Report

Activity 6: Community source survey at the Ezamokuhle community

Final Report: For Eskom

9th January 2023

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ARM
AIR RESOURCE MANAGEMENT

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EXECUTIVE SUMMARY

In accordance with the scope of work for *Activity 6* a community survey was undertaken in Ezamokuhle to determine the sources of pollution. In conjunction with Eskom Communications team, permission & approval was first obtained from both the local leadership structures and the Ezamokuhle community to conduct the survey.

A combination both of field and aerial based surveys were conducted for the Study. The field survey was conducted by ARM personnel who were equipped with GPS enabled mobile devices to log the relevant emission sources on designated routes in Ezamokuhle. The aerial survey utilised two unmanned aerial vehicles (UAV) to accurately capture the spatio-temporal variability and to map air pollution hotspots.

A detailed questionnaire was developed for the Study to capture the emissions for the historical, active and potential future sources of air pollution. Historical emission sources were identified based on evidence indicating a historical air pollution episode, for example a veld burn scar indicating a historic veld fire burning emissions incident. Active air pollution sources were identified based on active and visible atmospheric emissions present at the time of the survey. Potential future sources of air pollution were identified on the basis that whilst the source is dormant and in-active on the day of the survey, the source has the potential to be an active emission source in the future.

The only historical air pollution source categories identified in the assessment were historic waste burning and veld fires. Thirteen historic waste burning sites were identified in Ezamokuhle. These preliminary results indicate a growth in historic waste burning as the previous ARM UAV study (ARM, 2021) identified only 3 areas of historic waste burning. The field survey observed historic waste burning at open fields, next to a no dumping site and in the vicinity of a rusted skip. It was interesting to note that waste was been burnt in the school yard as well. A number of burn scars in the open grass veld provided evidence of historic veld fire burning. Veld fires are a significant source of CO, NOx, and VOCs emissions.

Based on the UAV imagery it was evident that ~40 household chimneys were emitting smoke at any one time during the day in Ezamokuhle. It’s also evident that the residential chimney

emissions are trapped by the inversion layer, this adverse meteorological conditions in winter inhibit dispersion and result in elevated ambient pollutant concentrations. It was evident from the field survey that informal homes attached to RDP homes were also a significant contributor to residential fuel burning emissions. Additionally, from the field survey, ARM noticed many incidents of residential fuel burning occurring in mbaula's. This coupled with the poor dispersion of household chimneys emissions resulted in elevated ground level pollutant concentrations.

From the aerial survey, a total of 4095 households were counted from the UAV survey. This is a slight increase in the total number of households of 3900 that was counted in 2021 (ARM, 2021). This growth is essentially due an increase in the number of self-built homes as well as informal households.

Seven incidents of active waste burning were observed in the field survey. These incidents occurred only in the mornings (19th to 21st July). The waste been burnt was general household waste that had disposed. In terms of waste segregation, it appeared to be roughly composed of ~30% plastics, ~30% organic household waste and ~30% paper packaging and 10% other.

In terms of vehicular emissions there is a higher traffic density in the morning along Bree Street as people leave for work. The rest of the day the roads were generally quite until late afternoon when the traffic density picked up again due to the workers arriving home. It's noted that the busses and taxis were well maintained with no excessive tailpipe emissions observed in the field survey.

The sources of fugitive dust for Ezamokuhle include dust on paved roads, unpaved roads, sidewalks and open sports fields. The inner roads of the township are all dust roads which compound the impact of particulate emissions. The field survey noted that at the intersection of paved/tarred roads and unpaved roads there is re-entrainment of dust emissions.

Waste and litter appear along all the streets in Ezamokuhle. ARM identified 20 communal areas where waste dumping was more prevalent. There were no waste skips present at any of these sites. These 20 communal waste sites (if burnt) have the potential to increase the ambient pollutant loading in the Ezamokuhle airshed unless they are collected and disposed of appropriately. Air quality offset intervention targeted for waste burning and fugitive dust suppression may be potential areas that can provide additional air quality improvements for the Ezamokuhle airshed

It was also evident from the aerial survey that almost all households (albeit formal or informal) in Ezamokuhle all have a chimney. This indicates that residential fuel burning will occur for purposes of space heating, bathing and cooking. This can be exacerbated during power-interruptions and colder ambient temperatures resulting in a higher loading of pollutants to the Ezamokuhle airshed as opposed to the aerial and field observations conducted over the Study period. Hence there is an opportunity to reduce human exposure to harmful levels of air pollution by reducing emissions from residential burning which is aligned to the roll-out of Eskom’s PMV air quality offset intervention project in Ezamokuhle.

1. BACKGROUND

1.1 AIR QUALITY OFFSETS GUIDELINE

An environmental offset is an action(s), designed to compensate for a negative environmental impact of resource use, a discharge, emission or other activity. The Department of Environment, Forestry & Fisheries (DEFF) defines air emissions offsets as an intervention, or interventions, specifically implemented to counterbalance the adverse and residual environmental impact of atmospheric emissions in order to deliver a net ambient air quality benefit within, but not limited to, the affected airshed where ambient air quality standards are being or have the potential to be exceeded and whereby opportunities and need for offsetting exist (Notice 333 of 2016).

1.2 ESKOM'S APPROACH TO AIR QUALITY OFFSETS

DEFF's Air Quality Offset Guideline has shaped and informed Eskom's Air Quality Offsets Implementation Plan. This Plan has been based on a scientific process of feasibility studies, testing and demonstration, and on consultation with key stakeholders. Figure 1 illustrates the concept schedule for the phased implementation of Eskom's air quality offsets.

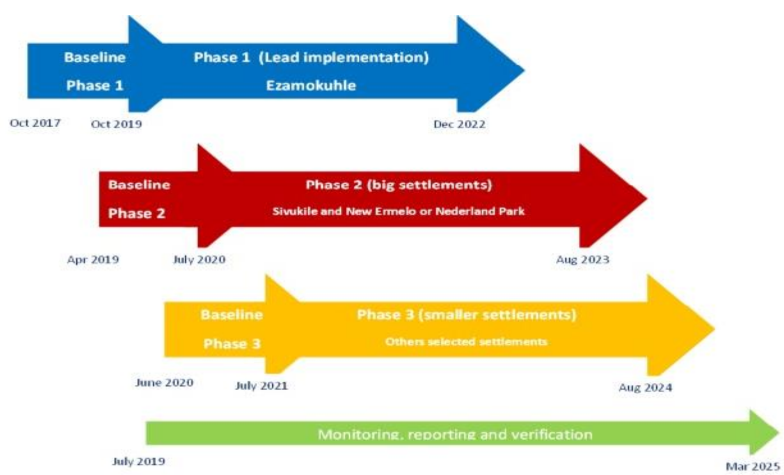

Figure 1: Concept Schedule for the implementation of Eskom's air quality offsets (Matimolane, 2020)

Eskom has adopted the phased approach (Figure 2) herein to increase the probability of success and to ensure that learnings from early phases are incorporated into the large-scale roll-out. (Matimolane, 2020).

Figure 2: Eskom's Phased approach to the rollout of air quality offset interventions (Matimolane, 2020)

Phase 1	Phase 2	Phase 3
• Lead Phase • The intervention is tested on an entire community in order to determine the best way forward for sclaing up the inititiative.	• Full implementation on the remaining households in the larger settlements • Learnings from the Lead Phase incorporated herein. • Intervention will be rolled out simultaneously at several large communities across the three district municipalities and selected areas in the Vaal.	• Full implementation on the remaining households in the smaller settlements • Learnings from the Lead Phase incorporated herein. • The intervention will be rolled out simultaneously at several small semi-rural communities the three district municipalities and selected areas in the Vaal.

Eskom's air quality offsets programme is designed to reduce human exposure to harmful levels of air pollution by reducing emissions from local sources, like domestic coal burning and waste burning. Thus, air quality offsets can improve ambient air quality in low-income communities in the vicinity of Eskom's power stations. Eskom has developed air quality offset (AQO) implementation plans for Majuba Power Station (Ezamokuhle township); Hendrina Power Station (Kwazamokuhle township) and Lethabo Power station (Sharpeville).

1.3 ESKOM'S PLANNING, MONITORING AND VERIFICATION (PMV) PROJECT

For Eskom's PMV Project, interventions to reduce household emissions from domestic coal/wood burning will be rolled out in KwaZamokuhle and Ezamokuhle in the Mpumalanga Highveld. For formal dwellings the intervention will be a thermal insulation retrofit and an electricity starter pack and installation. The intervention for informal dwellings still needs to be selected and tested. Interventions also need to be identified and implemented to improve air quality in Sharpeville, Gauteng. Since domestic coal burning is less prevalent in Sharpeville, it is expected that a community-scale intervention, like reducing waste burning, will be more suitable there.

Air Resource Management (ARM) (Pty) Ltd has been appointed by Eskom to support the PMV services in support of the *Phase 1: Lead implementation* at: KwaZamokuhle; Ezamokuhle and Sharpeville. Its ARM (Pty) Ltd understanding that the overall objective *Lead Implementation Phase* is to benefit the specific local communities, minimize implementation risk, increase practical and scientific knowledge, and develop and refine monitoring, reporting and verifications processes. To achieve this, Eskom has included sixteen targeted work package Activities (Table 1) for these respective communities. This report focuses on **Activity 6: Community source survey at Ezamokuhle community.**

Table 1: Eskom PMV Activity Schedule

Activities	Kwazamokuhle	Ezamokuhle	Sharpeville
Activity 1: Preliminary air quality assessment		✓	
Activity 2: Gather Area intelligence		✓	
Activity 3: Rapid in situ assessment		✓	
Activity 4: Obtain ethical clearance		✓	
Activity 5: Census	✓	✓	✓
Activity 6: Community source survey		✓	
Activity 7: Fuel source survey		✓	
Activity 8: Household surveys		✓	
Activity 9: Annual (household/community) surveys and monitoring of project effectiveness	✓	✓	✓
Activity 10: Ambient air quality monitoring	✓	✓	✓
Activity 11: Conduct indoor air quality monitoring	✓	✓	
Activity 12: Atmospheric Dispersion Model	✓	✓	✓
Activity 13: Design of Intervention		✓	✓
Activity 14: Development of Database Reporting	✓	✓	✓
Activity 15: Strategic Assistance and offsets methodology	✓	✓	✓
Activity 16: Research and Development	✓	✓	✓

1.4 Scope of Work

In accordance with the scope of work, for *Activity 6: Community source survey,* ARM must undertake a community survey to determine the sources of pollution in Ezamokuhle. The purpose of the community source survey is to collect data on small, distributed air pollution sources in public spaces. The survey collects evidence of historic air pollution events, active sources as well as potential sources.

2. GENERAL DESCRIPTION OF AREA

2.1 PROJECT LOCATION

Ezamokuhle The township of Ezamokuhle (Figure 3), which is located within a proximity to the Majuba Power Station, has been earmarked by Eskom for the rollout of air quality offset interventions. Ezamokuhle is divided into six sections namely: China 1, China 2, Jabavu, Roestein, Smallville and Phumlani (Nkambule, 2016).

Figure 3: Locality map for Ezamokuhle

2.2 Climate & Meteorology

The Highveld experiences a temperate climate with dry winters according to the Köppen Climate Classification system. The section provides an overview of the prevailing meteorological conditions present at Ezamokuhle when the Community Source Survey was conducted for the period 19th to 21st July 2022.

2.2.1 Rainfall & Temperature

Over the 19th to 21 July 2022, the region experienced atypical South African winter meteorological conditions. On the 19th a predominant Northerly wind direction was prevalent over Ezamokuhle due to the ridging south Atlantic high pressure system ,with high wind speeds between 3 to 7m/s being experienced from the late morning to the evening, and average of 2,56 m/s for the day. Temperatures were low in the early morning between 0 to 2 degrees, with late morning temperatures peaking to 19 ℃ in the midday.

On the 20th lower wind speeds were observed through the day (1,19m/s average) , with more constant predominant northerly wind direction due to the weak low pressure observed over the interior, with the ridging high pressure system from the east. Higher temperatures were observed in the morning compared to the 19th,but lower temperatures were observed through the late morning and afternoon, with a midday peak of 15.9 ℃. Late afternoon drizzle was observed in the area the late afternoon, but quickly dissipating into the evening.

On the 21st,wind speeds were lower than the two previous study days, with an average of 1.06m/s observed for the day, with a predominant southerly to south westerly wind due to the ridging south Indian high pressure system. Temperatures were fairly high compared to the previous study days, with morning temperatures ranging peaking at 18 ℃ in the morning (possible influence of the approaching cold front pushing the warm air into the interior before its approach), with a midday peak of 19 ℃

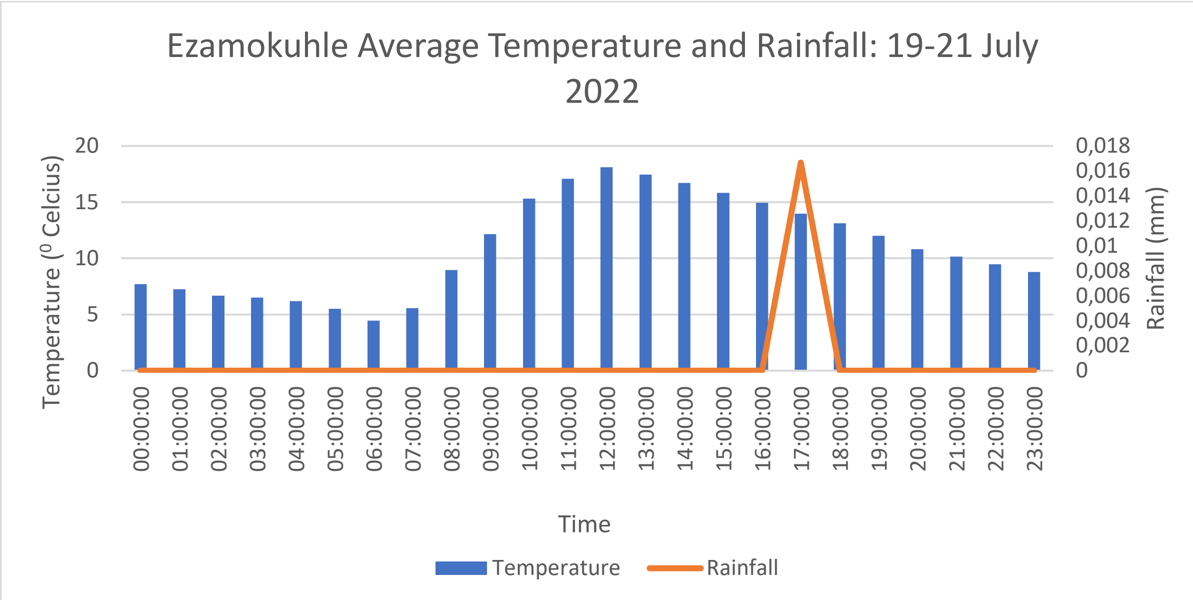

Figure 4: Average temperatures and rainfall for Ezamokuhle for the Study period

2.2.2 Surface & Near-Surface Winds

Air quality is strongly influenced by meteorology which covers an array of atmospheric processes that determines the evolution of emissions, chemical species, aerosols and particulate matter. Thus, an analysis of hourly average meteorological data was undertaken to facilitate a comprehensive understanding of the dispersion potential of the site. The horizontal dispersion of pollution is largely a function of the wind field. The wind speed determines both the distance of downward transport and the rate of dilution of pollutants. The windrose for the Eskom Ezamokuhle station is presented in Figure 5 .

At the Eskom Ezamokuhle air quality station, the average wind speed for the period was recorded at 1.6 meters/second with calm condition 0.5%. Calm conditions were defined as wind speeds recorded at zero meter/second (Carlaw, 2015). The predominant wind directions were south westerly winds (~ 17% frequency of occurrence) followed by both southerly (15%) and north westerly winds (~ 15% frequency of occurrence) with maximum wind speed of 5 – 8 meters/second.

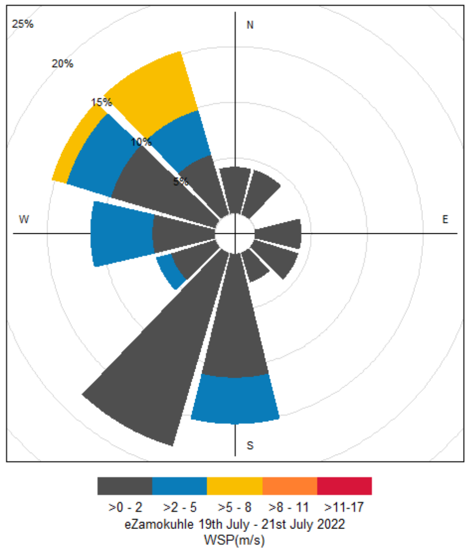

Figure 5: Wind rose for the Eskom Ezamokuhle station for the period 19th to 21st July 2022

2.3 Ambient Air Quality Monitoring Analysis

This section provides an overview of the relationship between measured air pollutant concentrations and prevailing meteorological conditions present at Ezamokuhle when the *Community source survey* was conducted (19/07/22 to 21/07/22). The Openair air quality model was utilised to statistically analyse these semi-empirical mathematical relationships. The Openair model was able to analyse emissions of pollutant sources, pollutant characteristics and trend estimates (Carslaw, 2015).

2.3.1 Trend analysis plots

The trend analysis (mean with 95% confidence interval) of ambient pollutant concentrations measured at the Eskom Ezamokuhle station show the variation of these pollutants over for the period.

For the study period its evident that there are three pronounced peaks for SO_2 which occur at ~ 07:00, 13:00 and 19:00 (Figure 6 & Figure 7). The midday peak (~ 13:00) is attributable to an industrial signature which is due to the break-up of an elevated inversion layer due to the development of daytime convective conditions causing the plume to be brought down to ground level relatively close to the point of release from tall stacks. The bimodal peak at 7:00 and 19:00 is a typical profile for residential fuel burning which is prevalent in winter.

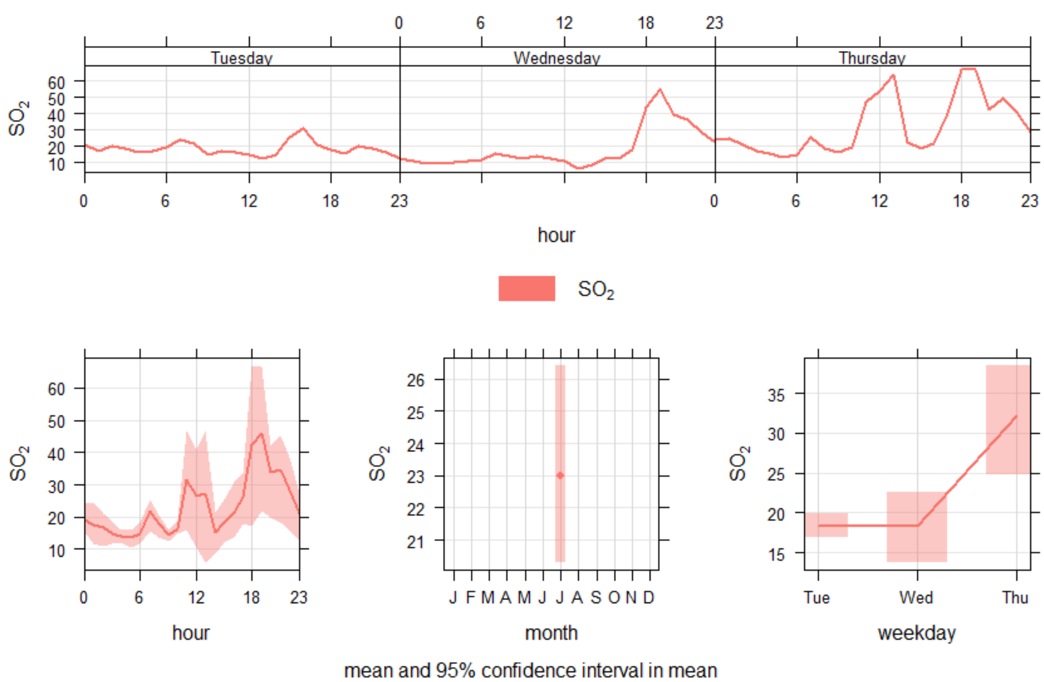

Figure 6: Mean SO2 concentrations in ug/m³ for the Eskom Ezamokuhle air quality station calculated for the period 19th to 21st July 2022

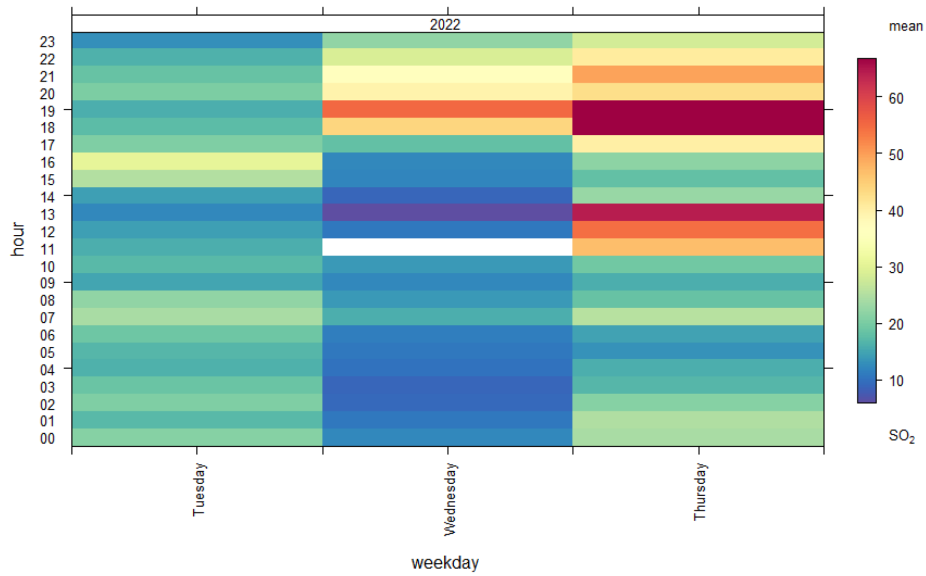

Figure 7: Trend level plot for SO_2 measured at the Eskom Ezamokuhle air quality station calculated for the period 19th to 21st July 2022

The Ezamokuhle NO_2 results (Figure 8 & Figure 9) explicitly reveal that the variability of this pollutant concentration is conditioned by vehicle, industrial and residential emissions. The 07:00 and 17:00 peaks correspond to the cyclical nature of traffic volume with marked peaks around the early-morning and late-afternoon rush-hours. The midday peak indicates the impact of a tall stack emission source/s whilst the 20:00 peak is associated with residential fuel burning. It's noted that there was no additional data captured at the Eskom Ezamokuhle station after 11:00 on the 20th July 2022.

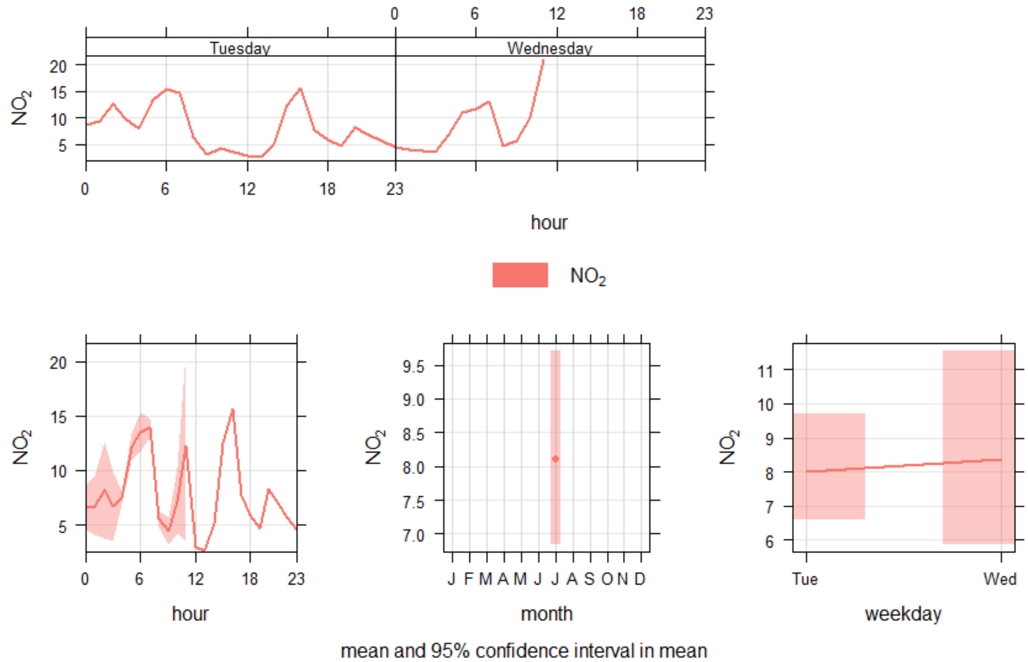

Figure 8: Mean NO_2 concentrations in ug/m^3 for the Eskom Ezamokuhle air quality station calculated for the period 19th to 21st July 2022

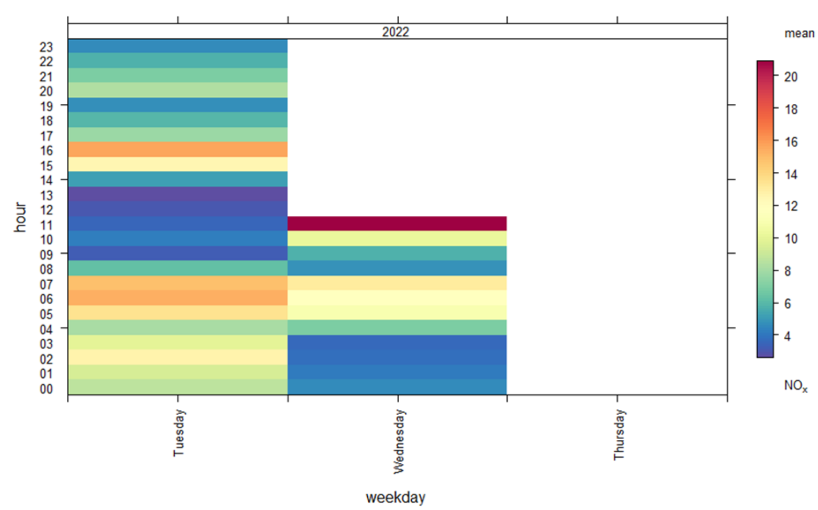

Figure 9: Trend level plot for NO_2 measured at the Eskom Ezamokuhle air quality station calculated for the period 19th to 21st July 2022

The bi-modal particulate matter peak for both PM_{10} and $PM_{2.5}$ (Figure 10 to Figure 13) are a typical profile for residential fuel burning. A morning peak occurs at 07:00 whilst the evening peak occurs at 18:00 to 19:00. The morning peaks reduces towards midday as the inversion layer rises & improves the mixing height of the planetary boundary layer.

Bivariate polar plots have proved to be extremely valuable for identifying and understanding sources of air pollution (Carslaw et al., 2006; Westmoreland et al., 2007). Figure 14 and Figure 15 shows the bivariate plots for the Eskom Ezamokuhle station conditioned for the mean pollutant concentration and wind speed. The impact of localised emission sources is observed during weak-wind conditions. At low wind speeds the symmetrical plot shows a localised contribution, most likely the result of residential fuel burning.

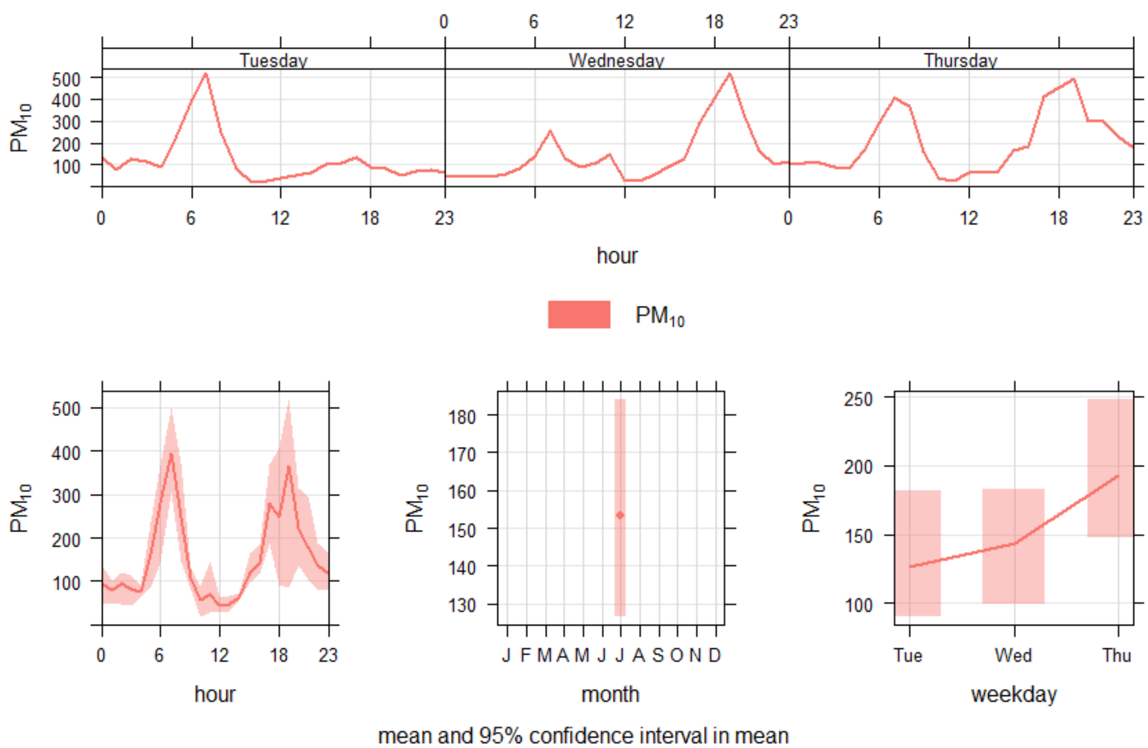

Figure 10: Mean PM_{10} concentrations in ug/m^3 for the Eskom Ezamokuhle air quality station calculated for the period 19th to 21st July 2022

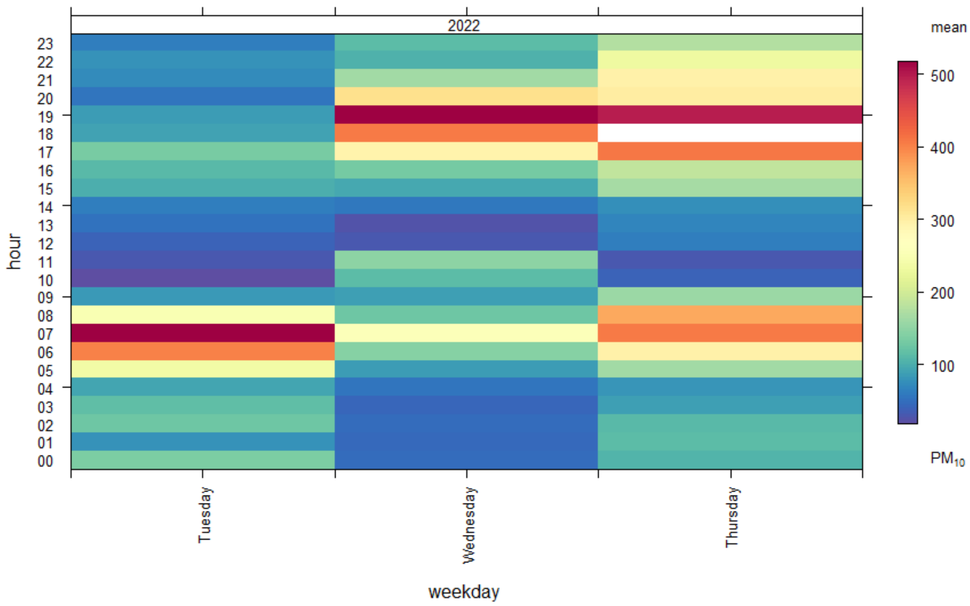

Figure 11: Trend level plot for PM_{10} measured at the Eskom Ezamokuhle air quality station calculated for the period 19th to 21st July 2022

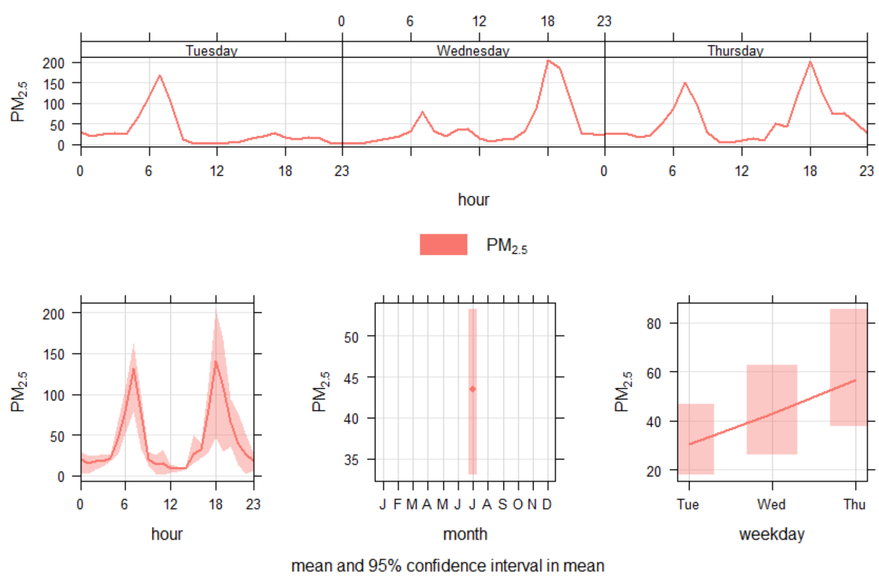

Figure 12: Mean $PM_{2.5}$ concentrations in ug/m^3 for the Eskom Ezamokuhle air quality station calculated for the period 19th to 21st July 2022

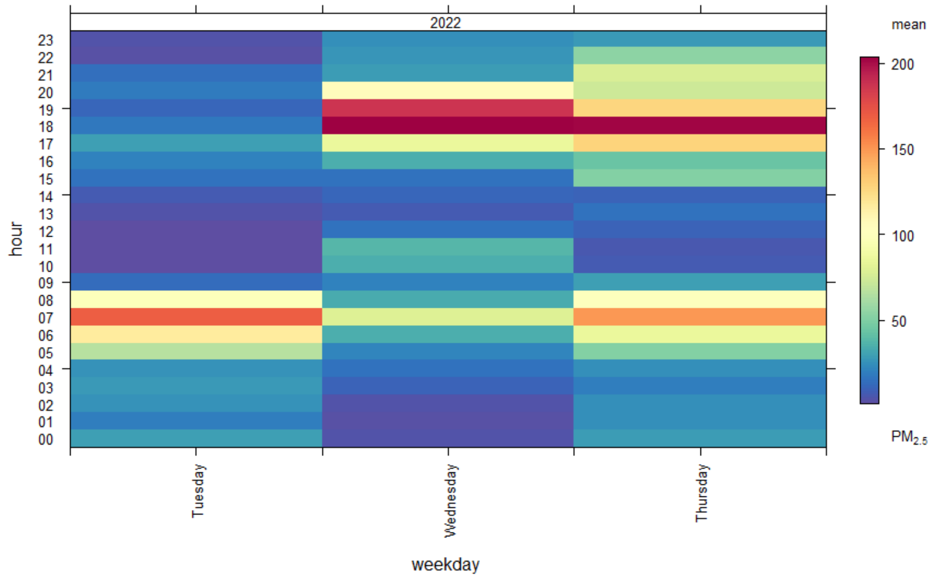

Figure 13: Trend level plot for $PM_{2.5}$ measured at the Eskom Ezamokuhle air quality station calculated for the period 19th to 21st July 2022

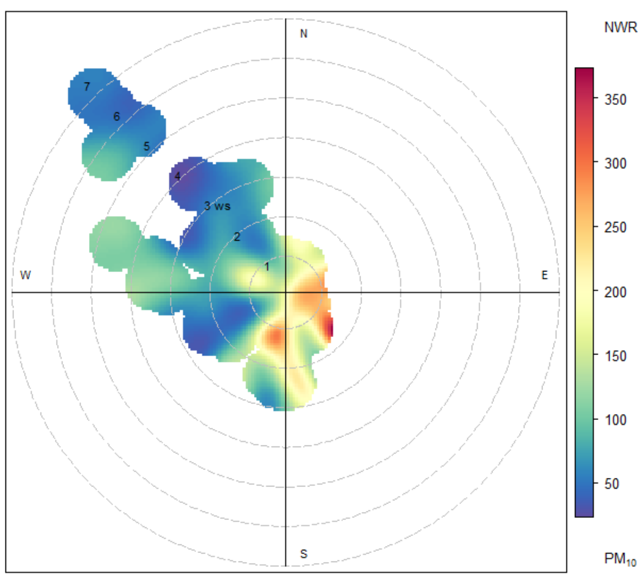

Figure 14: Polar plot of hourly mean PM_{10} concentration at the Eskom Ezamokuhle Station for the period 19th to 21st July 2022

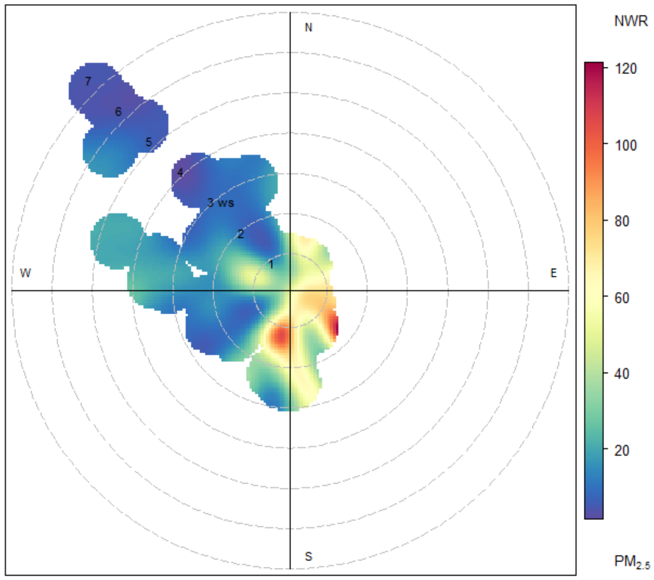

Figure 15: Polar plot of hourly mean $PM_{2.5}$ concentration at the Eskom Ezamokuhle Station for the period 19th to 21st July 2022

3. METHODOLOGY

The effect of air pollution on the environment, economic and health of the people in an affected community cannot be overemphasized (Anderson et al., 2012; Anenberg et al., 2010; Jian et al., 2016; Krall et al., 2013; Schwartz et al., 2017; Tao et al., 2011). Ezamokuhle is characterised by a broad spectrum of emission sources impacting on this area. This includes *inter alia*: industrial emissions, domestic fuel burning, vehicle tailpipe emissions, biomass burning, agricultural activities and numerous other fugitive sources. For the *Community source survey at Ezamokuhle* a combination both of field and aerial based surveys were conducted.

3.1 Ethical approach to the study

In conjunction with Eskom Communications team, authorization & approval from the local Ezamokuhle leadership was requested to conduct the *Community Source Survey* in Ezamokuhle. The request for authorisation included a formal letter detailing the purpose of the research, data collection methods, reporting, ethical considerations, and the intended contribution of the study. An engagement was held with the Ezamokuhle community wherein they together with the leadership structure (including councillors) provided ARM permission to conduct both the field surveys as well as the aerial survey in Ezamokuhle. None of the methods employed required direct contact with the community and no interviews were conducted with any community members.

During the field survey, photos were discreetly & respectfully taken. The team remained cautious of raising concerns in the community by their presence. For the aerial survey, all relevant parties were duly informed including the Municipality, SAPS, the Civil Aviation Authority of South Africa and the Community Leadership.

3.2 Field Survey

3.2.1 Survey Route

The field survey was conducted by ARM personnel who were equipped with GPS enabled mobile devices to log the relevant emission sources on designated routes in Ezamokuhle. For the Study, Ezamokuhle was delineated into 9 distinct zones (Figure 16). The corresponding ward for each zone is shown in Table 1. Fieldworkers were assigned to a specific zone with designated paths to identify historic air pollution events, active sources as well as potential sources of air pollution that may have an impact on the Ezamokhule airshed.

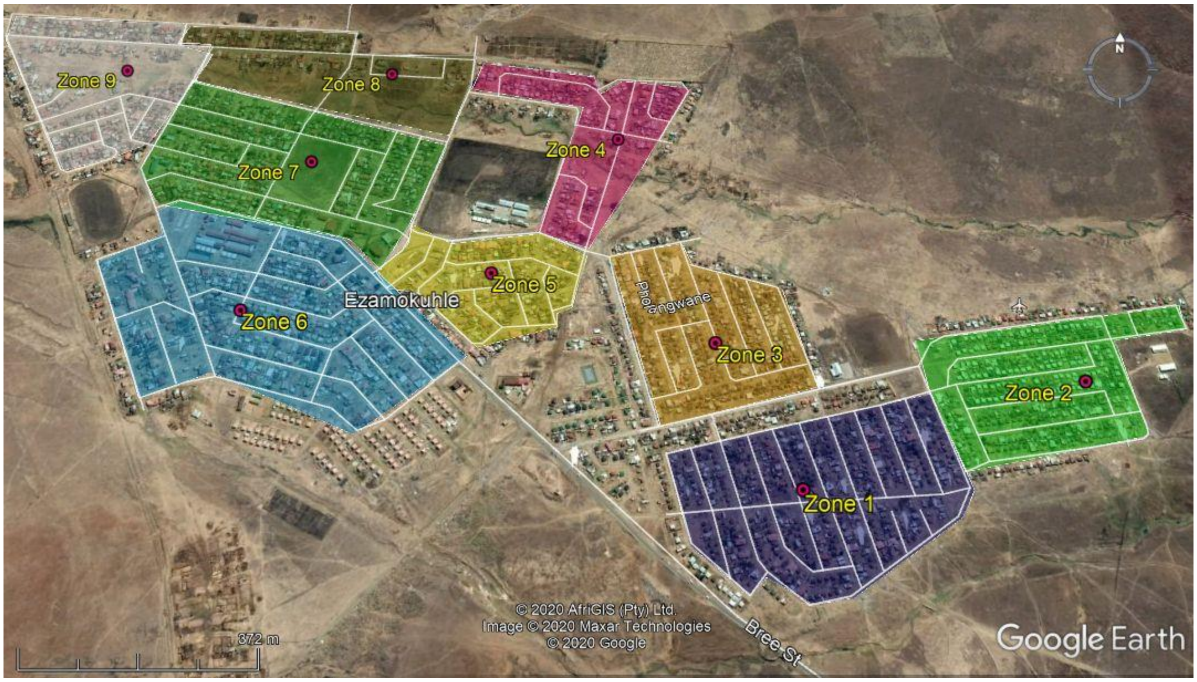

Figure 16: Ezamokuhle Zones for Field Survey

Table 2: Ward allocation to Zone

Ward	Associated zone
Phumala	Zone 2
China 2	Zone 1 and 3
Jabavu	Zone 9
Roestein	Zone 5, 6, 7, 8
Smallville	Zone 4

3.2.2 Questionnaires for the Community Source Survey

A detailed questionnaire (Annexure 1) was developed for the Study to capture the emissions for the historical, active and potential future sources of air pollution. Historical emission sources were identified based on evidence indicating a historical air pollution episode, for example a veld burn scar indicating a historic veld fire burning emissions incident. Active air pollution sources were identified based on active and visible atmospheric emissions present at the time of the survey. Potential future sources of air pollution were identified on the basis that whilst the source is dormant and in-active on the day of the survey, the source has the potential to be an active emission source in the future.

3.3 Aerial Survey

3.2.1 Survey Route

Unmanned aerial vehicles (UAVs) can accurately capture the spatio-temporal variability and to recognize pollution hotspots that are necessary to develop real-time exposure control strategies. For this study two UAV (Mavic Pro 3 & SenseFly eBeeX) were flown to conduct an aerial survey for Ezamokuhle. The UAVs flew at an altitude of 150m above Ezamokuhle for the pre-determined flight path (Figure 17). The Mavic Pro 3 drone (Figure 18) took off at 6:55 am for a rapid fly-over using a video, and a second fixed wing SenseFly eBeeX drone (Figure 19) was launched at 08:00 am to record high-resolution imagery for Ezamokuhle.

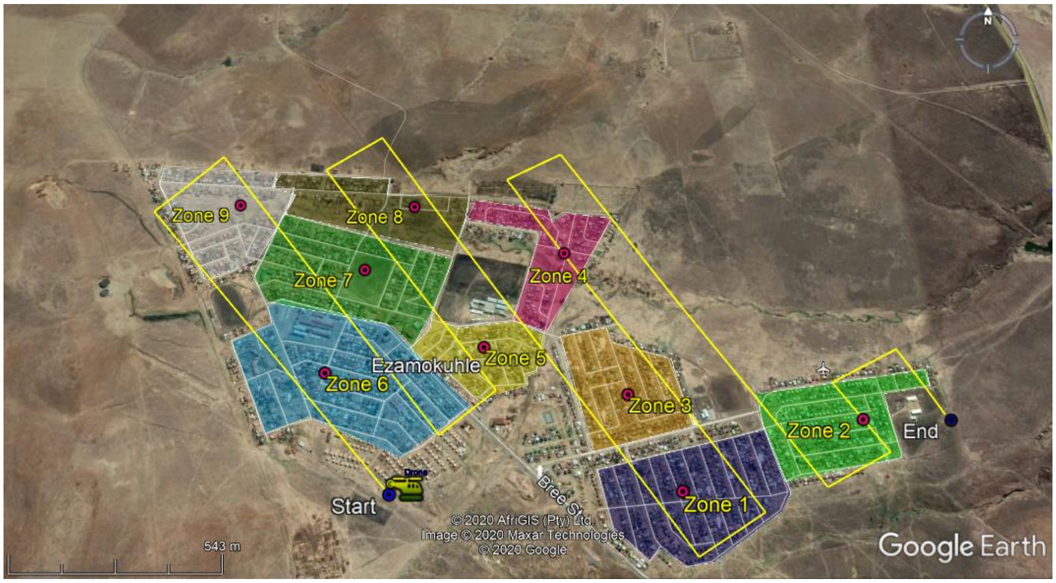

Figure 17: UAV Flight Path

Figure 18: Mavic Pro 3 UAV

Figure 19: SenseFly eBeeX UAV

3.4 Data analysis

The UAV images were stitched to provide a high-resolution aerial map at 2.5cm/pixel. The aerial video recording provided an aerial of the area and is available on request to Eskom. For the field and aerial survey, data from the questionnaire sheets were captured by the team and these consolidated findings are reported in the next section.

4. RESULTS & DISCUSSION

For the *Community source survey at Ezamokuhle*, ARM utilised a combination of both a field and aerial survey. Based on these surveys, the study has identified three categories of air pollution sources: historical, current and potential future sources of air pollution. Historical emission sources have been identified based on evidence indicating a historical air pollution episode, for example a veld burn scar indicating a historic veld fire burning emissions incident. Current air pollution sources were identified based on active and visible atmospheric emissions captured by the in-situ assessments. Potential future sources of air pollution were identified on the basis that whilst the source was dormant and in-active on the day of the in-situ assessment, the source had the potential to be an active emission source in the future. For example, a number of waste dumps were identified in the assessment, whilst these waste dumps were not burning of the day of the assessment, they have the potential during combustion to be a significant atmospheric pollutant emission source unless the waste herein is removed.

Figure 20 presents an overview of the evidence of historical, current and forthcoming (future) air quality problems that were document in the assessment. The following section unpacks these areas in detail.

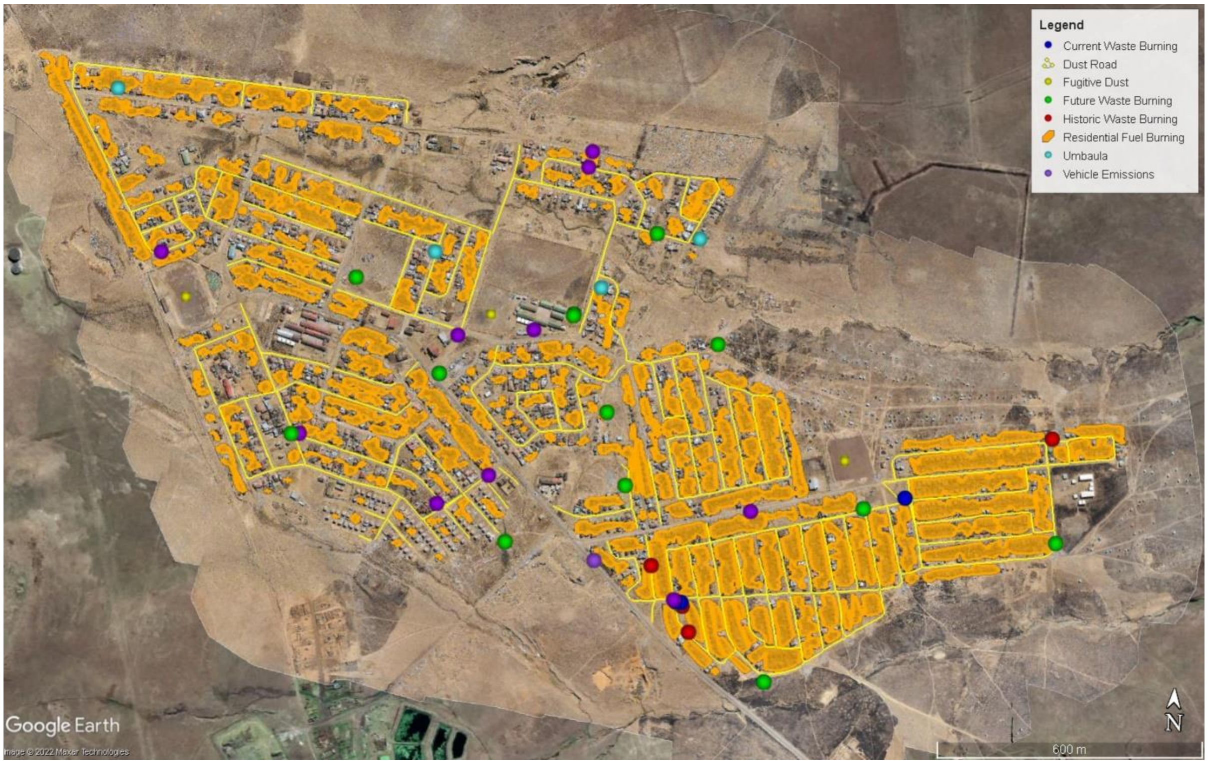

Figure 20: Overview of air pollution sources documented in Study

4.1 Historical air pollution sources

The only historical air pollution source categories identified in the assessment were historic waste burning and veld fires.

4.1.1 Waste Burning

Thirteen historic waste burning sites were identified in Ezamokuhle (Figure 21). These preliminary results indicate a growth in historic waste burning as the previous ARM UAV study (ARM, 2021) identified only 3 areas of historic waste burning. The field survey observed historic waste burning at open fields (Figure 22), next to a no dumping site (Figure 23) and in the vicinity of a rusted skip (Figure 24). It was interesting to note that waste was been burnt at the school (Figure 25).

Figure 21: Map showing the location of historic waste burning sites

Figure 22: Historic waste burning sites in open fields

Figure 23: Historic waste burning next to a "no dumping" site

Figure 24: Historic waste burning site adjacent to waste skip

Figure 25: Historic waste burning site within the school boundary

4.1.2 VELD FIRES

A number of burn scars in the open grass veld provided evidence of historic veld fire burning. Regional biomass burning, which includes open biomass burning (veld fires), is a significant source of CO, NOx, and VOCs (Macdonald et al., 2011; Crutzen and Andreae, 1990; Galanter et al., 2000; Simpson et al., 2011) in southern Africa. These ozone precursor species contribute to elevated ozone levels in Spring (Laban, 2018). The presence of tall grass along the roads of Ezamokuhle () suggest that veld fires are expected in the dry season.

Figure 26: Historic veld fire along the roads of Ezamokuhle

4.2 Current air pollution sources

Figure 27 provides an overview of the current air pollution source categories that were identified.

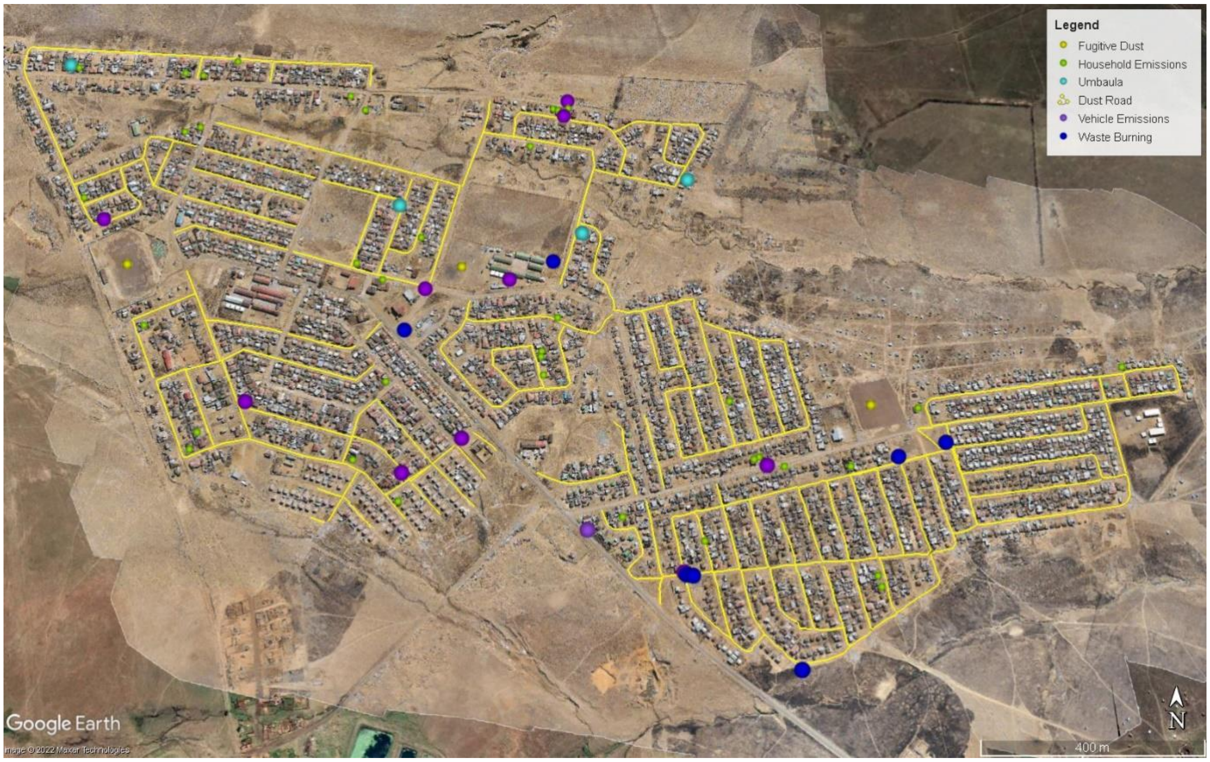

Figure 27: Map showing the location of current air pollution sources documented in the Study

The following current air pollution source categories were identified in the assessment:

4.2.1 Residential Fuel Burning

Based on the drone imagery (Figure 28 and Figure 29) it's evident that ~40 household chimneys were emitting smoke at any one time during the day in Ezamokuhle. It's also evident that the residential chimney emissions are trapped by the inversion layer (Figure 30), these adverse meteorological conditions in winter inhibit dispersion and result in elevated ambient pollutant concentrations. It was evident from the field survey that informal homes attached to RDP homes (Figure 31 & Figure 32) were also a significant contributor to residential fuel burning emissions.

Figure 28: Household emissions from chimney stacks

Figure 29: Residential fuel burning in Ezamokuhle

Figure 30: Residential fuel burning plumes trapped below the stable inversion layer

Figure 31: Chimney emissions from informal households located in the backyard of RDP homes

Figure 32: Residential burning emissions from informal households located in the backyard of RDP homes

Additionally, from the field survey, ARM noticed many incidents of residential fuel burning occurring in mbaula’s (Figure 33) and the poor dispersion of household chimneys (Figure 34) resulting in elevated ground level concentrations.

Figure 33: Residential fuel burning with Mbaulas

Figure 34: Poor dispersion from household chimneys

From the aerial survey, a total of 4095 households were counted from the UAV survey (Table 3). This is a slight increase in the total number of households of 3900 that was counted in 2021 (ARM, 2021). This growth is essentially due an increase in the number of self-built homes as well as informal households (Figure 35). Figure 36 indicates the locality wherein the RDP homes have been upgraded to self-built homes. Figure 37 & Figure 38 show the areas wherein there has been growth in informal households.

Table 3: Number of households in Ezamokuhle based on UAV 2022 survey

Ward	Zone	RDP houses	Standalone RDP Houses	RDP Housing with backyard dwelling	Mud Houses	Self built Houses	Stand alone big house	Big Houses with backyard Dwelling	Informal dwellings	Stand-alone informal dwelling	Informal with backyard	Houses with DSTV	TOTAL
China 2	1	327	118	209	6	90	6	84	272	14	258	177	695
	3	275	66	210	2	60	15	45	285	22	263	145	622
Jabavu	9	5	0	5	13	79	2	77	216	18	198	65	313
Phumala	2	228	39	189	7	34	7	27	250	14	236	135	519
Roestein	5	11	0	11	3	132	6	126	119	10	109	59	265
	6	207	74	133	12	139	29	110	260	4	256	78	618
	7	60	10	40	8	210	17	193	144	17	127	75	422
	8	0	0	0	2	53	1	57	95	5	90	19	150
Smallville	4	24	0	24	0	122	3	119	150	6	144	62	296
TOTAL		1137	307	821	53	919	86	838	1791	110	1681	815	3900

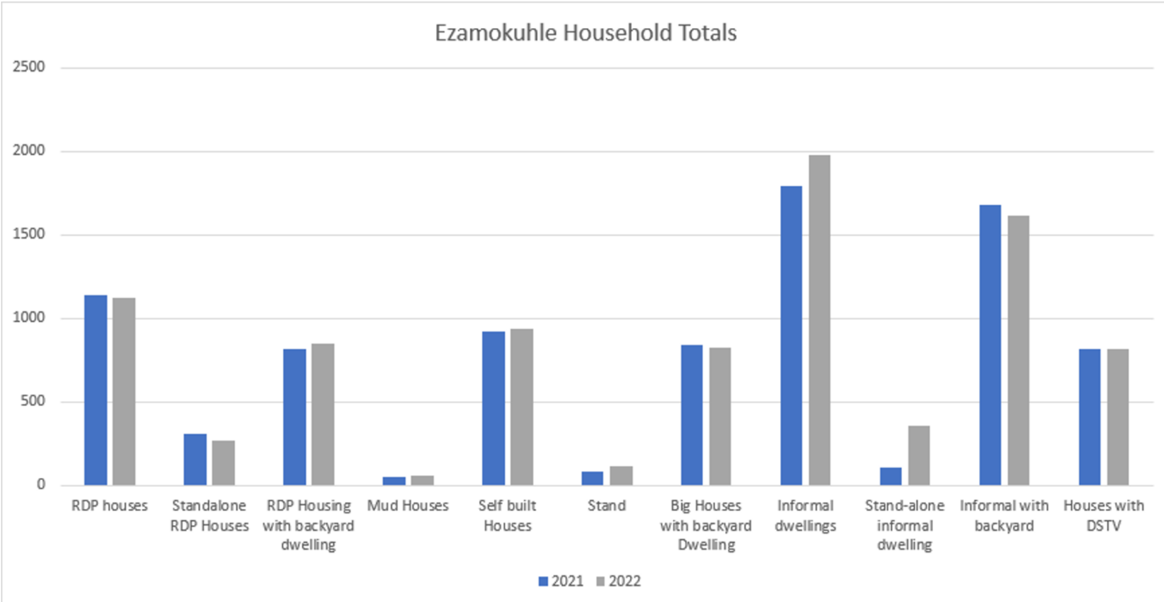

Figure 35: Comparison of 2021 and 2022 aerial survey results

Figure 36: Locality map showing where RDP homes have been upgraded

Figure 37: Map showing the areas wherein there has been a growth of informal houses

Figure 38: Aerial view showing the new informal houses in the background

4.2.2 WASTE BURNING

Seven incidents of active waste burning were observed in the field survey (Figure 39). These incidents occurred only in the mornings (19th to 21st July). The waste been burnt was general household waste that had disposed (Figure 40 to Figure 42). In terms of waste segregation, it appeared to be roughly composed of ~30% plastics, ~30% organic household waste and ~30% paper packaging and 10% other.

Figure 39: Locations of active waste burning

Figure 40: Active waste burning in Ezamokuhle

Figure 41: Waste burning in Ezamokuhle

Figure 42: Waste burning site in Ezamokuhle

4.2.3 VEHICULAR EMISSIONS

There is a higher traffic density in the morning along Bree Street as people leave for work (Figure 43). Busses favoured the bricked and tarred roads whilst the taxis drove slowly on the unpaved roads. The entrainment of dust was visible on the unpaved roads. The rest of the day the roads were generally quite (Figure 45) until late afternoon when the traffic density picked up again due to the workers arriving home. It’s noted that the busses and taxis were well maintained with no excessive tailpipe emissions observed in the field survey.

Figure 43: Map showing areas of high traffic activity

Figure 44: Higher traffic density around school

Figure 45: Ezamokuhle roads generally quiet for most of the day

4.2.4 Fugitive Dust

Dust arises from the mechanical disturbance of granular material exposed to the air. Dust generated from these open sources is termed "fugitive" because it is not discharged to the atmosphere in a confined flow stream. The sources of fugitive dust for Ezamokuhle include dust on paved roads, unpaved roads, sidewalks and open sports fields.

The inner roads of the township (Figure 46 & Figure 47) are all dust roads which compound the impact of particulate emissions. The field survey noted that at the intersection of paved/tarred roads and unpaved roads there is re-entrainment of dust emissions.

Figure 46: Ezamokuhle unpaved inner roads from aerial survey

Figure 47: Ezamokuhle unpaved inner roads from field survey

4.3 Potential future sources of air pollution

Figure 48 provides an overview of the potential future sources of air pollution that were identified.

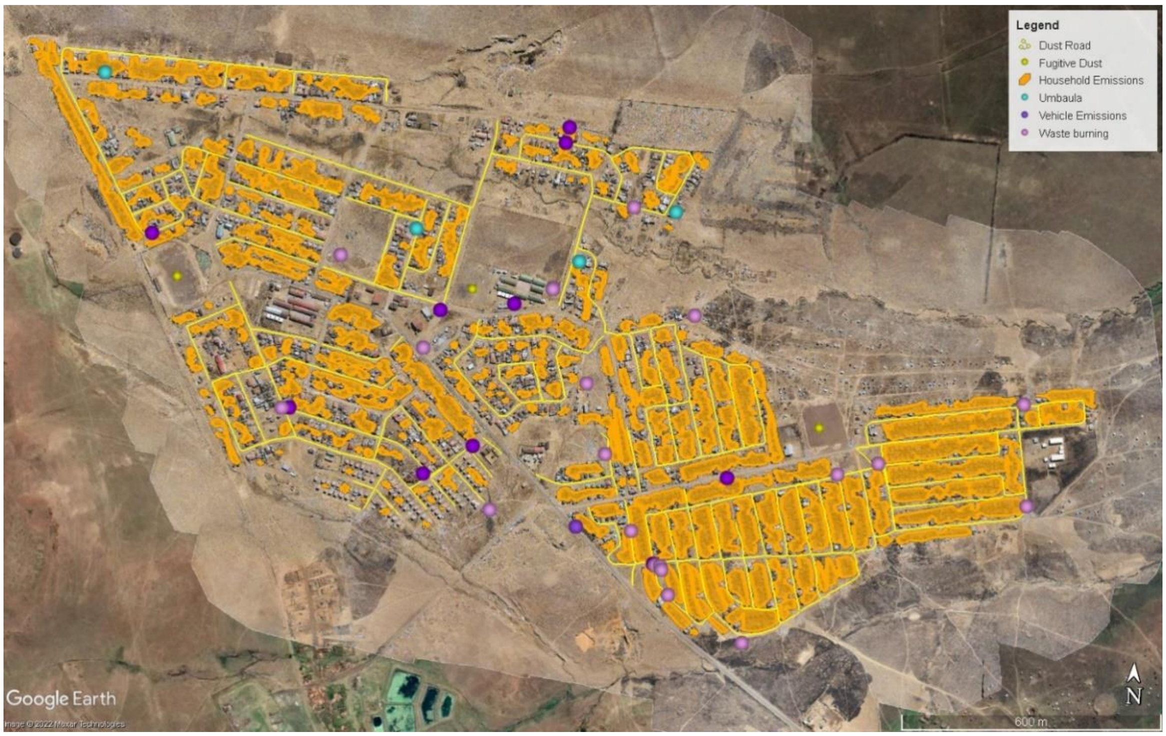

Figure 48: Map showing the location of potential future sources of air pollution documented in the Study

The following potential future sources of air pollution were identified in the assessment:

4.3.1 Waste Burning

Waste and litter appear along all the streets in Ezamokuhle. ARM identified 20 communal areas where waste dumping was more prevalent (Figure 46). At these communal waste dumping sites, the waste predominately plastic (~60%), cardboard (~20%), household waste (~10%) and other

(~10%). There were no waste skips present at any of these sites. Members of Ezamokuhle stated that the waste collection is usually late and that is the reason why they dump the waste which will be burnt at a later stage. Conversely speaking to the municipal waste pickers, they noted that the residents were impatient and hence burnt the waste. The municipal noted they collect waste weekly on a Thursday. Laban (2018) demonstrated that the open burning of waste resulted in elevated ambient concentration of PM, CO, NOx, VOCs and O_3.

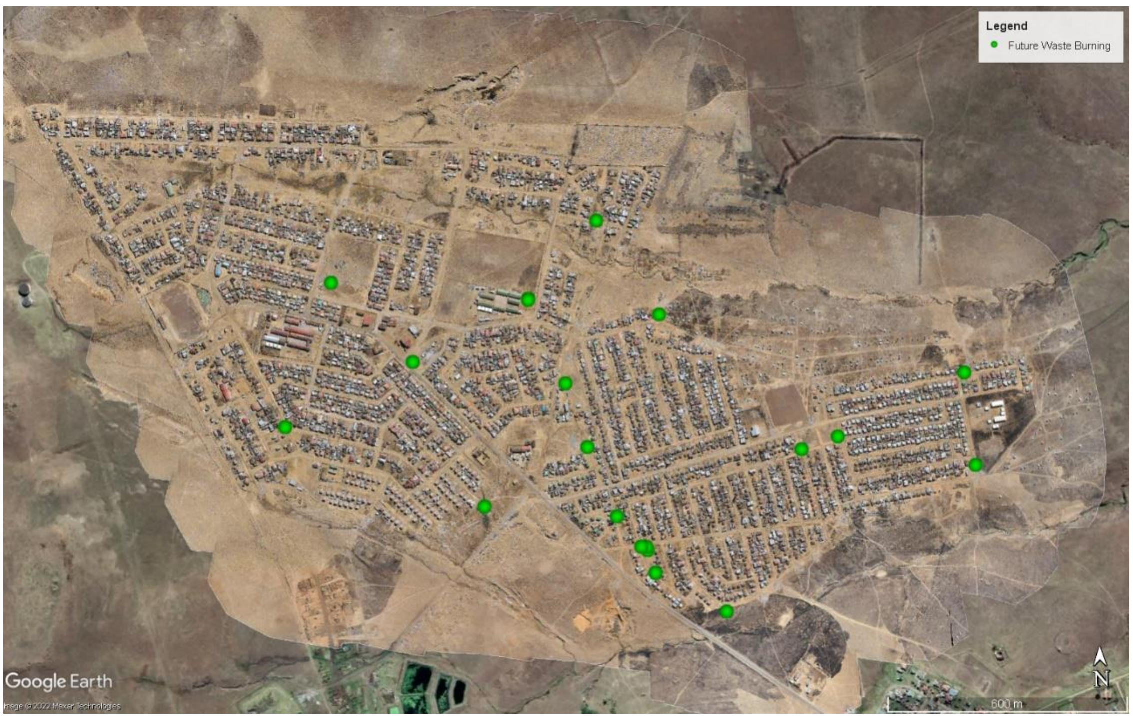

Figure 49: Potential future waste burning sites

4.3.2 Residential Fuel Burning

It was evident from the aerial survey that almost all households (albeit formal or informal) in Ezamokuhle all have a chimney. This indicates that residential fuel burning will occur for purposes of space heating, bathing and cooking. This can be exacerbated during power-interruptions and colder ambient temperatures resulting in a higher loading of pollutants to the Ezamokuhle airshed as opposed to the aerial and field observations over the Study period (19th to 21st July).

4.3.3 Fugitive dust emissions

The sources of fugitive dust for Ezamokuhle include sidewalks, dust on paved roads, unpaved roads and open sports fields. Due to a potentially higher traffic or pedestrian density, there will be an increased loading from these sources to the Ezamokuhle airshed.

5. CONCLUSION

For the *Community source survey at Ezamokuhle*, ARM utilised a combination of both a field and aerial survey. Based on these surveys, the study has identified three categories of air pollution sources: historical, current and potential future sources of air pollution. The only historical air pollution source categories identified in the assessment was historic waste burning and veld fires. Current air pollution source categories identified in the assessment included: residential fuel burning; vehicular emissions; waste burning and fugitive dust emissions. The potential future sources of air pollution identified in the study included: residential fuel burning; waste burning and fugitive dust emissions for paved roads, unpaved roads and open sports fields.

Air quality offset intervention targeted for waste burning and fugitive dust suppression may be potential areas that can provide additional air quality improvements for the Ezamokuhle airshed. It was also evident from the aerial survey that almost all households (albeit formal or informal) in Ezamokuhle all have a chimney. This indicates that residential fuel burning will occur for purposes of space heating, bathing and cooking. This can be exacerbated during power-interruptions and colder ambient temperatures resulting in a higher loading of pollutants to the Ezamokuhle airshed as opposed to the aerial and field observations conducted over the Study period. Hence there is an opportunity to reduce human exposure to harmful levels of air pollution by reducing emissions from residential burning which is aligned to the roll-out of Eskom's PMV air quality offset intervention project in Ezamokuhle.

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ANNEXURE 1: FINAL QUESTIONAIRES

A1: Household Emissions

Table 4: Household burning emissions questionnaire

Variable	Information (tick all that are applicable)	Additional Comments
Zone		
Exact Time	○	
Time of day	○ Morning ○ Midday ○ Afternoon	
GPS Location		
Street Name		
Photo	○ Yes ○ No	
Photo id		
Air quality issue	○ Historic ○ Current ○ Future	

Household emissions		
Height of chimney	○ 1 Tyre Width High (~cm) ○ 2 Tyres Width High (~cm) ○ 3 Tyres Width High (~cm) ○ 4 Tyres Width High (~cm) ○ 5 Tyres Width High (~cm) ○ Other (specify height)	
Height of smoke from chimney	○ 1 Tyre Width High (~cm) ○ 2 Tyres Width High (~cm) ○ 3 Tyres Width High (~cm) ○ 4 Tyres Width High (~cm) ○ 5 Tyres Width High (~cm) ○ Other (specify height)	
Colour of smoke from chimney	○ White ○ Light Grey ○ Dark Grey ○ Black	
Impact of smoke	○ On the Same Household ○ On Next-door Neighbours house ○ On Road ○ High into the air ○ Other (Specify)	

Smell of smoke	○ Woody ○ Coal ○ Gas ○ Paraffin ○ Other (Specify)	
Severity of emissions	○ Low (no cough caused by smoke) ○ Medium (slight cough from smoke) ○ High (heavy cough caused from smoke)	

General Comments

A2: WASTE BURNING

Table 5: Waste Burning Questionnaire

Variable	Information (tick all that are applicable)	Additional Comments
Zone		
Exact Time	○	
Time of day	○ Morning ○ Midday ○ Afternoon	
GPS Location		
Street Name		
Photo	○ Yes ○ No	
Photo id		
Air quality issue	○ Historic ○ Current ○ Future	
Waste Burning Emissions		
Details of area where waste burning is located	○ Front of household ○ Behind household ○ Open field (details in comments) ○ Edge of township ○ Traffic Circle ○ Road servitude ○ Open stand ○ Other	
Proximity of waste burning to households	○ Near (within 10m) ○ Intermediate (10 to 50m) ○ Far (more than 50m away)	
Frequency of burning	○ Continuous ○ Intermittent ○ Ad hoc ○ Unknown	
Complete or incomplete Combustion	○ All waste material burnt ○ Some waste material remains unburnt (Specify % unburnt in comments ___%)	
Waste been burnt and % of total heap	○ Paper (___%) ○ Leather/Rubber (___%) ○ Textile/Fiber ((___%) ○ Plastic (___%) ○ Vegetation (___%) ○ Organic (___%) ○ Glass (___%) ○ Metal (___%) ○ Ceramic (___%)	

	○ Wood (___%) ○ Electronic goods (___%) ○ Other (___%)	
Waste segregation and % for waste heap	○ Paper (___%) ○ Leather/Rubber (___%) ○ Textile/Fiber ((___%) ○ Plastic (___%) ○ Vegetation (___%) ○ Organic (___%) ○ Glass (___%) ○ Metal (___%) ○ Ceramic (___%) ○ Wood (___%) ○ Electronic goods (___%) ○ Other (___%) ○	
Method of transport of waste-to-waste heap	○ Thrown adhoc by hand (littering) ○ Wheelbarrow ○ Vehicle ○ Other	
Odour	○ No odour ○ Mild odour ○ Strong odour	
Size of waste heap	○ Small (radius up to 3m) ○ Medium (3m to 10m) ○ Large (>10m)	
Waste Skips Present	○ Yes ○ No	
Number of Waste Skips Present		
Waste segregation and % for Waste Skip (if Present)	○ Paper (___%) ○ Leather/Rubber (___%) ○ Textile/Fiber ((___%) ○ Plastic (___%) ○ Vegetation (___%) ○ Organic (___%) ○ Glass (___%) ○ Metal (___%) ○ Ceramic (___%) ○ Wood (___%) ○ Electronic goods (___%) ○ Other (___%) ○	

General Comments

A3: VEHICLE EMISSION SOURCES

Table 6: Vehicle Emissions Questionnaire

Variable	Information (tick all that are applicable)	Additional Comments
Zone		
Exact Time	○	
Time of day	○ Morning ○ Midday ○ Afternoon	
GPS Location		
Street Name		
Photo	○ Yes ○ No	
Photo id		
Air quality issue	○ Historic ○ Current ○ Future	

Transport Emissions		
Emission source	○ Cars ○ SUV ○ Taxi (minibus) ○ Taxi (other e.g., Avanza) ○ Bus ○ Truck	
Loading of vehicle	○ Loaded ○ Unloaded (only driver)	
Number of occupants	○	
Speed of vehicle	○ Slow (less than 20km) ○ Fair (20km to 50km) ○ Fast (greater than 50km)	
Type of emissions	○ Exhaust emissions ○ Dust (Comment on impact of dust, e.g., where pavement, road, rentrianment?) ○ Other	
Vehicle condition & maintenance	○ Poor (vehicle exhaust smoking visibly black/grey smoke) ○ Good (no visible smoke from exhaust)	
Number of vehicles at location	○ Quiet (1-3 vehicles) ○ Intermittent (3 to 10 vehicles) ○ Busy (more than 10 vehicles)	
Visibility	○ Poor (Dust and Exhaust plume impacts visibility)	

	○ Good (Visibility is clear)	
Type of Road	○ Tar ○ Paved ○ Gravel ○ Other	
Condition of Road	○ Poor ○ Good	
Pedestrian on Roads	○ Yes ○ No	
Pavement/Sidewalk on Road	○ Yes ○ No	
Emissions from lack of a sidewalk/pavement	○ Yes ○ If yes specify in comments ○ No	

General Comment

A4: INFORMAL VENDOR EMISSION SOURCES

Table 7: Informal Vendor Questionnaire

Variable	Information (tick all that are applicable)	Additional Comments
Zone		
Exact Time	○	
Time of day	○ Morning ○ Midday ○ Afternoon	
GPS Location		
Street Name		
Photo	○ Yes ○ No	
Photo id		
Air quality issue	○ Historic ○ Current ○ Future	

Informal Vendor Emissions		
Food item sold	○ Maize ○ Meat ○ Other (Please specify) ○ ________	
Type of fuel	○ Coal ○ Wood ○ Paraffin ○ Other (Please specify)	
Visibility of plume	○ Yes ○ If yes, color of smoke ○ No	
Magnitude of impact	○ Near (radius of less than 3m) ○ (Radius of 3m to 5m) ○ Far (greater than 5m)	
Severity of emissions	○ Low ○ High	

General Comment

A5: VELD FIRES

Table 8: Veld Fire Emissions Questionnaire

Variable	Information (tick all that are applicable)	Additional Comments
Zone		
Exact Time	○	
Time of day	○ Morning ○ Midday ○ Afternoon	
GPS Location		
Street Name		
Photo	○ Yes ○ No	
Photo id		
Air quality issue	○ Historic ○ Current ○ Future	

Veld fires		
Burn area size	○ Small (less than $5m^2$) ○ Intermediate (5 -$15m^2$) ○ Large (>$15m^2$)	
Vegetation type	○ Grassland ○ Trees ○ Other (Please specify)	
Visibility of plume	○ Yes ○ If yes, color of smoke ○ No	
Severity of emissions	○ Low ○ High	

General Comment

A6: ODOURS

Table 9: Odour Emissions Questionnaire

Variable	Information (tick all that are applicable)	Additional Comments
Zone		
Exact Time	○	
Time of day	○ Morning ○ Midday ○ Afternoon	
GPS Location		
Street Name		
Photo	○ Yes ○ No	
Photo id		
Air quality issue	○ Historic ○ Current ○ Future	

Odours		
Source	○ Sewage drains ○ Animal Carcass ○ Other (Details)	
Intensity	○ None ○ Moderate ○ Intense	
Localised odour to location	○ Yes ○ No	

General Comment

A7: COAL STOCKYARD

Table 10: Coal Stockyard Emissions

Variable	Information (tick all that are applicable)	Additional Comments
Zone		
Exact Time	○	
Time of day	○ Morning ○ Midday ○ Afternoon	
GPS Location		
Street Name		
Photo	○ Yes ○ No	
Photo id		
Air quality issue	○ Historic ○ Current ○ Future	

Coal Stock Yard Emissions		
Number of bags of coal present	○ Little (less than 10) ○ Few (10 to 20) ○ Many (More than 20)	
Operation	○ Busy ○ Quite	
Visible emissions	○ Yes ○ No	
Fugitive emissions	○ Localised impact (only stock yard) ○ Impact on surrounding area	
Transport of coal from stock yard	○ Trucks ○ Taxi ○ Other	

General Comment

A8: DUST EMISSIONS

Table 11: Vehicle Emissions Questionnaire

Variable	Information (tick all that are applicable)	Additional Comments
Zone		
Exact Time	○	
Time of day	○ Morning ○ Midday ○ Afternoon	
GPS Location		
Street Name		
Photo	○ Yes ○ No	
Photo id		
Air quality issue	○ Historic ○ Current ○ Future	

Dust Emissions		
Dust raised by	○ Vehicles ○ Pedestrians ○ Wind ○ Other	
Colour of dust	○ Brown ○ Red ○ Other	
Size of dust particles	○ Fine (like cigarette smoke size) ○ Large (larger than cigarette smoke size)	
Impact of dust	○ Near (within 1 meter within the area where it was raised) ○ Far (within 3 to 5 meters of the area where it was raised) ○ Very far (greater than 5m from where it was raised)	
Vegetation	○ No vegetation where dust was raised ○ Little vegetation where dust was raised ○ A lot of vegetation where dust was raised.	

General Comment

A9: OTHER EMISSION SOURCES

Table 12: Other Emission Sources Questionnaire

Variable	Information (tick all that are applicable)	Additional Comments
Zone		
Exact Time	○	
Time of day	○ Morning ○ Midday ○ Afternoon	
GPS Location		
Street Name		
Photo	○ Yes ○ No	
Photo id		
Air quality issue	○ Historic ○ Current ○ Future	

Other Emission Source		
Source	○	
Severity of the air quality incident	○	
Magnitude of the air quality incident	○	
Nature of the air quality incident	○	

General Comment

ANEXURE 2

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