Millsite Reclamation Project, near Randfontein, Gauteng Province

Air Quality Impact Assessment Report

Project Number:

SIB4276

Prepared for:

Sibanye-Stillwater

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DECLARATION OF INDEPENDENCE

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EXECUTIVE SUMMARY

Sibanye Gold Limited (Sibanye) appointed Digby Wells Environmental (Digby Wells) to undertake a suite of specialist studies in fulfilment of the Environmental Impact Assessment (EIA) and Environmental Management Plan (EMP) Process for the Millsite Reclamation Project, near Randfontein, Gauteng Province.

Sibanye will embark on the reclamation of gold bearing tailings from historical Millsite Tailings Storage Facilities (MSTFs) located near Randfontein. The total extent of the project footprint is approximately 453 hectares which is comprised of the five TSFs; Dams 38, 39, 40 and 41 and the Valley Dam. MSTF footprint covers farms Randfontein IQ 162, Waterval IQ 174, and Elandsvlei IQ 249.

This report constitutes the Air Quality Impact Assessment (AQIA) for the Millsite Reclamation Project. The AQIA assessed Project infrastructure and activities based on current scenario using sophisticated air transport and dispersion model software called the American Meteorological Society and U.S. Environmental Protection Agency (EPA) Regulatory Model (AERMOD). AERMOD was configured for an analysis of a 20 km^2 study domain centred on the Millsite Tailings Storage Facility (MSTF). Predictions of pollutant concentrations were generated for the different averaging period, 24 hour and annual for dust deposition, PM_{10} and $PM_{2.5}$ in order to compare with relevant South African standards assess impacts.

The following is a concise summary of the findings from the AQIA study:

- The predicted 24-hour GLC showed exceedances of the standard (75 µg/m³) at the MSTF site to some 5 km down south and southeast, reaching some sections of Randfontein. The area impacted shrank slightly after five years of reclamation, with minimal changes in the GLC. The Isopleth of predicted annual PM_{10} GLC confirm that exceedances of the standard (40 µg/m³) will be confined within the MSTF footprint. The predicted concentrations at the selected sensitive receptors were within limits.
- The predicted annual GLC for Year 1 and Year 5 are similar in pattern to the Isopleths for daily GLC. The areas were the daily standard of 40 µg/m³ are likely to be exceeded, extends southward, some 1.2 km towards Randfontein. The concentrations predicted at the various sensitive receptors are presented below. The Isopleth showing the predicted annual GLC of $PM_{2.5}$ at the proposed MSTF site showed that exceedances are no likely to be observed..
- The predicted dust deposition rates show that dust will be a cause for concern for receptors within a radius of 3 km, i.e. Greenhills. The predicted deposition rates at Greenhills will be in exceedance of the non-residential limit of 1 200 mg/m²/day (NDCR, 2013). However, this scenario will change after five years of reclamation. The area impacted is observed to have shrunk slightly after factoring in five years of reclamation, and predicted reduction in the deposition rates.

Although the areas with exceedances are small, and predicted emissions are general low and within regulatory limits at the selected receptors,Greenhills, adequate mitigation measures should be factored into the day to day operation once reclamation commences i.e. use of dust suppressants on dirt roads, exposed TSF areas and limiting clearing and unnecessary digging to non-windy days etc.

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ACRONYMS, ABBREVIATIONS AND DEFINITION

AERMOD	American Meteorological Society/United States Environmental Protection Agency Regulatory Model
AQIA	Air Quality Impact Assessment
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
GLC	Ground Level Concentrations
LOM	Life-of-Mine
MSTF	Millsite Tailings Storage Facility
MM5	Mesoscale model - Fifth generation
NEMAQA	National Environmental Management Air Quality Act
PSD	Particle Size Distribution
PM_{10}	Particulate Matter less than 10 microns in diameter
$PM_{2.5}$	Particulate Matter less than 2.5 microns in diameter
PSU/NCAR	Pennsylvania State University / National Center for Atmospheric Research
TSP	Total Suspended Particulates
USEPA	United States Environmental Protection Agency
WHO	World Health Organisation

1 Introduction

1.1 Project Background

Sibanye-Stillwater (Sibanye) appointed Digby Wells Environmental (Digby Wells) to undertake a suite of specialist studies in fulfilment of the Environmental Impact Assessment (EIA) and Environmental Management Plan (EMP) Process for the Millsite Reclamation Project, near Randfontein, Gauteng Province.

Sibanye will embark on the reclamation of gold bearing tailings from historical Millsite Tailings Storage Facilities (MSTF) located near Randfontein. The total extent of the project footprint is approximately 453 hectares which is comprised of the five TSFs; Dams 38, 39, 40 and 41 and the Valley Dam. MSTF footprints cover farms Rietfontein IQ 162, Waterval IQ 174, and Elandsvlei IQ 249 (Golder Associates, 2010).

Mining will comprise hydraulic reclamation of tailings with an expected life-of-mine (LOM) of approximately 9 years (Golder Associates, 2010). During the reclamation, it is anticipated that concurrent rehabilitation of the exposed footprint will take place. The slurry from the wet reclamation process is then pumped for processing through pipelines to the Cooke Plant via the Booster Pump Station (BPS) at Dump 20.

This report encompasses the scope, methodology and findings for the Air Quality Impact Assessment (AQIA) study. The AQIA study was aligned with the regulatory requirements of the South African National Environmental Management: Air Quality Act (NEMA: AQA), 2004 (Act No. 39 of 2004), GNR 919 in GG 37078 of 29 November 2013; GN R 486 in GG 35463 of 29 June 2012; GN R 1210 in GG 32816 of 29 December 2009 and GN R283 in GG 38633 of 2015.

1.2 Reclamation Process

Tailings reclamation will be undertaken by hydraulic reclamation techniques to create slurry ((using high-pressure water "guns") onto the MSTF results in the mobilisation of material and thus creating slurry), which flows down into trenches to a pumping station. The slurry first flows over a coarse grizzly screen where wood, rubbish, vegetation and lumps of tailings are captured and removed from the process. The grizzly screen underflow slurry then flows into a pump hopper below, where it is pumped to a vibrating trash screen to collect coarse waste material that has passed through the first grizzly.

The vibrating screen underflow slurry will flow by gravity to a mechanically agitated tank which will in turn pump slurry to the treatment plant. Process flow after pumping to the Cooke Plant is not considered in this report.

1.3 Terms of Reference

Digby Wells was required to assess potential impacts the proposed reclamation of the MSTF will have on the ambient air quality. The Terms of Reference (ToR) encompasses the following tasks:

- To assessment the site meteorology;
- To identify all sensitive receptors in the vicinity of the Project;
- To conduct emissions inventory based on the reclamation process;
- Development of a dispersion model;
- To assess latest legislative and regulatory requirements and emission limits; and
- Assess predicted Ground Level Concentrations (GLC) against applicable standards.

In addition, Digby Wells was required to provide recommendations regarding appropriate monitoring programme to assess emissions and evaluate the efficiency of the mitigation and management plans.

2 Specialist Details

Matthew Ojelede completed his B.Sc. (Hons) degree at the University of Benin; an M.Sc. in Environmental Science (Wits University) and a Ph.D. in Environmental Management from the University of Johannesburg. He has been in the Atmospheric Research field since 2005 and now actively involved in atmospheric dispersion modeling and emissions inventories compilation. He has authored and co-authored several research articles in peer reviewed journals and compiled dispersion modeling impact assessments reports.

3 Baseline Environment

3.1 Receptor Assessment

Receptors in the vicinity of the proposed MSTF Project area include Greenhills, Kagiso, Krugersdorp and Randfontein. From the assessment, these are all classified as residential areas. According to the United States Environmental Protection Agency (USEPA), (2016), a sensitive receptor encompasses but not limited to "*hospitals, schools, daycare facilities, elderly housing and convalescent facilities. These are areas where the occupants are more susceptible to the adverse effects of exposure to toxic chemicals, pesticides, and other pollutants*". The identified receptors are all human settlement where one or more of the above mentioned facilities are present, and involuntary exposure to airborne particulate matter is likely to occur. The proximate distances from the MSTF to these receptors are listed in Table 3-1 below.

Table 3-1: Distance and Direction to Major Settlements

Town	Status	Distance (km)	Direction
Greenhills	Residential		S
Kagiso	Residential		SE
Krugersdorp	Residential		NE
Randfontein	Residential		S

3.2 Climate and Meteorological Overview

Climate data from Lakes Environmental was used to assess the meteorology of the Project ea. Emphasis was placed on meteorological parameters of relevance to wind erosion and storm episodes, such as: wind speed and direction and rainfall. These are discussed below.

3.2.1 Wind Direction

Wind field plays a vital role in the erosion, dispersion and deposition of fugitive dust, i.e. the generation potential, the extent dust can travel downwind and the dilution potential. The amount of dust mobilised at any given location at any given period is a function of the frequency and duration of the wind events. The observed mechanical turbulence is similarly a function of the wind speed, in combination with the surface roughness (Cowherd *et al*, 1998; Cowherd *et al*, 2010).

The amount of particulate matter generated by wind is highly dependent upon the wind speed. Below the wind speed threshold for a specific particle type, no particulate matter is liberated, while above the threshold, particulate matter liberation tends to increase with wind speed. The amount of particulate matter generated by wind is dependent also on the surface properties, for example, the fraction of erodible particles, and the particle size distribution (Fryrear et al., 1991).

The predominant wind direction is from northeast, with the secondary contributions from the east northeast and east respectively (Figure 3-1). Contributions from the northeast and southeast quadrant are dominant. Calm conditions (wind speeds < 0.5 m/s) occurred for 4.2 % of the time. Figure 3-2 shows the wind class frequency distribution for the area.

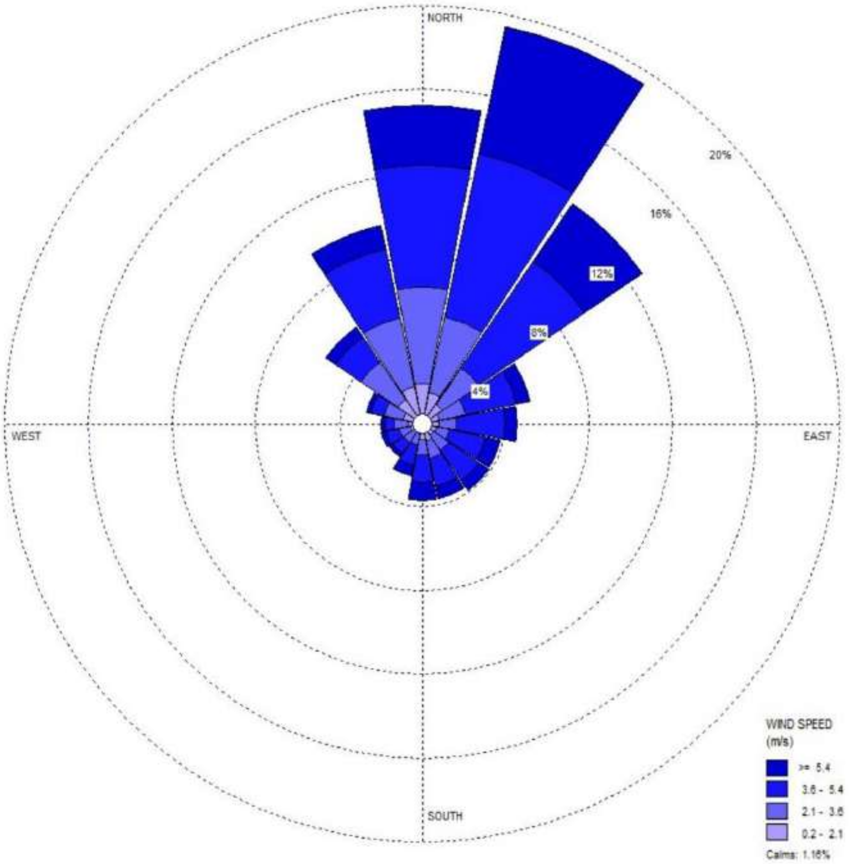

Figure 3-1: Surface Wind Rose for Millsite Project Area

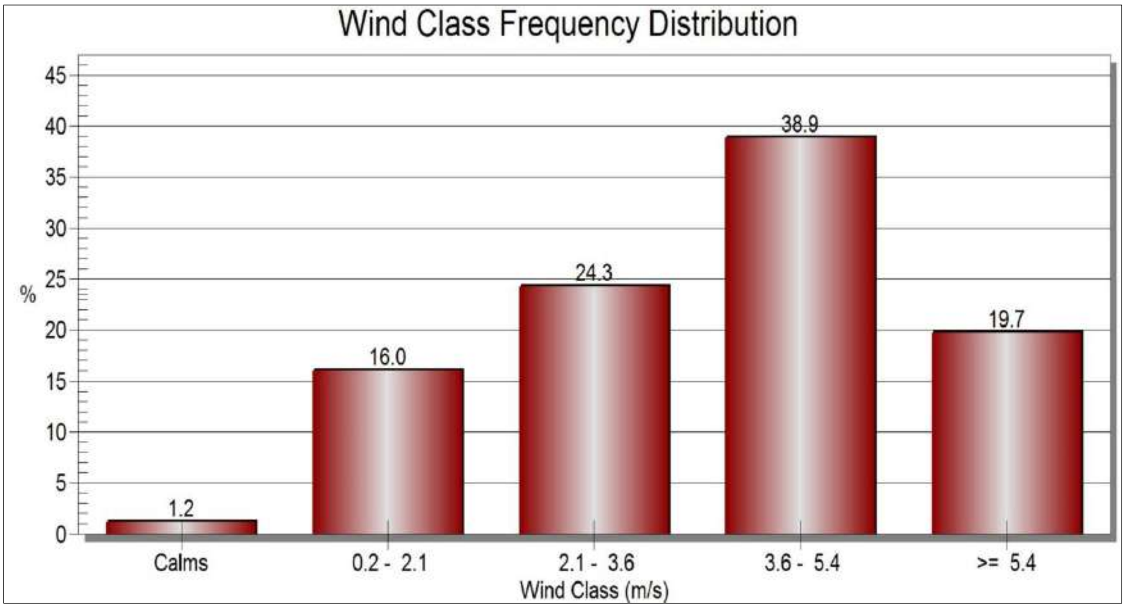

Figure 3-2: Wind Class Frequency – Millsite Project Area

3.2.2 Wind Speed

One of the factors that favour the suspension and resuspension of loose particulates in the atmosphere is the intensity of the wind speed regime. Wind speed greater than 5.4 m/s leads to erosion of loose dust PM and the degree of dispersion across the landscape (Table 3-2 and Figure 3-2). Figure 3-2 shows that wind speed greater than 5.4 m/s occur every month with increases observed from the months of June to October. Although average wind speed is generally below 5.4 m/s, it can be seen from Table 3-2 that the potential is there for wind erosion to occur each month. In total, wind speed greater than 5.4 m/s occurred 19.7% of the time. The latter is equivalent to 72 days of high wind speed capable of causing erosion in a year. This is twice the scenario observed in some areas. This is more than two months of wind speed regime capable of causing erosion.

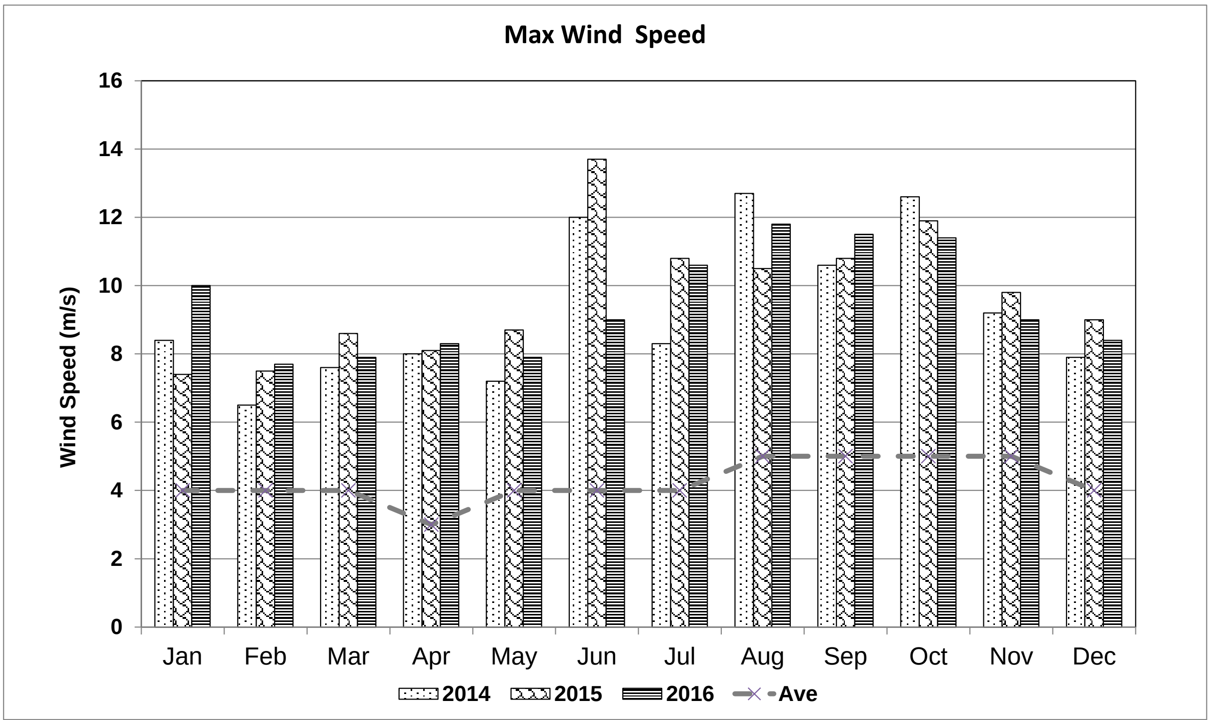

Figure 3-2: Monthly Maximum Wind Speed

Table 3-2: Monthly Wind Speed Records

Wind Speed (m/s)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Monthly Max.	10	8	9	8	9	14	11	13	12	13	10	9	10
Monthly Ave	4	4	4	3	4	4	4	5	5	5	5	4	4

3.2.2.1 Precipitation

The total monthly and average rainfalls for the period under review are reported in Table 3-3 for the three-year period (2014-2016). This is represented graphically in Figure 3-3. The highest precipitation of 269 mm observed in December. The lowest recorded precipitation (4 mm) was observed from May to June. The annual total and average rainfall reached 1259 mm and 865 mm respectively.

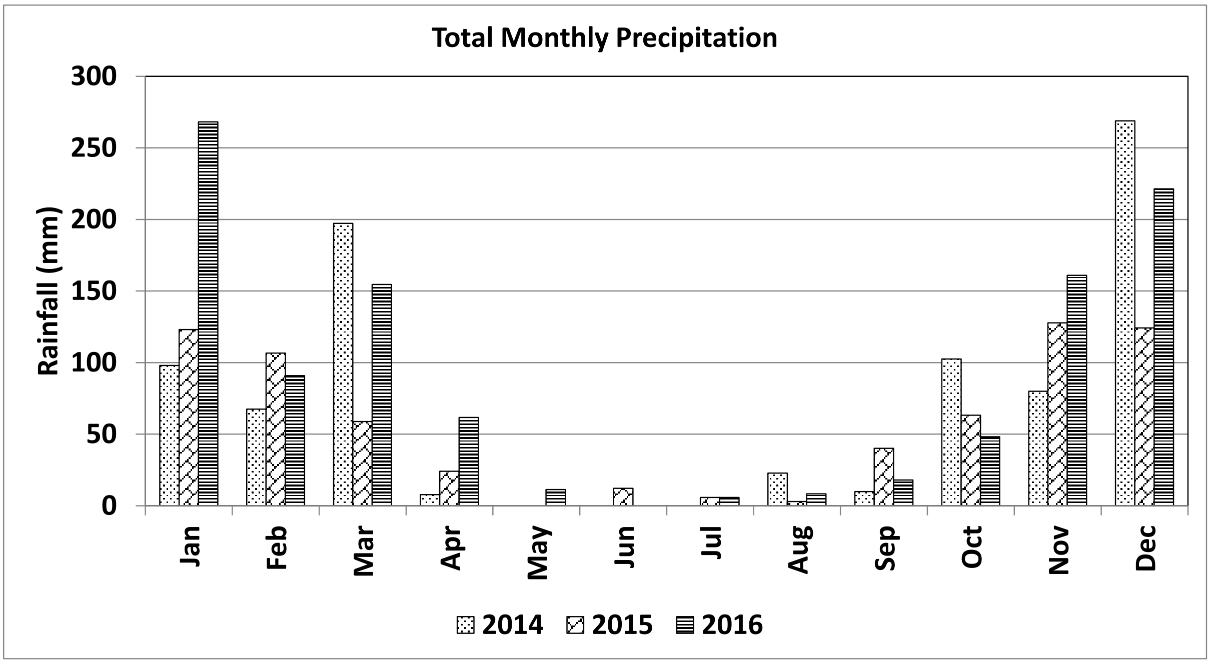

Figure 3-3: Total Monthly Precipitation

Table 3-3: Total Monthly Precipitation Records

Rainfall (mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Tot. Mon Rainfall (Max)	268	107	197	62	11	12	6	23	40	103	161	269	1259
Aver. Mon Rainfall	163	88	137	31	4	4	4	11	23	71	123	205	865

4 Legal Context (Legislations, Policies and Guidelines)

4.1 National Environmental Management: Air Quality Act 39 of 2004

The prevailing legislation in the Republic of South Africa with regards to ambient air quality is the National Framework for Air Quality management in the Republic of South Africa, Government Notice 919, Gazette No. 37078 as contemplated in Section 7 of the National Environment Management: Air Quality Act (Act No. 39 of 2004) (NEM: AQA), Government Notice: R898, Gazette No. 28016. The NEM: AQA repealed the Atmospheric Pollution Prevention Act (45 of 1965) (APPA).

According to NEM: AQA, the Department of Environmental Affairs (DEA), the provincial environmental departments and local authorities (district and local municipalities) are separately and jointly responsible for the implementation and enforcement of various aspects of NEM: AQA. Each of these spheres of government is obliged to appoint an air quality officer and to co-operate with each other and co-ordinate their activities through mechanisms provided for in the National Environment Management Act (NEMA), 1998 (Act 107 of 1998).

The purpose of National Framework and NEM: AQA is to set norms and standards that relate to:

- Institutional frameworks, roles and responsibilities;
- Air quality management planning;
- Air quality monitoring and information management;
- Air quality management measures; and
- General compliance and enforcement.

Amongst other things, it is intended that the setting of norms and standards will achieve the following:

- The protection, restoration and enhancement of air quality in South Africa;
- Increased public participation in the protection of air quality and improved public access to relevant and meaningful information about air quality; and
- The reduction of risks to human health and the prevention of the degradation of air quality.

Although data to establish a distinction between levels for absolute safety and acceptable risk are unavailable, scientific judgment and consensus are employed in establishing standards that indicate acceptable levels of population exposure for different pollutants. These standards, which are legally enforceable once adopted (World Health Organization, 2000) prescribe the allowable ambient concentrations of pollutants which are not to be exceeded during a specified time period in a defined area. If the air quality guidelines/standards are exceeded, the ambient air quality is adjudged poor and the potential for health effects is greatest.

4.2 Ambient Air Quality Standard

A fundamental aspect of the new approach to the air quality legislation, as reflected in the NEM: AQA, is the establishment of National Ambient Air Quality Standards (NAAQS). The NEM: AQA provides for the identification of priority pollutants and the setting of ambient standards with respect to these pollutants. In addition, provincial and local authorities are allowed to formulate stricter standards.

In terms of Sections 9, 10 and 11 of NEM: AQA, DEA has established the National Ambient Air Quality Standards for the criteria pollutants in the Government Notice 1210, Government Gazette 32816:2009.

Table 4-1 gives an overview of the NAAQS, as well reference methods and compliance dates for criteria pollutants in South Africa.

Table 4-1: National Ambient Air Quality Standards as of 24 December 2009

AVERAGING PERIOD	LIMIT VALUE (µg/m^3)	FREQUENCY OF EXCEEDANCE	COMPLIANCE DATE
National Ambient Air Quality Standard for Particulate Matter (PM_{10})			
24 hour	75 µg/m^3	4	January 2015
1 year	40 µg/m^3	0	January 2015
The reference method for the determination of the PM10 fraction of suspended particulate matter shall be EN 12341.			

The Minister of Water and Environmental Affairs, in terms of section 9 (1) of the NEM: AQA established the National Ambient Air Quality Standard for particulate matter of aerodynamic diameter less than 2.5 micron metre ($PM_{2.5}$), published in Government Notice R 486, Government Gazette 35463 of 29 June 2012 (Table 4-2).

Table 4-2: National Ambient Air Quality Standard for Particulate Matter $PM_{2.5}$

AVERAGING PERIOD	CONCENTRATION	FREQUENCY OF EXCEEDANCE	COMPLIANCE DATE
National Ambient Air Quality Standard for Particulate Matter ($PM_{2.5}$)			
24 hours	40 µg/m^3	4	1 January 2016 – 31 December 2029
1 year	20 µg/m^3	0	1 January 2016 – 31 December 2029
The reference method for the determination of the $PM_{2.5}$ fraction of suspended particulate matter shall be EN 14907.			

In line with NEM: AQA, the National Department of Environmental Affairs has published the National Dust Control Regulations in Government Notice 827 in Gazette No. 36974 on 1 November 2013. In the regulations, terms like target, action and alert thresholds were omitted. Another notable observation was the reduction of the permissible frequency from three to two incidences within a year. The standard actually adopted a more stringent approach than previously, and will require dedicated mitigation plans now that this is in force.

The National Dust fallout standard is given in the Table 4-3 below.

Table 4-3: Acceptable Dust Fall Rates (using ASTM D1739:1970 or equivalent)

Restriction Areas	Dust fall rate (mg/m^2/day, 30-days average)	Permitted Frequency of exceeding dust fall rate
Residential Area	< 600	Two within a year, not sequential months
Non-Residential Area	< 1200	Two within a year, not sequential months

The reclamation process will have a negligible impact on the background concentration of gases in the area, the reason being that mining will be conducted mainly as a wet process. Gaseous emissions and impacts associated with employee vehicles are adjudged insignificant, as this is limited to travel to and off site.

4.3 Health Effects of Pollutants

4.3.1 Air Pollutants

The main pollutants of concern associate with the construction and operational phases of the reclamation process will be particulate matter, whether in the form of total suspended particulates (TSP), PM_{10} and $PM_{2.5}$. Gaseous emissions from the use of vehicles to and off site are considered negligible, due to the number of vehicles involved.

4.3.1.1 Particulate Matter

Particulate matter (PM) in the environment is generated mainly by human activities: transport, energy production, domestic fuel combustion and by a wide range of activities. There is no evidence of a safe level of exposure or a threshold below which no adverse health effects occur.

Particulate matter can be classified by their aerodynamic properties into coarse particles, PM_{10} (particulate matter with an aerodynamic diameter of less than 10 µm) and fine particles, $PM_{2.5}$ (particulate matter with an aerodynamic diameter of less than 2.5 µm) (Harrison and van Grieken, 1998). Emissions of these particulate will be from drilling and blasting and material handling processes (loading and offloading, hauling and from wind erosion). The composition is mainly earth crust materials (Fenger, 2002).

In terms of health effects, particulate air pollution is associated with complaints of the respiratory system (WHO, 2000). The aerodynamic properties i.e. particle size is a strong determinant as it controls the depth of penetration in the respiratory system. Fine particles are thought to be more damaging to human health than coarse particles as larger particles are less respirable in that they do not penetrate deep into the lungs compared to smaller particles (Manahan, 1991). Larger particles are deposited into the extra thoracic parts of the respiratory tract while smaller particles are deposited into the smaller airways leading to the respiratory bronchioles (Patel et al., 2009; McConnell et al., 2003; WHO, 2000).

The range of public health effects associated with PM is broad, involving respiratory and cardiovascular systems in children and adults (Patel et al., 2009; McConnell et al., 2003). There are claims that sufficient evidence exist to infer a causal relationship between exposure and deaths from respiratory diseases in the post-neonatal period. Adverse effects of PM on lung development include reversible deficits of lung function as well as chronically reduced lung growth rate and long-term lung function deficit. The available evidence is also sufficient to assume a causal relationship between exposure to PM and aggravation of asthma, as well as cough and bronchitis symptoms. Daily mortality and hospital admissions have been linked with short term variation of PM levels Patel et al., 2009; McConnell et al., 2003).

Existing evidence of adverse health effects at low levels of exposure prompted WHO to revise its Air Quality Guidelines (AQG) for particulate matter in 2005. For $PM_{2.5}$, the annual and daily (24-hours) guideline values are 10 µg/m^3 and 25 µg/m^3 (not to be exceeded for more than 3 days in a year). The corresponding guidelines for PM_{10} were set at 20 µg/m^3 (annual) and 50 µg/m^3 (daily).

Numerous epidemiological studies conducted in Europe and in other parts of the world have shown adverse health effects of exposure to PM_{10} and $PM_{2.5}$ at concentrations that are currently observed in Europe and the rest of the world. WHO estimated that approximately 700 annual deaths from acute respiratory infections in children aged 0–4 years could be attributed to PM_{10} exposure in the WHO European Region in the late 1990s alone. Population health effects of exposure to PM in adults are dominated by mortality associated with long-time exposure to fine PM ($PM_{2.5}$). Short-term and long-term health effects associated with exposure to particulate matter are presented in Table 4-4 (WHO, 2010).

4.3.2 Short-term Exposure

Recent studies suggest that short-term exposure to particulate matter is associated with health effects, even at low concentrations of exposure. Various studies undertaken during the 1980s and early 1990s have looked at the relationship between daily fluctuations in particulate matter and mortality at low levels of exposure. Pope *et al* (1992) studied daily mortality in relation to PM_{10} concentrations in Utah Valley during the period 1985 - 1989. A maximum daily average concentration of 365 µg/m^3 was recorded with effects on mortality observed at concentrations of < 100 µg/m^3. The increase in total daily mortality was 13% per 100 µg/m^3 increase in the 24 hour average. Studies have shown that increases in daily mortality were experienced with an increase in PM_{10} concentrations (Pope and Dockery, 1992; Pope and Kanner, 1993; Schwartz, 1993). Relative risks for chronic lung disease and cardiovascular deaths were higher than deaths from other causes.

However, in the past, daily particulate concentrations were in the range 100 – 1000 µg/m^3 whereas in more recent times, daily concentrations are between 10 – 100 µg/m^3. Overall, exposure-response can be described as curvilinear, with small absolute changes in exposure at the low end of the curve having similar effects on mortality to large absolute changes at the high end (WHO, 2000).

4.3.3 Long-term Exposure

Long-term exposure to low concentrations (~10 µg/m^3) of particulates is associated with mortality and other chronic effects such as increased rates of bronchitis and reduced lung function (WHO, 2000).The short term and long term effects associated with particulate matter are depicted in Table 4-4.

Studies have indicated an association between lung function and chronic respiratory disease and airborne particles. Older studies by Chestnut *et al* (1991) found that Forced Vital Capacity decreases with increasing annual average particulate levels with an apparent threshold at 60 µg/m^3. Using chronic respiratory disease data, Schwartz (1993) determined that the risk of chronic bronchitis increased with increasing particulate concentrations, with no apparent threshold.

Table 4-4: Short-term and Long-term Health Effects Associated with Exposure to PM (WHO, 2004)

Pollutant	Short-term exposure	Long-term exposure
Particulate matter	▪ Lung inflammatory reactions ▪ Respiratory symptoms ▪ Adverse effects on the cardiovascular system ▪ Increase in medication usage ▪ Increase in hospital admissions ▪ Increase in mortality	▪ Increase in lower respiratory symptoms ▪ Reduction in lung function in children ▪ Increase in chronic obstructive pulmonary disease ▪ Reduction in lung function in adults ▪ Reduction in life expectancy ▪ Reduction in lung function development

5 Air Quality Impact Assessment

Emissions generated from the reclamation activities are associated mainly with fugitive dust, such as: PM_{10}, $PM_{2.5}$ and dust fallout from wind erosion of exposed areas. Gaseous emissions such as SO_2, NO_2 and CO are not anticipated from the wet reclamation process, since power will be sourced from the national grid. In addition, vehicle emissions from employee commute is considered negligible. Emission inventory conducted based on MSTF sources and related activities is discussed in detail below (Section 5.1). Emission rates generated from the aforementioned were combined with the site meteorological data as input parameters in a dispersion model environment to predict GLC of particulate pollutants anticipated from the reclamation process.

5.1 Emissions Inventory

Fugitive emissions from the proposed reclamation process were quantified by applying “emissions factors” for mining and related activities. The reclamation process is devoid of the usual activities associated with a mining, such as: drilling and blasting, hauling, material handling processes, which results in significant emissions, especially from the haul road.

The establishment of an emissions inventory forms the basis for any air quality impact assessment. Air pollution emissions may typically be obtained using actual sampling at the point of emission, or estimating it from mass and energy balances or emission factors which have been established at other, similar operations. The method adopted here is the latter. Emission factor equations published by the US-EPA in its AP-42 document “Compilation of Air Pollution Emission Factors” were employed.

The TSFs that make up the MSTF have been deposited there for decades. The current status of the TSFs shows that vegetation types and Cryptograms biomass cover some sections, coupled with hard soil crust in places. Envisaged emissions from the proposed reclamation of MSTF include:

- Inhalable particulates, with aerodynamic diameters less than or equal to 10 micron (PM_{10}) and 2.5 micron ($PM_{2.5}$)from all mining sources; and
- Total suspended particulates (TSP).

Quoting directly from the USEPA – AP-42 (2016), …”*air pollutant emission factors are representative values that attempt to relate the quantity of a pollutant released to the ambient air with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant (e.g., kilograms of particulate emitted per megagram of coal burned). Such factors facilitate estimation of emissions from various sources of air pollution. In most cases, these factors are simply averages of all available data of acceptable quality, and are generally assumed to be representative of long-term averages*”.

Although vegetation cover, presence of cryptograms biomass and hard soil crust are erosion limiting in nature, the worst case scenario was adopted (i.e. emissions from the exposed surfaces of the TSFs). The establishment of this emissions inventory is necessary to provide the source and emissions data required as input to the dispersion simulations.

The estimation of emissions before emission reduction controls are applied is depicted in Equation 1, and once emissions reduction is applied Equation 2 will apply:

$$E = A * EF$$

Equation 1

$$E = A * EF * \left(1 - \frac{ER}{100}\right)$$

Equation 2

Where:

- E=emission rate
- A=activity rate
- EF=emission factor
- ER=Overall emission reduction efficiency (%)

The emission factors and equations used in the assessment for the proposed MSTF reclamation process are described in the sections below.

5.1.1 Construction Phase

The construction phase quantified emissions using the USEPA “emissions factor for construction activities”, site preparation, which encompasses clearing. The emissions factors as suggested by the USEPA’s Compilation of Air Pollutant Emission Factor, 5th Edition, 1995 (AP-42) for “Heavy Construction Operation” and “Wind Erosion from Construction Site” was used. The equation assumed 10 working hours per day, while the wind erosion equation assumed wind erosion for the whole day over the construction site, which adopted a phased approach i.e. area cleared in phases (Equation 3 and Equation 4). For the proposed reclamation of the MSTF it was assumed that this phase will have a negligible impact on ambient air quality. Hence, this activity was not assessed in this report.

$$Emission\,rate\ (Heavy\ Construction) = 2.69 * \frac{10^6}{1000 * 30 * 3600}$$

Equation 3

$$Emission\,rate\ (Wind\ Erosion) = 0.85 * \frac{10^6}{10000 * 365 * 24 * 3600}$$

Equation 4

5.1.2 Operational Phase

As mentioned previously, the reclamation process will be wet, hence not associated with dust emissions. Emission sources that will be associated with the operational phase of the reclamation process will encompass mainly:

- Vehicle entrainment of dust from access roads i.e. employee commute to and off site; and
- Wind erosion from cleared and exposed surface of the TSFs.

5.1.2.1.1 Vehicle Generated Dust from Unpaved Access Roads

Employee commute to rehabilitation site every day on dirt from either R24 or R28 paved roads. Emissions from this activity are considered negligible due to the limited number of vehicles and the number of trips per day (perhaps two vehicles per day doing return trips). Vehicular movement on unpaved roads, coupled with the rotation of the wheels caused pulverisation of surface material and entrainment of dust. The airborne dust takes time to settle depending on the aerodynamic diameter.

The AP-42 emissions factor for wheel-generated dust from unpaved roads for passenger vehicles was used. In addition to the volume of traffic, parameters such as vehicle speeds, mean vehicle weight, average number of wheels per vehicle and road surface moisture and silt contents are factors that determine emissions (USEPA, 1995). Emission rates for TSP, PM_{10} and $PM_{2.5}$ from this source was estimated using Equation 5.

$$EF_{(\frac{KG}{VKT})} = \frac{0.4536}{1.6093} * k * (\frac{s(\%)}{12})a * (\frac{w(t))}{3})b$$

Equation 5

Where:

- k_{TSP} = 4.9 for total suspended particles
- $k_{PM_{10}}$ = 1.5 for PM_{10}
- $s_{(\%)}$ = silt content of material (%)
- $W_{(t)}$ = vehicle mass (t)
- a_{TSP} = 0.7 (empirical constant)
- $a_{PM_{10}}$ = 0.9 (empirical constant)
- b = 0.45 (empirical constant)

5.1.2.2 Wind Erosion from Exposed Surfaces

AP-42 (USEPA, 1998) states that 50% of the TSP is emitted as PM_{10} in the fugitive emissions mix. Using Equation 6 and the site specific particle size data the emissions factor for the different pollutants are estimated (USEPA, 2006). The parameters used in the calculations of the emissions associated with wind erosion are given below (Table 5-1).

The AP-42 emission factor equation for wind erosion is:

$$EF_{TSP(kg/ha/yr)} = 1.9 \times \left(\frac{s_{(\%)}}{1.5}\right) \times 365 \times \left(\frac{365 - p}{235}\right) \times \left(\frac{f_{(\%)}}{15}\right)$$

Equation 6

Where:

- $s_{(\%)}$ = silt content (% by weight)
- p = number of days per year when rainfall is greater than (0.25 mm)
- $f_{(\%)}$ = percentage of time that wind speed is greater than 5.4 m/s at the mean height of the stockpile

Table 5-1: Wind Erosion from Exposed Areas and Derived Emission Factors without Mitigation

Activity	Unit	TSP	PM_{10}	$PM_{2.5}$
TSF	$g/m^2/s$	2.5E-05	1.3E-05	2.6E-06

Significant emissions can arise due to the mechanical disturbance of granular material from open areas and MSTF. Parameters which have the potential to impact on the rate of emission of fugitive dust include the extent of surface compaction, moisture content, ground cover, the shape of the TSF, particle size distribution, wind speed and precipitation. Any factor that binds the erodible material, or otherwise reduces the availability of erodible material on the surface, decreases the erosion potential of the source. High moisture content, whether due to precipitation or deliberate wetting, promotes the aggregation and cementation of fines to the surfaces of larger particles, thus decreasing the potential for dust emissions. Surface compaction and ground cover similarly reduces the potential for dust generation. The shape of a storage pile influences the potential for dust emissions through the alteration of the airflow field. The particle size distribution of the material on the disposal site is important since it determines the rate of entrainment from the surface, the dispersion of the dust plume, and the rate of deposition.

Dust emissions due to the erosion of open storage piles and exposed areas occur when the threshold wind speed is exceeded (Cowherd *et al.*, 1988; USEPA, 1995). The threshold wind speed is dependent on the erosion potential of the exposed surface, which is expressed in terms of the availability of erodible material per unit area (mass/area). Studies have shown that when the threshold wind speed is exceeded, erosion rates tend to increase rapidly (Cowherd *et al.*, 1988).

It is anticipated that dust will be eroded from identified sources at the proposed project mining area at wind speeds of greater than 5.4 m/s (i.e. threshold friction velocity of 0.26 m/s). Fugitive dust generation resulting from wind erosion under high winds (i.e. > 5.4 m/s) is directly proportional to the wind speed. Wind speeds of 5.4 m/s and stronger will occur for some 72 days per year was calculated from the modelled data.

Wind erosion is generally a selective material-loss process, which moves particles of various size fractions at different mass-flow rates. One also needs to understand how the particle-size distribution (PSD) is related to material properties of the eroded material.

PSD is the key parameter, determining the entire process of wind erosion, from entrainment through transport to deposition. Table 5-2 gives PSD as adopted from a similar operation. These values were used as input parameters into the model to estimate the dust deposition rates.

Wind erosion is generally a selective material-loss process, which moves particles of various size fractions at different mass-flow rates; one also needs to understand how the particle-size distribution (PSD) is related to material properties. PSD is a key parameter determining the entire process of wind erosion, from entrainment through transport to deposition.

PSD values for the MSTF were utilised for the dust deposition assessment. Table 5-2 gives the PSD values that were employed.

Table 5-2: Particle Size Distribution for MSTF (University of Johannesburg 2010).

Source	PARTICLE SIZE FRACTION %			
	2.5 µm	10µm	30µm	75µm
Millsite TSFs	0.16	0.18	0.27	0.38

5.2 Atmospheric Dispersion Modelling and Compliance Assessment

5.2.1 Dispersion Modelling

Dispersion models compute ambient concentrations as a function of source configurations, emission strengths and meteorological characteristics, thus providing a useful tool to ascertain the spatial and temporal patterns in the ground level concentrations arising from various sources within the proposed operation. All emission scenarios will be simulated using the US Environmental Protection Agency's Preferred/Recommended Models: AERMOD modelling system (as of December 9, 2006, AERMOD is fully promulgated as a replacement to ISC3 model). AERMOD modelling system incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, including treatment of both surface and elevated sources, and both simple and complex terrain.

The daily average concentrations were calculated as the 4th highest value (99th percentile). Annual mean values were shown as the highest values (100th percentile) according to the NEM: AQA Air Dispersion Regulation (2012).

Model results will predict contributions from the proposed Project on surrounding atmosphere and generate contour plots (maps) of ground level concentration zones per pollutant.

5.2.1.1 Modelling Domain

There are two input data processors that are regulatory components of the AERMOD modelling system:

- AERMET, a meteorological data pre-processor that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts; and

- AERMAP, a terrain data pre-processor that incorporates complex terrain using USGS Digital Elevation Data.

The influence of the terrain will vary with the source height and position and the local meteorology. Table 5-3 gives an overview of meteorological parameters and basic setup options for the AERMOD model runs.

The AERMAP terrain pre-processor requires the user to define a modelling domain. The modelling domain is defined as the area that contains all the receptors and sources being modelled with a buffer to accommodate any significant terrain elevations.

AERMOD's three models and required model inputs are as follows:

- AERMET: calculates boundary layer parameters for input to AERMOD:
  - Model inputs: wind speed; wind direction; cover; ambient temperature; albedo; surface roughness; Bowen ratio.
- AERMAP: calculates terrain heights and receptor grids for input to AERMOD:
  - Model inputs: DEM data [x,y,z]; design of receptor grid (pol., cart., disc.); and
  - Model outputs for AERMOD: [x,y,z] and hill height scale for each receptor.
- AERMOD: calculates temporally-averaged air pollution concentrations at receptor locations for comparison to the relevant standard:
  - Model inputs: source parameters (from permit application); boundary layer meteorology (from AERMET); receptor data (from AERMAP).

Table 5-3: Summary of AERMET Parameters

Number of grids (spacing)	1 (200 m)
Number of grids points	81x81
Years of analysis	Jan 2014 to Dec 2016
Centre of analysis	Randfontein (7110017.43 S, 570155.26 E)
Meteorological grid domain	20 km (east-west) x 20 km (south-north)
Meteorological grid cell resolution	20 km x 20 km
Station Base Elevation	1618 m
MM5-Processed Grid Cell (Grid Cell Centre)	7110017.43 S, 570155.26 E
Anemometer Height	13 m
Sectors	The surrounding area land use type was considered to be residential

Albedo	0.28 (generated with the AERMOD Model – when the land use types are specified)
Surface Roughness	0.0725
Bowen Ratio	0.75
Terrain Option	Elevated

5.2.2 Analysis and Interpretation

Impacts were assessed based on the predicted GLC estimated by the model which was compared to regulatory standards at the site and immediate vicinity.

It is noted that:

- The current standard was applied to all locations where members of the public may be exposed to the averaging periods (e.g. 1-hour, 24-hours, annual).

Analysis of dispersion model highlighted the following:

- Predicted zones of maximum GLC;
- Evaluation of potential for human health and environmental impacts; and
- Recommendations of impact management zones.

Once the areas of maximum impacts were identified, recommendations were provided regarding the mitigation measures to adopt. These recommendations should be incorporated into the day-to-day operation of the mine to prevent, control and abate emissions.

5.2.3 Operational Parameters Considered

To determine the maximum deposition rates and vehicle travel on internal access road, the following factors were considered:

- Transportation of employees to and from site; and
- Wind erosion of MSTF.

5.2.4 Sources

5.2.4.1 Line Source

It was assumed that the access road to MSTF was unpaved. Emissions due to vehicle entrainment were modelled as line sources and the modelling parameters were based on guidance from AERMOD User's Guide.

The majority of emissions on the access road network will be due to vehicle commute, which will be variable (morning and evenings respectively).

5.2.4.2 Area Source

Emissions from MSTF were modelled as an area source, taking into consideration the height, width, length and particle size distribution of the material respectively.

6 Evaluation of Dispersion Modelling Results

6.1 Isopleth Plots and Evaluation of Modelling Results

6.1.1 PM_{10}

6.1.1.1 PM_{10} Daily

The Isopleth showing different concentration zones for PM_{10} as a result of wind erosion from the MSTF is presented in Figure 6-1 (Year 1) and Figure 6-2 (Year 5) respectively. The predicted 24-hour (daily) concentrations show that the standard (75 µg/m³) is exceeded at the MSTF site and extending to some 5 km down south and southeast reaching some sections of Randfontein. In both cases the limit value (75 µg/m³) is exceeded several kilometres from the edge of MSTF. The area impacted shrank slightly, and the GLC did not change significantly after five years, however, the source of pollution will continue to decrease until if disappears from the landscape.

6.1.1.2 PM10 Annual

The Isopleth of predicted annual PM_{10} ground level concentration is presented in Figure 6-3 and Figure 6-4 respectively. The areas were the current standard of 40 µg/m³ are likely to be exceeded are confined within the MSTF footprint. The predicted concentrations at the selected sensitive receptors are presented in Table 6-1 and Table 6-2.

6.1.2 $PM_{2.5}$

6.1.2.1 $PM_{2.5}$ Daily

The predicted annual GLC for Year 1 and Year 5 are similar in pattern to the Isopleths for daily GLC. The areas were the daily standard of 40 µg/m³ is likely to be exceeded, extends southward, some 1.2 km towards Randfontein (Figure 6-5 and Figure 6-6). The concentrations predicted at the various sensitive receptors are presented bellow (Table 6-1 and Table 6-2).

6.1.2.2 $PM_{2.5}$ Annual

The Isopleth showing the predicted annual GLC of $PM_{2.5}$ at the proposed MSTF site are presented in Figure 6-7 and Figure 6-8 respectively. Exceedances are no likely to be observed as predicted GLC are low. Concentrations predicted at the sensitive receptors are reported in (Table 6-1 and Table 6-2).

6.1.3 Dust Deposition

Figure 6-9 and Figure 6-10 show the predicted dust deposition rates from the MSTF for Year 1 and Year 5 respectively. The predicted dust deposition rates show that dust will be a cause for concern for receptors within a radius of 3 km, i.e. Greenhills. The predicted deposition rate at Greenhills exceeded the non-residential limit of 1 200 $mg/m^2/day$ (NDCR, 2013). Deposition rates predicted at the other receptors were within the limit for residential areas (1 200 $mg/m^2/day$) (Table 6-1 and Table 6-2).

The area impacted shrank slightly after factoring in five years of reclamation and the predicted dust deposition rates decreased slightly. Overtime, the pollution source will be mined out and risk associated with dust from MSTF eliminated completely.

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Table 6-1: Comparison of Predicted GLC at Receptors with Standards - Year 1

Pollutant	Averaging Period	Ambient Air Quality Standard (µg/m³)	Levels at receptors (µg/m³)			
			Greenhills	Kagiso	Krugersdorp	Randfontein
(PM_{10})	24 hour	75(1)	26	6	7	27
	Annual	40(1)	6	0.3	0.2	4
($PM_{2.5}$)	24 hour	40(1)	5	1.3	1.2	9
	Annual	25(1	1.2	0.04	0.05	0.8
Dust fall (mg/m²/day)						
Dust deposition	monthly	600(3)	**1502**	87	85	430

(1) National Ambient Air Quality Standards, 2009 (NAAQS)
(2) National Ambient Air Quality Standard for Particulate Matter With Aerodynamic Diameter Less Than 2.5 Microns Meter ($PM_{2.5}$).
(3) National Dust Control Regulation, 2013 (NDCS)

Table 6-2: Comparison of Predicted GLC at Receptors with Standards – Year 5

Pollutant	Averaging Period	Ambient Air Quality Standard (µg/m^3)	Levels at receptors (µg/m^3)			
			Greenhills	Kagiso	Krugersdorp	Randfontein
(PM_{10})	24 hour	75(1)	11	3	4	18
	Annual	40(1)	2	0.1	0.1	3
($PM_{2.5}$)	24 hour	40[(1)]	2	0.7	0.9	7
	Annual	25[(1]	0.5	0.02	0.02	0.5
Dust fall (mg/m^2/day)						
Dust deposition	monthly	600[(3)]	**752**	39	32	207

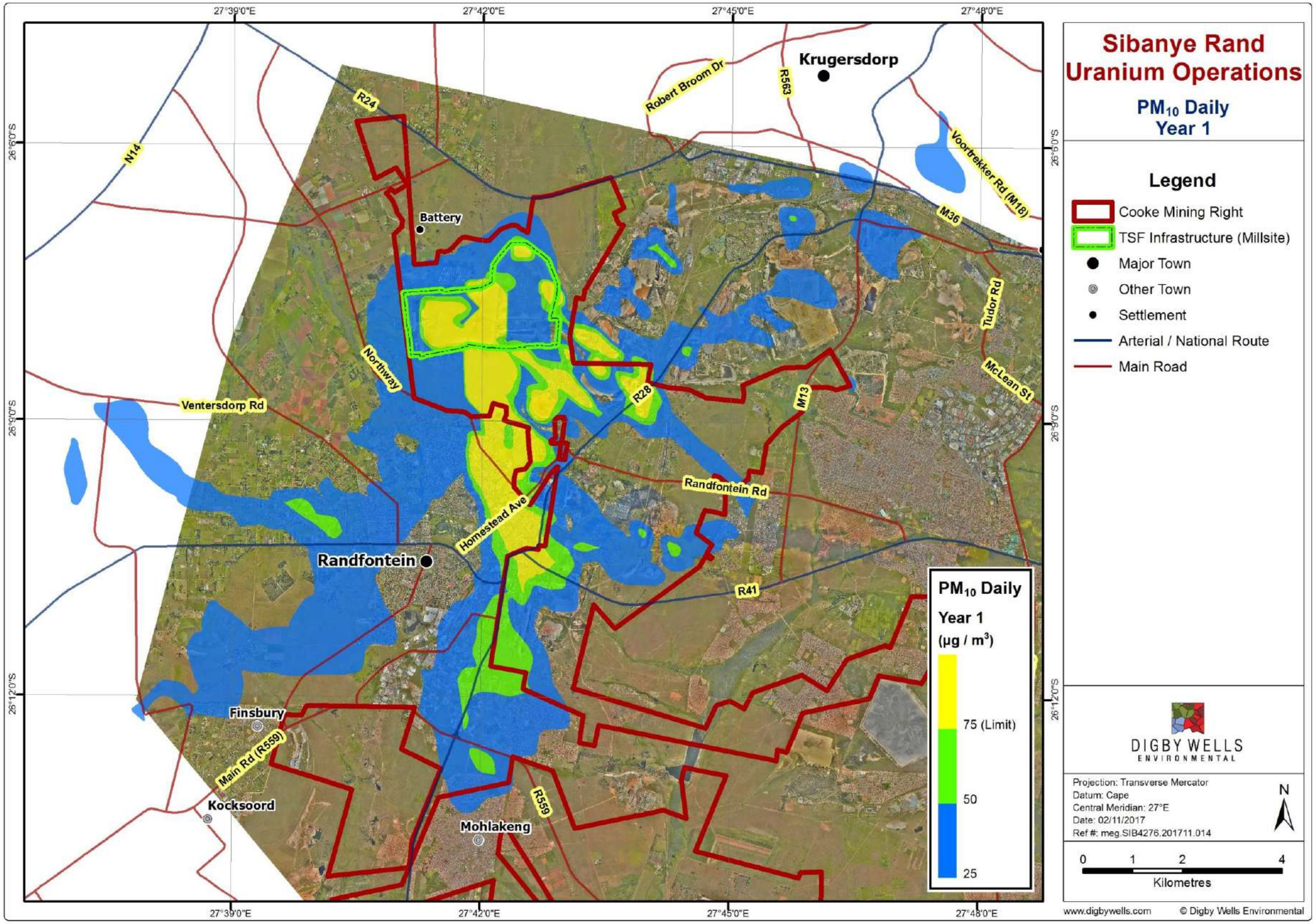

Figure 6-1: Predicted 4th highest (99th percentile) daily PM_{10} concentrations (µg/m^3) – Year 1

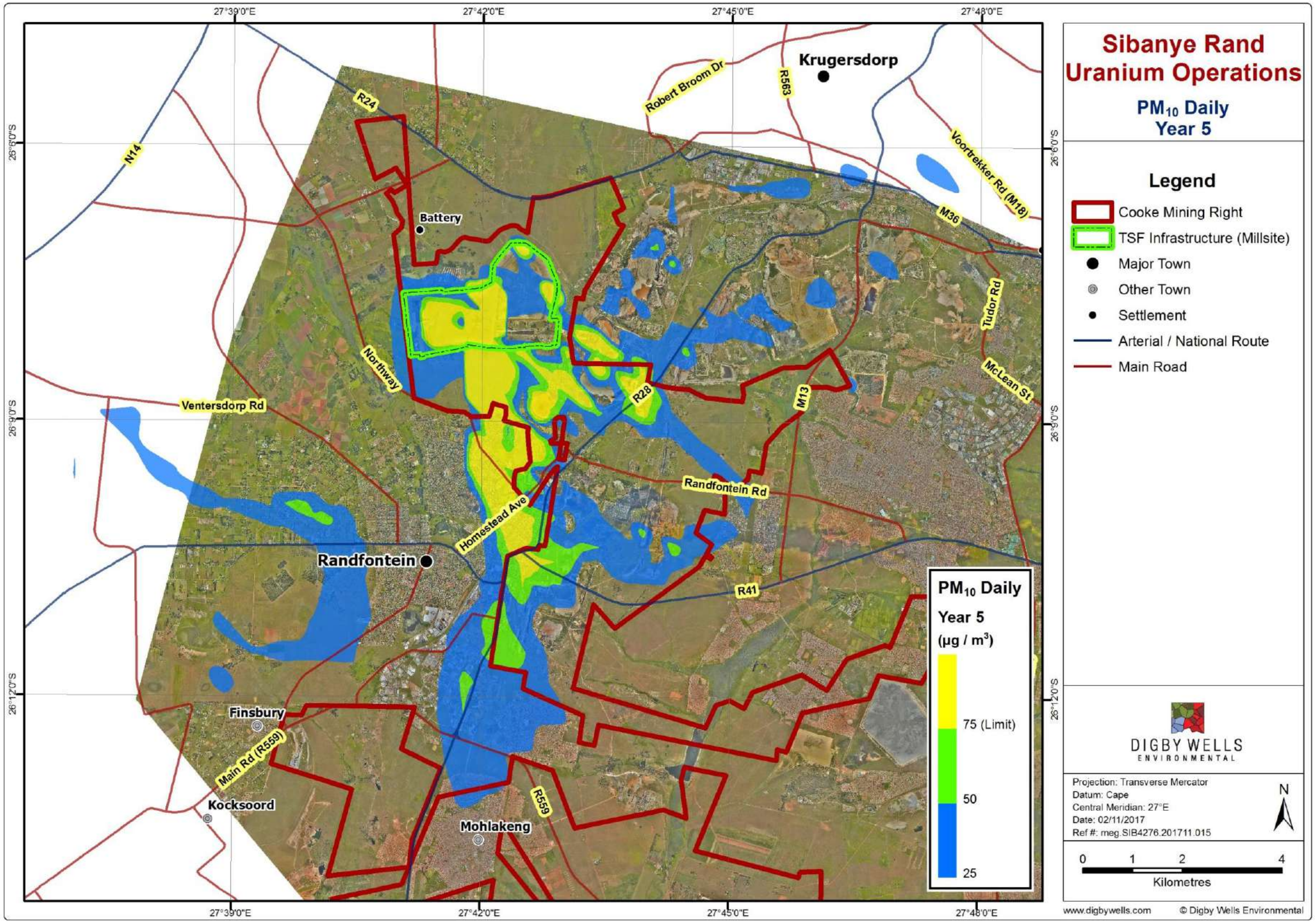

Figure 6-2: Predicted 4th highest (99th percentile) daily PM_{10} concentrations ($\mu g/m^3$) Year 5

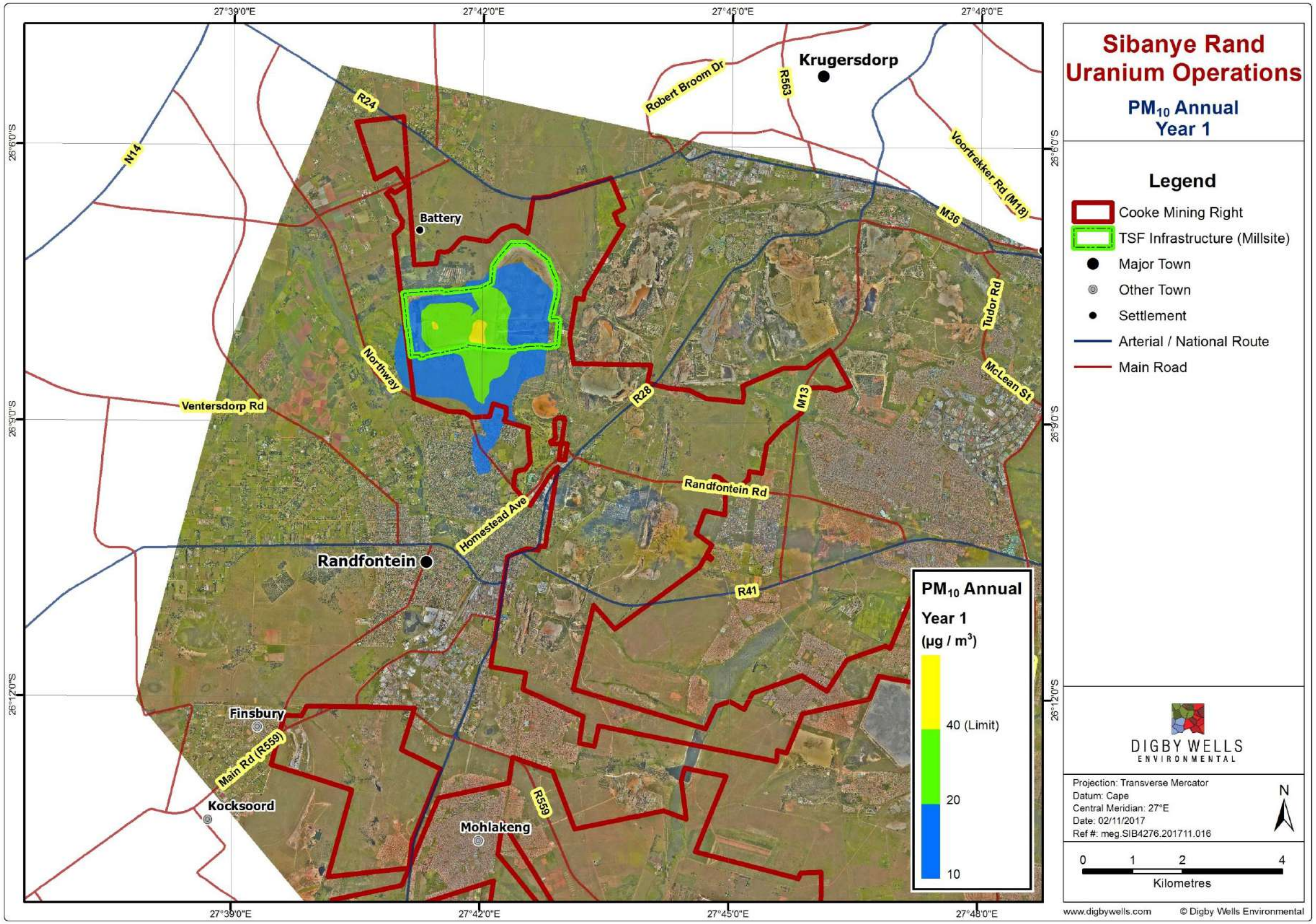

Figure 6-3: Predicted 1st highest (100th percentile) Annual PM_{10} concentrations (µg/m^3) - Year 1

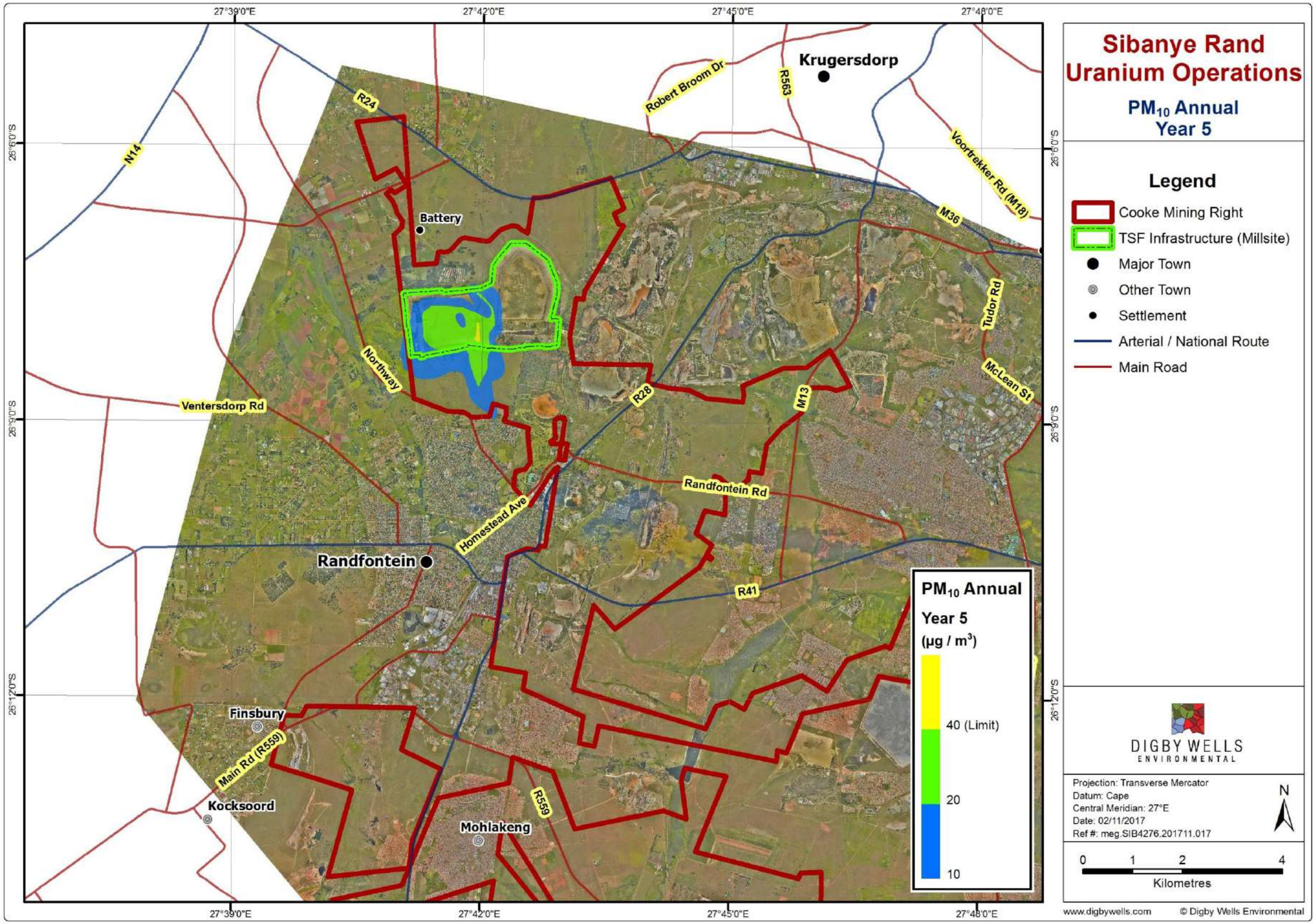

Figure 6-4: Predicted 1st highest (100th percentile) Annual PM$_{10}$ concentrations (µg/m^3) – Year 5

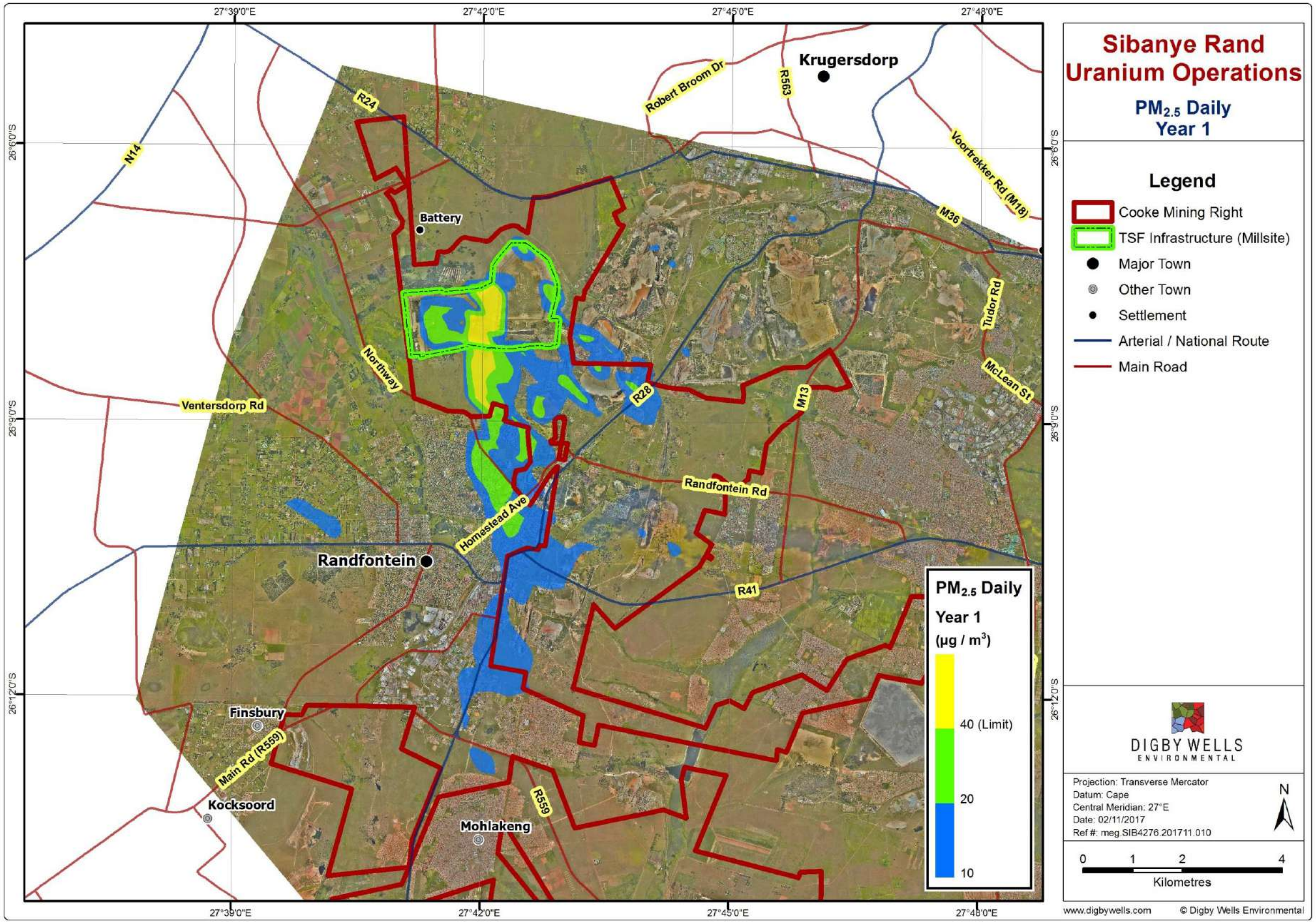

Figure 6-5: Predicted 4th highest (99th percentile) daily $PM_{2.5}$ concentrations ($\mu g/m^3$) Year 1

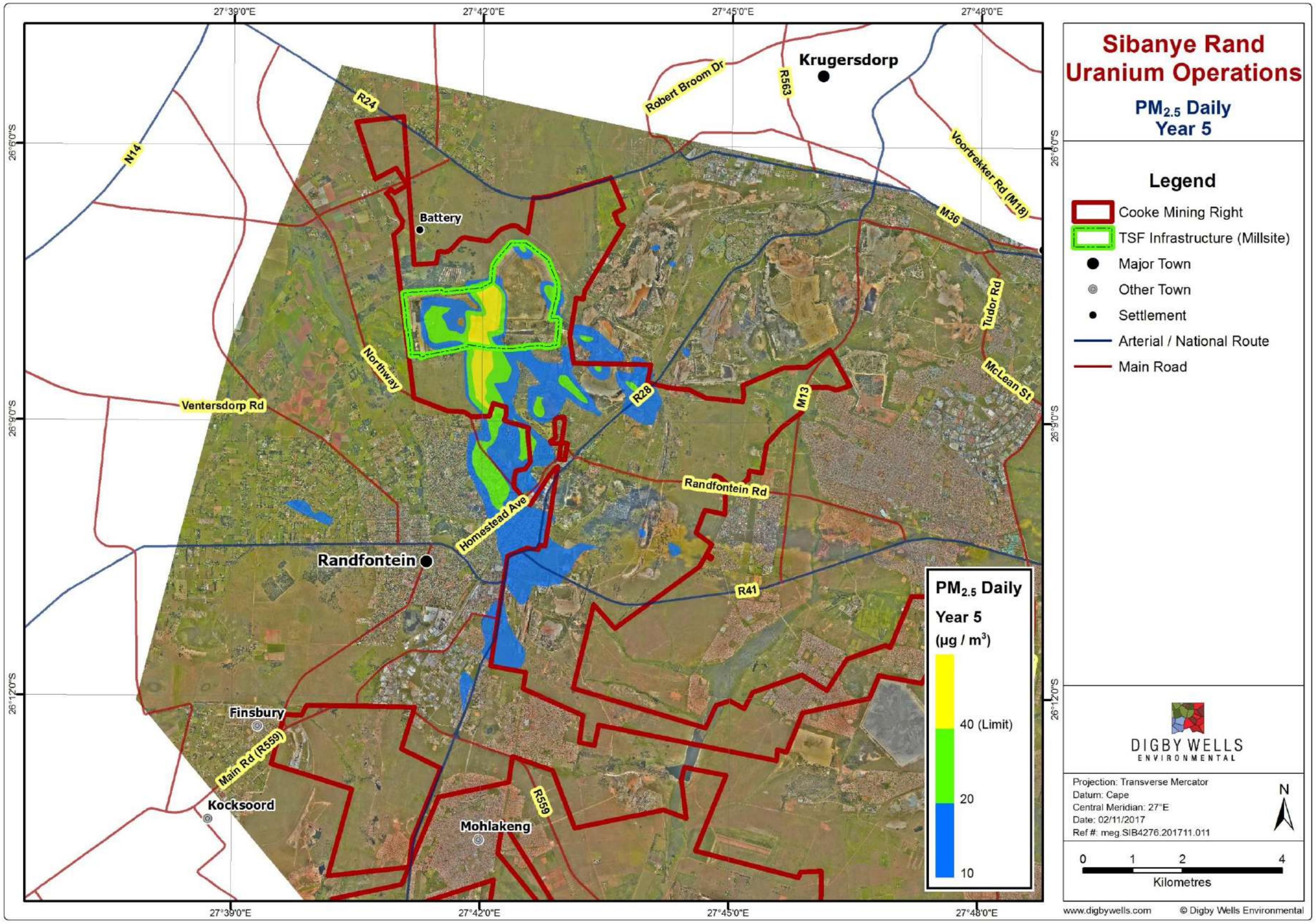

Figure 6-6: Predicted 4th highest (99th percentile) daily $PM_{2.5}$ concentrations (µg/m^3) Year 5

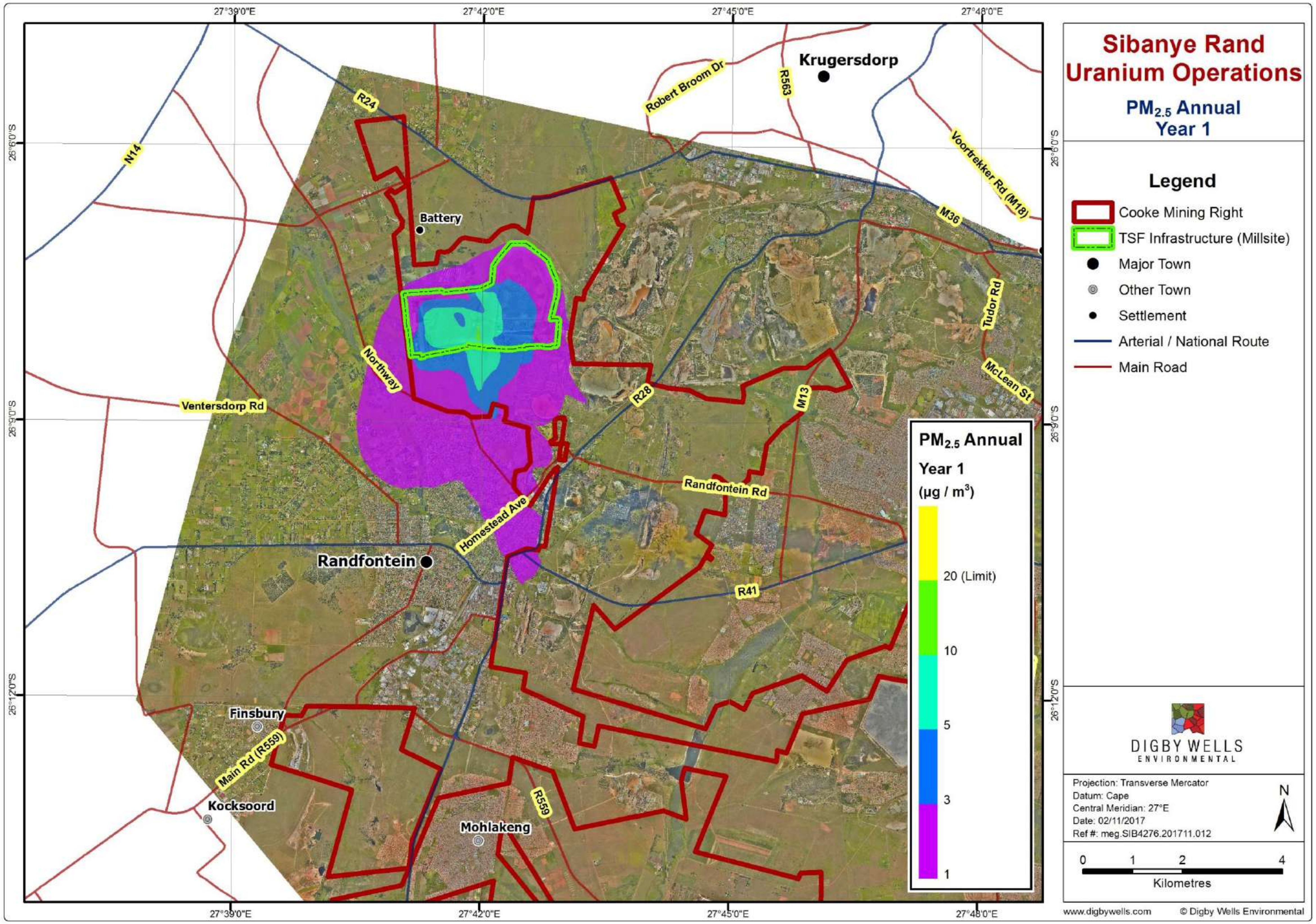

Figure 6-7: Predicted 1st highest (100th percentile) Annual $PM_{2.3}$ concentrations (µg/m^3) – Year 1

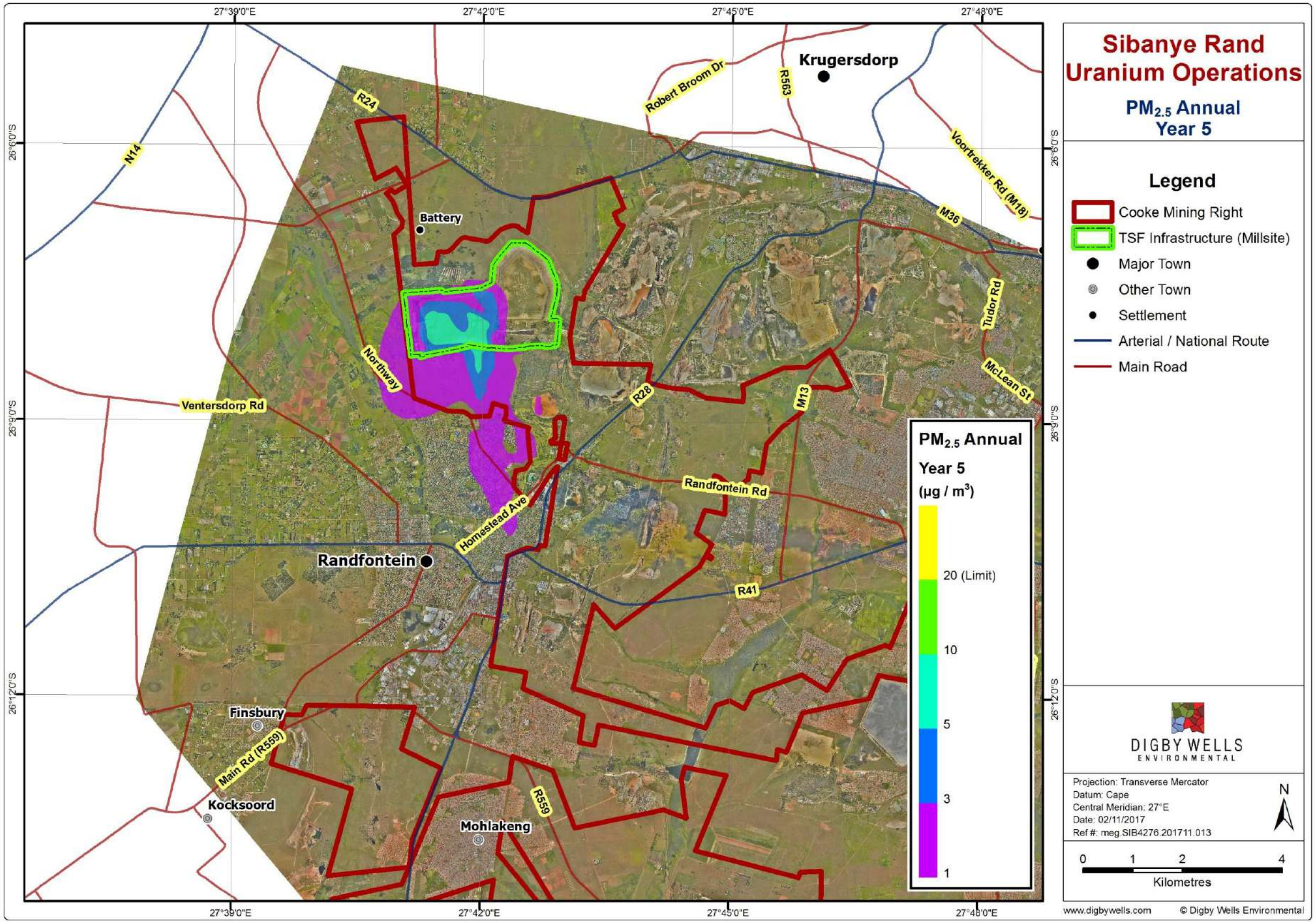

Figure 6-8: Predicted 1st highest (100th percentile) Annual $PM_{2.5}$ concentrations ($\mu g/m^3$) Year 5

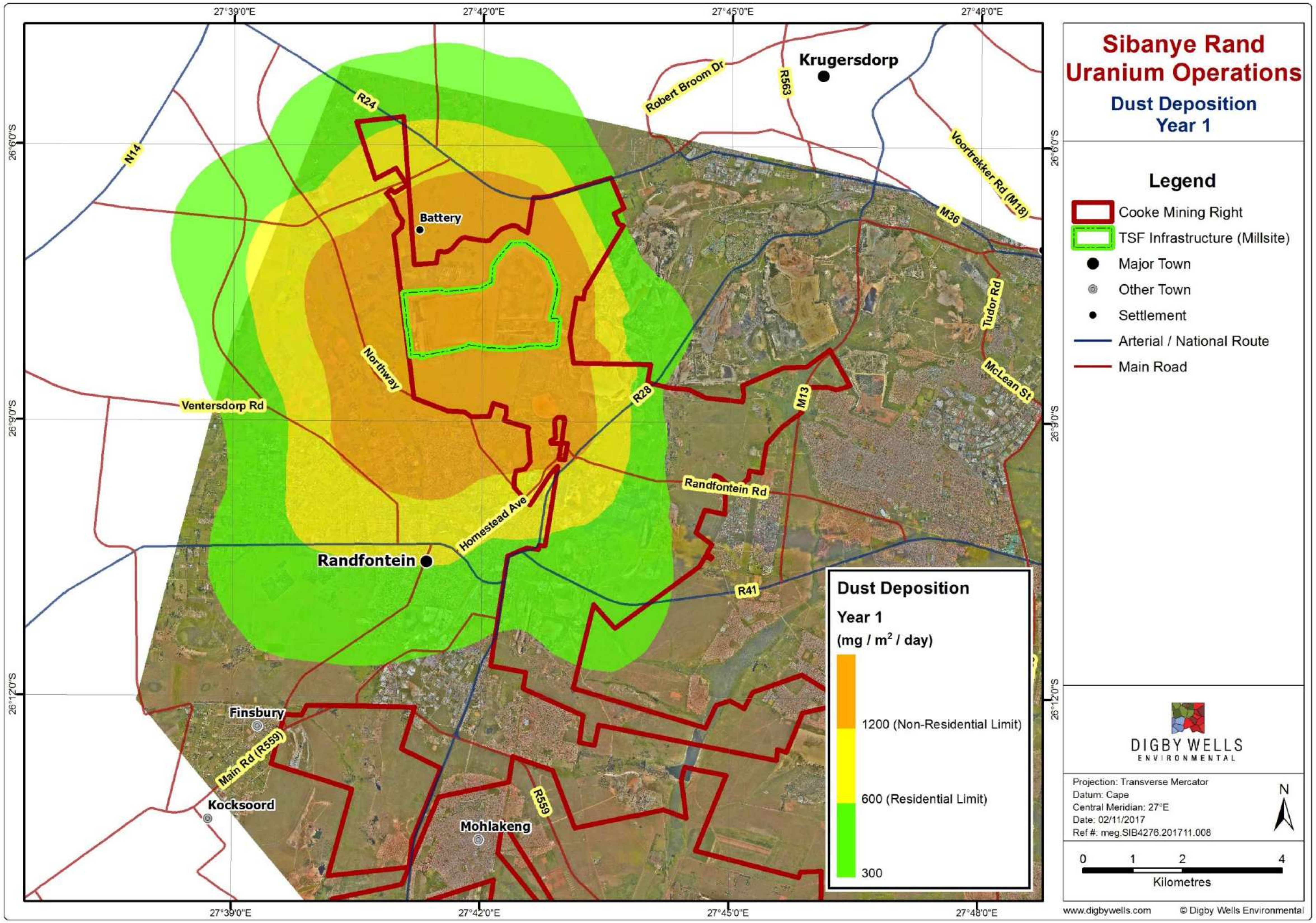

Figure 6-9: Predicted maximum (100th percentile) dust deposition (mg/m^2/day) – Year 1

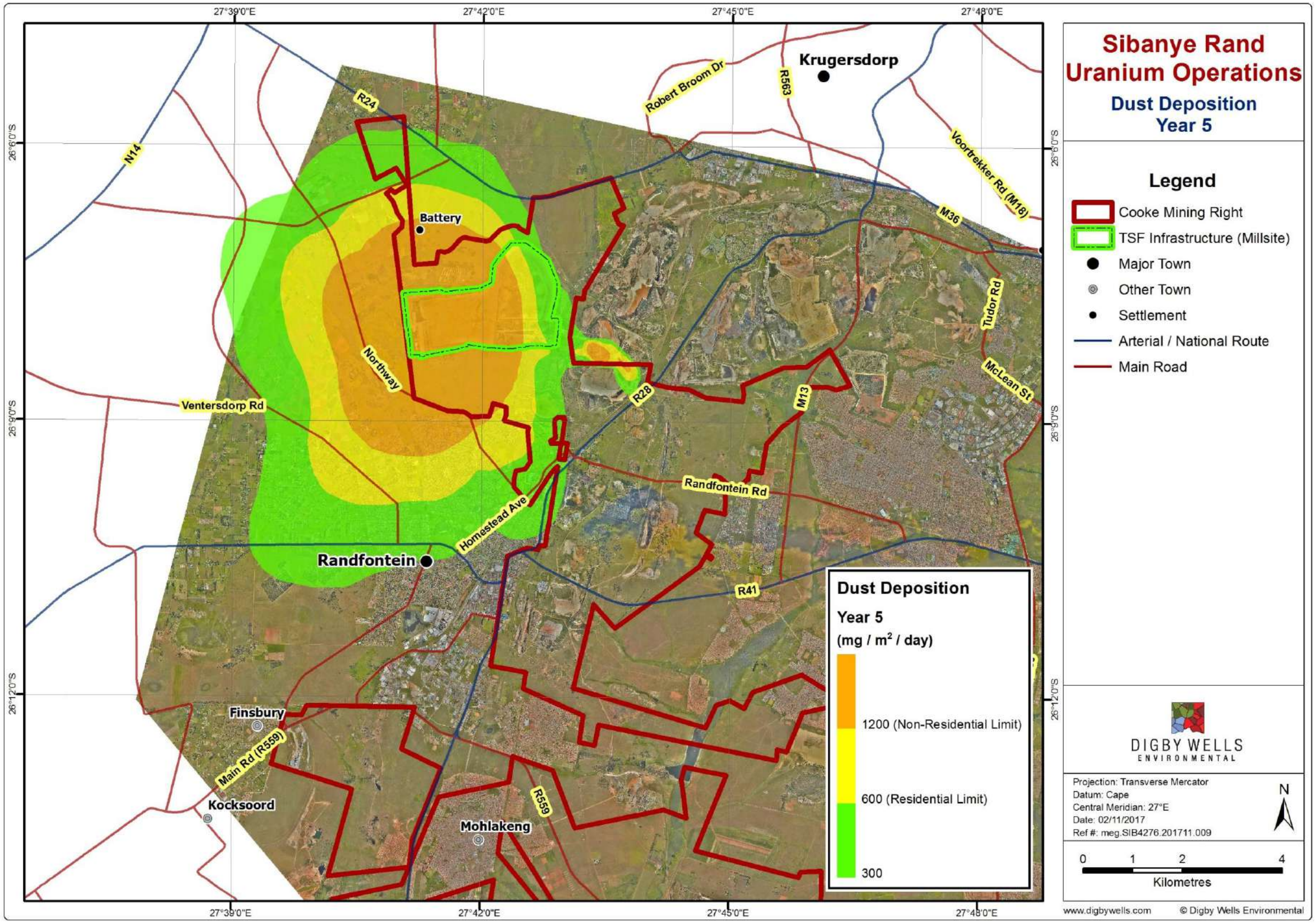

Figure 6-10: Predicted maximum (100th percentile) dust deposition (mg/m^2/day) Year 5

6.2 Discussion

The emissions predicted from the MSTF reclamation process have been assessed from model simulations of GLC. The wet reclamation process itself will exact mitigating effects on wind erosion, and emissions will be due mainly to the reopening of previously vegetated areas using mechanical equipment and the wind erosion of loose tailings material that resulted from the process.

6.2.1 Findings

The AQIA study shows that airborne particulate pollution as a result of wind erosion and vehicle entrainment on unpaved road from the reclamation process. The GLCs show that impacts will be minimal on ambient air quality (base on predictions from the worst case scenario …i.e. no vegetation cover, hard crust or cryptogram biomass). It is worth mentioning that mining will take place sequentially, with wind erosion limited to exposed sections of the TSF surfaces, and impacts will be lower than predicted. The other major activity on site, i.e. screening, is a wet process and not associated with particulate emissions. The main findings of this AQIA study are summarised as follows:

- The predicted 24-hour GLC showed exceedances of the standard (75 µg/m³) at the MSTF site to some 5 km down south and southeast, reaching some sections of Randfontein. The area impacted shrank slightly after five years of reclamation, with minimal changes in the GLC. The Isopleth of predicted annual PM_{10} GLC confirm that exceedances of the standard (40 µg/m³) will be confined within the MSTF footprint. The predicted concentrations at the selected sensitive receptors were within limits.
- The predicted annual GLC for Year 1 and Year 5 are similar in pattern to the Isopleths for daily GLC. The areas were the daily standard of 40 µg/m³ are likely to be exceeded, extends southward, some 1.2 km towards Randfontein. The concentrations predicted at the various sensitive receptors are presented below. The Isopleth showing the predicted annual GLC of $PM_{2.5}$ at the proposed MSTF site showed that exceedances are no likely to be observed.
- The predicted dust deposition rates show that dust will be a cause for concern for receptors within a radius of 3 km, i.e. Greenhills. The predicted deposition rates at Greenhills will be in exceedance of the non-residential limit of 1 200 mg/m^2/day (NDCR, 2013). However, this scenario will change after five years of reclamation. The area impacted is observed to have shrunk slightly after factoring in five years of reclamation, and predicted reduction in the deposition rates.

Although the areas with exceedances are small, and predicted emissions are general low and within regulatory limits, adequate mitigation measures should be factored into the day to day operation once reclamation commences i.e. use of dust suppressants on dirt roads, exposed TSF areas and limiting clearing and unnecessary digging to non-windy days etc.

7 Impact Assessment

7.1 Methodology used in Determining and Ranking the Nature, Significance, Consequence, Extent, Duration and Probability of Potential Environmental Impacts and Risks

Details of the impact assessment methodology used to determine the significance of physical, bio-physical and socio-economic impacts are provided below.

The significance rating process follows the established impact/risk assessment formula:

Significance = Consequence x Probability x Nature

Where

Consequence = Intensity + Extent + Duration

And

Probability = Likelihood of an impact occurring

And

Nature = Positive (+1) or negative (-1) impact

Note: In the formula for calculating consequence, the type of impact is multiplied by +1 for positive impacts and -1 for negative impacts

The matrix calculates the rating out of 147, whereby Intensity, Extent, Duration and Probability are each rated out of seven as indicated in Table 7-3. The weight assigned to the various parameters is then multiplied by +1 for positive and -1 for negative impacts.

Impacts are rated prior to mitigation and again after consideration of the mitigation measure proposed in this EIA/EMP Report. The significance of an impact is then determine and categorised into one of eight categories, as indicated in Table 7-2, which is extracted from Table 7-1. The description of the significance ratings is discussed in Table 7-3.

It is important to note that the pre-mitigation rating takes into consideration the activity as proposed, i.e. there may already be certain types of mitigation measures included in the design (for example due to legal requirements). If the potential impact is still considered too high, additional mitigation measures are proposed.

Table 7-1: Impact Assessment Parameter Ratings

Rating	Intensity/Replicability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	**Positive Impacts (Nature = +1)**			
7	Irreplaceable loss or damage to biological or physical resources or highly sensitive environments. Irreplaceable damage to highly sensitive cultural/social resources.	Noticeable, on-going natural and / or social benefits which have improved the overall conditions of the baseline.	International The effect will occur across international borders.	Permanent: The impact is irreversible, even with management, and will remain after the life of the project.	Definite: There are sound scientific reasons to expect that the impact will definitely occur. >80% probability.
6	Irreplaceable loss or damage to biological or physical resources or moderate to highly sensitive environments. Irreplaceable damage to cultural/social resources of moderate to highly sensitivity.	Great improvement to the overall conditions of a large percentage of the baseline.	National Will affect the entire country.	Beyond project life: The impact will remain for some time after the life of the project and is potentially irreversible even with management.	Almost certain / Highly probable: It is most likely that the impact will occur. <80% probability.

Rating	Intensity/Replicability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	**Positive Impacts (Nature = +1)**			
5	Serious loss and/or damage to physical or biological resources or highly sensitive environments, limiting ecosystem function. Very serious widespread social impacts. Irreparable damage to highly valued items.	On-going and widespread benefits to local communities and natural features of the landscape.	Province/ Region Will affect the entire province or region.	Project Life (>15 years): The impact will cease after the operational life span of the project and can be reversed with sufficient management.	Likely: The impact may occur. <65% probability.
4	Serious loss and/or damage to physical or biological resources or moderately sensitive environments, limiting ecosystem function. On-going serious social issues. Significant damage to structures / items of cultural significance.	Average to intense natural and / or social benefits to some elements of the baseline.	Municipal Area Will affect the whole municipal area.	Long term: 6-15 years and impact can be reversed with management.	Probable: Has occurred here or elsewhere and could therefore occur. <50% probability.

Rating	Intensity/Replicability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	Positive Impacts (Nature = +1)			
3	Moderate loss and/or damage to biological or physical resources of low to moderately sensitive environments and, limiting ecosystem function. On-going social issues. Damage to items of cultural significance.	Average, on-going positive benefits, not widespread but felt by some elements of the baseline.	Local Local extending only as far as the development site area.	Medium term: 1-5 years and impact can be reversed with minimal management.	Unlikely: Has not happened yet but could happen once in the lifetime of the project, therefore there is a possibility that the impact will occur. <25% probability.
2	Minor loss and/or effects to biological or physical resources or low sensitive environments, not affecting ecosystem functioning. Minor medium-term social impacts on local population. Mostly repairable. Cultural functions and processes not affected.	Low positive impacts experience by a small percentage of the baseline.	Limited Limited to the site and its immediate surroundings.	Short term: Less than 1 year and is reversible.	Rare / improbable: Conceivable, but only in extreme circumstances. The possibility of the impact materialising is very low as a result of design, historic experience or implementation of adequate mitigation measures. <10% probability.

Rating	Intensity/Replicability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	**Positive Impacts (Nature = +1)**			
1	Minimal to no loss and/or effect to biological or physical resources, not affecting ecosystem functioning. Minimal social impacts, low-level repairable damage to commonplace structures.	Some low-level natural and / or social benefits felt by a very small percentage of the baseline.	Very limited/Isolated Limited to specific isolated parts of the site.	Immediate: Less than 1 month and is completely reversible without management.	Highly unlikely / None: Expected never to happen. <1% probability.

Table 7-2: Probability/Consequence Matrix

Significance

Probability \ Consequence	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
7	-147	-140	-133	-126	-119	-112	-105	-98	-91	-84	-77	-70	-63	-56	-49	-42	-35	-28	-21	21	28	35	42	49	56	63	70	77	84	91	98	105	112	119	126	133	140	147
6	-126	-120	-114	-108	-102	-96	-90	-84	-78	-72	-66	-60	-54	-48	-42	-36	-30	-24	-18	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120	126
5	-105	-100	-95	-90	-85	-80	-75	-70	-65	-60	-55	-50	-45	-40	-35	-30	-25	-20	-15	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105
4	-84	-80	-76	-72	-68	-64	-60	-56	-52	-48	-44	-40	-36	-32	-28	-24	-20	-16	-12	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	84
3	-63	-60	-57	-54	-51	-48	-45	-42	-39	-36	-33	-30	-27	-24	-21	-18	-15	-12	-9	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63
2	-42	-40	-38	-36	-34	-32	-30	-28	-26	-24	-22	-20	-18	-16	-14	-12	-10	-8	-6	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42
1	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21

Consequence

Table 7-3: Significance Rating Description[1]

Score	Description	Rating
109 to 147	A very beneficial impact that may be sufficient by itself to justify implementation of the project. The impact may result in permanent positive change	Major (positive) (+)
73 to 108	A beneficial impact which may help to justify the implementation of the project. These impacts would be considered by society as constituting a major and usually a long-term positive change to the (natural and / or social) environment	Moderate (positive) (+)
36 to 72	A positive impact. These impacts will usually result in positive medium to long-term effect on the natural and / or social environment	Minor (positive) (+)
3 to 35	A small positive impact. The impact will result in medium to short term effects on the natural and / or social environment	Negligible (positive) (+)
-3 to -35	An acceptable negative impact for which mitigation is desirable. The impact by itself is insufficient even in combination with other low impacts to prevent the development being approved. These impacts will result in negative medium to short term effects on the natural and / or social environment	Negligible (negative) (-)
-36 to -72	A minor negative impact requires mitigation. The impact is insufficient by itself to prevent the implementation of the project but which in conjunction with other impacts may prevent its implementation. These impacts will usually result in negative medium to long-term effect on the natural and / or social environment	Minor (negative) (-)
-73 to -108	A moderate negative impact may prevent the implementation of the project. These impacts would be considered as constituting a major and usually a long-term change to the (natural and / or social) environment and result in severe changes.	Moderate (negative) (-)
-109 to -147	A major negative impact may be sufficient by itself to prevent implementation of the project. The impact may result in permanent change. Very often these impacts are immitigable and usually result in very severe effects. The impacts are likely to be irreversible and/or irreplaceable.	Major (negative) (-)

[1] It is generally sufficient to only monitor impacts that are rated as negligible or minor

7.2 Project Activity Assessed

The activities and interactions associated with the construction and operational phases are summarised in Table 7-4 below and potential impacts are briefly listed.

Table 7-4: Interactions and Impacts on Air Quality

Activity No.	Activity and Interaction	Potential Impact
1	Site clearing	Health impacts as a result of exposure to airborne particulate matter. Nuisance due to dust fallout.
2	Development and use of access roads	Health impacts as a result of exposure to airborne particulate matter. Nuisance due to dust fallout
3	Wet reclamation	Dust suppression
4	Demolition of infrastructure and rehabilitation of TSF footprint	Health impacts as a result of exposure to airborne particulate matter. Nuisance due to dust fallout
5	Rehabilitation of TSF footprint	Health impacts as a result of exposure to airborne particulate matter. Nuisance due to dust fallout

7.3 Impact Assessment

The overall management objective for the construction and operational phases will be to:

- To ensure that on-site and off-site emissions during these activities are within The South African standards for the various pollutants i.e. PM_{10} (75 µg/m^3) and dust fallout (600 mg/m^2/day); and
- To explore adequate mitigation measures for the protection of human health and wellbeing and the environment in line with regulatory standards;
- Air quality monitoring at upwind and downwind locations;
- Application of dust suppressants i.e. Dust-A-Side on access roads and exposed areas to minimise emissions.

7.3.1 Construction Phase

7.3.1.1 Project Activities Assessed

As part of the Construction Phase, the following activity is identified that may impact on the ambient air quality of the area i.e. increasing particulate matter loading in the atmosphere:

- Site clearing and removal of vegetation.

Table 7-5: Interactions and Impacts of Construction Phase

Interaction	Impact
Site clearing and removal of vegetation	Health impacts as a result of exposure to airborne particulate matter.
	Nuisance due to dust fallout.

7.3.1.2 Impact Ratings

Table 7-6: Significance Ratings for Impacts on Air Quality during Site Clearing

Activity and Interaction (Site Clearing))			
Dimension	**Rating**	**Motivation**	**Significance**
Impact Description: Reduction in ambient air quality Site clearing, which encompasses the removal of vegetation using a range of heavy construction equipment, can result in breaking the surface structure of tailings leading to the availability of loose material, providing the right conditions for fugitive emissions comprising TSP, PM_{10} and $PM_{2.5}$ from vehicle wheels and wind erosion. Fugitive emissions from site clearing are considered negligible due to the relatively short-term nature of this activity. Also, the area to be worked on will be cleared in phases, hence limiting the area disturbed or exposed to wind erosion.			
Prior to mitigation/ management			
Duration	Short term (1)	Dust generation will be less than 1 year and is reversible	Negligible (negative) – 30
Extent	Limited (2)	Limited to the reclamation site and immediate surroundings.	
Intensity	Minor (2)	Minor effect on surrounding area is anticipated	
Probability	Almost certain (6)	There is certainty that dust will be generated during this activity.	
Nature	Negative		
Mitigation/ Management actions			
▪ Application dust suppressant on exposed areas; ▪ Limit activity to non-windy days (wind speed ≤5.4 m/s); ▪ The area of disturbance at all times must be kept to a minimum and no unnecessary clearing, digging or scraping must occur, especially on windy days (with wind speed ≥ 5.4 m/s).			
Post- mitigation			
Duration	Short term (1)	Dust generation will be less than 1 year and is reversible	Negligible (negative) – 12

Activity and Interaction (Site Clearing))			
Dimension	**Rating**	**Motivation**	**Significance**
Extent	Very Limited (1)	After mitigation measures are implemented, It is expected that dust impacts will be limited to isolated parts of the site.	
Intensity	Minimal (1)	Generated dust will have minimal impacts on air quality after mitigation	
Probability	Probable (4)	Probable that impact on ambient air quality may occur.	
Nature	Negative		

7.3.2 Operational Phase

7.3.2.1 Project Activities Assessed

The reclamation process will be conducted as a wet process; hence dust generation will not occur during the Operational Phase. However, the following activities will have some impacts on the ambient air quality of the area:

- Use of unpaved access roads; and
- Wet reclamation.

Table 7-7: Interactions and Impacts of Operational Phase

Interaction	Impact
Use of unpaved access road	Health impacts as a result of exposure to airborne particulate matter.
	Nuisance due to dust fallout.

Table 7-8: Significance Ratings for Development and use of Access Roads

Activity and Interaction (Development and use of access roads will result in fugitive emissions and reduction in air quality)			
Dimension	**Rating**	**Motivation**	**Significance**
Impact Description: Fugitive emissions and reduction in air quality During the operational phase, there will be movement of equipment and employee commute using dirt roads, leading to dust generation. This will be conducted throughout the Project life.			
Prior to mitigation/ management			

Activity and Interaction (Development and use of access roads will result in fugitive emissions and reduction in air quality)			
Dimension	**Rating**	**Motivation**	**Significance**
Duration	Project life (5)	Dust will be generated throughout the project life	Minor (negative) – 36
Extent	Limited (2)	Airborne dust may extend across the Project site.	
Intensity	Minor (2)	Minor environmental effect is anticipated	
Probability	Unlikely (4)	It is unlikely that impact will occur.	
Nature	Negative		
Mitigation/ Management actions			
▪ Application dust suppressant on access areas; and ▪ There is need to set maximum speed limits on access roads and to have these limits enforced.			
Post- mitigation			
Duration	Project life (5)	Dust will be generated throughout the project life	Negligible (negative) – 16
Extent	Very Limited (1)	Airborne dust limited to the site and its immediate surrounding after mitigation measures are applied.	
Intensity	Minor (2)	Minor impact anticipated after mitigation measures are applied	
Probability	Rare (2)	It is probable impact will occur.	
Nature	Negative		

Table 7-9: Significance Ratings for Wet Reclamation of Tailings

Activity and Interaction (Wet reclamation of tailings will result in dust suppression and improves air quality)			
Dimension	**Rating**	**Motivation**	**Significance**
Impact Description: Fugitive emissions and reduction in air quality During the operational phase, the wet screening and reclamation process will result in the suppression of dust, leading to a cleaner atmosphere.			
Prior to mitigation/ management			
Duration	Project life (5)	Dust will be suppressed throughout the project life	Negligible (Positive) – 7

Activity and Interaction (Wet reclamation of tailings will result in dust suppression and improves air quality)			
Dimension	**Rating**	**Motivation**	**Significance**
Extent	Very limited (1)	Airborne dust may extend across the Project site.	
Intensity	Minimal (1)	Minor environmental effect is anticipated	
Probability	Highly unlikely (1)	It is highly unlikely that impact will occur.	
Nature	Positive		
Mitigation/ Management actions			
▪ Not applicable			
Post- mitigation			
Duration	Project life (5)	Dust will be suppressed throughout the project life	Negligible (Positive) – 7
Extent	Very limited (1)	Airborne dust may extend across the Project site.	
Intensity	Minimal (1)	Minor environmental effect is anticipated	
Probability	Highly unlikely (1)	It is highly unlikely that impact will occur.	
Nature	Positive		

7.3.3 Decommissioning Phase

7.3.3.1 Project Activities Assessed

As part of the Decommissioning Phase, the following activities are identified that may impact on the ambient air quality of the area:

- Demolition and removal of all infrastructure; and
- Rehabilitation of TSF footprint.

Table 7-10: Interactions and Impacts of Decommissioning Phase

Interaction	**Impact**
Demolition & removal of infrastructure	Health impacts as a result of exposure to airborne particulate matter
	Nuisance due to dust fallout
Rehabilitation	Health impacts as a result of exposure to airborne particulate matter

Interaction	Impact
	Nuisance due to dust fallout

Table 7-11: Significance ratings for the Demolition of Infrastructure

Activity and Interaction (Demolition of infrastructure and rehabilitation of TSFs footprint results in fugitive emission and reduction in air quality)			
Dimension	**Rating**	**Motivation**	**Significance**
Impact Description: Reduction in air quality The dismantling of site infrastructure and rehabilitation of the TSFs footprint will involve the use of heavy machinery and vehicles similar to those used in the construction phase. This will result in the generation of fugitive dust containing TSP, PM_{10} and $PM_{2.5}$.			
Prior to mitigation/ management			
Duration	Short term (2)	Impact will be limited to the duration of the decommissioning phase	Negligible (negative) – 20
Extent	Limited (2)	Impact is limited to site and immediate surroundings	
Intensity	Minor (1)	Minor impact	
Probability	Probable (4)	It is probable that dust impact will occur.	
Nature	Negative		
Mitigation/ Management actions			
▪ The dismantling area disturbed must be kept to a minimum; ▪ Drop heights when loading and offloading materials offsite must be minimised; ▪ There is need to set maximum speed limits on site and to have these limits enforced. It is confirmed that the dust generating capacity of particles less than 10 micro meters is reduced by 58% when speed controls are reduced from 25 mph (40 km/h) to 10 mph (16 km/h) (Flocchini et al., 1994; Watson et al., 1996);and ▪ Limit demolition activities to non-windy days (≥5.4 m/s).			
Post- mitigation			
Duration	Short term (2)	Impact will be limited to the duration of the decommissioning phase	Negligible (negative) – 12
Extent	Very Limited (1)	Impact will be limited to isolate parts of the site after mitigation.	
Intensity	Minimal (1)	Minimal dust impact anticipated after mitigation	
Probability	Unlikely (3)	It is unlikely that dust will impact will occur.	

Activity and Interaction (Demolition of infrastructure and rehabilitation of TSFs footprint results in fugitive emission and reduction in air quality)			
Dimension	**Rating**	**Motivation**	**Significance**
Nature	Negative		

Table 7-12: Significance ratings for Rehabilitation

Activity and Interaction (Rehabilitation of project area results in fugitive emission)			
Dimension	**Rating**	**Motivation**	**Significance**
Impact Description: Reduction in air quality			
Prior to mitigation/ management			
Duration	Short term (2)	Impact on air quality is limited to the duration of the decommissioning phase	Negligible (negative) – 18
Extent	Limited (2)	Impact will be limited to site and surroundings.	
Intensity	Minor (2)	Minor impact	
Probability	Unlikely (3)	Unlikely that dust generated from this activity will impact ambient air quality	
Nature	Negative		
Mitigation/ Management actions			
▪ Drop heights when offloading materials for rehabilitation must be minimised; ▪ Limit rehabilitation activities to non-windy days (≥ 5.4 m/s); ▪ Rehabilitated landscape should be vegetated; and ▪ Use of dust suppressant on dirt roads and exposed areas; and ▪ Wind speed of vehicle on dirt road during rehabilitation must be minimised. It is confirmed that the dust generating capacity of particles less than 10 micro meters is reduced by 58% when speed controls are reduced from 25 mph (40 km/h) to 10 mph (16 km/h) (Flocchini et al., 1994; Watson et al., 1996).			
Post- mitigation			
Duration	Short term (2)	Impact on air quality is limited to the duration of the decommissioning phase	Negligible (negative) – 12
Extent	Very Limited (1)	Airborne dust will be limited to the development site area.	
Intensity	Minimal (1)	Minimal dust impact after mitigation measures are applied	

Activity and Interaction (Rehabilitation of project area results in fugitive emission)			
Dimension	**Rating**	**Motivation**	**Significance**
Probability	Unlikely (3)	It is unlikely that the air quality will be impacted on if mitigation measures are applied.	
Nature	Negative		

7.4 Cumulative Impacts

The model predictions show that ambient GLC will increases in the vicinity of MSTF during the operational phase. The predicted emissions confirm exceedances of the regulatory limit that are confined to the Project footprint without mitigation. As a result of the aforementioned, the runs for mitigation were not generated. The open spaces around the MSTF served as an unplanned buffer to potential emissions. Predicted GLC at the surrounding receptors were all within the applicable standards without mitigation measures in place.

As mentioned above, the operation of the MSTF will have minimal impact on ambient air quality of the area. Despite the aforementioned, various mitigation measures should be incorporated into the day to day reclamation process as best practice to operation is conducted within compliance.

8 Environmental Management Plan

8.1 Project Activities with Significant Air Quality Impacts

This section lists the main aspects that are expected to impact on ambient air quality during the operation (Table 8-1), based on the simulations from model predictions.

Table 8-1: Most Significant Impacts

Aspects	Potential Significant Impacts
Operational Phase	
Wind erosion from the TSFs	Health impacts as a result of exposure to airborne particulate matter Nuisance due to dust fallout
Use of access roads	Health impacts as a result of exposure to airborne particulate matter Nuisance due to dust fallout

8.2 Summary of Mitigation and Management

Table 8-2 to Table 8-4 provide a summary of the proposed project activities, environmental aspects and impacts on the receiving environment. Information on the frequency of mitigation, relevant legal requirements, recommended management plans, timing of implementation, and roles / responsibilities of persons implementing the EMP.

Table 8-2: Impacts

Activities	Phase	Size and scale of disturbance	Mitigation Measures	Compliance with Standards	Time period for Implementation
Site clearing	Construction	▪ Impact is limited to the site and immediate surrounding.	▪ Site clearing should be done in phases and limited to the area to be reclaimed; ▪ Use of suppressants and binders on exposed areas to reduce dust generation; ▪ The area of disturbance at all times must be kept to a minimum and no unnecessary clearing, digging or scraping must occur, especially on windy days (with wind speed ≥ 5.4 m/s).	▪ National Environmental Management: Air Quality Act, Act.39 of 2004: GN 486 GG35463; GN1210 GG32816 ▪ National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) - National Dust Control Regulations (2013): GN827 GG36974	▪ At the commencement of construction phase
Development and use of access roads	Operational	▪ Impact is limited to the site and immediate surrounding	▪ The use of dust suppressants and binders on access roads to reduce dust generation; ▪ There is need to set maximum speed limits on access roads and to have these limits enforced.	▪ National Environmental Management: Air Quality Act, Act.39 of 2004: GN 486 GG35463; GN1210 GG32816; GN827 GG36974	▪ At the start of the operation phase and for the project life.
Demolition of infrastructure and rehabilitation of TSF footprints	Decommissioning	▪ Impact is limited to the site and immediate surroundings.	▪ The dismantling area disturbed must be kept to a minimum; ▪ Drop heights when offloading must be minimised; ▪ Limit demolition activities to non-windy days; Rehabilitated landscape should be vegetated; and ▪ Use of dust suppressant on dirt roads and exposed areas; ▪ There is need to set maximum speed limits on access roads and to have these limits enforced.	▪ National Environmental Management: Air Quality Act, Act.39 of 2004, 2004: GN 486 GG35463; GN1210 GG32816; GN827 GG36974	▪ At the start of the decommissioning phase and few months after it ends.

Table 8-3: Objectives and Outcomes of the EMP

Activities	Potential impacts	Aspects affected	Phase	Mitigation	Standard to be achieved/objective
Site clearing	▪ Potential health implication due to poor air quality ▪ Nuisance from dust fallout	▪ Air Quality	▪ Construction	▪ The use of dust suppressants and binders on haul roads to reduce dust generation; ▪ Limit activity to non-windy days; ▪ The area of disturbance at all times must be kept to a minimum and no unnecessary clearing, digging or scraping must occur, especially on windy days (with wind speed ≥ 5.4 m/s)	▪ South African National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004): GN 486 GG35463; GN1210 GG32816; GN827 GG36974

Activities	Potential impacts	Aspects affected	Phase	Mitigation	Standard to be achieved/objective
Development and use of access roads	▪ Potential health implication due to poor air quality ▪ Nuisance from dust fallout	▪ Air Quality	▪ Operational	▪ The use of dust suppressants and binders on access roads to reduce dust generation; ▪ There is need to set maximum speed limits on access roads and to have these limits enforced.	▪ South African National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004): GN 486 GG35463; GN1210 GG32816; GN827 GG36974
Demolition of infrastructure and rehabilitation of TSF footprints	▪ Potential health implication due to poor air quality ▪ Nuisance from dust fallout	▪ Air Quality	▪ Decommissioning	▪ The dismantling area disturbed must be kept to a minimum; ▪ Drop heights when offloading must be minimised; ▪ Limit demolition activities to non-windy days; Rehabilitated landscape should be vegetated; and ▪ Use of dust suppressant on dirt roads and exposed areas; ▪ There is need to set maximum speed limits on access roads and to have these limits enforced.	▪ South African National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004): GN 486 GG35463; GN1210 GG32816; GN827 GG36974

Table 8-4: Mitigation

Activities	Potential impacts	Aspects affected	Mitigation type	Time period for implementation	Compliance with standards
Site clearing	▪ Potential health implication due to poor air quality ▪ Nuisance from dust fallout	▪ Air Quality	▪ The use of dust suppressants and binders on access roads to reduce dust generation; ▪ Limit activity to non-windy days; ▪ There is need to set maximum speed limits on access roads and to have these limits enforced; ▪ The area of disturbance at all times must be kept to a minimum and no unnecessary clearing, digging or scraping must occur, especially on windy days (with wind speed ≥ 5.4 m/s); ▪ The drop heights when loading onto trucks and at tipping points should be minimised.	▪ Must be carried out concurrently with mining operations	▪ Implementation of the mitigation measure will ensure dust emissions are contained within regulatory standard (South African National Environmental Management: Air Quality Act, 2004, Act No. 39 of 2004 -, National Dust Control Regulations, 2013).
Development and use of access roads	▪ Potential health implication due to poor air quality ▪ Nuisance from dust fallout	▪ Air Quality	▪ The drop heights when loading onto trucks and at tipping points should be minimised; ▪ The use of dust suppressants and binders on access roads to reduce dust generation; ▪ There is need to set maximum speed limits on access roads and to have these limits enforced.	▪ Must be carried out concurrently with the day to day operation of the site	▪ Implementation of the mitigation measure will ensure dust emissions are contained within regulatory standard (South African National Environmental Management: Air Quality Act, 2004, Act No. 39 of 2004 ▪ National Dust Control Regulations, 2013).

Activities	Potential impacts	Aspects affected	Mitigation type	Time period for implementation	Compliance with standards
Demolition of infrastructure and rehabilitation of TSF footprints	▪ Potential health implication due to poor air quality ▪ Nuisance from dust fallout	▪ Air Quality	▪ The area of disturbance during rehabilitation must be kept to a minimum; ▪ Limit demolition activities to non-windy days (with wind speed ≥ 5.4 m/s).	▪ Must be carried out concurrently with the day to day operation during the decommissioning phase	▪ South African National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004), National Dust Control Regulations (2013).

Table 8-5: Prescribed Environmental Management Standards, Practice, Guideline, Policy or Law

Specialist field	Applicable standard, practice, guideline, policy or law
Air quality	National Environmental Management: Air Quality Act, Act.39 of 2004, 2004 - GN 486 GG35463; GN1210 GG32816
	National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) - National Dust Control Regulations (2013) - GN827 GG36974

9 Monitoring Plan

9.1 Dust Monitoring Programme

The predicted dust deposition rates are well below the recommended standards, it is advised that monitoring be commissioned to assess dust deposition rates in the vicinity of the proposed MSTF reclamation. Although model prediction have shown potential impacts to be minimal, the unlikely event of “dust storm” episode cannot be ruled out (which is common on the Witwatersrand).

Monitoring is mainly for compliance and management purposes, so that proactive measures can be in place to mitigate unforeseen episode and effect reduction deposition rates. As the reclamation progress, the sources of emission get smaller overtime and eventually disappear.

9.2 PM_{10} Monitoring Programme

The model predictions show that the areas where the PM_{10} standards are exceeded are confined to the MSTF footprint (without mitigation measures in place). Predicted GLC at the respective receptors are well below the standards (daily and annual). As a result, it is not recommended that a compliance monitoring be initiated. The dust deposition rates are showing non-compliance, once off monitoring campaign can be conducted to ambient levels of this pollutant. If the latter is the case, data collected can be useful in management decision making on the way forward.

10 Summary of Significant Impacts

The impact assessments for the proposed MSTF Reclamation Project show that this will be negligible, with no significant impacts anticipated. The predicted GLC for the different pollutants will continue to decrease as mining progresses owing to the continuous removal of the TSF material, which will overtime disappear from the landscape. Reclamation of the MSTF and associated activities will not exacerbate particulate matter loading in the ambient atmosphere.

11 Mitigation and Management Measures

The mitigation and management measures discussed are recommended to ensure that emissions associated with the reclamation activities do not degrade the quality of air near the Project site and beyond. The mitigation and management measures are very similar irrespective of the phase.

12 Recommendations

Based on the results presented in this report, the following recommendations should be applied during the course of reclamation:

- Commission a dust monitoring network for compliance monitoring for the life of mining;
- Site clearing should be done in phases and limited to the area to be reclaimed;
- The area of disturbance at all times must be kept to a minimum and no unnecessary clearing, digging or scraping must occur, especially on windy days (with wind speed ≥ 5.4 m/s);
- Use of suppressants on exposed areas and access road to reduce dust generation; and
- Monitor the air quality management measures and information to ensure that adopted measures are sufficient to achieve current air quality standards at site and the closest receptors for the duration of the project.

13 Conclusion

The conclusions reached in this reported are informed by the outcome of the dispersion model. The dispersion model predictions have shown that wind erosion of MSTF can exacerbate airborne particulate load at the Project area and surroundings. The daily GCL for both PM_{10} and $PM_{2.5}$ showed exceedances, south of MSTF, some 4 km into sections of Randfontein (as shown in the Isopleths generated). The predicted dust deposition rates will show that dust will be a cause for concern for receptors within a radius of 3 km, i.e. Greenhills.

Despite the findings reported herein, the Project can proceed as the recommended mitigation measures if implemented will ensure the reclamation activities are conducted within compliance. Overtime, the pollution source will be mined out and the risk associated with dust from MSTF will be eliminated completely.

It is recommended that the mine management commissions a dust monitoring network prior to the commencement of reclamation to collect dust deposition records. With the aforementioned in place, pre and during reclamation dust levels will be readily available scrutiny. Such invaluable data can be queried to assess the efficiency of the mitigation measures that will be in place, which will inform environmental decision making during the operational phase.

14 References

ASTM D1739 – 98, "*Standard Test Method for Collection and Measurement of Dust fallout* (Settleable Particulate Matter)", 2010.

Cowherd, C., Muleski G. E, and J. S. Kinsey, Control of Open Fugitive Dust Sources, EPA-450/3-88-008, United States Environmental Protection Agency, Research Triangle Park, North Carolina, 1988.

Cowherd, C., Donaldson J. Jr, Hegarty, R, and O. Duane, Proposed *Revision to Fine Fractions used for AP-42 Fugitive Dust Emissions*, Midwest Research Institute, 425 Volker Blvd, Kansas City, MO 64110, 2010.

Fenger, J., Urban air quality, In J. Austin, P. Brimblecombe and W. Sturges (eds), Air pollution science for the 21st century, Elsevier, Oxford, 2002.

Flocchini, R.G., Cahill, T. A. Matsamura, R. T. Carcacho, O. & Lu, Z. Q., Evaluation of emissions of PM10 particulates from unpaved roads in the San Joaquin Valley. Final Report prepared for the San Joaquin Valley Unified Air Pollution Control District, U. S. EPA and California Air Resources Board, April, 1994, 61 p

Fryrear, D. W., Stout, J. E. Hagen, L. J. Vories, E. D., Wind erosion, field measurements and analysis. *American Society of Agricultural Engineers*, Volume 34 (1), 1991

Golder Associates, Amendment to Rand Uranium's Environmental Management Programme for the proposed Millsite Tailings Storage Facility (MSTF) as part of the interim disposal component of the Cooke Uranium Project, Final Environmental Management Programme (EMP) Amendment, 2010

Government of the Republic of South Africa, Atmospheric Pollution Prevention Act, (Act 45 of 1965), 1965.

Government of the Republic of South Africa, National Environment Management Act, (Act 107 of 1998), 1998.

Government of the Republic of South Africa, National Environmental Management: Air Quality Act, (Act.39 of 2004), 2004.

Government of the Republic of South Africa, National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004), Regulation regarding Air Dispersion Modelling, Government Notice R533, Gazette No. 37804, 2012.

Government of the Republic of South Africa, National Dust Control Regulations, Government Notice R827, Government Gazette No. 36974, 2013.

Harrison, R M., and G. R. van René, Atmospheric particles, In *Environmental Chemistry*, edited by S, E Manahan, Lewis Publishers Inc, Wiley, Chichester; New York, United States of America, 1991.

McConnell, R., Berhane, K. Gilliland, F. Molitor, J. Thomas, D. Lurmann, F. Avol, E. Gauderman, W. J. & Peters, J.M., Prospective Study of Air Pollution and Bronchitic

Syptoms in Children with Asthsma, American Journal of Respiratory and Critical Care Medicine 168 (7), 2003.

Manahan, S. E., Environmental Chemistry, CRC Press LLC, Oxford. 600 pp, 1991.

Patel, M.M. & Miller, R.L., Air pollution and childhood asthma: recent advances and future directions, *Curr Opin Pediatr*, 21 (2): 235–242. doi:10.1097/MOP.0b013e3283267726, 2009

Pope, C. A., and D. W, Dockery, Acute health effects of PM10 pollution on symptomatic and asymptomatic children. *American review of respiratory disease, 145*, 1123–1128, 1992.

Pope, C. A. and R. E Kanner, Acute effects of PM 10 pollution on pulmonary function of smokers with mild to moderate chronic obstructive pulmonary disease. *American review of respiratory disease 147*,1336–1340, 1993.

Schwartz, J, Air Pollution and Daily Mortality in Birmingham, Oxford University Press, Alabama, 1993.

USEPA (United States Environmental Protection Agency), Compilation of Air Pollution Emission Factors (AP-42), 6th Edition, Volume 1, as contained in the AirCHIEF (AIR Clearinghouse for Inventories and Emission Factors) CD-ROM (compact disk read only memory), US Environmental Protection Agency, Research Triangle Park, North Carolina, 1995

USEPA (United States Environmental Protection Agency), Revision of Emission Factors for AP-42. Chapter 11: Mineral Products Industry. Section 11.9: Western Surface Coal Mining. http://www.epa.gov/ttn/chief/ap42/index.html. Accessed 5 May 2017, 1998a

USEPA (United States Environmental Protection Agency), Revision of Emission Factors for AP-42. Chapter 13: Miscellaneous Source. Section 13.2.2: Unpaved Roads (Fugitive Dust Sources). http://www.epa.gov/ttn/chief/ap42/index.html. Accessed 16 May 2009, 2006a

USEPA (United States Environmental Protection Agency), Revision of Emission Factors for AP-42. Chapter 13: Miscellaneous Source. Section 13.2.4: Aggregate Handling and Storage Piles (Fugitive Dust Sources). http://www.epa.gov/ttn/chief/ap42/index.html. Accessed 10 May 2009, 2006b

USEPA (United States Environmental Protection Agency), Revision of Emission Factors for AP-42. Chapter 13: Miscellaneous Source. Section 13.2.4: Aggregate Handling and Storage Piles (Fugitive Dust Sources). http://www.epa.gov/ttn/chief/ap42/index.html. Accessed 2 June, 2016.

USEPA (United States Environmental Protection Agency), MOVES (Motor Vehicle Emissions Simulator), 2013. Available at: https://www.epa.gov/moves/april-2013-moves-model-review-work-group-meeting-materials. Accessed 10 August 2017

Watson, J.G, Chow, J.C, Gillies, J.A, Moosmüller, H, Rogers, C.F., DuBois, D.W., and Derby, J.C, 1996, Effectiveness demonstration of fugitive dust control methods for public unpaved roads and unpaved shoulders on paved roads. Report No. 685-5200.1F prepared for San Joaquin Valley Unified Air Pollution Control District, Fresno, CA, by Desert Research Institute, Reno, NV.

WHO (World Health Organisation), Air quality guidelines for Europe, *(2nd ed)*, Copenhagen, World Health Organization Regional Office for Europe, WHO Regional Publications, European Series, No. 91, 2000.

WHO (World Health Organisation), Air Quality Guidelines Global Update, World Health Organisation, October 2005, Germany, 2005

WHO, Regional Office for Europe, Health and Environment in Europe, Scherfigsvej8, DK-2100 Copenhagen Ø, Denmark, 2010