	0	0	0	0	0	0	0	0	0	0	0	0	57.14	28.57	14.29

Table 14: O_3 night-time hourly mean 98th percentile event table

Dir.	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Eve.	0	0	0	0	0	0	0	0	0	0	0	0	2	3	1	1
%	0	0	0	0	0	0	0	0	0	0	0	0	28.57	42.86	14.29	14.29

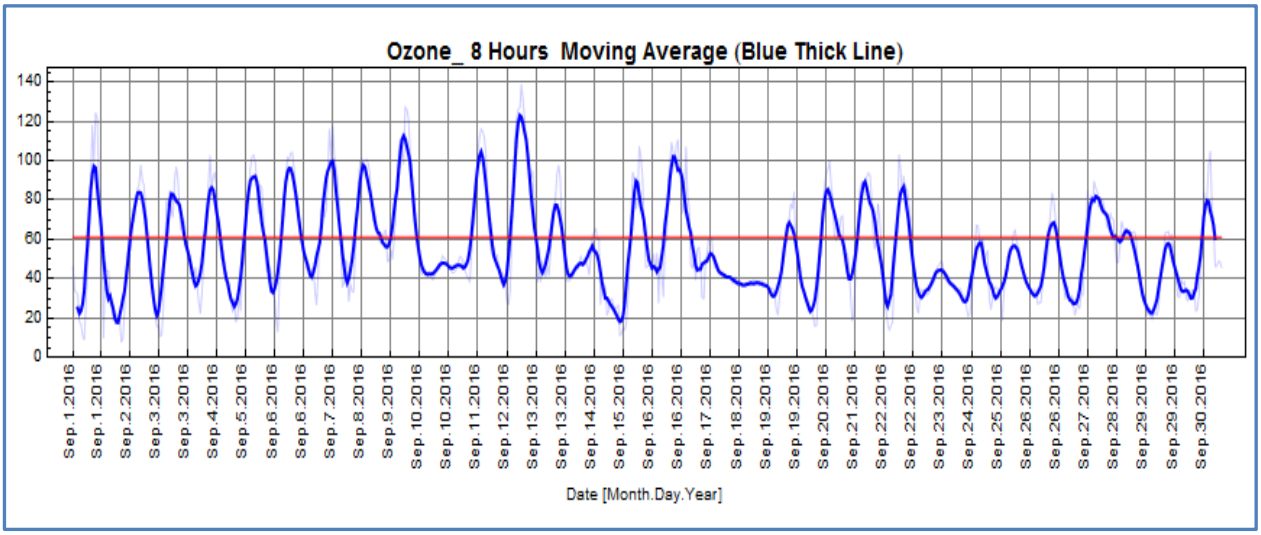

Figure 13: O_3 8 Hours Moving Average (Blue Thick Line)

7. HISTORICAL MONTHLY CONCENTRATIONS

7.1. MONTHLY MEANS FOR THE CURRENT CALENDER YEAR 2016

Table 15: Monthly means for all parameters measured for the current calendar year 2016

Parameter measured	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
$PM_{2.5}$ ($\mu g/m^3$)							36.3	36	23.1
PM_{10} ($\mu g/m^3$)							61.6	57.5	13.2
NO_2 (ppb)							5.1	11.8	6.2
O_3 (ppb)							21.4	39.7	55.4
SO_2 (ppb)							8.4	8.9	6.4

7.2 NUMBER OF EXCEEDANCES OF NATIONAL AIR QUALITY LIMITS

Table 16: Number of exceedances of the National Air Quality Limits

Monitoring at Ezamokuhle started in July 2016.

	SO_2 hourly	SO_2 daily	NO_2 hourly	PM_{10} daily	$PM_{2.5}$ daily	O_3 8- Hourly
Jul 2016	0	0	0	5	6	0
Aug 2016	0	0	0	11	11	87
Sep 2016	0	0	0	0	1	251
Total	**0**	**0**	**0**	**16**	**18**	**338**
Allowed no of exceedances	88	4	88	4	4	11

The exceedances of PM_{10}, $PM_{2.5}$ daily and O_3 8-hourly moving average limits at Ezamokuhle between July and September 2016 have exceeded their respective allowed number of exceedances per year, and therefore already in non-compliance with their national ambient standards.

8. CONCLUSIONS

Good representative percentage data was recovered for most of the parameters monitored during the monitoring period under review at the site.

There was one exceedance of the $PM_{2.5}$ daily limit of 40 µg/m^3 and two hundred and fifty one (251) exceedances of O_3 8-hour moving average limit of 61ppb, no exceedances recorded for other parameters monitored (Table 3) at Ezamokuhle during the September 2016 monitoring period. There is already non-compliance with the daily PM_{10}, daily $PM_{2.5}$ and 8-hourly ozone ambient standards at this site for 2016.

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Approved by: Kristy Langerman

Air Quality Centre of Excellence
Eskom Environmental Management

9. ABBREVIATIONS

DEA	Department of Environmental Affairs
deg	Degree
deg C	Degree Celsius
E	East
ENE	East-north-east
ESE	East-south-east
FPM	Fine particulate matter
HUM	Humidity
m/s	Meters per second
MWP	Megawatt Park
N	North
NE	North-east
NNE	North-north-east
NNW	North-north-west
NO1	Nitric oxide
NO2	Nitrogen dioxide
NOX	Oxides of nitrogen
NW	North-west
O_3	Ozone
PM_{10}	Particulate matter < 10 microns in diameter
$PM_{2.5}$	Particulate matter < 2.5 microns in diameter
ppb	Parts per billion
ppm	Parts per million
S	South
SANAS	South African National Accreditation System
SE	South-east
SGT	Sigma theta
SSE	South-south-east
SSW	South-south-west
SW	South-west
TMP	Ambient temperature
ug/m^3	Microgram per cubic meter
W	West
WDR	Wind direction from true North
WNW	West-north-west
WSP	Wind speed
WSW	West-south-west
WVL	Wind velocity

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