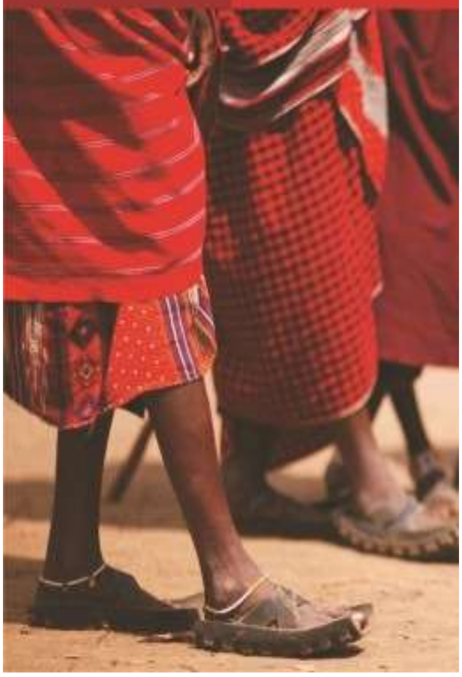

DIGBY WELLS
ENVIRONMENTAL

Air Quality Impact Assessment Report

The proposed Palmietkuilen Mining Project, near Springs, Gauteng Province

Project Number:

CNC4065

Prepared for:

Canyon Coal

January 2017

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Report Type:	**The proposed Palmietkuilen Mining Project, near Springs, Gauteng Province**
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Name	**Responsibility**	**Signature**	**Date**
Matthew Ojelede	Report Writer		January 2017
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DECLARATION OF INDEPENDENCE

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I, Matthew Ojelede as duly authorised representative of Digby Wells and Associates (South Africa) (Pty) Ltd., hereby confirm my independence (as well as that of Digby Wells and Associates (South Africa) (Pty) Ltd.) and declare that neither I nor Digby Wells and Associates (South Africa) (Pty) Ltd. have any interest, be it business, financial, personal or other, in any proposed activity, application or appeal in respect of Canyon Coal, other than fair remuneration for work performed, specifically in connection with the proposed Palmietkuilen Colliery Project.

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Experience (years):	Eight Years
Registration(s):	National Association for Clean Air (NACA)

EXECUTIVE SUMMARY

The scope of work for the overall environmental authorisation process encompasses several specialist studies of which Air Quality Impact Assessment (AQIA) forms an integral component. The AQIA was conducted to assess the potential impacts and recommend mitigation measures to reduce emission to the ambient environment. The AQIA scope included evaluation of the baseline environment and dispersion modelling to assess future impacts of the proposed Project on air quality.

The potential impact associated with the proposed Palmietkuilen Mining Project was assessed through modelling a defined domain of 20 km x 20 km, with a reference mid-point within the future project area. This domain, defined as the zone of potential impact due to potential air pollution emanating from the proposed Palmietkuilen Mine stretches 10 km north, south, east and west from the reference point. This zone of impact was assessed and encompasses nearby settlements, including scattered farmhouses in the area.

An emissions inventory was established comprising emissions anticipated from the operation of the proposed Palmietkuilen Mine - the inventory calculated emissions of total suspended particulate (TSP), PM_{10} and $PM_{2.5}$ from the material handling processes, topsoil and overburden stockpile, run-off-mine (ROM), roads as well as drilling and blasting operations. Gaseous emissions from the generator set were quantifies and the assumption was that this will be operation throughout the year.

Model predications presented in this report have shown that pollutants level attributed to the proposed Palmietkuilen Mine - dust fallout, PM_{10} and $PM_{2.5}$ will not exceed regulatory standards. It is worth mentioning that predicted concentrations are not in exceedance at the mine boundary and at surrounding sensitive receptors (concentrations at the selected sensitive receptors are within the dust fall, PM_{10} and $PM_{2.5}$ daily and annual standards). Emissions from the haul roads, stockpiles and crushers represent the highest contributors.

With multiple activities conducted at the same time, this results in multiple sources of emissions.

The AQIA study shows that particulate pollution from the proposed Palmietkuilen Mine operation will exert impact on current ambient air quality of the area. With multiple activities conducted at the same time, this results in multiple sources of emission (i.e. drilling and blasting, loading and offloading, hauling of ore and overburden, tipping, and crushing). The main findings of this AQIA study are summarised as follows:

- The predicted highest daily PM_{10} concentration at the mine boundary exceeds the South African standard of 75 µg/m³ at the project boundary without mitigation measures in place. The predicted highest annual concentrations were within the standard (40 µg/m³) at the project boundary. However, exceedances of the current standard were predicted within the project area.
- The predicted $PM_{2.5}$ daily concentrations at the mine boundary were within the standard (40 µg/m³). Exceedances predicted were within the project area. The

predicted highest annual concentration was within the current limit of 20 µg/m³ at the project boundary. The impacts associated with the predicted daily and annual concentrations were minimised after mitigation measures were applied.

- The highest dust deposition rates were predicted, exceeded the 1200 mg/m^2/day recommended for non-residential areas (National Dust Control Regulation, 2013). However, once mitigation measures were applied, the predicted dust deposition rates and the zones of impact were minimised and limited to the project area.

- The maximum 1-hour average nitrogen dioxide concentrations are predicted to be higher than limit of 200 µg/m$_3$ without mitigation measures in place. However, the annual average nitrogen dioxide concentrations are predicted to be below the project 40 µg/m$_3$ and within compliance.
- The maximum 1-hour average and 8-hour average carbon monoxide concentrations are predicted to be below the project criteria of 30 mg/m^3 (30 000 µg/m^3) and 10 mg/m^3 (10 000 µg/m^3), respectively, at the project area and the sensitive receptor.

Overall, once the sources are curtailed with adequate mitigation measures factored into the day to day operation of the mine i.e. use of dust suppressants on dirt roads, use of water sprayers at active stockpiles, vegetation of long-term stockpiles and enclosure / fogging of crushers etc., the particulate release into the ambient atmospheres was reduced drastically at the mine and surroundings receptors.

The main outcome of this air quality impact assessment is that particulate pollution – fallout dust, PM_{10} and $PM_{2.5}$ will have an impact on the ambient air quality of the project area. Hence, suitable monitoring and mitigation measures should be factored into the day to day operation of the mine to assess and curtail potential emissions.

Mitigation measures are recommended in the Environmental Management Plan section tailored to the proposed activities. Implementation of the suggested mitigations will confirm the commitment to ameliorate potential impacts and ensure compliance with regulatory requirements.

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1 Introduction

The application process for the proposed project will be managed by Pandospan (Pty) Ltd. (hereinafter Pandospan), a subsidiary of Canyon Resources (Pty) Ltd. (hereinafter Canyon Coal), who will also construct and operate the Project if the MRA is successful. Digby Wells and Associates (South Africa) (Pty) Ltd. (hereinafter Digby Wells) has been appointed by Canyon Coal as the EAP to complete the EIA. This report is the outcome of the Air Quality Impact Assessment (AQIA) study, which forms part of a suite of specialist assessments that were undertaken as part of the EIA.

Canyon coal is planning the development of a greenfields coal mine and associated infrastructure on a site approximately four kilometres (km) east of Springs, within Gauteng Province (i.e. the Project). Anglo Operations Limited currently holds a prospecting right (30/5/1/1/2 (201/10026) PR) for the proposed Project site, which comprise Portions 1, 2, 4, 9, 13 and 19 of the Palmietkuilen 241 IR property.

In terms of the requirements of the Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002) (MPRDA), as amended, a successful Mining Right Application (MRA) must be submitted to the Department of Mineral Resources (DMR), in order to convert the prospecting right into a mining right. This MRA should include an Environmental Impact Assessment (EIA) completed by an independent Environmental Assessment Practitioner (EAP), in accordance with the EIA Regulations outlined in the National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA) and updated in 2014.

This proposed project involves the development of a new open pit coal mine and supporting infrastructure. The raw coal, once extracted, will be transported to a processing plant for crushing, screening and washing. The coal product will either be transported via haul roads from the product stockpile area to the existing Welgedacht siding for distribution by rail or directly to prospective clients by road. The proposed mine will require supporting infrastructure such as water storage, sewage treatment, power supply, fuel storage and hauls roads.

The current resource is estimated at 125.98 Mt. The life of mine for the project is 53 years including a 2 year ramp-up period. Once the mine has been established, a full production rate of 200 000 t / month will be maintained for 51 years.

1.1 Project Background

Canyon Coal is a subsidiary of the Canyon Group of companies and functions as the operational division. Pandospan forms part of the Canyon Group. In June 2016, Pandospan concluded a contract with Anglo Operations Limited for the acquisition of a Prospecting Right (DMR Ref: GP 30/5/1/1/2 (201/10026) PR) on Portions 1, 2, 4, 9, 13 and 19 of Palmietkuilen 124 IR.

The current EA process and associated enviro-legal applications of the Project are being completed by Digby Wells, and managed by Pandospan (*i.e. Canyon Coal*) on behalf of Anglo Operations Limited as the applicant.

The proposed Project will entail the establishment of a new open pit coal mine and supporting infrastructure. Proposed mining methods include bench and strip mining techniques. Drilling and blasting will be employed to remove overburden or bedrock and expose the coal seams.

Extracted coal will be transported via haul roads and stored on a Run of Mine (RoM) stockpile area. It is proposed that the coal be transported to the processing plant via conveyor for beneficiation, after which the coal product will be stored prior to distribution.

From the processing plant, the coal product is proposed to be transported to the Welgedacht siding for distribution via rail or directly via truck to the relevant markets. A temporary discard dump containing one year's capacity will be constructed to store discard before being either rewashed or backfilled into mined out areas.

1.2 Terms of Reference

The Terms of Reference (ToR) for the AQIA scope of work are outlined below:

- Baseline assessment;
  - Evaluation of site specific meteorology;
  - Evaluation of background ambient air quality data;
  - Set up dust fallout monitoring network and monitor dust fallout for a period 1 year;
  - Review of environmental implications of airborne pollutants;
- Emissions inventory;
- Dispersion modelling;
- Impact assessment; and
- Recommendation of mitigation measures incorporating Best Practicable Environmental Option.

2 Details of the Specialist

Matthew Ojelede completed his BSc (Hons) degree at the University of Benin, Edo State, Nigeria; an MSc in Environmental Science (Wits University) and a PhD in Environmental Management from the University of Johannesburg. He has been in the Atmospheric Research field since 2005 and now actively involved in air pollution research, associated impacts and application of regulatory requirements. Authored and co-authored research articles in peer Reviewed Journals and Dispersion Modelling Impact Assessments Reports. He has attended specialised courses in atmospheric dispersion modelling (AERMOD and CALPUFF).

3 Aims and Objectives

The overall aim of the AQIA study was to establish the impacts on air quality due to the proposed Project and related activities. To achieve this aim, the following objectives were undertaken:

- To identify all potential sources of pollution within the Project area;
- To identify all sensitive receptors in the vicinity of the Project;
- To assess available air quality monitoring data; and
- Assess predicted impacts against regulatory standards governing pollutants from the proposed Project.

4 Assumptions and Limitations

Assumptions and limitations associated with this study are listed below:

- The impact assessment was limited to the emissions generated from the construction and operational phases with emphasis on particulates (PM2.5, PM10, and dust fallout) and some gases from the generators, such as oxides of nitrogen (NOx), carbon monoxide (CO) and hydrocarbons (HC) based on manufacturer's specification. Although the proposed construction and operational phases and associated activities will result in the emissions of gaseous pollutants from vehicle exhausts, these were assumed negligible. Assessment was limited to gaseous impacts from the generator sets only.
- Due to the unavailability of local emission factors, the US-EPA and Australian NPI emission factors were utilised extensively in the emissions inventory;
- Background air quality assessment was limited to monitoring dust deposition rates;
- This assessment was based on the proposed opencast Palmietkuilen Mining Project project infrastructure provided by client.

5 Site Characterisation

5.1 Site Location

The proposed Project site is situated in the eastern extremities of Gauteng Province, with eastern border of the site running alongside the provincial boundary with Mpumalanga. Gauteng Province comprises 18 176 square kilometres (km^2) of land and borders Limpopo Province to the north, North-West Province to the west, Free State to the south, and Mpumalanga Province to the east (Gauteng Provincial Government, 2009). Gauteng comprises five main administrative regions, including three Metropolitan Municipalities (i.e. City of Tshwane, City of Johannesburg and Ekurhuleni) and two District Municipalities (i.e. Sedibeng and West Rand).

The Project area is situated within Sedibeng District Municipality (SDM), which comprise three local municipalities (LMs); Midvaal, Emfuleni and Lesedi. The MRA is located entirely within Ward 12 of Lesedi Local Municipality (LLM) and directly borders Ward 7 of the Victor Khanye LM (VKLM), located in the Nkangala District Municipality (Mpumalanga Province) and Ward 75 and 76 of the Ekurhuleni Metropolitan Municipality (EMM).

5.2 Topography

The topography surrounding the proposed Palmietkulien Mine is shown in Figure 5-1 below. Elevations in the project area range from approximately 1489 – 1666 metres above mean sea level (masl).

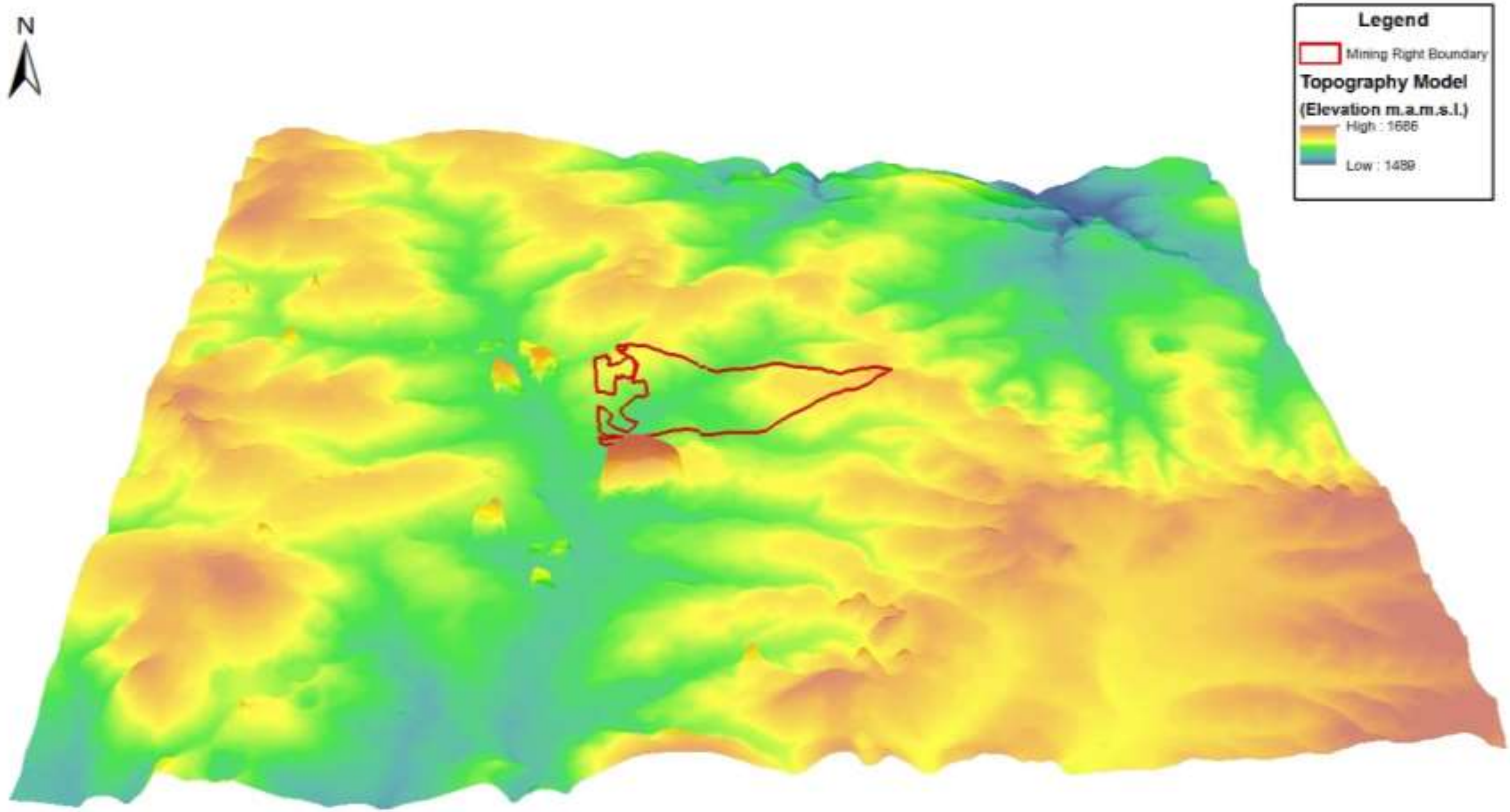

Figure 5-1: Topography in the vicinity of Palmietkulien Mine (red polygon)

5.3 Sensitive Receptors

Sensitive receptors closest to the proposed Palmietkulien Mine include Aston Lake, Endicott and Vischkuil (2km south), Sundra (2.5km north), Welgedacht (3km north-west) and Springs (4km east). In addition, poultry farms are located in the northwest and northeast sections respectively. According to the United States Environmental Protection Agency (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"*. Human settlement where involuntary exposure is likely to occur is not exempted. Identified human settlements and proximate distances from the proposed Palmietkulien Mine boundary are listed in Table 5-1 below.

Table 5-1: Sensitive Receptors in the Vicinity of the Proposed Project Area

Sensitive Receptor	Receptor Type	Distance from the mine boundary (km)
Aston Lake Community	Residential	350 m west
Endicott	Residential	~2 km south
Springs	Residential	~4 km west
Sundra	Residential	~2.5 km north
Vischkuil	Residential	~2 km south
Welgedacht	Residential	~4 km east

6 Legal Context (Legislations, Policies and Guidelines)

6.1 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 Environment Management: Air Quality Act (Act No. 39 of 2004) (NEM: AQA). 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, 1998 (Act 107 of 1998) (NEMA).

The purpose of 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. 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 poor and the potential for health effects is greatest.

6.2 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.

The Department of Environmental Affairs (DEA) has established the National Ambient Air Quality Standards for the criteria pollutants in the Government Notice - GN1210:2009.

Table 6-1 gives an overview of the established NAAQS, as well reference methods and compliance dates for criteria pollutants in South Africa.

Table 6-1: National Ambient Air Quality Standards as of 24 December 2009

AVERAGING PERIOD	LIMIT VALUE ($\mu g/m^3$)	LIMIT VALUE (ppb)	FREQUENCY OF EXCEEDANCE	COMPLIANCE DATE
National Ambient Air Quality Standard for Sulphur Dioxide (SO_2)				
10 Minutes	500	191	526	Immediate
1 hour	350	134	88	Immediate
24 hours	125	48	4	Immediate

AVERAGING PERIOD	LIMIT VALUE (µg/m^3)	LIMIT VALUE (ppb)	FREQUENCY OF EXCEEDANCE	COMPLIANCE DATE
1 year	50	19	0	Immediate
The reference method for the analysis of SO_2 shall be ISO 6767.				
National Ambient Air Quality Standard for Nitrogen Dioxide (NO_2)				
1 hour	1 hour	1 hour	526	Immediate
1 year	1 year	1 year	88	Immediate
The reference method for the analysis of NO_2 shall be ISO 7996.				
National Ambient Air Quality Standard for Particulate Matter (PM_{10})				
24 hour	24 hour	1 hour	526	Immediate
1 year	1 year	1 year	88	Immediate
The reference method for the determination of the PM10 fraction of suspended particulate matter shall be EN 12341.				
National Ambient Air Quality Standard for Ozone (O_3)				
8 hours (running)	8 hours (running)	8 hours (running)	8 hours (running)	8 hours (running)
The reference method for the analysis of ozone shall be the UV photometric method as described in SANS 13964.				
National Ambient Air Quality Standard for Benzene (C_6H_6)				
1 year	1 year	1 year	1 year	1 year
The reference methods for the sampling and analysis of benzene shall either be EPA compendium method TO-14 A or method TO-17.				
National Ambient Air Quality Standard for Lead (Pb)				
1 year	1 year	1 year	1 year	1 year
The reference method for the analysis of lead shall be ISO 9855.				
National Ambient Air Quality Standard for Carbon Monoxide (CO)				
1 hour	30	26	88	Immediate
8 hour (calculated on 1 hourly averages)	10	8.7	11	Immediate
The reference method for analysis of CO shall be ISO 4224.				

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 GN R 486 in GG 35463 of 29 June 2012 (Table 6-2).

Table 6-2: 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
24 hours	25 µg/m^3	4	1 January 2030
1 year	20 µg/m^3	0	1 January 2016 – 31 December 2029
1 year	15 µg/m^3	0	1 January 2030
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 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 6-3 below.

Table 6-3: 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

In terms of control and management of air pollutants, the listing of activities that are sources of emission gazetted and the subsequent application for emission licences is in force. The Minister of Water and Environmental Affairs published the List of Activities, in Government Notice 248, in Gazette 33064 on 31 March 2010 (amended in Government Notice 893, in Gazette 37054 on 22 November 2013). Listed activities are defined as activities which ‘result in atmospheric emissions with potential to have ‘adverse’ impacts on public health and ecosystem. As a result, minimum emissions standard are established for pollutants arising from each activity. Facilities with listed activities now require an atmospheric emission licence to operate, with Metropolitan and District Municipalities saddled with the responsibility of issuing these licences.

In addition, the Minister may by notice in a Gazette declare any substance contributing to air pollution as a priority pollutant (Section 29 – NEM: AQA 2004). Any industries or industrial sectors that emit these priority pollutants will be required to prepare and submit for approval and implement a Pollution Prevention Plan.

6.3 Health Effects of Pollutants

6.3.1 Air Pollutants

The main pollutants of concern associate with the construction and operational phases of the proposed Palmietkuilen Mine and infrastructure will be particulate matter, whether in the form of total suspended particulates (TSP), PM_{10} or $PM_{2.5}$ and gaseous emissions from of-road diesel engines and generators.

6.3.1.1 Particulate Matter

Particulate matter (PM) 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 6-4 (WHO, 2010).

6.3.2 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 by Schwartz (1993) in Birmingham recorded daily concentrations of 163 µg/m^{3}and noted that an increase in daily mortality was experienced with an increase in PM_{10} concentrations. 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).

Morbidity effects associated with short-term exposure to particulates include increases in lower respiratory symptoms, medication use and small reductions in lung function. Pope and Dockery (1992) studied panels of children in Utah Valley in winter during the period 1990 – 1991. Daily PM_{10} concentrations ranged between 7 – 251 µg/m^3. Peak Expiratory Flow was decreased and respiratory symptoms increased when PM_{10} concentrations increased. Pope and Kanner (1993) utilised lung function data obtained from smokers with mild to moderate chronic obstructive pulmonary disease in Salt Lake City. The estimated effect was a 2%

decline in Forced Expiratory Volume over one second for each 100 µg/m^3 increase in the daily PM_{10} average.

6.3.3 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 6-4.

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.

Few studies have been undertaken documenting the morbidity effects of long-term exposure to particulates. Recently, the Harvard Six Cities Study showed increased respiratory illness rates among children exposed to increasing particulate, sulphate and hydrogen ion concentrations. Relative risk estimates suggest an 11% increase in cough and bronchitis rates for each 10 µg/m^3 increase in annual average particulate concentrations.

Table 6-4: 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

6.3.3.1 Sulfur dioxide (SO_2)

Sulfur dioxide (SO_2) forms part of the entire group of sulfur oxides (SO_x), and constitutes the component of greatest concern. Emissions that lead to high concentrations of SO_2 generally also lead to the formation of other SO_x. In the context of this project, sources of SO_2 emissions are mainly from fossil fuel combustion in vehicles and heavy equipment and at power plants that burn fuel with high sulfur content. SO_2 can have adverse effect public health and the environment (Alberta Health & Wellness, 2006).

Short-term exposures to SO_2 can result in difficulties for the human respiratory system, making breathing difficult. Children, the elderly, and those who suffer from asthma are particularly sensitive to effects of SO_2.

SO_2 emissions that lead to high concentrations of SO_2 in the air generally also lead to the formation of other sulfur oxides (SO_x). SO_x can react with other compounds in the atmosphere to form small particles. These particles contribute to particulate matter (PM) pollution: particles may penetrate deeply into sensitive parts of the lungs and cause additional health problems. At high concentrations, gaseous SO_2 can harm trees and plants by damaging foliage and decreasing growth. SO_2 and other sulfur oxides can contribute to acid rain which can harm sensitive ecosystems. Pollutants associated the CAT Diesel Generators used in our assessment excludes SOx, hence this pollutant will not be considered further.

6.4 Nitrogen Dioxide (NO_2)

Nitrogen dioxide is a nasty-smelling gas. Some nitrogen dioxide is formed naturally in the atmosphere by lightning and some is produced by plants, soil and water. However, only about 1% of the total amount of nitrogen dioxide found in our cities' air is formed this way.

In terms of the proposed project, nitrogen dioxide will arise mainly the burning of fossil fuels in heavy duty engines and power plant. Exposure to elevated levels of nitrogen dioxide present the likelihood of respiratory problems. This pollutant inflames the lining of the lungs, reducing immunity to lung infections – exacerbating the occurrence of wheezing, coughing, colds, flu and bronchitis (Kraft et al, 2005).

Increased levels of nitrogen dioxide can have significant impacts on people with asthma because it can cause more frequent and more intense attacks. Children with asthma and older people with heart disease are most at risk.

6.5 Carbon Dioxide (CO)

Carbon monoxide (CO), a poisonous, colourless, odourless and tasteless gas is known to be widely associated with incomplete combustion of natural gas and any other material containing carbon such as gasoline, kerosene, oil, propane, coal, or wood. Forges, blast furnaces and coke ovens produce CO, but in our context, it is the internal combustion engine.

Carbon monoxide is harmful when breathed because it displaces oxygen in the blood and deprives the heart, brain, and other vital organs of oxygen. Exposure to high concentrations of CO can result in loss of consciousness and suffocation. Prior to the aforementioned, tightness across the chest, headache, fatigue, dizziness, drowsiness, or nausea is common symptoms. Symptoms vary widely from person to person. CO poisoning may occur sooner in those most susceptible: young children, elderly people, people with lung or heart disease, people at high altitudes, or those who already have elevated CO blood levels, such as smokers.

The Occupational Safety and Health Administration (OSHA) standards prohibit worker exposure to more than 50 parts of the gas per million parts of air averaged during an 8-hour time period (OSHA's Safety and Health Program Management Guidelines, 2006).

7 Methodology

7.1 Baseline Environment

7.1.1 Meteorological Overview

Ambient air quality in this region of South Africa is strongly influenced by regional atmospheric movements, together with local climatic and meteorological conditions.

There are distinct summer and winter weather patterns that affect the dispersal of pollutants in the atmosphere. In summer, unstable atmospheric conditions result in mixing of the atmosphere and rapid dispersion of pollutants. Summer rainfall also aids in removing pollutants through wet deposition. Precipitation reduces wind erosion potential by increasing the moisture content of exposed surface materials–this represents an effective mechanism for suppressing wind-blown dust. Rain-days are defined as days experiencing 0.1 mm or more rainfall.

In contrast, winter is characterised by atmospheric stability caused by a persistent high-pressure system over South Africa. This dominant high-pressure system results in subsidence, causing clear skies and a pronounced temperature inversion over interior of South Africa. This inversion layer traps pollutants from near surface sources in the lower atmosphere, which results in reduced dispersion and poorer air quality. Preston-Whyte and Tyson (1988) described the atmospheric conditions in the winter months as highly unfavourable for the dispersion of atmospheric pollutants. Emissions from elevated sources, such as from tall stacks, remain stratified in the mid-troposphere and have a reduced probability of reaching the surface with high concentrations near the source.

In the absence of site specific meteorological records, three years' worth of hourly weather MM5 modelled meteorological data (2013-2015) from Lakes Environmental Software was analysed and used to generate wind rose plots and determine the local prevailing weather conditions. This dataset, from the Pennsylvania State University / National Center for Atmospheric Research (PSU/NCAR) meso-scale model is a limited-area, non-hydrostatic, terrain-following sigma-coordinate model designed to simulate or predict meso-scale atmospheric circulation. This data, obtained for a point (26.254039 S, 28.490397 E) in the proposed project area, has been tested extensively and has been found to be accurate. Generally, a data set of greater than 90% completeness is required for that month/year to be considered representative of the assessed area (SANS, 2011).

Dispersion of atmospheric pollutants is a function of the prevailing wind characteristics at any site. The vertical dispersion of pollution is largely a function of the wind field. The wind speed determines both the distance of downward transport and the rate of dilution of pollutants. The generation of 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, whether the material is crusted, the fraction of erodible particles, and the particle size distribution (Fryrear et al., 1991).

Wind roses generally comprises of 16 spokes which represent the frequencies and the directions from which winds blew during the period. The colours reflect the different categories of wind speeds. The dotted circles provide information regarding the frequency of occurrence of wind speed and different categories. The figures at the bottom of the legend represent the frequency at which calms occurred (periods with wind speed <0.5 m/s).

The spatial and annual variability in the wind field for the proposed Palmietkuilen Project area is evident in Figure 7-1. The dominant winds are blowing from North of Northeast (14%) and North (12%) respectively. Calm conditions (wind speeds <0.5 m/s) occurred 4.2% of the time. The wind class frequency distribution per sector is given in Figure 7-4 and Table 7-1.

There is some diurnal variation in the meteorological data shown in Figure 7-2. The predominant wind direction is North of Northeast at night time (21%), North of Northeast (16%) in the morning, North of Northwest in the afternoon (11%) and North (12%) in the evening.

The seasonal variability in wind direction is depicted in Figure 7-3. The seasonal signature is similar to the diurnal patterns with winds from the North of Northeast and North dominating the wind regime.

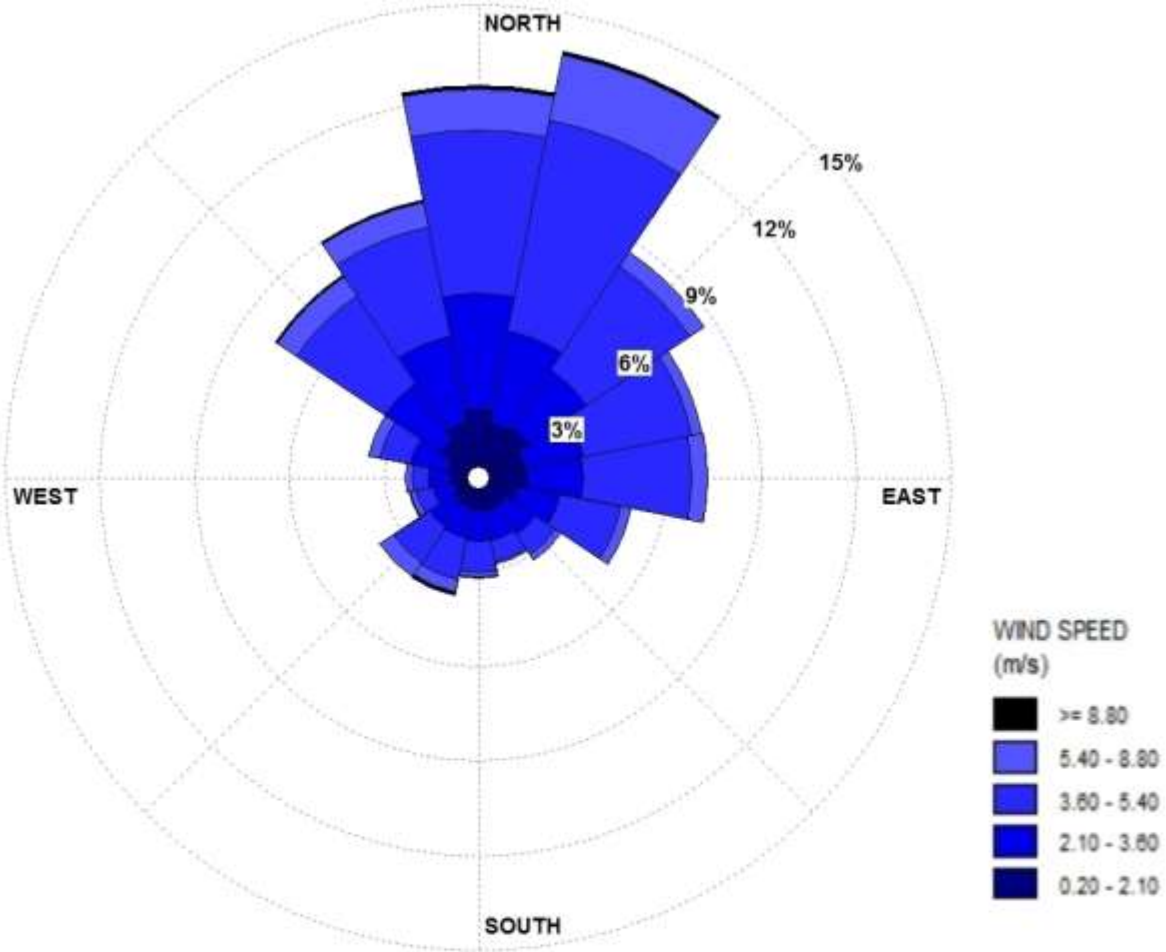

Figure 7-1: Surface Wind Rose at the Proposed Project Site

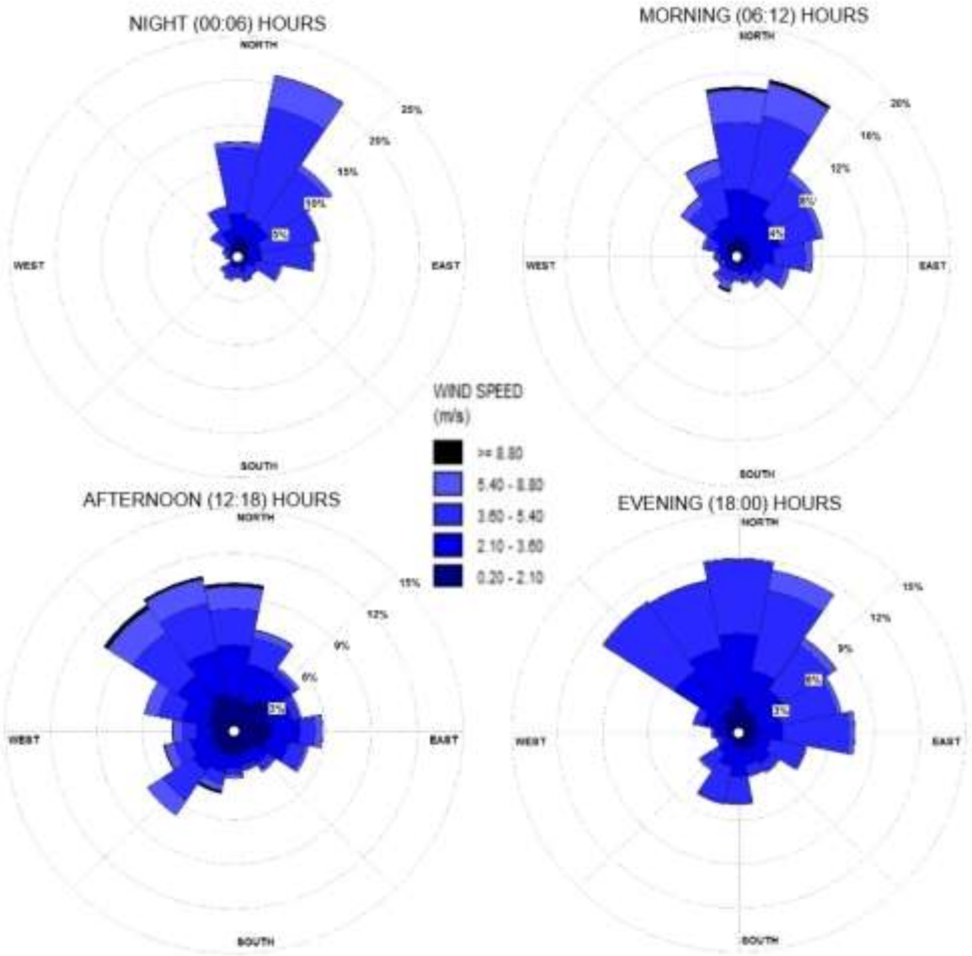

Figure 7-2: Diurnal variations of wind at night-time: 00:00 – 06:00 (top left), morning 06:00 – 12:00 (top right), afternoon 12:00 – 18:00 (bottom left) and evening 18:00 – 00:00 (bottom right)

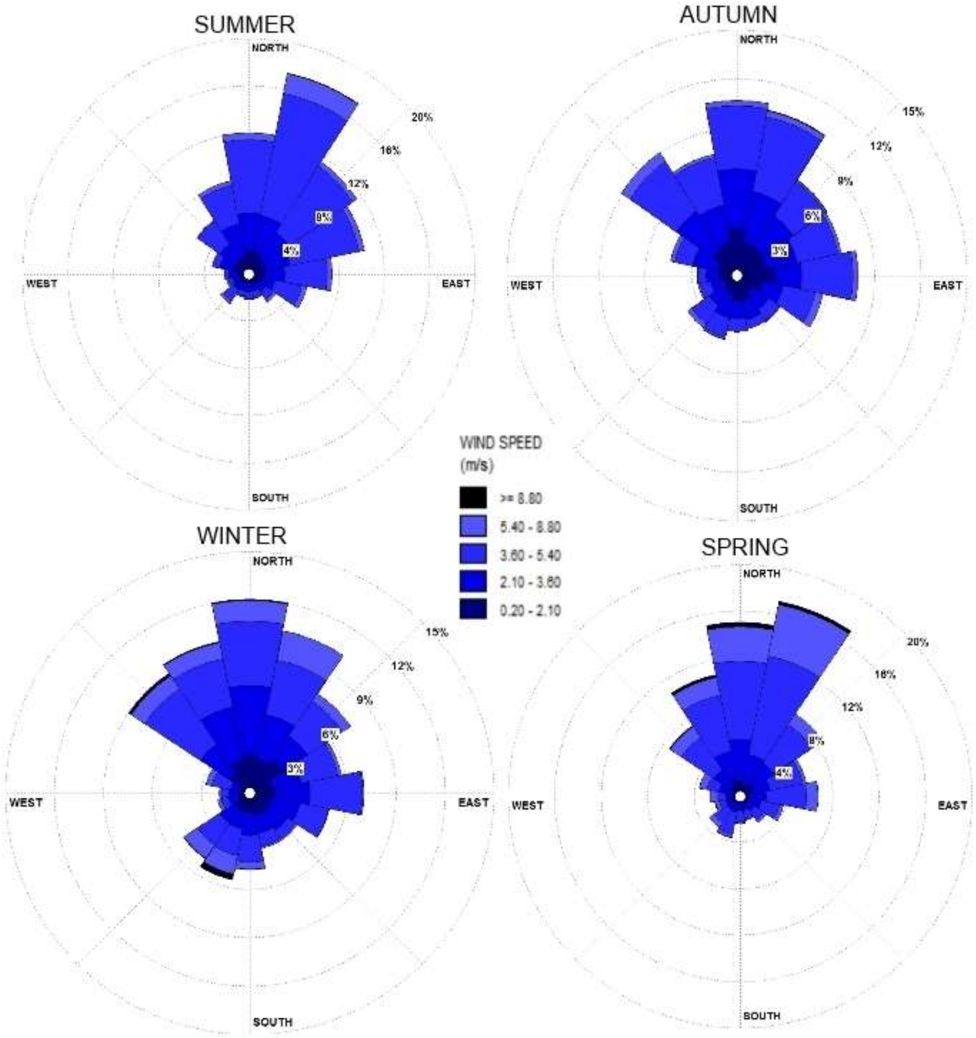

Figure 7-3: Seasonal variability of winds in summer (December – February); autumn (March – May); winter (June – August) and spring (September – November)

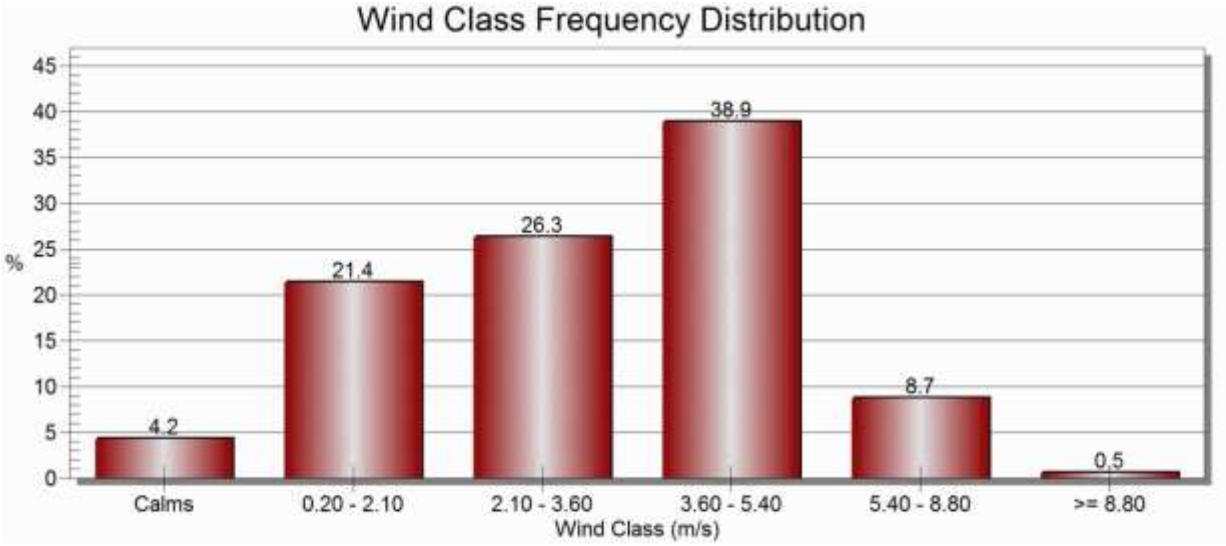

Figure 7-4: Wind Class Frequency Distribution

Table 7-1: Wind Class Frequency Distribution

	Directions (m/s)	0.20 - 2.10	2.10 - 3.60	3.60 - 5.40	5.40 - 8.80	>= 8.80	Total (%)
1	N	2.19	3.66	5.17	1.30	0.11	12.44
2	NNE	1.82	2.94	6.79	2.10	0.10	13.75
3	NE	1.93	2.20	3.93	0.55	0.01	8.61
4	ENE	1.51	1.89	3.50	0.31	0.01	7.22
5	E	1.58	1.78	3.41	0.49	0.00	7.25
6	ESE	1.26	1.37	1.96	0.33	0.00	4.93
7	SE	1.10	1.08	0.78	0.20	0.00	3.17
8	SSE	1.11	0.92	0.68	0.08	0.00	2.79
9	S	1.03	1.00	1.00	0.15	0.01	3.18
10	SSW	0.98	0.99	1.34	0.40	0.10	3.80
11	SW	0.92	0.96	1.37	0.52	0.00	3.77
12	WSW	0.80	0.68	0.55	0.20	0.02	2.25
13	W	0.87	0.75	0.49	0.21	0.01	2.34
14	WNW	1.02	1.18	1.00	0.33	0.00	3.54
15	NW	1.43	2.15	3.36	0.73	0.07	7.74
16	NNW	1.81	2.76	3.54	0.79	0.08	8.98
	Sub-Total	**21.36**	**26.30**	**38.88**	**8.70**	**0.53**	**95.76**
	Calms						4.24
	Missing/Incomplete						0
	Total						**100**

7.1.2 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 particulate matter and dispersion across the landscape (Table 7-2 and Figure 7-5). Figure 7-5 shows wind speed greater than 5.4 m/s occurs every month with potential to result in erosion of open surfaces. Although on average the wind speed is below 5.4 m/s, it can be seen from Table 7-2 that the potential is there. In total, 31 days in a year recorded wind speed greater than 5.4 m/s (~ 3 days in a month).

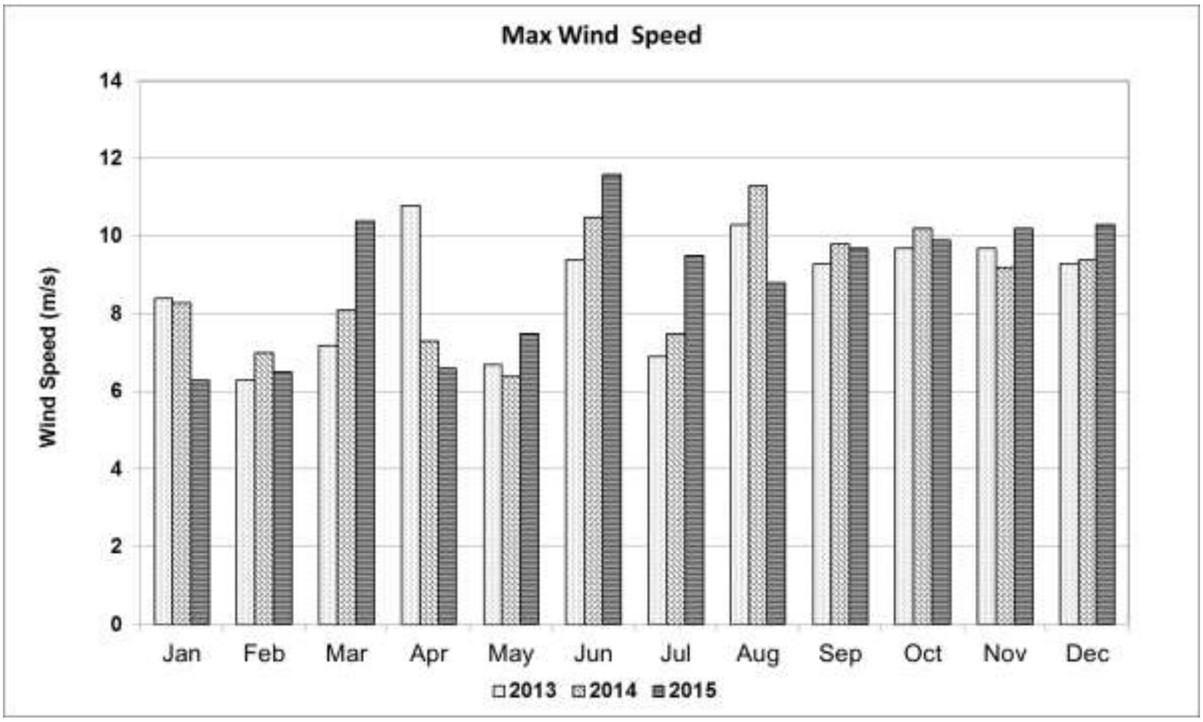

Figure 7-5: Monthly Maximum Wind Speed

Table 7-2: Monthly Wind Speed Records

Wind Speed (m/s)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Monthly Max.	8	7	10	11	8	12	10	11	10	10	10	10	10
Monthly Ave	4	3	3	3	3	3	3	4	4	4	4	4	3

7.1.3 Temperature

The monthly maximum and average temperature for the project area is given in Figure 7-6 and Table 7-3. The maximum temperatures were observed from October to February with the month of December recording the highest temperature of 31°C. The monthly averages ranged from 9°C in June/July to 21°C in December/January/February. The annual average temperature for the proposed project site is given as 16°C.

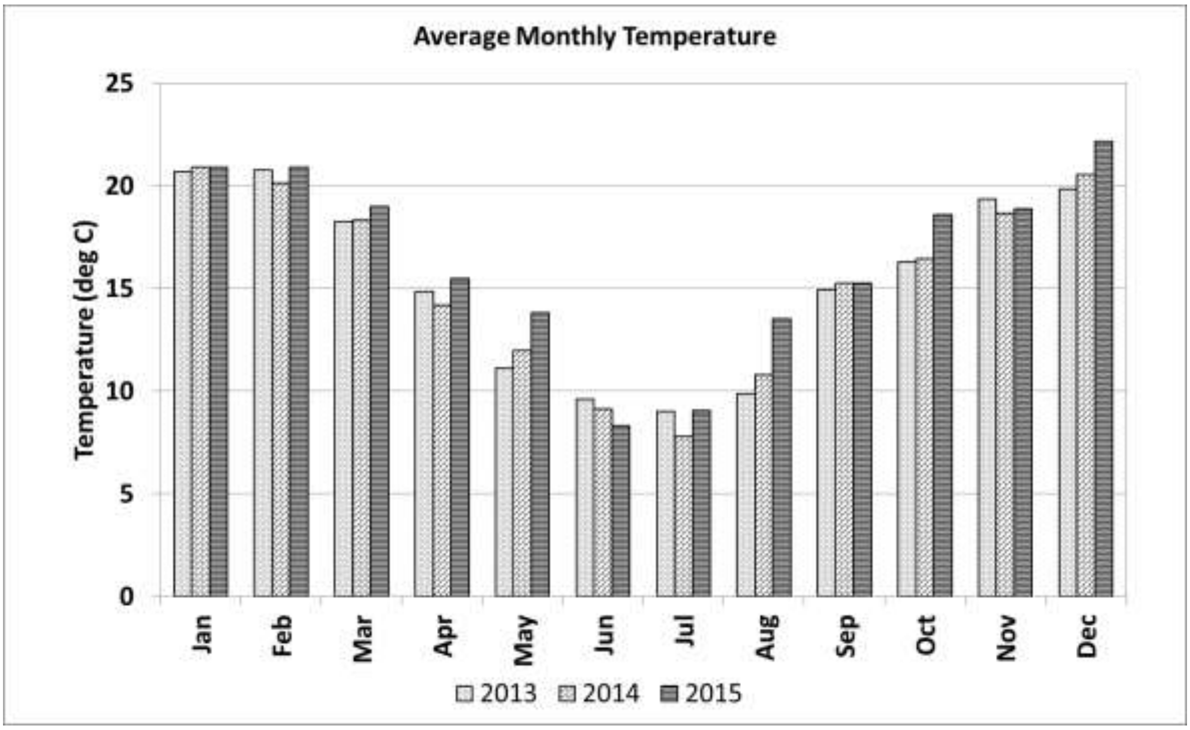

Figure 7-6: Average Monthly Temperature

Table 7-3: Monthly Temperature Records

Temp(°C)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Monthly Max.	30	30	27	25	22	19	18	24	25	29	28	31	26
Monthly Ave	21	21	19	15	12	9	9	11	15	17	19	21	16

7.1.4 Precipitation

The total monthly and the average rainfall for the period under review are reported in Table 7-4 for the three-year period (2013-2015). The highest total monthly precipitation (226 mm) observed in January. The lowest recorded precipitation (4 mm) was observed in June. The annual total rainfall (Max) is 1125 mm and average monthly rainfall is 787 mm respectively. The total monthly rainfall for the three years period is depicted in Figure 7-7.

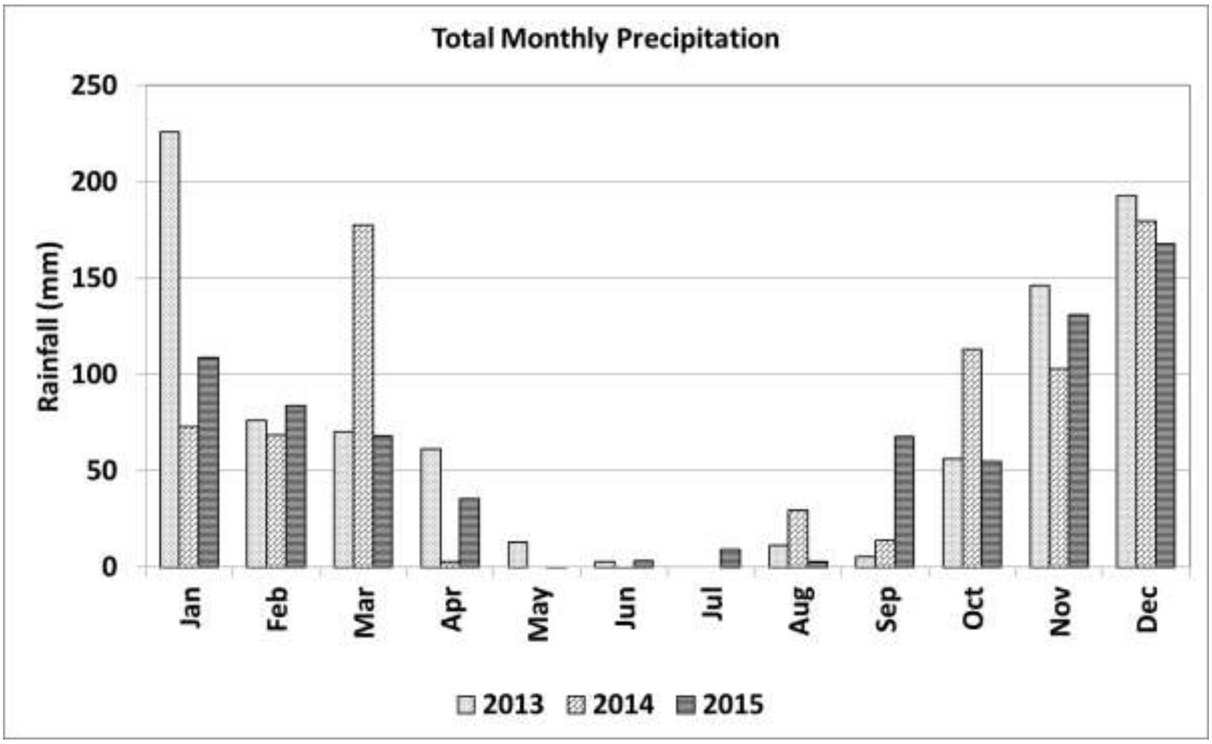

Figure 7-7: Total Monthly Precipitation

Table 7-4: Total Monthly Precipitation Records

Precipitation (mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Tot. Mon Rainfall (Max)	226	84	178	61	13	4	9	30	68	113	146	193	1125
Aver. Mon Rainfall	136	76	105	34	5	3	3	15	29	75	127	180	787

7.1.5 Relative Humidity

The data in Table 7-5 are representative of the relative humidity for the proposed project area. The annual maximum and average relative humidity is given as 100% and 69.5% respectively. The monthly maximum reaches 100% for the whole year. The monthly average relative humidity is above 60% for the whole year, except the month of November. The monthly average peaked in the months of June and July respectively (Table 7-5 and Figure 7-8).

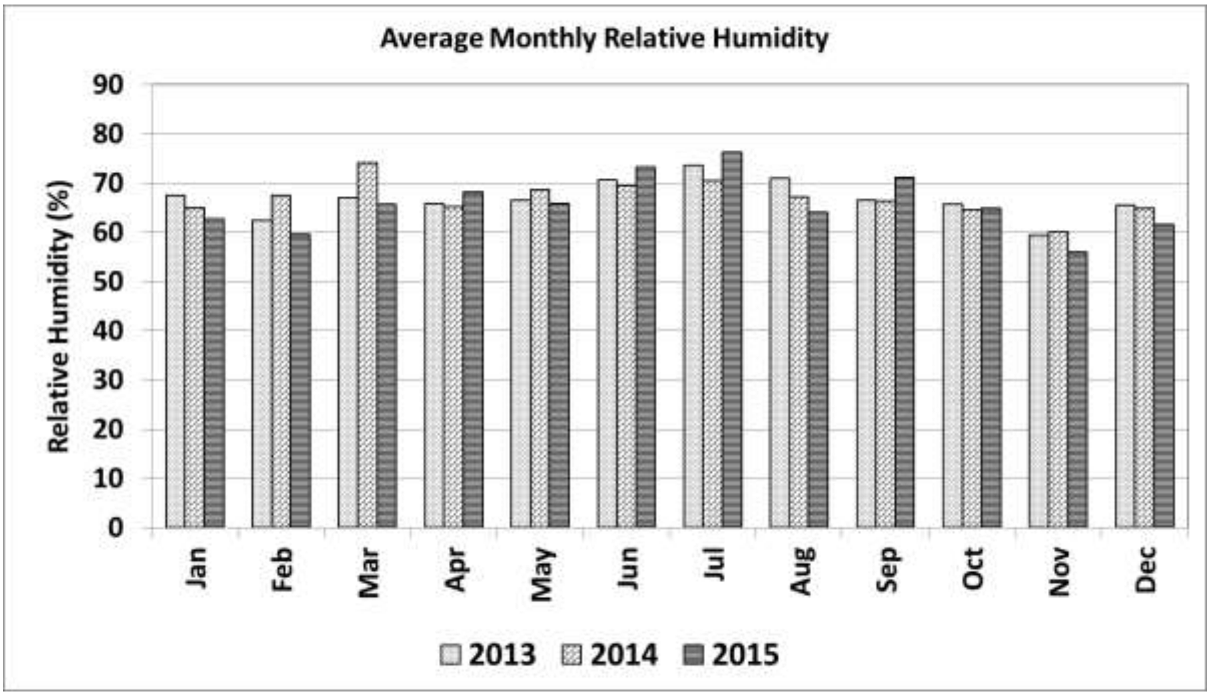

Figure 7-8: Average Monthly Relative Humidity

Table 7-5: Average Monthly Relative Humidity

Relative Humidity (%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Monthly Max	100	100	100	100	100	100	100	100	100	100	100	100	100
Monthly Ave	65	63	69	66	67	71	74	67	68	65	59	64	67

7.2 Baseline Air Quality Scenario

7.2.1 Dust Deposition Rate

Baseline monitoring of dust fallout has been on-going in the proposed project area since September 2016 (a period of 4 months) and the results obtained are evaluated and discussed below. Dust deposition data is crucial as it shows monthly, seasonal, and inter-annual variability in deposition tares – pre, during and post mining operation.

The amount of dust collected at any given time is a function of the rate of deposition, which may vary widely depending on meteorological factors such as wind speed, direction, rainfall and variations in the background dust concentrations. The dust fallout sampling, analyses, comparison and interpretation was conducted according to the internationally recognised American Society for Testing and Methods (ASTM) D1739 – 98 Standard Test Method for Collection and Measurement of Dustfall (Settleable Particulate Matter). The standard procedure accepted internationally is adopted by the South African National Standard (SANS 1137:2012).

The buckets are filled with distilled water mixed with copper sulphate in solution (to stop algae growth inside the bucket) and the monitoring units will be left out on site for a period of 30±2 days. The buckets are collected and replaced with new ones on a monthly basis and transported to the laboratory for analysis.

In the South African *National Dust Control Regulations (2013) standards*, terms like target, action and alert thresholds were omitted. Another notable observation was the reduction of the permissible frequency of exceedance from three to two incidents within a year, non-sequential months. The standard actually adopted a more stringent approach than previously permitted and thus requires dedicated mitigation plans to ameliorate impacts. The dust fallout standard is given in the Table 7-6 below.

Table 7-6: Acceptable dust fall rates as measured (using ASTM D1739:1970 or equivalent) at and beyond the boundary of premises where dust originates

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

For the dust monitoring programme, sample log sheets have shown that the exposure period each month were not in violation of the consistent for the 30±2 days sampling window recommended in the standard. Hence, sampling each month complied with the American Society for Testing and Methods (ASTM) D1739 – 98 Standard Test Method for Collection and Measurement of Dustfall (Settleable Particulate Matter). The dust deposition rates observed for the different monitoring locations are displayed below in Table 7-7 and graphically in Figure 7-10. Dust deposition rate is reported for all sites in September, except sites CNC_06 and CNC_08 (access was not granted at the time to install monitors). However, for the months of October and November, data availability was 100%. Since the South African National Standard (SANS 1137:2012) "Standard Test Method for Collection and Measurement of Dustfall" (Settleable Particulates Matter) was used, the values obtained at the different sites should ideally be compared to the standard (Table 7-6). All the sites are assessed as residential sites. Months with exceedances are in red and bolded. From the observation of the field officers, agricultural activities i.e. tilling of soil is ongoing in the area, a possible reason why the deposition rates are high at some sites. The residential limit of 600 mg/m2/day is exceeded, and in sequential months at sites CNC_01 (Oct and Nov) and CNC_04 (Sep, Oct and Nov). Hence, the aforementioned sites are in violation of the permissible frequency of exceedance (two within a year – not in sequential months as observed in the months of Oct and Nov respectively). Sites CNC_02, CNC_05 and CNC_07 all recorded at least one month of exceedance of the residential standard of 600 mg.m^2/day. In the month of December, dust deposition rates were within regulatory limit at all sites.

Table 7-7: Dust Fallout Results

Dust levels measured in mg/m^2/day				
Site ID	**Sep**	**Oct**	**Nov**	**Dec**
CNC_01	243	**1209**	**752**	252
CNC_02	**808**	179	**1573**	405
CNC_03	247	182	501	75
CNC_04	**749**	**967**	**993**	238
CNC_05	465	495	**721**	280
CNC_06	*	317	477.0	112
CNC_07	395	536	**1095**	153
CNC_08	*	199	346	84

*No data (access was not granted at the time to install dust monitors)

**Awaiting data from the laboratory

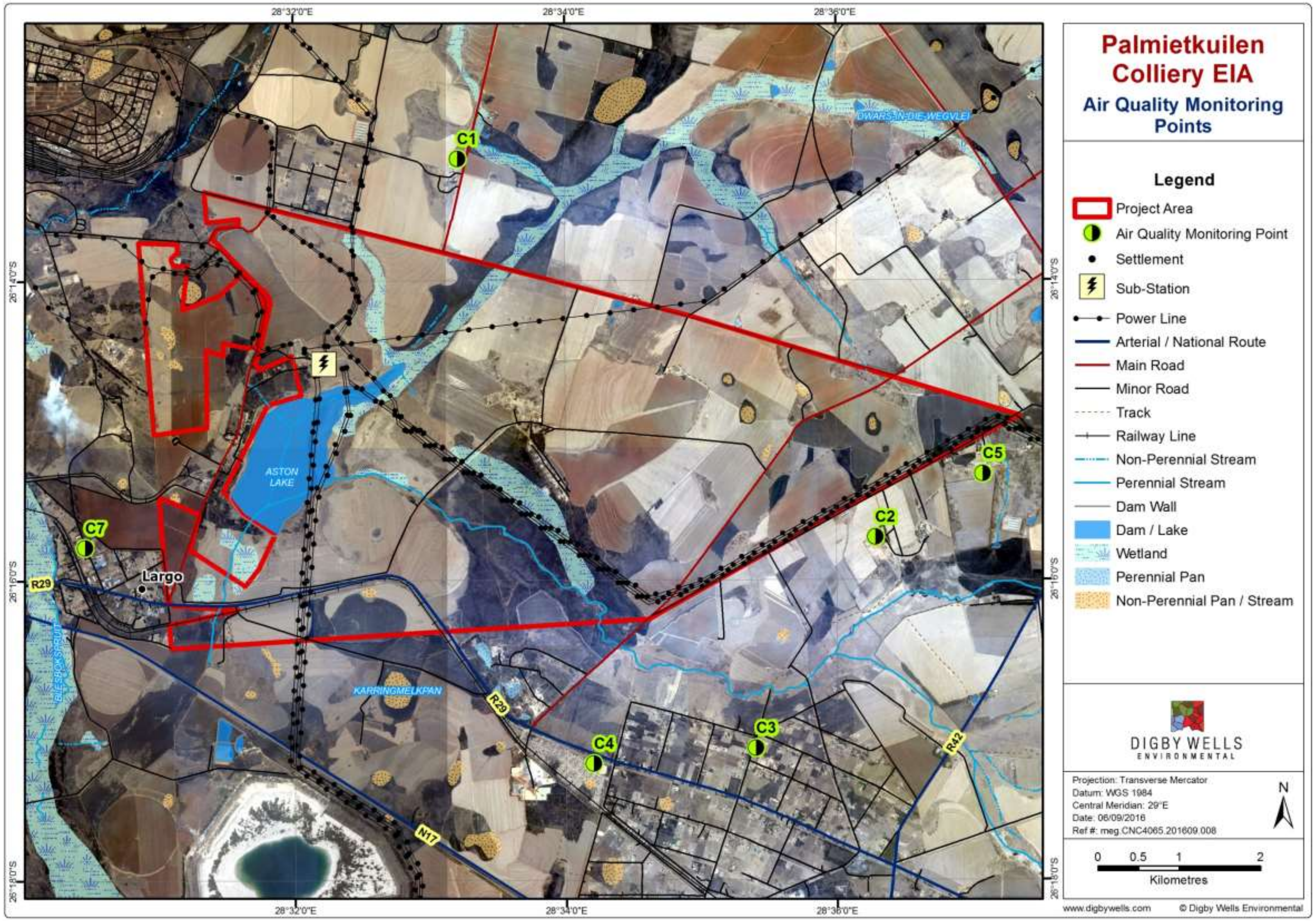

Figure 7-9: Dust Monitoring Locations

Figure 7-10: Dust Deposition Rates observed in the Vicinity of the Proposed Project Area

7.2.2 PM_{10} and $PM2_{.5}$

7.2.2.1 PM_{10} Concentration

The proposed Palmietkuilen Mine is going to be an open pit operation employing heavy equipment (i.e. front end loaders, haul trucks and bulldozers). The subsequent crushing and grinding, processes will have an effect on ambient air pollution with the release of fine airborne particulates both within and outside the mine premises. Currently, ambient particulate monitors are not in place to monitor background PM_{10} levels prior to mining.

However, the AQIA section, emission rates have been calculated and used in the absence of real-time measurement to assess potential impacts of the proposed project on ambient air quality during the operational phase of the mine.

7.2.2.2 $PM_{2.5}$ Concentrations

The same discussion as above applies to the monitoring of $PM_{2.5}$ in the proposed project area. Since $PM_{2.5}$ baseline data is not available, the AQIA accessed what the ambient $PM_{2.5}$ impacts would be during the operational phase of the mine. This is crucial for management planning purposes in order to curtail related impacts on ambient air quality.

7.2.3 Gaseous Pollutants

There was no real-time measurement or passive monitoring for gaseous pollutants in the proposed project area. Background levels of gaseous pollutants, such as: SO_2, Ozone, NO_2, and CO was not available for analysis and assessment as at the time of compiling this report. Such data is always critical to determine ambient levels prior to the commencement of mining.

8 Air Quality Impact Assessment

Emissions generated from mining activities are associated mainly with fugitive dust emissions, such as: PM_{10}, $PM_{2.5}$ and dust fallout. Gaseous emissions such as SO_2, NO_2 and CO are mostly from the vehicle fleet and generators used during the operational phase of the mine. Assessment of gaseous emissions is limited to those from the generator set in this study. Emissions inventory conducted based on various sources and activities is discussed in detail below (Section 8.1). Emission rates generated from the aforementioned were combined with the site meteorological data as input parameters in a dispersion model environment to predict ground level concentrations for the different pollutants (Section 8.1).

8.1 Emissions Inventory

Coal mining is a high dust generation process. Fugitive emissions from coal mining and processing was quantified by applying "emissions factors" for mining and related activities. Emissions associated with the hauling, material handling processes and from power generators operating (24 hours/day and 365/year) were considered.

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 factors published by the US-EPA in its AP-42 document "Compilation of Air Pollution Emission Factors" and Australian National Pollutant Inventory "Emission Estimation Technique (EET)" manuals were employed.

There are various sources of emissions anticipated from any mining operation, which spans through the construction, operational and decommissioning phases. Envisaged emissions from the proposed coal mining operation 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;
- Total suspended particulates (TSP); and
- Gaseous emissions from mine fleet of vehicles i.e.NO and NO_2, jointly known as NO_x; SO_2 and carbon monoxide (CO) respectively.

An emissions inventory was established comprising emissions from project activities at the proposed Palmietkuilen Mining Project with implication on ambient air quality (Table 8-1). The establishment of this emissions inventory is necessary to provide the source and emissions data required as input to the dispersion simulations.

Table 8-1: Project Activities

Project Phase (duration)	Activity
Construction *(year 0-1)*	Site establishment
	Site clearing, including removal of topsoil and vegetation
	Construction of mine related infrastructure, including roads, pipes and dams
	Construction of washing plant
	Relocation of infrastructure
	Blasting and development of initial box-cut, including stock piling
	Temporary storage of hazardous products, i.e. fuel, explosives, waste, sewage
Operational *(year 1 – 51)*	Stripping of topsoil and soft overburden
	Removal of overburden, including drilling and blasting
	Loading, hauling and stockpiling of overburden
	Drilling and blasting

Project Phase (duration)	Activity
	Load, haul and stockpiling of RoM coal
	Use and maintenance of haul roads
	On-site water use and storage
	Storage, handling and treatment of hazardous products and waste
Decommissioning and closure *(year 51-53)*	Demolition and removal of all infrastructure
	Rehabilitation
	Environmental monitoring of decommissioning activities
	Storage, handling and treatment of hazardous products and waste
	Post-closure monitoring and rehabilitation

The construction phase is assumed to be short-term (1-year) and limited to site preparation activities and construction of mine infrastructure. The operational phase took cognisance of the proposed mining processes and consumption rates, assuming continuous operation for 24 hours per day, 365 days per year.

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*".

The equation for 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:

$$E = A * EF \quad \text{Equation 1}$$

$$E = A * EF * \left(1 - \frac{ER}{100}\right) \quad \text{Equation 2}$$

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 Palmietkuilen Mining Project are described in the sections below.

8.1.1 Construction Phase

The construction phase quantified emissions using the USEPA "emissions factor for construction activities", site preparation, which encompasses clearing, stockpiling and landscaping respectively. 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 (Equation 3 and Equation 4).

$$\boldsymbol{Emission\ rate\ (Heavy\ Construction) = 2.69 * \frac{10^6}{1000*30*3600}} \quad \text{Equation 3}$$

$$\boldsymbol{Emission\ rate\ (Wind\ Erosion) = 0.85 * \frac{10^6}{10000*365*24*3600}} \quad \text{Equation 4}$$

8.1.2 Operational Phase

Emission sources that will be associated with the proposed operational phase at the proposed Palmietkuilen Mine will encompass:

- Drilling and blasting;
- Materials handling operations;
- Vehicle entrainment on unpaved roads;
- Wind erosion from exposed area and volume sources; and
- Point sources (generator stacks).

8.1.2.1 *Drilling and Blasting*

Emissions from drilling were calculated using a TSP emissions factor of 0.59 kg/hole (USEPA, 1998b: Table 11.9-4). Clearly, other variables such as the depth of the hole, diameter of the hole, and moisture content of the material being drilled would also be relevant and the emission factor equation should take account of these variables.

In general, two types of emissions are generated from blasting. The detonation of the explosives and the associated chemical reactions will result in emissions of compounds such as SO_2, NOx and CO, coupled with fugitive particulate emissions. Data on the estimated amount of ammonia nitrate mixed with fuel oil (ANFO) and emulsions were not available, hence gaseous emissions from blasting were not quantified.

Fugitive particulate emissions resulting from blasting were calculated using Equation 5 below (AP-42 (1998a).

$$EF_{TSP\ (kg/blast)} = 0.00022 \times A^{1.5}_{(m^2)} \text{ ....Equation 5}$$

Where:

EF = emission factor (kg/blast), and

A = blast mine area (square metre (m^2))

The emissions factor for particulate matter with aerodynamic diameter 10 µm and 2.5 µm were obtained by multiplying the resultant TSP value by 0.52 and 0.03 respectively.

8.1.2.2 Material Handling

8.1.2.2.1 Bulldozing

The USEPA approves an emissions equation specifically for activities from bulldozers since this equation takes silt content and moisture into account. Emissions from bulldozing activities on top of the overburden and coal stockpiles at the proposed mine were calculated using the Equation 6 and Equation 7 below:

$$EF_{TSP\,(kg/t)} = 2.6 \times (s)^\wedge 1.2 * (M)^\wedge 1.3 \qquad \text{Equation 6}$$

$$EF_{PM_{10}\,(kg/t)} = 0.75 \times 0.45 \times (s)^\wedge 1.5 * (M)^\wedge 1.4 \qquad \text{Equation 7}$$

Where:

EF=emission factor

s=Silt content (%)

M=Moisture content

8.1.2.2.2 Loading and Offloading of Material

The following equations were used to calculate TSP, PM_{10} and $PM_{2.5}$ emissions associated with loading and offloading of material. Moisture contents of 3.4% for coal and 6.9% for overburden were used. Emission rates for the loading and offloading are calculated using Equations 8 and Equation 9 below.

$$EF_{TSP\,(kg/t)} = k_{TSP} \times 0.0016 \times \frac{\left(\frac{U_{(m/s)}}{2.2}\right)^{1.3}}{\left(\frac{M_{(\%)}}{2}\right)^{1.4}} \qquad \text{Equation 8}$$

$$EF_{PM_{10}\,(kg/t)} = k_{PM_{10}} \times 0.0016 \times \frac{\left(\frac{U_{(m/s)}}{2.2}\right)^{1.3}}{\left(\frac{M_{(\%)}}{2}\right)^{1.4}} \qquad \text{Equation 9}$$

Where:

$EF_{TSP\,(kg/t)}$	= emission factor for total suspended particles (kg/t)
$EF_{PM_{10}\,(kg/t)}$	= emission factor for PM_{10} (kg/t)
k_{TSP}	= 0.74 for particles less than 30 micrometres aerodynamic diameter
$k_{PM_{10}}$	= 0.35 for particles less than 10 micrometres aerodynamic diameter
$U_{(m/s)}$	= mean wind speed (m/s)
$M_{(\%)}$	= moisture content (% by weight).

8.1.2.2.3 Crushing and Screening

Crushing and screening is done at the ROM pad when considering emissions from metalliferous mining operations, it is useful to note that any ore with moisture greater than 4% by weight, either naturally or by virtue of added water, is considered as a “high moisture” ore. If an ore is “high moisture” at the primary crusher, then it will remain so unless it is dried in the process. Emissions from a primary crushing activity include emissions from the screens, the crusher and the surge bin that are integral to the crusher.

Emissions were quantified using the approach from the NPI emissions factors (NPI, 2012) for coal ore processing. In assessing mitigation of fugitive dust emissions it was assumed that the dust suppression system has an efficiency of 75%. The crushing and screening was for 365 days and the emissions factors are summarized in Table 8-3.

Crushers are used to reduce the size of the ore for ease of processing. In most cases this is a significant source of fugitive dust with large quantities of respirable fractions of dust released into the ambient atmosphere. The crushers will be working for 8760 hours per year. The parameters used in the calculations of the emissions are given below (Table 8-2) and estimated emission Table 8-3.

Table 8-2: Tonnes of Material and Moisture Content Feed to the Crushers

Source	Tonnes per annum	Moisture content (%)
Primary Crusher	2,075,471.70	3.4
Secondary Crusher	2,075,471.70	3.4

Table 8-3: Emissions Factor for the Crushers

Operation/activity	Emission factor					
	High Moisture Content (g/s)			Low Moisture Content (g/s)		
	TSP (a)	PM_{10} (a)	$PM_{2.5}$ (c)	TSP (a)	PM_{10} (a)	$PM_{2.5}$ (c)
Primary crushing	0.01	0.004		0.2	0.02	
Secondary crushing	0.03	0.012		0.6	NDA	
Tertiary crushing	0.03	0.01		1.4	0.08	

Source: Reference NPI EET Manual for Mining (NPI, 2012)
The mitigation efficiency adopted was obtained from the NPI EET Manual (NPI, 2012)

8.1.2.2.4 Wheel Generated Dust from Unpaved Road

The hauling of coal via mine dirt roads leads to vehicle-entrained dust emissions. Emissions from this activity represent a significant source of fugitive particulate pollutants at the mine from unpaved roads. Vehicular movement on unpaved road, the rotational of the wheels caused pulverisation of surface material and subsequent entrainment dust in the wake of the haul trucks, which takes time to settle depending on the aerodynamic diameter. Data on the number of vehicle on the vehicle fleet and diesel consumption was not available.

CAT® 789D trucks with rated payload of ~200 tonnes (with six wheels) are assumed to be employed in transporting excavated materials from the pits. This emission inventory estimated emissions from the pits via the haul road to ROM stockpile and waste dump sites. The estimate took into cognisance the annual tonnage and hauling of ore and waste rock and the travel distances to and from the pit to dump sites.

The AP-42 emissions factor for wheel-generated dust from unpaved roads was used. There is an equation for “unpaved roads at industrial sites”. 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). Although vehicle entrainment on unpaved roads results in significant emissions, these impacts are higher adjacent to source. Emissions rate from this source is estimated using Equation 10.

$$EF\left(\frac{KG}{VKT}\right) = \frac{0.4536}{1.6093} * k * \left(\frac{s(\%)}{12}\right) a * \left(\frac{W(t)}{3}\right) b \qquad \text{Equation 10}$$

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)

8.1.2.3 Wind Erosion from Exposed Surfaces

For the fine dust component of particulate emissions from industrial wind erosion, a $PM_{2.5}/PM_{10}$ ratio of 0.15 is recommended. Industrial wind erosion is associated with crushed aggregate materials or ore piles. Examples would include open storage piles at mining operations (USEPA, 2006). The parameters used in the calculations of the emissions associated with wind erosion are given below (Table 8-4).

Table 8-4: Wind Erosion from Exposed Areas and Derived Emission Factors without Mitigation

Activity	Unit	TSP emission factors	PM_{10} emission factors	$PM_{2.5}$ emission factors
Waste rock	$g/m^2/s$	4.0E-06	2.0E-06	4.2E-07
Topsoil stockpile	$g/m^2/s$	6.9E-06	3.4E-06	7.2E-07
ROM	$g/m^2/s$	6.9E-06	3.4E-06	7.2E-07
Unpaved roads erosion (ore)	g/s	16.01	4.12	2.97E-04

Significant emissions can arise due to the mechanical disturbance of granular material from open areas and storage piles. 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 storage pile, 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 fugitive 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 nature of 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 31 days on average in a year was calculated from the modelled data, an average of 3 days in a month.

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 8-5 gives PSD as adopted from a similar opencast operation. These values were used as input parameters into the model to estimate the dust deposition rates.

Table 8-5: Particle Size Distribution for Various Materials

SOURCE	PARTICLE SIZE FRACTION (%)			
	75µm	30 µm	10 µm	2.5 µm
Topsoil stockpile	0.26	0.30	0.24	0.20
Run of Mine (ROM)	0.49	0.27	0.14	0.10
Waste dump (WRD)	0.44	0.27	0.15	0.14

8.1.2.3.1 Vehicle Tailpipe Emission

Gaseous emissions from the mine fleet of vehicles and other mine machineries were not appraised. With the lack of appropriate data, assessment of criteria contaminants SO_2, NOx and CO from vehicle fleet was not quantified.

8.1.2.3.2 Point Sources

Emission from diesel generators encompasses pollutants such as: PM_{10}, NOx, CO, HC respectively based on the specifications of CAT® assumed for this assessment. Particulate and gaseous emissions from this source were obtained from the generator capacity supplied by the Canyon Coal (6 X 630 Kva Generators). The stack parameters and emission rates from CAT diesel generator with same captivity were adopted (Table 8-6).

$$E = EF * EO \ * OP\ )$$ Equation 11

Where:

E	=Emission (ton/yr)
EF	=Emission Facto (g/Kw-hr)r
EO	=Engine Output (kW)
OP	=Operating Period (hr/yr)

Table 8-6: Generator Stacks Parameters

Source	Emission Source	Stack Height (m)	Stack Diameter (m)	Gas Exit Temp (k)	Vol Flow Rate (m^3/s)	Gas Exit Temp (m/s)
Generator Stack (6X630)	1 to 6	15	0.3	578	0.54	7.6

8.1.3 Summary of Estimated Emissions

A summary of the estimated annual emissions from the proposed Palmietkuilen Mine by source group is provided in Table 8-7.

Table 8-7: Summary of Estimated Emissions from the Proposed Palmietkuilen Mining Project by Source Group

Source Group	Estimated Annual Emissions by Source Group (t/a)					
	$PM_{2.5}$	PM_{10}	TSP	CO	NOx	HC
Drilling and Blasting	0.1	1.6	3.0	-	-	-
Loading and unloading	0.41	2.71	4.41	-	-	-
Crushing and Screening	0.15	1.02	12.51	-	-	-
Vehicle Entrained Dust from Unpaved Road	35.7	237.9	1179.9	-	-	-
Windblown Dust	19.08	90.84	181.68	-	-	-
Point Source	0.05	0.33	-	7.09	143.13	0.22
Total	**55.49**	**334.4**	**1381.5**	**7.09**	**143.13**	**0.22**

8.2 Atmospheric Dispersion Modelling and Compliance Assessment

Atmospheric dispersion modelling is the mathematical simulations of how airborne pollutants disperse in the ambient atmosphere, making use of algorithms that mimic the dispersion and transformation of pollutants in the natural atmosphere. With the latter, downwind concentration of air pollutants emitted from various sources can be predicted. Isopleths of pollutants concentration generation are then used to assist in the design and assessment of various control strategies and abatement technologies for emission reductions.

The mathematical equations employed in these models attempt to describe processes observed in nature, which enables scientists to create replicas of natural systems with a computer, so that the causes and effects of system behaviour may be better understood. The primary focus of dispersion modelling is to estimate the ambient concentrations of primary pollutants that have been emitted in the atmosphere. There are a number of dispersion models that have been developed around the world. The widely used AERMOD dispersion model is one such example.

8.2.1 AERMOD Suite of Models

Dispersion models are used to predict the ambient concentration in the air of pollutants emitted to the atmosphere from a variety of processes (South African National Standards - SANS 1929:2011). 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 the emissions of various sources. Increasing reliance has been placed on concentration estimates from models as the primary basis for environmental and health impact assessments, risk assessments and emission control requirements. It is therefore important to carefully select a dispersion model for the purpose.

All emission scenarios have been simulated using the USA 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).

The 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.

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. Other non-regulatory components of this system include: AERSCREEN, a screening version of AERMOD; AERSURFACE, a surface characteristics pre-processor, and BPIPPRIME, a multi-building dimensions program incorporating the GEP technical procedures for PRIME applications.

AERMOD model is capable of providing ground level concentration estimates of various averaging times, for any number of meteorological and emission source configurations (point, area and volume sources for gaseous or particulate emissions), as well dust deposition estimates.

The effect of complex terrain is modelled by changing the plume trajectory and dispersion to account for disturbances in the air flow due to the terrain. This may increase or decrease the concentrations calculated. The influence of the terrain will vary with the source height and position and the local meteorology. Table 8-8 gives an overview of meteorological parameters and basic setup options for the AERMOD model runs.

Table 8-8: Summary of Meteorological and AERMET Parameters used for this Study

Number of grids (spacing)	1 (200 m)
Number of grids points	81x81
Years of analysis	Jan 2013 to Dec 2015
Centre of analysis	26.254039 S, 28.490397 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	1595 m
MM5-Processed Grid Cell (Grid Cell Centre)	26.254039 S, 28.490397 E
Anemometer Height	13 m
Surface meteorological stations	1 site at the proposed Palmietkuilen project site using data generated by AERMET
Upper air meteorological stations	1 site at the proposed Palmietkuilen project site using data generated by AERMET
Simulation	Jan 2013 to Dec 2015)
Sectors	The surrounding area land use type was considered to be *cultivated land*
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

8.2.2 Geophysical Model Input Data

Geophysical data requirements include land use type and terrain elevation. Land use categories and terrain of the surrounding region are defined when processing AERMET and AERMAP respectively. Often, the in-built land use classification type and the terrain heights derived from the 90m SRTM DEM product are employed. The aforementioned parameters exact strong influence on wind speed and turbulence, which are key components for dispersion. AERMOD model system and for this study include: emissions source data, meteorological data and information on the nature of the receptor grid. Parameters required depend on the source type (point, line, area or volume).

Meteorological data is crucial as this principal factor to the dispersion of pollutants in the atmosphere i.e. vertical profiles of wind speed and direction, atmospheric turbulence and ambient air temperature. It is worth mentioning that topography plays a significant role in dispersion of emissions from source. Topographic features create mechanical drag, inducing turbulence and the subsequent dispersion of pollutants and atmospheric mixing / dilution. The surrounding topography is generally flat and this is prominent in the landscape of the proposed Palmietkuilen project area.

8.3 Impact Assessment Summary

All relevant averaging periods were modelled for pollutants of concern. In all instances the worst case scenario has been presented to demonstrate the highest predicted impact. It is important to note that highest period-averages (i.e. highest hourly-average and highest 24-hour-average) presented in the maps are indicative of the highest expected concentrations for the period-average for the modelled year at each position in the modelled domain, and must not be interpreted as being representative of general conditions. The intent of the maps is to conservatively present the worst case scenario for those averaging periods.

The daily values option controls the output options for tables of concurrent values summarised by receptor for each day processed. For each averaging period for which the daily values option is selected, the model will print in the main output file the concurrent averages for all receptors for each day of data processed. Results are output for each source group.

In general, the ground level concentrations follow closely the main wind directions (wind roses generated for the site). Numerical values of maximum depend on the emission rate and the prevailing meteorological condition of the area. Simulations were undertaken to determine concentrations of particulate matter with a particle size of less than 10 µm in size (PM_{10}), particle size of less than 2.5 µm in size ($PM_{2.5}$) and for dust deposition (≥ 30 µm). These simulations were undertaken to determine concentrations without-mitigation.

Isopleth plots of predicted concentrations of pollutants: PM_{10}, $PM_{2.5}$, and dust deposition rates for the worst case scenario (where mitigation measures are not applied for topsoil, overburden dumps and activities like tipping and haulage) were predicted for the respective averaging periods).

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). Isopleths of ground level concentrations generated for the different pollutants associated with the proposed Palmietkuilen Mine are generated and presented.

8.3.1 Isopleth Plots and Evaluation of Modelling Results

8.3.1.1 PM_{10} Predicted Impacts

The predicted highest 4th highest 24-hour (daily) concentration of PM_{10} attributed to the proposed Palmietkuilen Mine is presented in Figure 8-1. The highest concentration predicted at the project boundary, in all four compass directions exceeded 75 µg/m³ (current limit value). The *major contributors are dirt roads and wind erosion*. In terms of spatial impact, much of the area impacted is outside the proposed project area.

The predicted concentrations are the likely additions that can be anticipated from the proposed Palmietkulien Mine on ambient air quality and not cumulative impact from all the existing sources in the area. *It is therefore possible that the highest daily concentration predicted to occur at a certain location may only be true for one day during the entire period.* Once mitigation measures were applied, exceedances were limit to the project area (Figure 8-6).

The predicted 1st highest annual concentration for PM_{10} for the area is within the current standard of 40 µg/m³ at the project boundary (Figure 8-2). Exceedances were observed within the project area without mitigation measures in place. Once mitigation measures were applied, the zone of impact was minimised further (Figure 8-6). Table 8-9 shows the predicted concentrations for the selected sensitive receptors in the vicinity of the proposed project.

8.3.1.2 $PM_{2.5}$ Predicted Impacts

The predicted highest 4th highest 24-hour (daily) concentration for $PM_{2.5}$ at the proposed Palmietkuilen Mine is presented in Figure 8-3. This isopleth plot of predicted maximum daily values for $PM_{2.5}$ from all sources without mitigation measures is in exceedance of the standard (65 µg/m³) within the project boundary. The predicted $PM_{2.5}$ concentrations at the mine boundary were mainly in the range 5 µg/m³ - 20 µg/m³. The zones of impact were minimised once mitigation measures were applied (Figure 8-8)

The predicted 1st highest annual ground level concentration for $PM_{2.5}$ that will be generated by the proposed Palmietkuilen Mine is presented in Figure 8-4. Exceedances of the current standard of 20 µg/m³ were not observed at the project boundary. Once mitigation measures were applied, the zones of impact were minimised (Figure 8-9).

8.3.1.3 Dust Deposition Predicted Impacts

The predicted dust deposition rates anticipated from the proposed operation shows that dust levels will be a course for concern without mitigation measures in place. The predicted maximum concentration at the mine boundary is higher than the 1 200 mg/m^2/day (NDCR 2013) recommended standard for industrial areas. Exposure will be higher within the mine boundary (Figure 8-5). Major contributions are coming from the use of haul roads and from wind erosion of stockpiles respectively. The average dust deposition rates for the past three months at each of the selected receptors – CNC01 01 – CNC03 are taken as the background. The predicted dust deposition rates at these locations were added to the background to assess impacts (Table 8-11).

8.3.1.4 Gaseous Emissions

Gaseous emissions from the proposed mining operation were limited to those released from generators stacks. As mentioned previously, the CAT Diesel generator was assumed and reported emissions factor for: NO_2, CO and PM_{10} and $PM_{2.5}$ were used in this assessment. Since SO_2 emission factor was not given in the list of pollutants from this generator, it is assumed that emission from source are negligible.

8.3.1.5 Predicted Nitrogen Dioxides (NO_2) Concentrations

The hourly South African standard for NO_2 is (200 µg/m^3) and annual averages (40 µg/m^3). The highest hourly concentration generated was in exceedance of the standard at the project boundary and beyond, with concentrations at the selected sensitive receptors in the vanity all higher than the 200 µg/m^3 (Figure 8-11). Once mitigation measures were applied, exceedances of the standard were limited to the project boundary (Figure 8-13).

Annual concentrations predicted for the project area and surrounding residential receptors are all below the current standard of 40 µg/m^3 at the project boundary (Figure 8-12). Once mitigation measures were applied, a further reduction was observed in the pollutant footprint (Figure 8-14). The predicted ground level concentrations at the selected sensitive receptors are presented in Table 8-10.

8.3.1.5.1 Predicted Carbon Monoxide (CO) Concentrations

The South African standard is adopted. The South African standards for CO is 1 hour limit value of 30 000 µg/m^3 and 8 hourly limit (10 000 µg/m^3) are used in this report. The predicted carbon monoxide concentrations were very low and below the standard within the mine and surrounding residential sites (sensitive receptors) as the model predicted a maximum of ~2 µg/m^3. As a result, the model plots were not generated for CO with and without mitigation.

Table 8-9: Predicted Concentrations of PM_{10}, $PM_{2.5}$ and Dust Deposition Rates at Selected Sensitive Receptors

Pollutants	Averaging Period	Ambient Air Quality Standard (µg/m³)	Predicted Ground Level Concentration (µg/m³)					
			Sundra	CNC1_CF NW	Vischkuil	Endicott	CNC2_CF NE	Aston Lake
PM_{10} (No Mitigation)	Daily	75(1)	39	115	132	71	63	208
	Annual	40(1)	2	6	12	6	4	14
PM_{10} (Mitigated)	Daily	75(1)	2.8	7	5	4	4	15
	Annual	40(1)	0.14	0.55	0.58	0.27	0.18	1.25
$PM_{2.5}$ (No Mitigation)	Daily	40(1), 25(2)	3	6	4	3	3	11
	Annual	25(1), 15(2)	0.13	0.53	0.36	0.21	0.16	1.12
$PM_{2.5}$ (Mitigated)	Daily	40(1), 25(2)	0.94	1.78	1.95	1.15	1.27	3.22
	Annual	25(1), 15(2)	0.03	0.11	0.19	0.09	0.07	0.23
Dust Deposition Rates (mg/m²/day)								
Dust deposition (No Mitigation)	Monthly	600(3)	968	1720	4323	2008	953	4288
Dust deposition (Mitigated)	Monthly	600(3)	10	18	32	18	21	33

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 8-10: Predicted Concentrations of NOx, CO at selected Sensitive Receptors

Pollutants	Averaging Period	Ambient Air Quality Standard (µg/m³)	Predicted Ground Level Concentration (µg/m³)					
			Sundra	CNC1_CF NW	Vischkuil	Endicott	CNC2_CF NE	Aston Lake
NO_2 (No Mitigation)	1 hour	200[(1)]	565	445	362	287	821	542
	1 year	40[(1)]	1.25	1.42	1.66	1.23	1.14	3.98
NO_2 (Mitigated)	1 hour	200[(1)]	33	26	21	17	48	32
	1 year	40[(1)]	0.07	0.08	0.1	0.07	0.07	0.23
CO (No Mitigation)	1 hour	30[(1)]	0.03	0.03	0.02	0.02	0.05	0.03
	8 year	10 [(1)]	-	-	-	-	-	-
CO (Mitigated)	1 hour	30[(1)]	-	-	-	-	-	-
	8 year	10[(1)]	-	-	-	-	-	-

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 8-11: Evaluation of Measured/Model Dust Deposition Rates at Selected Sites

Emission Specie (TSP)	Averaging period	Average Background deposition rate per site (mg/m²/day)	Background (Background + Modelled) No mitigation (mg/m²/day)	Background + Modeled – with mitigation (mg/m²/day)	Standard (mg/m²/day)
CNC_01	Monthly	735	2455	978	600
CNC_02	Monthly	853	1806	874	600
CNC_03	Monthly	310	4633	342	600
The predicted concentrations at the monitoring sites are in bracket					

The measured dust deposition data shows that particulate emissions from the proposed Palmietkuilen mining operation can exert impacts on ambient air quality of the area. Table 8-11 shows the cumulative impacts of the dust emissions from the mine on ambient dust deposition rates. However, with dust deposition, once mitigation measures were applied the predicted dust deposition rates were reduced considerably.

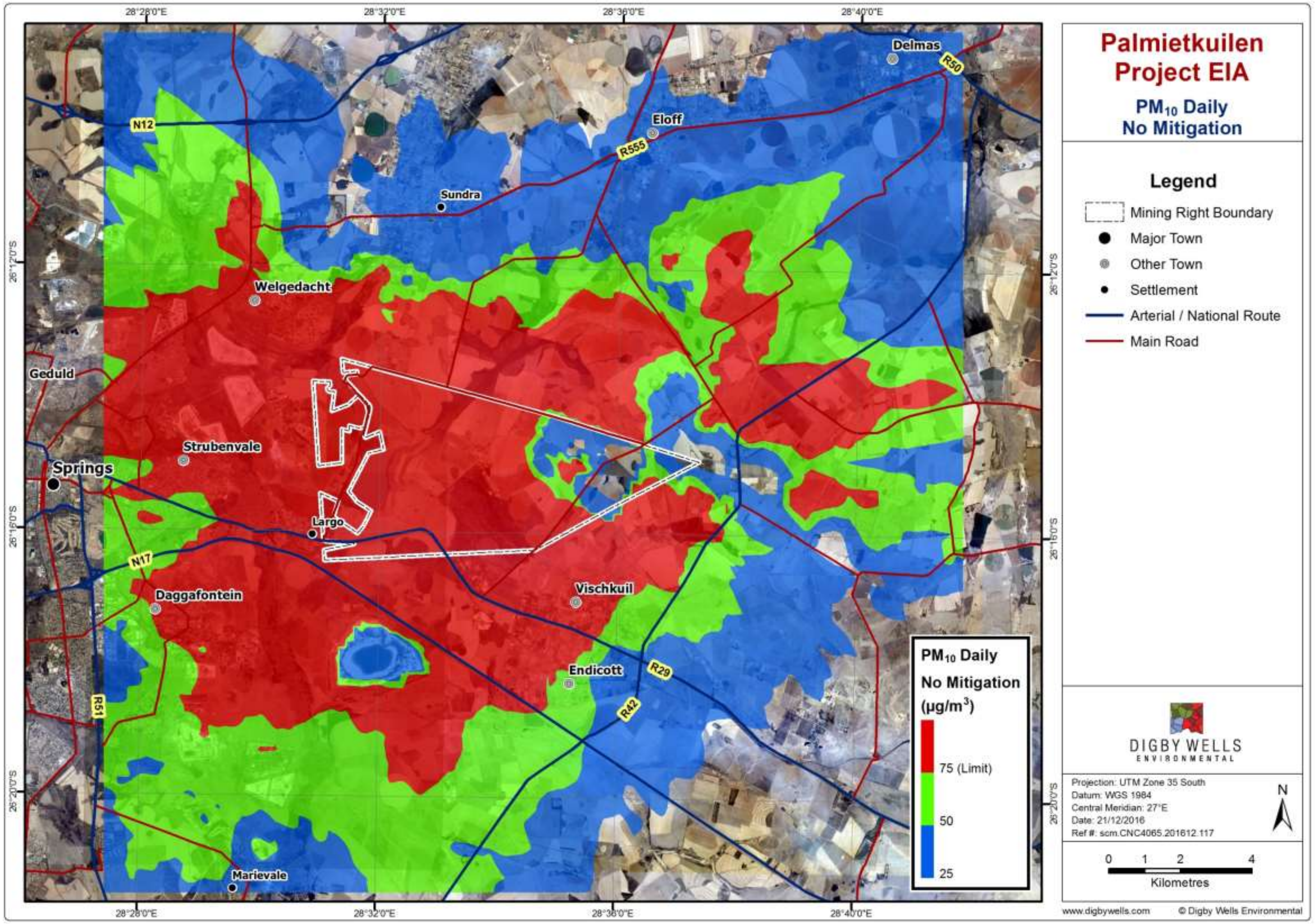

Figure 8-1: Predicted 4th highest (99th percentile) daily PM_{10} concentrations (µg/m^3)

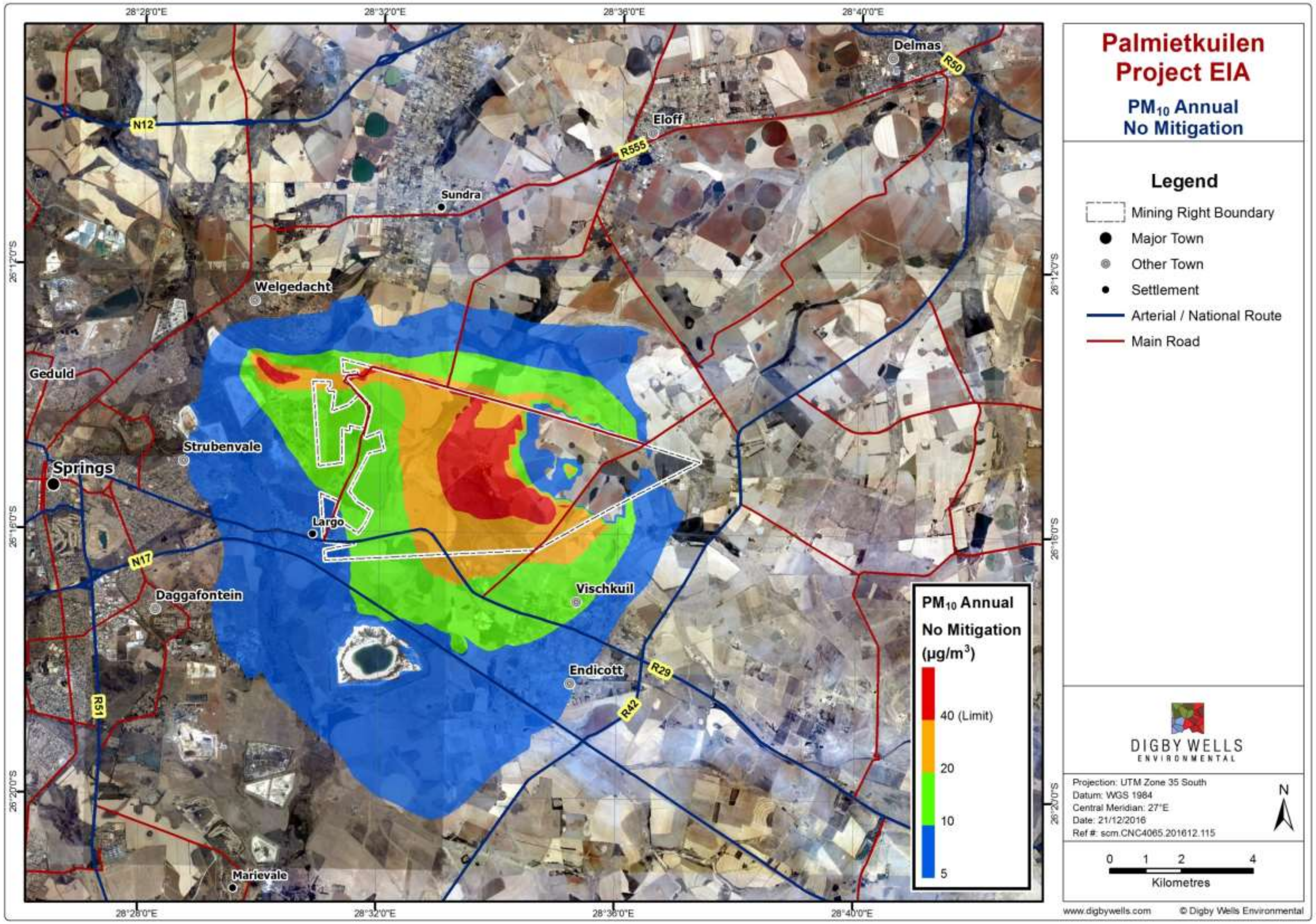

Figure 8-2: Predicted 1st highest (100th percentile) Annual PM_{10} concentrations (µg/m³)

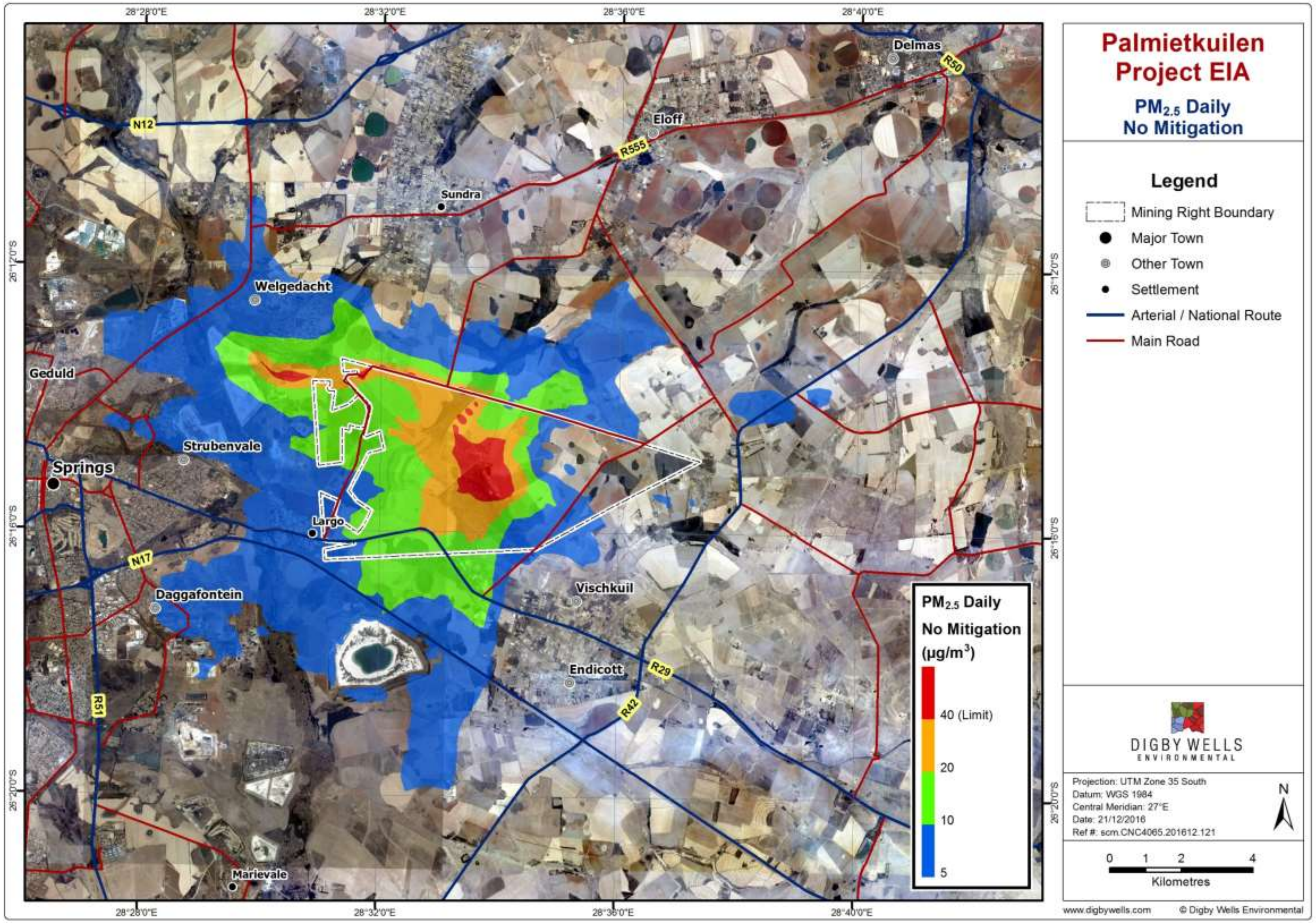

Figure 8-3: Predicted 4th highest (99th percentile) daily $PM_{2.5}$ concentrations (µg/m^3)

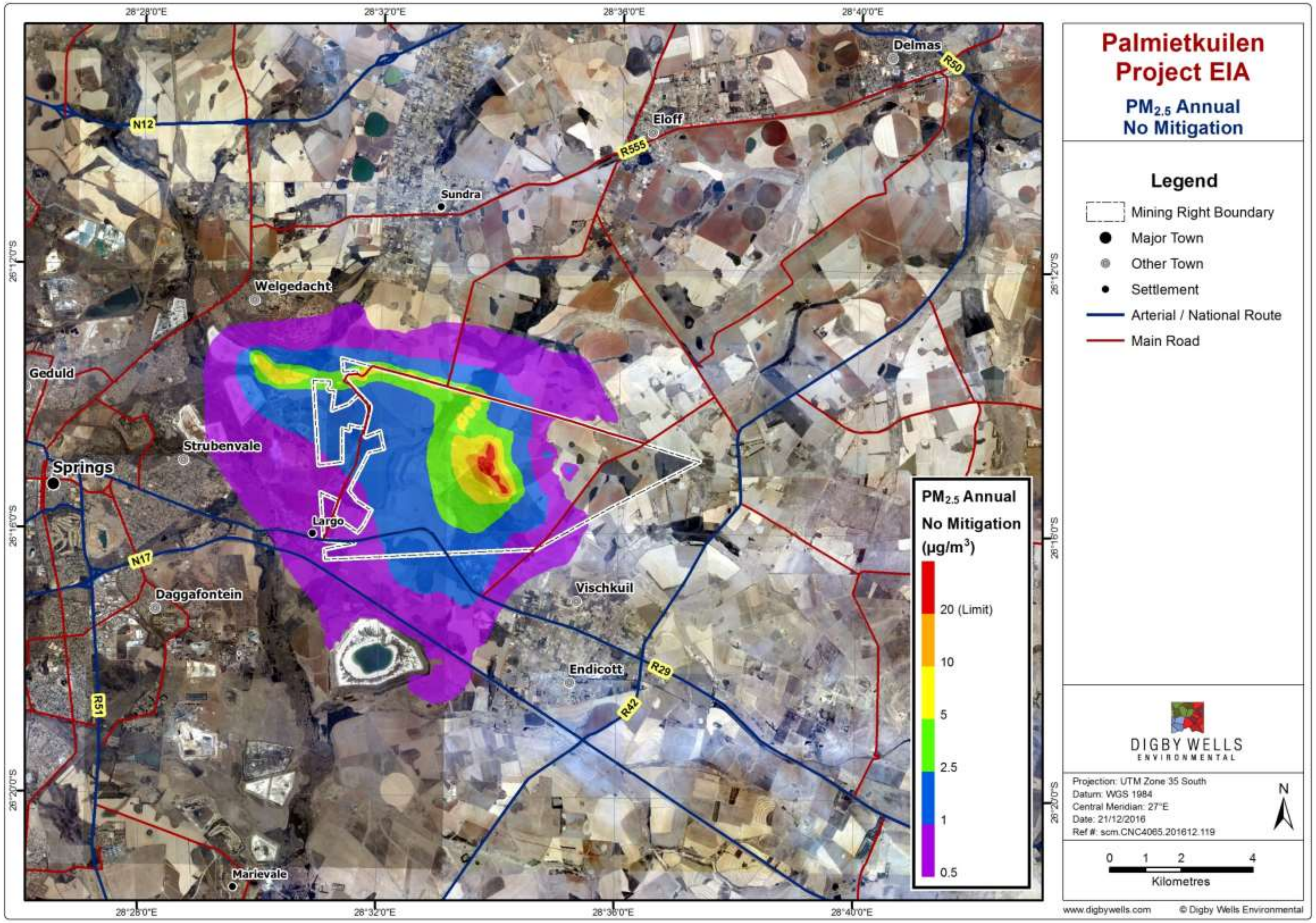

Figure 8-4: Predicted 1st highest (100th percentile) Annual $PM_{2.5}$ concentrations (µg/m³)

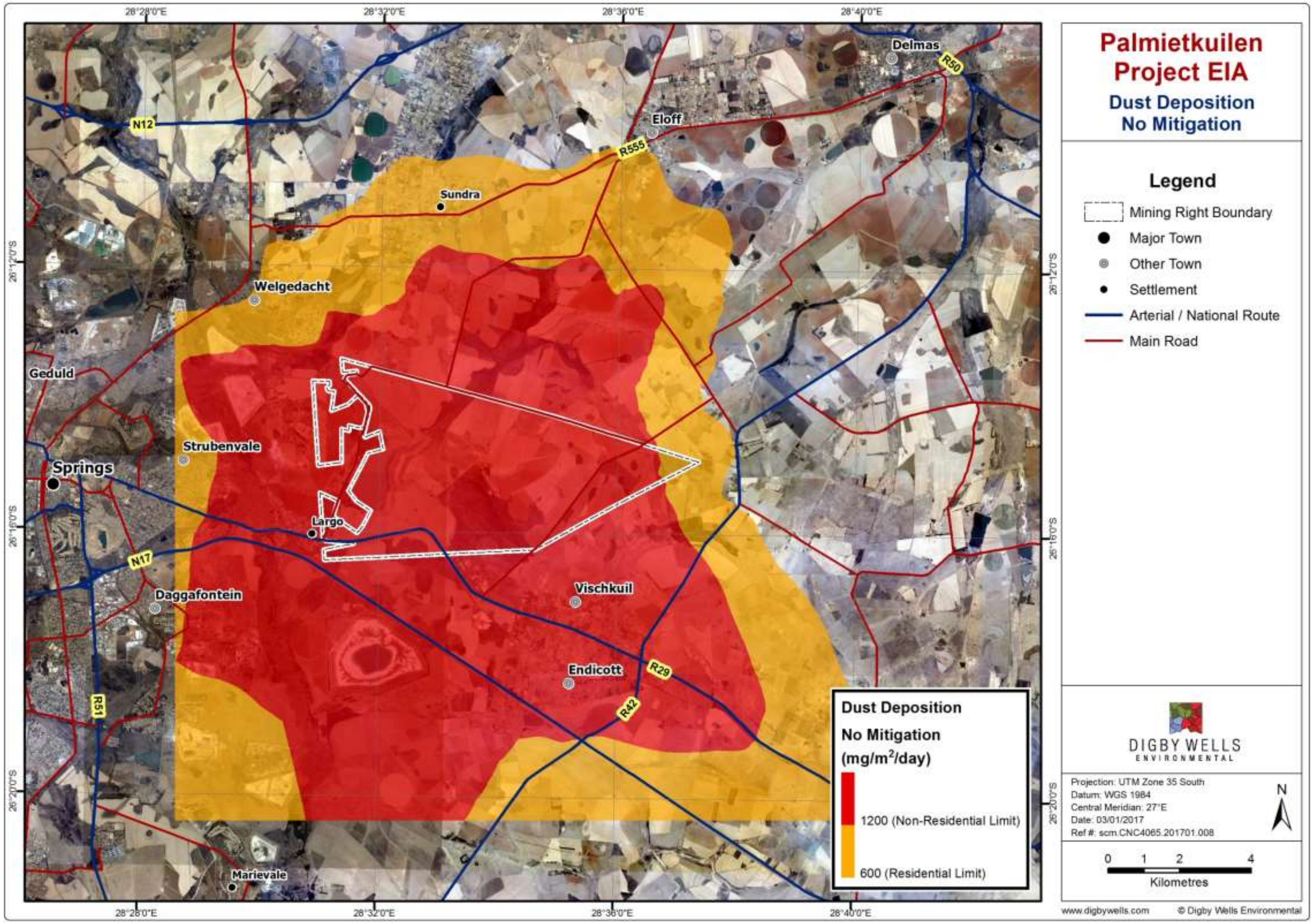

Figure 8-5: Predicted maximum (100th percentile) dust deposition (mg/m^2/day) No mitigation

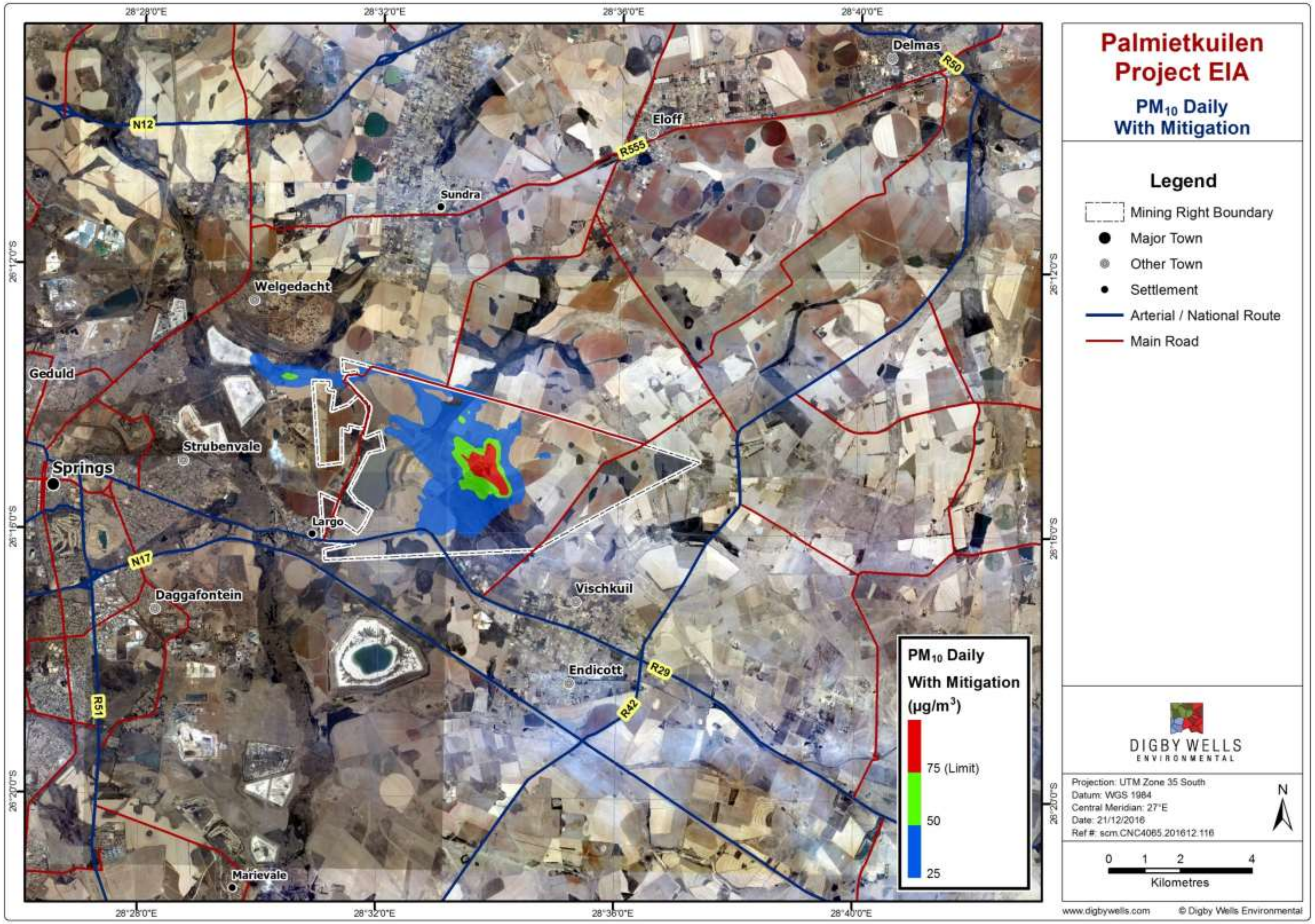

Figure 8-6: Predicted 4th highest (99th percentile) daily PM_{10} concentrations (µg/m^3) with mitigation

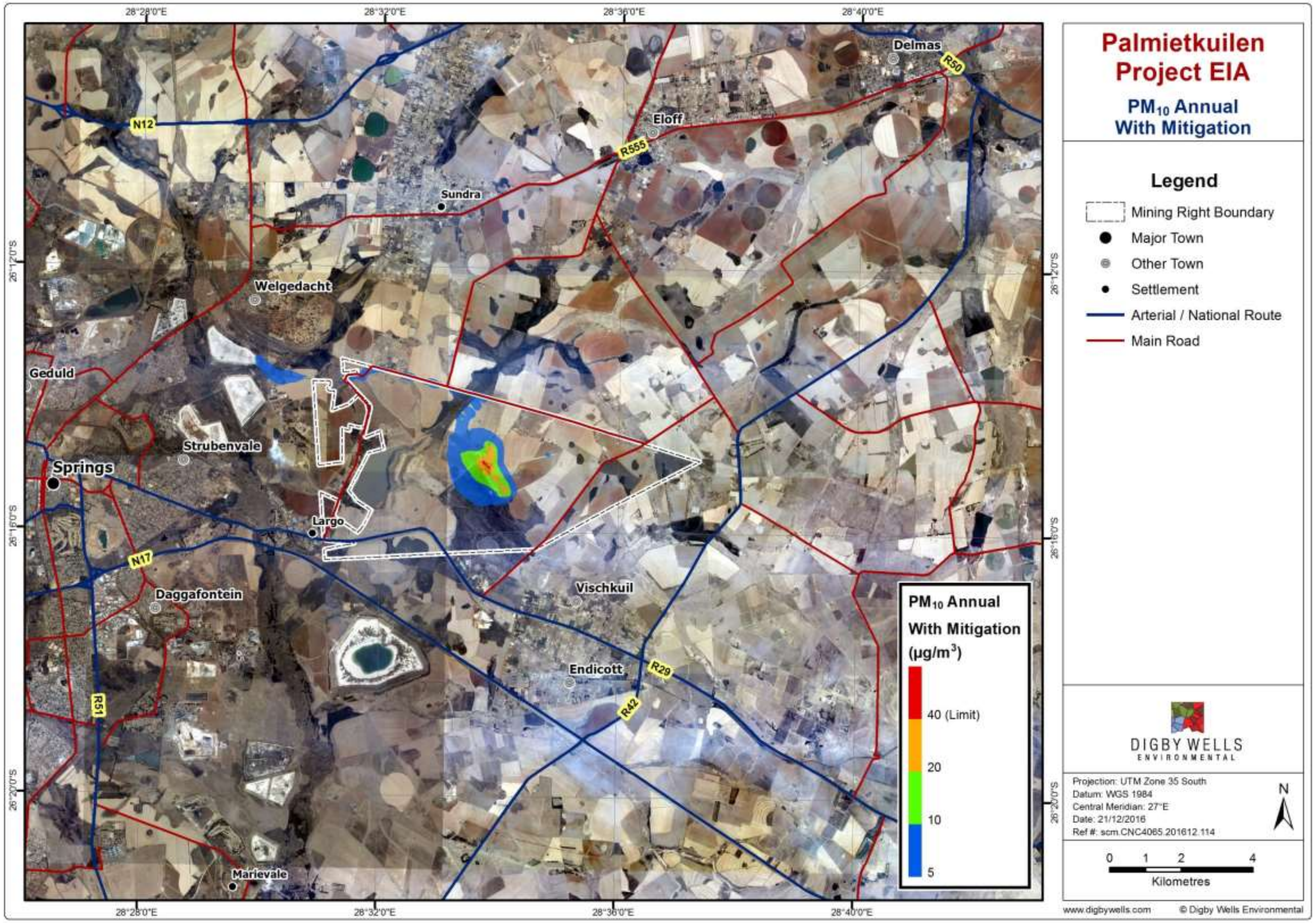

Figure 8-7: Predicted 1st highest (100th percentile) Annual PM_{10} concentrations ($\mu g/m^3$) with mitigation

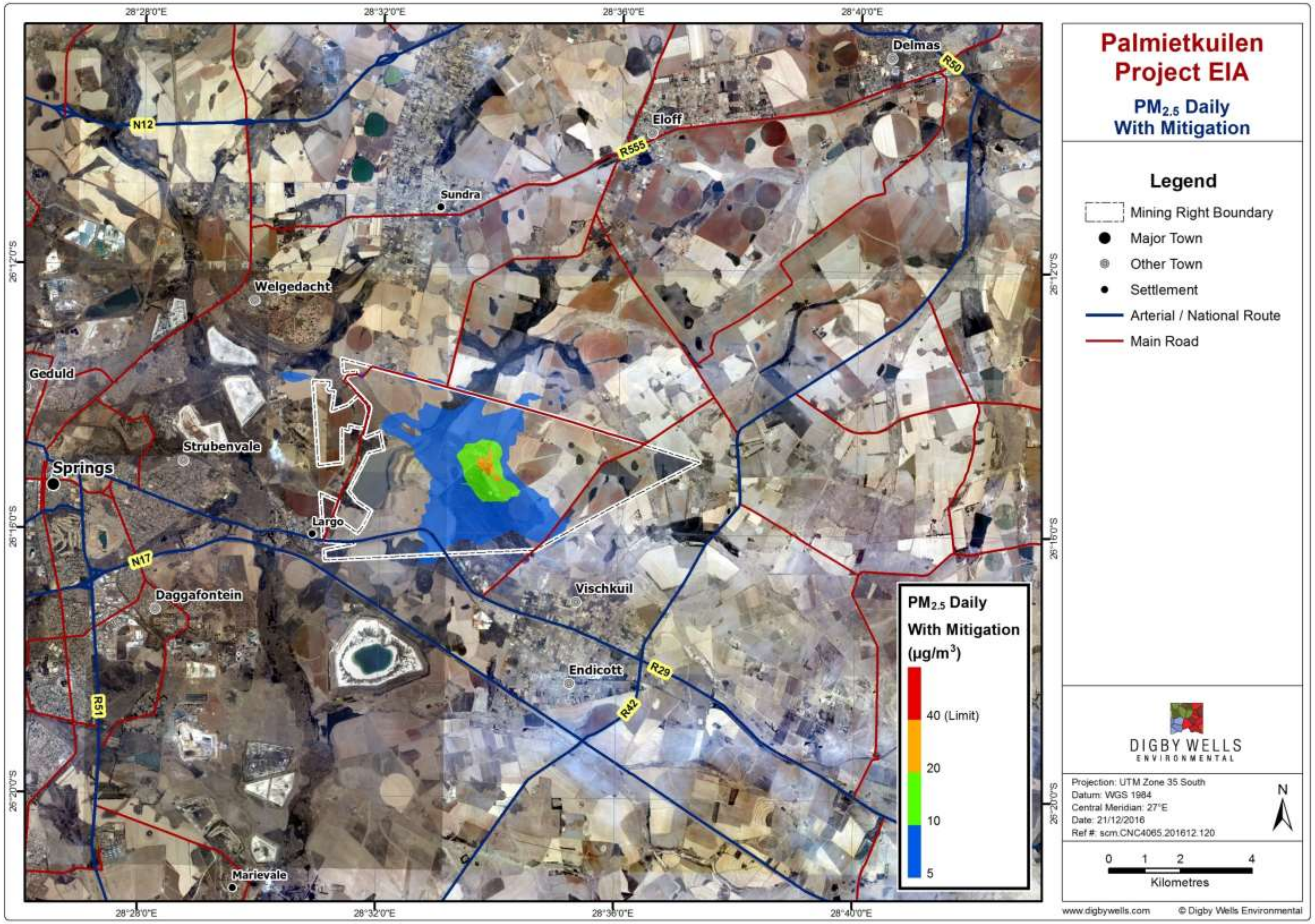

Figure 8-8: Predicted 4th highest (99th percentile) daily $PM_{2.5}$ concentrations (µg/m^3)

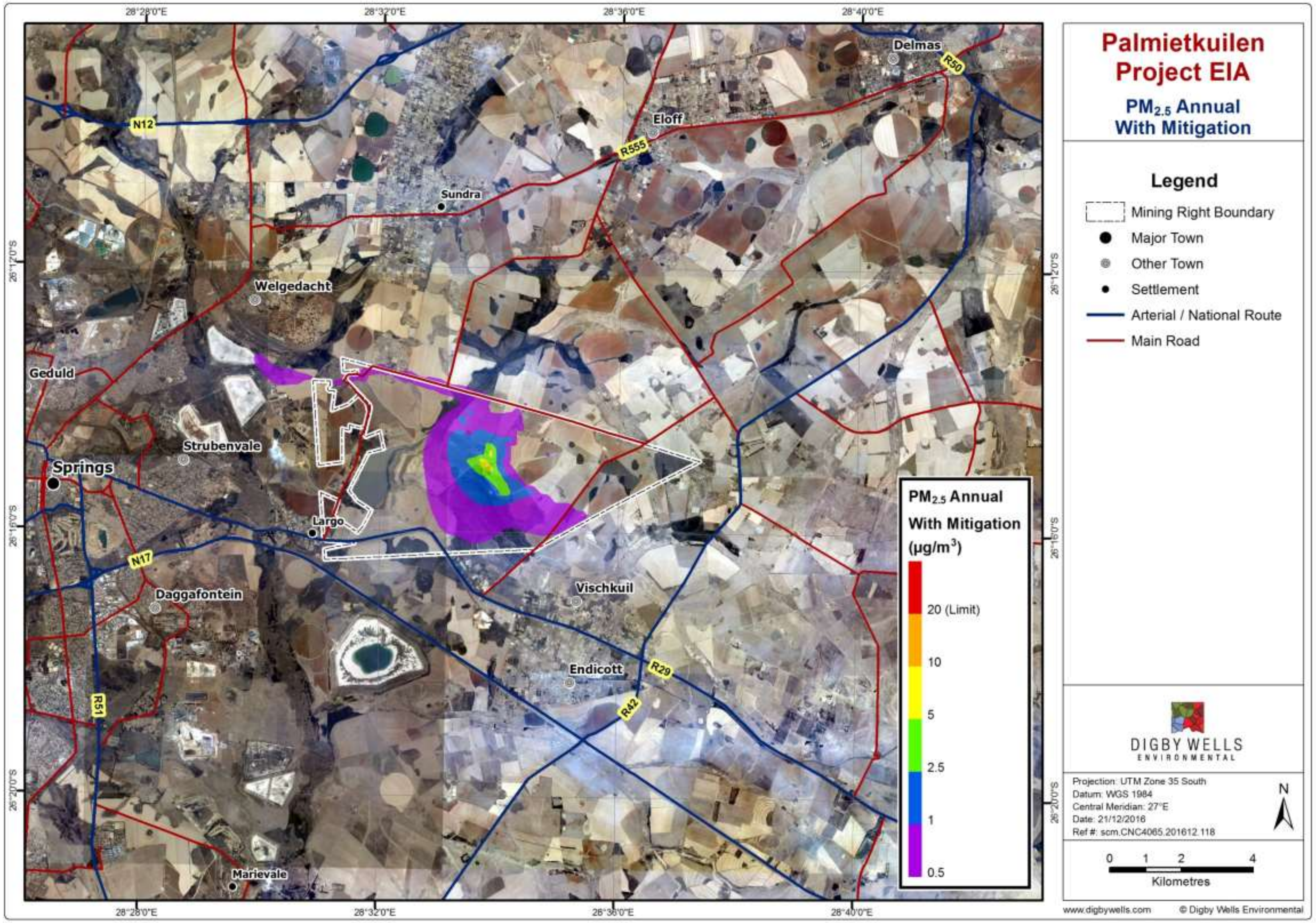

Figure 8-9: Predicted 1st highest (100th percentile) Annual $PM_{2.5}$ concentrations (µg/m³)

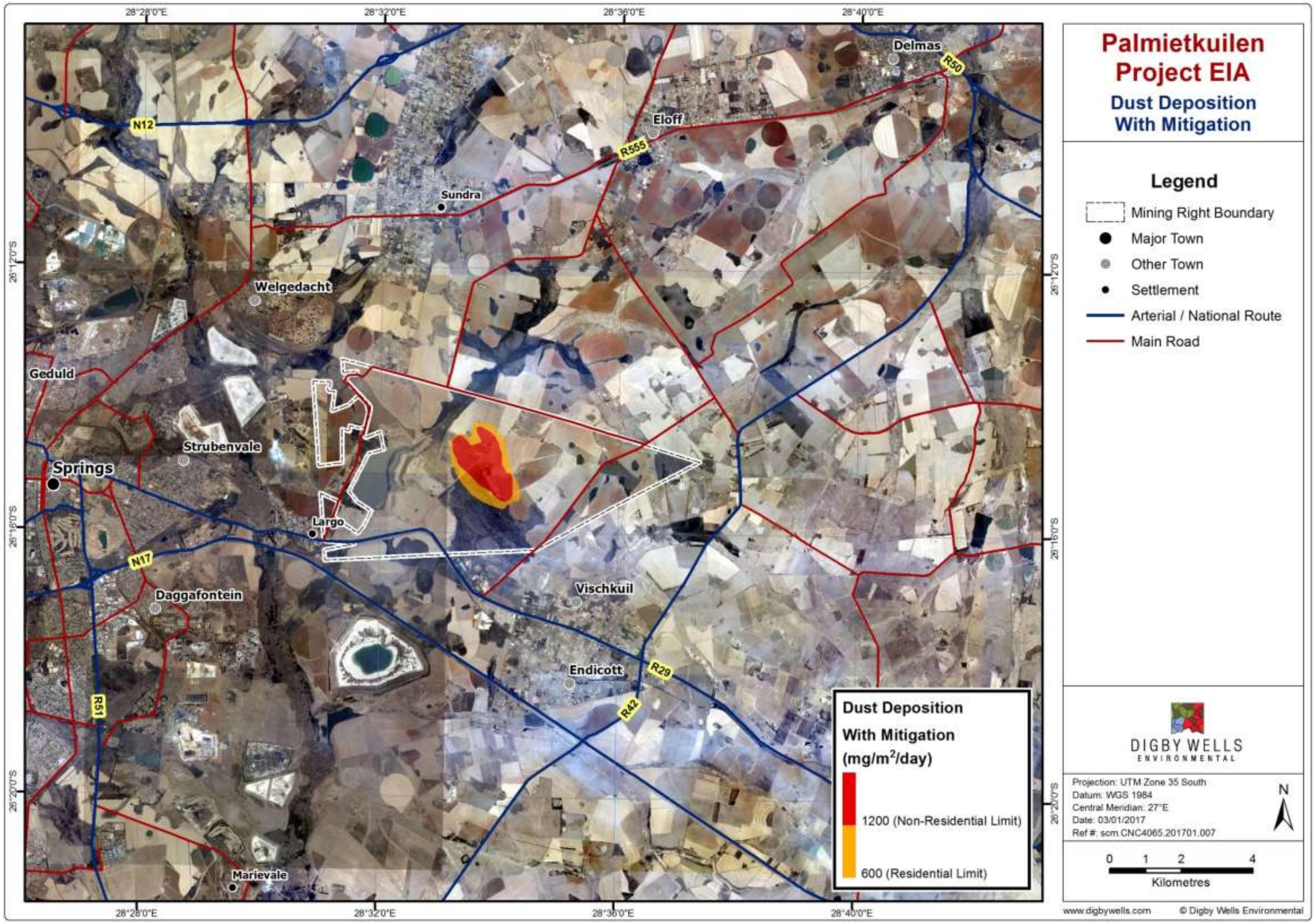

Figure 8-10: Predicted maximum (100th percentile) dust deposition (mg/m^2/day) with mitigation

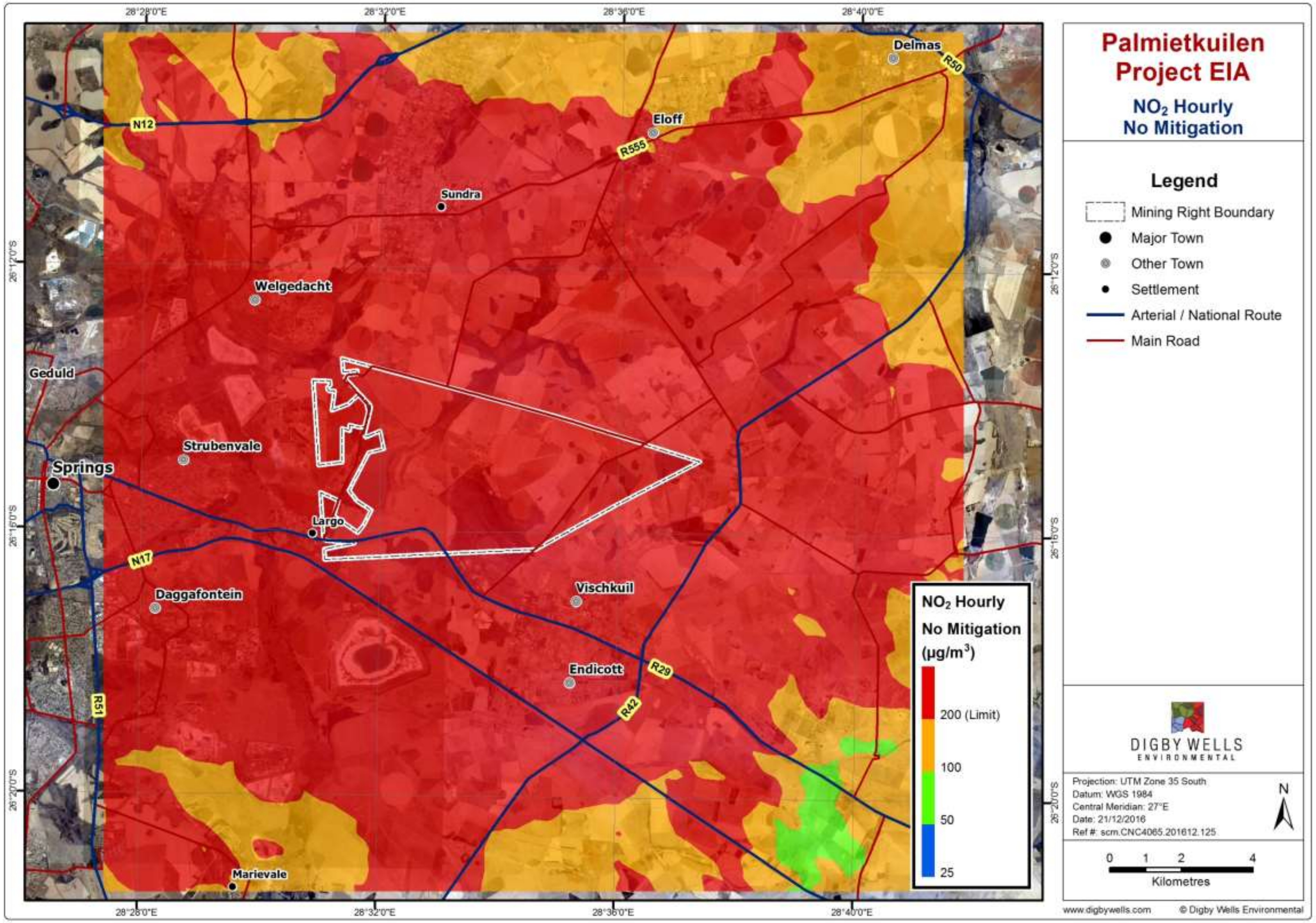

Figure 8-11: Predicted 4th highest (99th percentile) hourly NO_2 concentrations (µg/m^3)

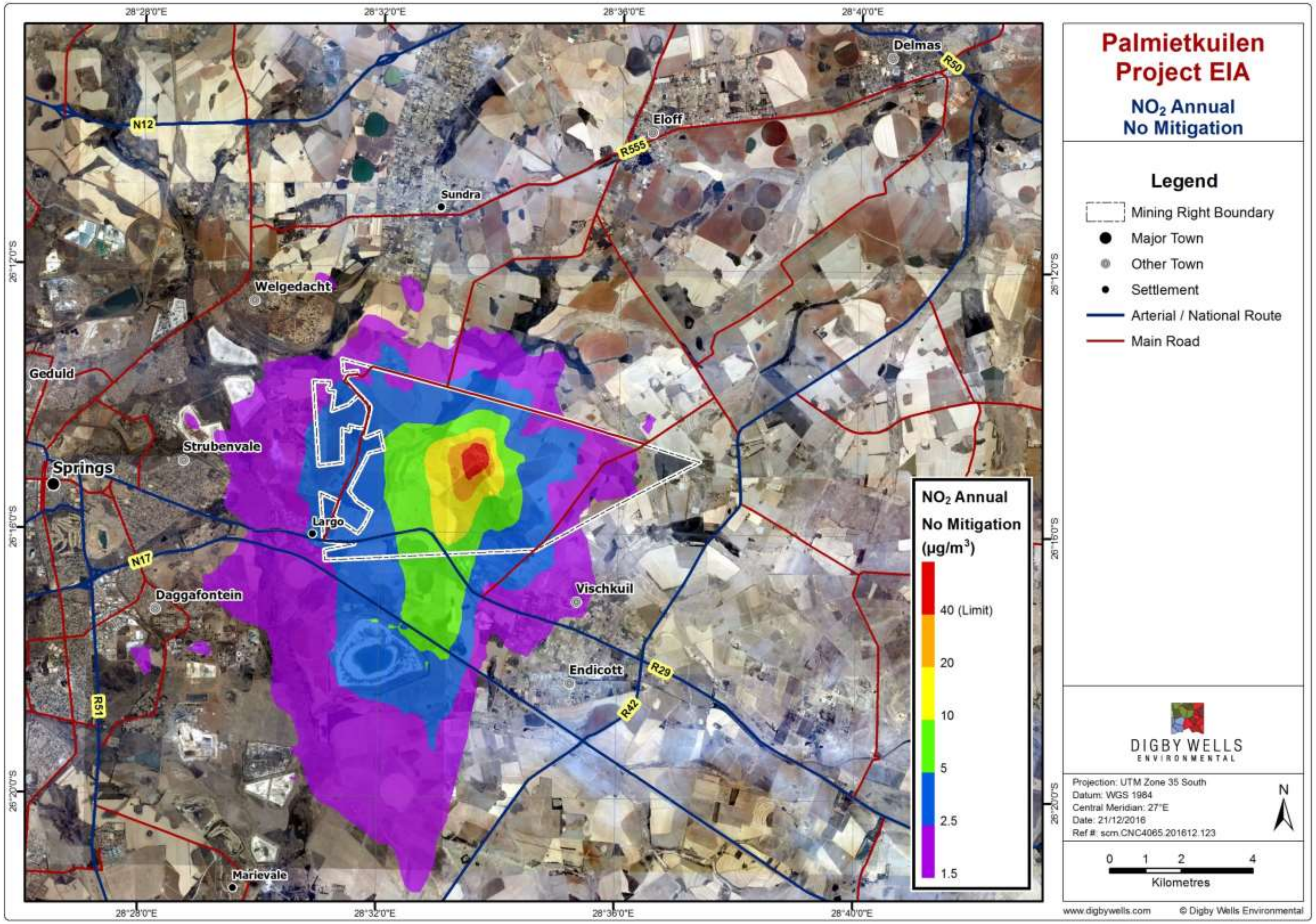

Figure 8-12: Predicted 1st highest (100th percentile) annual average NO_2 concentrations (µg/m^3)

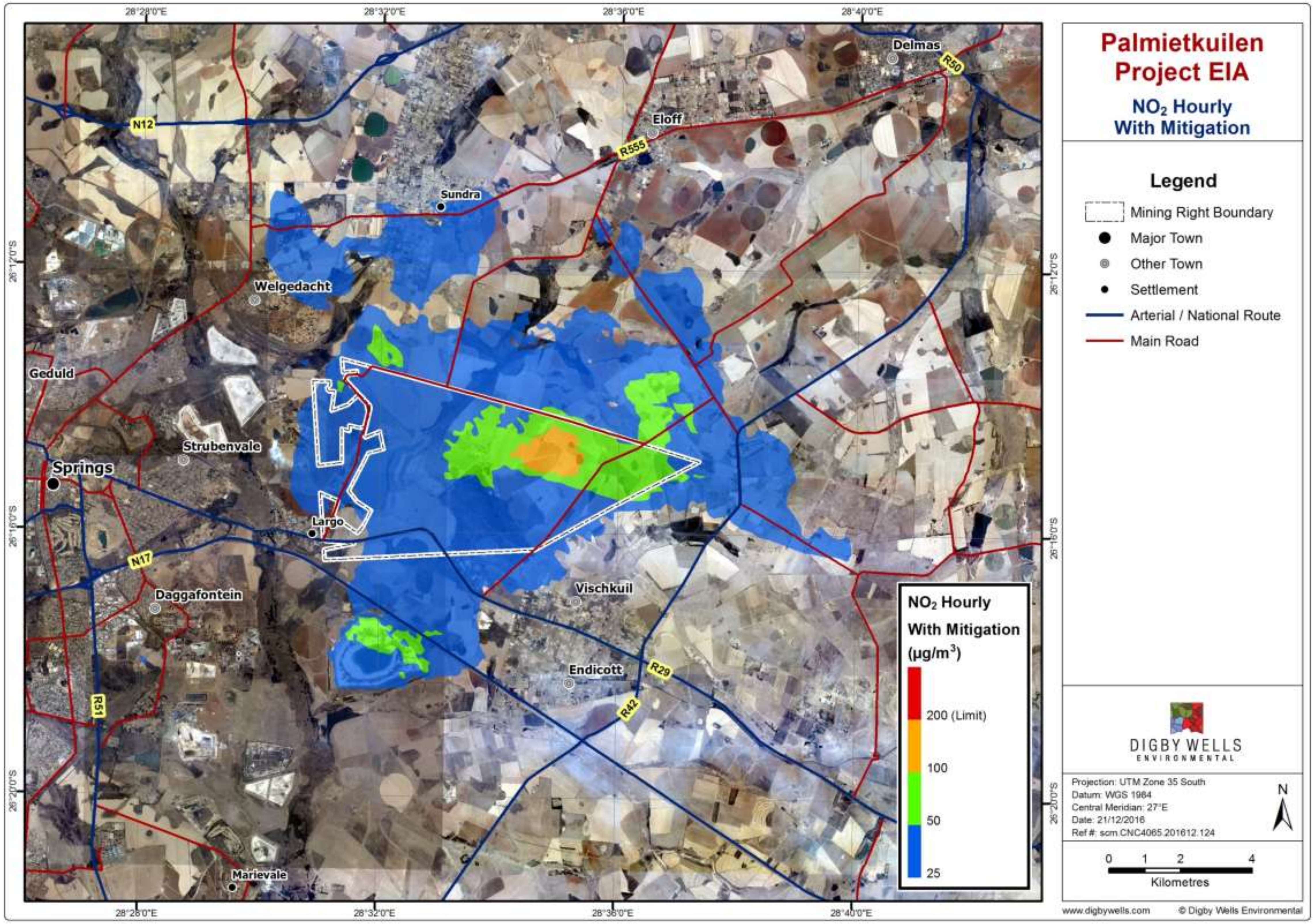

Figure 8-13: Predicted 4th highest (99th percentile) hourly NO_2 concentrations (µg/m^3)

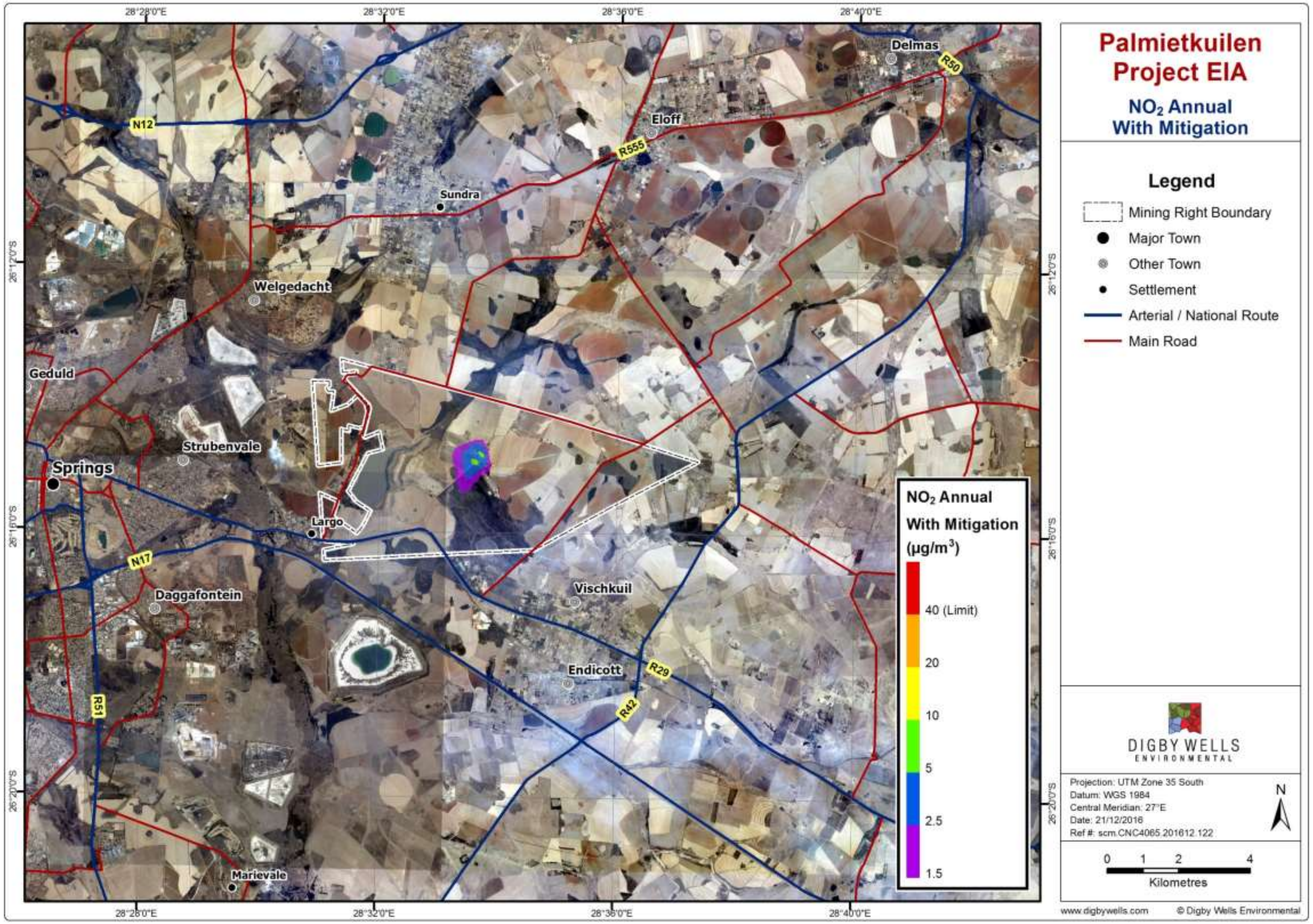

Figure 8-14: Predicted 1st highest (100th percentile) annual average NO_2 concentrations (µg/m^3)

8.4 Discussion

The impacts arising from pollutants associated with the proposed Palmietkuilen Mine operational phase have been appraised using predicted concentrations and spread across the landscape from AERMOD dispersion model.

8.4.1 Findings

The AQIA study shows that particulate pollution from the proposed Palmietkuilen Mine operation will exert impact on current ambient air quality of the area. With multiple activities conducted at the same time, this results in multiple sources of emission (i.e. drilling and blasting, loading and offloading, hauling of ore and overburden, tipping, and crushing). The main findings of this AQIA study are summarised as follows:

- The predicted highest daily PM_{10} concentration at the mine boundary exceeds the South African standard of 75 µg/m³ at the project boundary without mitigation measures in place. The predicted highest annual concentrations were within the standard (40 µg/m³) at the project boundary. However, exceedances of the current standard were predicted within the project area.
- The predicted $PM_{2.5}$ daily concentrations at the mine boundary were within the standard (40 µg/m³). Exceedances predicted were within the project area. The predicted highest annual concentration was within the current limit of 20 µg/m³ at the project boundary. The impacts associated with the predicted daily and annual concentrations were minimised after mitigation measures were applied.
- The highest dust deposition rates were predicted, exceeded the 1200 mg/m²/day recommended for non-residential areas (National Dust Control Regulation, 2013). However, once mitigation measures were applied, the predicted dust deposition rates and the zones of impact were minimised and limited to the project area.
- The maximum 1-hour average nitrogen dioxide concentrations are predicted to be higher than limit of 200 µg/m3 without mitigation measures in place. However, the annual average nitrogen dioxide concentrations are predicted to be below the project 40 µg/m3 and within compliance.
- The maximum 1-hour average and 8-hour average carbon monoxide concentrations are predicted to be below the project criteria of 30 mg/m³ (30 000 µg/m³) and 10 mg/m³ (10 000 µg/m³), respectively, at the project area and the sensitive receptor.

Overall, once the sources are curtailed with adequate mitigation measures factored into the day to day operation of the mine i.e. use of dust suppressants on dirt roads, use of water sprayers at active stockpiles, vegetation of long-term stockpiles and enclosure / fogging of crushers etc., the particulate release into the ambient atmospheres was reduced drastically at the mine and surroundings receptors.

The findings from this study should inform mine management on the monitoring and mitigation measures to ensure impacts on the ambient air quality of the area are minimised. Some of the numerous mitigation measures recommended are listed below:

- 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. Coupled with the use of dust suppressants and binders on haul roads to reduce dust generation.
- Travel speed and distances should be minimised. Dust generating capacity of particles less than 10 µm is contained by 58% when vehicle speed is reduced from 25 mph (40 km/h) to 15 mph (24 km/h).
- Vegetation of long-term storage facilities i.e. topsoil and waste stockpiles are imperative throughout the lifespan of the mine to avoid exposing surfaces to wind erosion.
- Enclosure and fogging of the crushers to avoid particulate emissions.
- Use of NOx reduction abatement technology to reduce generators emissions.

8.5 Conclusion

An AQIA study was undertaken as part of an EIA for the proposed Palmietkulien Coal Mine near east of Springs, within Gauteng Province.

Pollutants quantified and evaluated in this assessment encompass particulate matter: PM_{10}, $PM_{2.5}$ and TSP. The modelling results presented in this report confirm that the potential is there to exacerbate the ambient air quality in the area. The dispersion modelling results showed impacts that are exceeding the regulatory standard. Hauling of coal and overburden via dirt roads represent the main contributors followed by erosion from stockpiles. Gaseous emissions from the onsite generators will lead to NO_2 1-hour emissions without mitigation measures. However, the aforementioned will be reduced by more than 90% after mitigation measures are applied. Adequate mitigation measures suggested in this report will help reduce emissions from major sources and ensure compliance with regulatory standards.

Results of the dispersion modelling exercise have shown what the anticipated implications are on surrounding ambient air quality. Hence, mitigation measures should be implemented to bring pollutants levels within the mine boundary and surroundings receptors into compliance with the set standards. In conclusion, fugitive emissions associated with the operation of the proposed Palmietkuilen Mine have potential to impact ambient air quality beyond the mine boundary.

9 Impact Assessment

9.1 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 9-3. 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 determined and categorised into one of eight categories, as indicated in Table 9-2, which is extracted from Table 9-1. The description of the significance ratings is discussed in Table 9-3.

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 9-1: 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 9-2: Probability/Consequence Matrix

Probability	Significance																																					
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
	-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 9-3: 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

9.2 Project Activities

Table 9-4: Project Activities and Infrastructure Development

Project Phase (duration)	Activity
Construction *(year 0-1)*	Site establishment
	Site clearing, including removal of topsoil and vegetation
	Construction of mine related infrastructure, including roads, pipes and dams
	Construction of washing plant
	Relocation of infrastructure
	Blasting and development of initial box-cut, including stock piling
	Temporary storage of hazardous products, i.e. fuel, explosives, waste, sewage
Operational *(year 1 – 44)*	Stripping of topsoil and soft overburden
	Removal of overburden, including drilling and blasting
	Loading, hauling and stockpiling of overburden
	Drilling and blasting
	Load, haul and stockpiling of RoM coal
	Use and maintenance of haul roads
	On-site water use and storage
	Storage, handling and treatment of hazardous products and waste
Decommissioning and closure *(year 45-53)*	Demolition and removal of all infrastructure
	Rehabilitation
	Environmental monitoring of decommissioning activities
	Storage, handling and treatment of hazardous products and waste
	Post-closure monitoring and rehabilitation

9.3 Impact Assessment

9.3.1 Construction Phase

9.3.1.1 *Project Activities Assessed*

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

- Site clearing;
- Development of surface infrastructure – haul roads, access roads, topsoil area, overburden dump area, ROM tip area; and
- Blasting and development of initial box-cut for mining, including stockpiling from initial box-cuts, etc.

Table 9-5: Interactions and Impacts of Construction Phase

Interaction	Impact
Site clearing	Generation of dust from vehicle wheels
	Direct reduction in the quality of ambient air airborne dust
Exposure of loose soils due to loss of vegetation cover	Wind erosion of loose particulate matter
	Increased particulate matter load in the atmosphere leading to poor air quality
	Soiling of surfaces due to fall out dust

9.3.1.1.1 *Impact Description*

Site clearing, removal of vegetation and grading, development of surface infrastructure takes place using a range of heavy construction equipment. This will lead to exposure of loose soils due to loss of vegetation cover and generation of fugitive emissions comprising TSP, PM_{10} and $PM_{2.5}$ from vehicle wheels and material handling. There will be clearing prior to the construction of haul roads, access road, overburden dump etc. There is movement of contractor and permanent workforce, vehicle activity on access roads, and the levelling and compacting of surfaces during this activity.

Emissions from the site clearing were based on the projected area to be cleared. The inventory assumed that 50% of the area will be cleared at a time. Impacts associated with this are considered negligible due to the relatively short-term nature.

9.3.1.2 Management Objectives

- The management objective is to ensure that nuisance and contaminated dust emissions associated with construction phase comply with regulatory standards for the protection of the environment, human health and wellbeing.
- The management objective should ensure that both on-site and off-site airborne emission levels are within compliance.

9.3.1.3 Management Actions and Targets

- Particulate monitoring at upwind and downwind of project area at sensitive receptor locations.
- Application of dust suppressants i.e. Dust-A-Side on haul roads and exposed areas to ensure compliance.
- Ensure compliance with the air quality standards within the mine boundary, at the project boundary and beyond i.e. PM_{10} (75 µg/m^3) and dust fallout (1 200 mg/m^2/day).

9.3.1.4 Impact Ratings

Table 9-6: Significance ratings for impacts on air quality during Site Clearing and Development of Surface Infrastructure

Activity and Interaction (Site Clearing and Development of Surface Infrastructure)			
Dimension	**Rating**	**Motivation**	**Significance**
Impact Description: Reduction in ambient air quality			
Prior to mitigation/ management			
Duration	Short term (1)	Dust will be generated for duration of the construction phase	Negligible (negative) – 30
Extent	Limited (2)	Limited to the project area and immediate surroundings.	
Intensity	Minor (2)	Minor effect on surrounding area is anticipated	
Probability	Almost certain (6)	There is a possibility that generated dust will impact ambient air quality.	
Nature	Negative		
Mitigation/ Management actions			
▪ Application dust suppressant on the dirt road and exposed areas; ▪ Limit activity to non-windy days; ▪ Set maximum speed limits on dirt 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.			
Post- mitigation			
Duration	Short term (1)	Dust generation will be less than 1 year	Negligible

Activity and Interaction (Site Clearing and Development of Surface Infrastructure)			
Dimension	**Rating**	**Motivation**	**Significance**
		and is reversible	(negative) – 12
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 will occur.	
Nature	Negative		
Activity and Interaction (Exposed surfaces due to site clearing will results in the wind erosion of loose soil)			
Impact Description: Wind erosion; Poor air quality			
Prior to mitigation/ management			
Duration	Short term (1)	Wind erosion will occur for the duration of the construction phase (less than 1 year)	Negligible (negative) – 30
Extent	Limited (2)	Wind erosion will be limited to the site and it immediate surroundings	
Intensity	Minor (2)	Airborne dust will have minimal impact on ambient air quality during construction phase	
Probability	Almost certain (6)	It is likely that wind erosion will impact on ambient air quality.	
Nature	Negative		
Mitigation/ Management actions			
▪ Application of wetting agents or dust suppressant on exposed areas; ▪ Set maximum speed limits for vehicles working on exposed areas and 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 (wind speed ≥ 5.4 m/s).			
Post management			
Duration	Short term (1)	Wind erosion will occur for the duration of the construction phase	Low (negative) – 12
Extent	Very Limited (1)	After mitigation measures are implemented, it is expected that wind erosion will be limited to isolated parts of the site.	
Intensity	Minimal (1)	Minimal impact on ambient air quality during construction phase	
Probability	Probable (4)	Probable that impact on ambient air quality will occur.	

Activity and Interaction (Site Clearing and Development of Surface Infrastructure)			
Dimension	**Rating**	**Motivation**	**Significance**
Nature	Negative		

9.3.2 Operational Phase

9.3.2.1 Project Activities Assessed

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

- Stripping topsoil and soft overburden;
- Drilling and blasting of coal and overburden;
- Removal of RoM coal and overburden;
- Loading, hauling and stockpiling of RoM coal and overburden
- Generation of power
- Use and maintenance of haul roads for the transportation of coal to the washing plant;
- Storage, handling and treatment of hazardous products (including fuel, explosives and oil) and waste.

Table 9-7: Interactions and Impacts of Operational Phase

Interaction	Impact
Dust emission	Increased pollutant load in air
	Direct reduction in air quality
Wind erosion	Erosion of loose soils
	Direct reduction in air quality

9.3.2.1.1 Impact Description

During the operational phase, series of activities take place simultaneously at the mine, leading to multiple sources of fugitive emissions. Stripping of soils and soft overburden will result in the generation of dust from heavy construction equipment and subsequent erosion of loose soils. Also, drilling and blasting is performed to fragment the coal and overburden for mining. Blasting in particular will result in fugitive dust (containing TSP, PM_{10} and $PM_{2.5}$). Material handling activities such as loading, hauling of ore and overburden, unloading and crushing of ROM are dust generating processes with potential to impact the quality of ambient air. The hauling of ROM and overburden using dirt roads represent the highest dust generating source within a mine. These activities will be conducted for the life of mine and as such represent perennial sources of dust. During the operational phase, waste is produced as the demand and consumption increases. Impacts include evaporation of diesel fuel and heavy fuel from temporary tanks and possible spills during loading of fuel from tanks on site that are used for re-fuelling of heavy machinery and trucks. Some of the waste produced includes waste oils, chemicals and hazardous substances.

9.3.2.2 Management Objectives

The management objective is to ensure that both on-site and off-site levels of dust comply with the relevant environmental and health protection criteria.

9.3.2.3 Management Actions and Targets

- Management will ensure that monitoring data are collected and analyse to ensure compliance with the air quality standards on-site and at off-site locations.

9.3.2.4 Impact Ratings

Table 9-8: Stripping Topsoil and Soft Overburden

Activity and Interaction (Stripping topsoil and soft overburden)			
Dimension	**Rating**	**Motivation**	**Significance**
Impact Description: Stripping activity will result in fugitive dust emissions and reduction in air quality			
Prior to mitigation/ management			
Duration	Project life (5)	Dust will be generated for the project life	Minor (negative) – 66
Extent	Local (3)	Airborne dust may extend across the development site area.	
Intensity	Moderate (3)	Moderate impact on ambient air quality	
Probability	Almost certain (6)	It is highly probable that impact will occur.	
Nature	Negative		
Mitigation/ Management actions			
▪ Application of wetting agents or dust suppressant; ▪ The area of disturbance at all times must be kept to a minimum and no unnecessary stripping must occur, especially on windy days (wind speed ≥ 5.4 m/s) ▪ The drop heights when loading onto trucks and at tipping points should be minimised.			
Post- mitigation			
Duration	Project life (5)	Dust will be generated duration of the operational phase	Minor (negative) – 36
Extent	Limited (2)	Airborne dust will be limited to project site and its immediate surrounding after mitigation.	
Intensity	Minor (2)	Moderate environmental impact is anticipated after mitigation measures are applied	

Activity and Interaction (Stripping topsoil and soft overburden)			
Dimension	**Rating**	**Motivation**	**Significance**
Probability	Almost certain (6)	Probable that impact will occur.	
Nature	Negative		

Table 9-9: Significance ratings for Drilling and Blasting of RoM Coal and Overburden

Activity and Interaction (Drilling and blasting result in fugitive emissions and reduction in air quality)			
Dimension	**Rating**	**Motivation**	**Significance**
Impact Description: Drilling and blasting will result in fugitive emissions and reduction in air quality			
Prior to mitigation/ management			
Duration	Project life (5)	Dust will be generated throughout the project life	Minor (negative) – 55
Extent	Local (3)	Airborne dust may extend across the development site area.	
Intensity	Moderate (3)	Moderate environmental effect is anticipated	
Probability	Likely (5)	It is likely that impact will occur.	
Nature	Negative		
Mitigation/ Management actions			
▪ Wet drilling; and ▪ Conduct blasting judiciously by avoid windy days (≥ 5.4 m/s)			
Post- mitigation			
Duration	Project life (5)	Dust will be generated throughout the project life	Minor (negative) – 60
Extent	Limited (2)	Airborne dust limited to the site and its immediate surrounding mitigation measures are applied.	
Intensity	Moderate (3)	Moderate environmental impact	
Probability	Almost certain (6)	It is likely that impact will occur.	
Nature	Negative		

Table 9-10: Significance ratings for Loading, Hauling and Stockpiling of ROM Coal and Overburden

Activity and Interaction (Loading, hauling and stockpiling of ROM Coal and Overburden result in fugitive emission)			
Dimension	**Rating**	**Motivation**	**Significance**
Impact Description: Loading, Hauling and Stockpiling of ROM Coal and Overburden will result in result in fugitive emissions and reduction in air quality			
Prior to mitigation/ management			
Duration	Project life (5)	Dust will be generated for the project life	Moderate (negative) – 105
Extent	Municipal (4)	Airborne dust may extend across the region.	
Intensity	Very Serious (5)	Very serious long term environmental implications on air quality	
Probability	Certain (7)	Impact will definitely occur.	
Nature	Negative		
Mitigation/ Management actions			
▪ The drop heights when loading onto trucks and at tipping points should be minimised; ▪ The use of dust suppressants and binders on haul roads to reduce dust generation; ▪ There is need to set maximum speed limits on haul roads and to have these limits enforced.			
Post- mitigation			
Duration	Project life (5)	Dust will be generated duration the operational life of mine	Minor (negative) – 45
Extent	Limited (2)	Airborne dust will be limited to site and its immediate surroundings after mitigation.	
Intensity	Minimal (2)	Generated dust will have minimal effect after mitigation	
Probability	Likely (5)	Impacts may occur.	
Nature	Negative		

Table 9-11: Significance ratings for Crushing and Screening of ROM Coal

Activity and Interaction (Crushing and screening result in fugitive emissions)			
Dimension	**Rating**	**Motivation**	**Significance**
Impact Description: Crushing and screening lead to fugitive dust emissions and reduction in air quality			
Prior to mitigation/ management			
Duration	Project life (5)	Fugitive emissions will occur throughout the project life	Minor (negative) – 60
Extent	Limited (2)	Fugitive dust will be limited the site and surrounding area.	

Activity and Interaction (Crushing and screening result in fugitive emissions)			
Dimension	**Rating**	**Motivation**	**Significance**
Intensity	Moderate (3)	Moderate impact is anticipated	
Probability	Almost certain (6)	It is likely that impact will occur.	
Nature	Negative		
Mitigation/ Management actions			
▪ Enclosure of crushers; and ▪ Application of fogging system at the crusher			
Post- mitigation			
Duration	Project life (5)	Fugitive emissions will occur throughout the project life	Medium-Low (negative) – 21
Extent	Isolated (1)	After mitigation measures are implemented, It is expected that dust impacts will be limited to the crushing site.	
Intensity	Minimal (1)	Generated dust will have minor effect	
Probability	Unlikely (3)	Impacts are unlikely to occur after adequate mitigation.	
Nature	Negative		

Table 9-12: Generation of power using diesel generators

Activity and Interaction (Generation of power leads to gaseous emissions: NOx, CO and particulate matter)			
Dimension	**Rating**	**Motivation**	**Significance**
Impact Description: Reduction in air quality due to gaseous emissions			
Prior to mitigation/ management			
Duration	Project life (5)	Emissions of gases during operational phase will occur for the project life	Moderate (negative) – 91
Extent	Local (3)	Impact can be felt locally, extending outside the mine boundary as gaseous pollutants are easily dispersed.	
Intensity	Very serious (-5)	Significant changes of the ambient air quality baseline	
Probability	Definite (7)	It is certain that emissions will occur	
Mitigation/ Management actions			
▪ Ensure generators are working at optimum conditions; ▪ Fitting of gas scrubbers; and ▪ Fitting electrostatic precipitators or bag house.			

Activity and Interaction (Generation of power leads to gaseous emissions: NOx, CO and particulate matter)			
Dimension	**Rating**	**Motivation**	**Significance**
Post- mitigation			
Duration	Project life (5)	Emissions of gases will occur for the operational life or project life	Negligible (negative) – 30
Extent	Limited (2)	Impacts will be limited to the Project site.	
Intensity	Moderate (-3)	The area impacted will be minimised after mitigation measures are applied.	
Probability	Unlikely (3)	It is unlikely that emissions will have considerable impact on air quality after mitigation measures are applied	

Table 9-13: Significance ratings for the Storage, Handling and Treatment of Hazardous products

Activity and Interaction (Spills and evaporation from fuel, heavy fuel oil and used chemical will lead to reduction in air quality)			
Dimension	**Rating**	**Motivation**	**Significance**
Impact Description: Spills and evaporation will lead to fugitive emission and reduce in air quality			
Prior to mitigation/ management			
Duration	Project life (5)	Spills and evaporation will occur throughout the project life	Minor (negative) – 72
Extent	Local (3)	Emissions will extend as far as the project site	
Intensity	Serious (4)	Serious impact on air quality is anticipated	
Probability	Almost certain (6)	It is most likely that the impact would occur.	
Nature	Negative		
Mitigation/ Management actions			
▪ Strict adherence to products and waste management plan; ▪ Handled, stored and disposed hazardous substances in accordance with the local regulations; ▪ Store hazardous substances in clearly labelled containers; ▪ Deal with emergency situations promptly i.e. spills; ▪ Provision of secondary containment for fuel storage.			
Post- mitigation			
Duration	Project life (5)	Hazardous substances will impact ambient air quality for the project life	Negligible (negative) – 28

Activity and Interaction (Spills and evaporation from fuel, heavy fuel oil and used chemical will lead to reduction in air quality)			
Dimension	**Rating**	**Motivation**	**Significance**
Extent	Isolated (1)	Isolated to the site and its immediate surroundings	
Intensity	Minimal (1)	The impact will have minimal effect after mitigation measures	
Probability	Probable (4)	It is probable that impacts will occur.	
Nature	Negative		

9.3.3 Decommissioning Phase

9.3.3.1 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, including transporting materials off site;
- Rehabilitation, including spreading of soil, re-vegetation and profiling or contouring;
- Storage, handling and treatment of hazardous products (including fuel, explosives and oil) and waste.

Table 9-14: Interactions and Impacts of Decommissioning Phase

Interaction	Impact
Dust generation	Increased pollutant load in air
	Poor air quality
Wind erosion	Erosion of loose material
	Poor air quality

9.3.3.2 Impact Description

The dismantling of mine infrastructure and rehabilitation of the project area including the stockpiles will involve the use of heavy machinery and vehicles similar to those used in the construction phase. This will result in the release of fugitive dust containing TSP, PM_{10} and $PM_{2.5}$. During this phase, hazardous products must be handled following operational protocol to avoid spills and evaporation from sources.

9.3.3.3 Management Objectives

The management objective is to ensure that emissions on-site and of-site from the dismantling process and subsequent rehabilitation of the project area are not in exceedance of the applicable standards.

9.3.3.4 Management Actions and Targets

- Monitoring of emission levels pollutants on site, at upwind and downwind locations.

Table 9-15: Significance ratings for the Demolition and Removal of Infrastructure

Activity and Interaction (Demolition of Infrastructure results in fugitive emission and reduction in air quality)			
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 – 28
Extent	Local (3)	Impact can extend to development site	
Intensity	Minor (1)	Minor impact is expected	
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 offloading materials offsite must be minimised; and ▪ Limit demolition activities to non-windy days.			
Post- mitigation			
Duration	Short term (2)	Impact on air quality is limited to the duration of the decommissioning phase	Negligible (negative) – 15
Extent	Limited (2)	Impact will be limited to site after mitigation.	
Intensity	Minimal (1)	Minimal dust impact anticipated after mitigation	
Probability	Unlikely (3)	It is unlikely that dust will impact will occur.	
Nature	Negative		

Table 9-16: 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) – 30
Extent	Limited (2)	Impact will be limited to site and surroundings.	

Activity and Interaction (Rehabilitation of project area results in fugitive emission)			
Dimension	**Rating**	**Motivation**	**Significance**
Intensity	Minor (2)	Minor impact is expected	
Probability	Likely (5)	Likely 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; ▪ Rehabilitated landscape should be vegetated; and ▪ Use of dust suppressant on dirt roads and exposed areas.			
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	
Probability	Unlikely (3)	It is unlikely that the air quality will be impacted on if mitigation measures are applied.	
Nature	Negative		

Table 9-17: Significance ratings for Storage, Handling and Treatment of Hazardous products (including fuel, explosives and oil) and waste.

Activity and Interaction (Spills and evaporation from fuel, heavy fuel oil and used chemical will lead to reduction in air quality)			
Dimension	**Rating**	**Motivation**	**Significance**
Impact Description: Reduction in air quality			
Prior to mitigation/ management			
Duration	Short term (1)	Spills and evaporation will occur for the duration of this phase	Negligible (negative) – 30
Extent	Limited (2)	Emissions will be limited to site	
Intensity	Minor (2)	minor impact on air quality is anticipated	
Probability	Almost certain (6)	It is most likely that the impact would occur.	
Nature	Negative		
Mitigation/ Management actions			

<table>
<tr><th colspan="4">Activity and Interaction (Spills and evaporation from fuel, heavy fuel oil and used chemical will lead to reduction in air quality)</th></tr>
<tr><th>Dimension</th><th>Rating</th><th>Motivation</th><th>Significance</th></tr>
<tr><td colspan="4">Strict adherence to products and waste management plan;
Handled, stored and disposed hazardous substances in accordance with the local regulations;
Store hazardous substances in clearly labelled containers;
Emergency situations must be dealt with promptly i.e. spills.
Provision of secondary containment for fuel storage.</td></tr>
<tr><td colspan="4">Post- mitigation</td></tr>
<tr><td>Duration</td><td>Project life (5)</td><td>Hazardous substances will impact ambient air quality for the project life</td><td rowspan="5">Low (negative) – 18</td></tr>
<tr><td>Extent</td><td>Isolated (1)</td><td>Isolated to the site and its immediate surroundings</td></tr>
<tr><td>Intensity</td><td>Minimal (1)</td><td>The impact will have minimal effect after mitigation measures</td></tr>
<tr><td>Probability</td><td>Probable (4)</td><td>It is probable that impacts will occur.</td></tr>
<tr><td>Nature</td><td>Negative</td><td></td></tr>
</table>

9.4 Cumulative Impacts

Air quality data from the existing dust monitoring network in the vicinity of the proposed project area was used to assess background (Table 7-7). The dust deposition rates measured in the area have shown that the potential is there exceed regulatory limit (Table 8-11). After mitigation measures were factored into the model simulations, the predicted deposition rates at the project area and surroundings were reduced considerably. A similar pattern will be seen in the levels of PM_{10} and $PM_{2.5}$ if background data was available for assessment.

The operational phase of the Palmietkuilen Mining Project will impact the ambient air quality of the area. However, if adequate mitigation measures are in place, the potential impacts might be reduced to within regulatory requirements. It is not envisaged that the proposed project will exacerbate the current ambient air quality scenario if mitigation is factored into the day to day operation at the mine.

10 Environmental Management Plan

10.1 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 10-1), based on the simulations from model predictions.

Table 10-1: Most Significant Impacts

Aspects	Potential Significant Impacts
Operational Phase	
Haulage of ore and overburden	*Dust generation, reduction in air quality*
Wind erosion from the different stockpiles	*Dust generation, reduction air quality*
Power generation	*Release of gases, reduction in air quality*

10.2 Summary of Mitigation and Management

Table 10-2 to Table 10-5 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 10-2: Impacts

Activities	Phase	Size and scale of disturbance	Mitigation Measures	Compliance with Standards	Time period for Implementation
Site clearing	Construction	▪ It was assumed that clearing would occur in phases ▪ Impact is limited to the site and immediate surrounding.	▪ Site clearing must be done in phases; ▪ 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); ▪ The drop heights when loading onto trucks and at tipping points should be minimised.	▪ National Environmental Management: Air Quality Act, Act.39 of 2004; ▪ National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) - National Dust Control Regulations (2013).	▪ Immediately the construction phase commences.
Construction of mine related infrastructure, including roads, pipes and dams	Construction	▪ Few meters from project activity. Impacts will be limited to the site and immediate surroundings.	▪ Activity must be carried out judiciously to ameliorate dust emissions. ▪ Use of suppressants on exposed areas to reduce dust generation.	▪ National Environmental Management: Air Quality Act, Act.39 of 2004; ▪ National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) - National Dust Control Regulations (2013).	▪ Immediately the construction phase commences.
Blasting and development of initial box-cut for mining, including stockpiling from initial box-cuts	Construction	▪ Impact will be localized, extending across the site to nearby settlements.	▪ Activity must be carried out judiciously to ameliorate dust emissions ▪ Wet drilling	▪ National Environmental Management: Air Quality Act, Act.39 of 2004; ▪ National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) - National Dust Control Regulations (2013).	▪ Immediately the construction phase commences.
Temporary storage of hazardous products, including fuel and explosives, as well as waste and sewage.	Construction	▪ Impacts will be limited to the site and immediate surroundings	▪ Strict adherence to products and waste management plan; ▪ Handled, stored and disposed hazardous substances in accordance with the local regulations; ▪ Store hazardous substances in clearly labelled containers; ▪ Emergency situations must be dealt with promptly i.e. spills. ▪ Provision of secondary containment for fuel storage.	▪ National Environmental Management: Air Quality Act, Act.39 of 2004; ▪ National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) - National Dust Control Regulations (2013).	▪ Immediately the construction phase commences.

Activities	Phase	Size and scale of disturbance	Mitigation Measures	Compliance with Standards	Time period for Implementation
Stripping topsoil and overburden	Operational	▪ It was assumed that stripping will occur in phases ▪ Impact is limited to the site and immediate surrounding.	▪ Stripping must be done in phases; ▪ 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); ▪ The drop heights when loading onto trucks and at tipping points should be minimised.	▪ National Environmental Management: Air Quality Act, Act.39 of 2004; ▪ National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) - National Dust Control Regulations (2013).	▪ Immediately the construction phase commences.
Drilling and blasting of RoM ore and overburden	Operational	▪ Impact will be localized, extending across the site to nearby settlements.	▪ Activity must be carried out judiciously to ameliorate dust emissions ▪ Wet drilling	▪ National Environmental Management: Air Quality Act, Act.39 of 2004; ▪ Ambient air quality - Limits for common pollutants, SANS1929:2005. ▪ National Environmental Management: Air Quality Act (Act.39 of 2004) – Listed Activities and Associated Minimum Emission Standard, 2013.	▪ Measurement must commence prior to the start of operation and for the project life.
Loading, handling and stockpiling of RoM ore and overburden	Operational	▪ Emissions will extend as far as the project site	▪ The drop heights when loading onto trucks and at tipping points should be minimised; ▪ The use of dust suppressants and binders on haul roads to reduce dust generation; ▪ There is need to set maximum speed limits on haul roads and to have these limits enforced.	▪ National Environmental Management: Air Quality Act, Act.39 of 2004; ▪ Ambient air quality - Limits for common pollutants, SANS1929:2005. ▪ National Environmental Management: Air Quality Act (Act.39 of 2004) – Listed Activities and Associated Minimum Emission Standard, 2013.	▪ Measurement must commence prior to the start of operation and for the project life.
Generation of power using diesel generators	Operational	▪ Impact can be felt locally, extending outside the mine boundary as gaseous pollutants are easily dispersed	▪ Selective catalytic reduction technology; and ▪ Use of electrostatic precipitators; ▪ Gas scrubbers.	▪ National Environmental Management: Air Quality Act, Act.39 of 2004; ▪ Ambient air quality - Limits for common pollutants, SANS1929:2005. ▪ National Environmental Management: Air Quality Act (Act.39 of 2004) – Listed Activities and Associated Minimum Emission Standard, 2013.	▪ Measurement must commence prior to the start of operation and for the project life.

Activities	Phase	Size and scale of disturbance	Mitigation Measures	Compliance with Standards	Time period for Implementation
Storage, handling and treatment of hazardous material	Operational	▪ Impact will extend as far as the project site	▪ Handled, stored and disposed hazardous substances in accordance with the local regulations; ▪ Store hazardous substances in clearly labelled containers; ▪ Deal with emergency situations promptly i.e. spills; ▪ Provision of secondary containment for fuel storage.	▪ National Environmental Management: Air Quality Act, Act.39 of 2004; ▪ Ambient air quality - Limits for common pollutants, SANS1929:2005. ▪ National Environmental Management: Air Quality Act (Act.39 of 2004) – Listed Activities and Associated Minimum Emission Standard, 2013.	▪ Measurement must commence prior to the start of operation and for the project life.
Dismantling removal of infrastructure	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.	▪ National Environmental Management: Air Quality Act, Act.39 of 2004, 2004; ▪ National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004), National Dust Control Regulations (2013).	▪ Measurement must commence prior to the decommissioning operation and few month after it ends.
Rehabilitation of Project area	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.	▪ National Environmental Management: Air Quality Act, Act.39 of 2004, 2004; ▪ National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004), National Dust Control Regulations (2013).	▪ Measurement must commence prior to the decommissioning operation and few month after it ends.

Table 10-3: Objectives and Outcomes of the EMP

Activities	Potential impacts	Aspects affected	Phase	Mitigation	Standard to be achieved/objective
Site clearing	▪ Poor air quality due to site clearing and wind erosion	▪ Air Quality	▪ Construction	▪ The use of dust suppressants and binders on haul roads to reduce dust generation; ▪ Limit activity to non-windy days; ▪ There is need to set maximum speed limits on haul 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.	▪ South African National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) - National Dust Control Regulations (2013).

Activities	Potential impacts	Aspects affected	Phase	Mitigation	Standard to be achieved/objective
Drilling, blasting, stockpiles, crushing, loading, hauling .	▪ Reduced air quality due to dust generation	▪ Air Quality	▪ Operational	▪ Wet drilling; and ▪ Limit blasting activity to non-windy days; ▪ The drop heights when offloading at the stockpiles and conveyor tipping points should be minimised; ▪ The use of dust suppressants and binders on haul roads to reduce dust generation; ▪ There is need to set maximum speed limits on haul roads and to have these limits enforced; ▪ Monitoring of dust deposition rates and PM10.	▪ South African National Environmental Management: Air Quality Act, Act.39 of 2004, 2004. ▪ National Environmental Management: Air Quality Act (Act.39 of 2004) – Listed Activities and Associated Minimum Emission Standard, 2013 ▪ National Atmospheric Emissions Reporting Regulation, 2015
Dismantling and rehabilitation of Project area	▪ Reduced air quality due to dust generation from rehabilitation and wind erosion	▪ 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.	▪ South African National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004), National Dust Control Regulations (2013).

Table 10-4: Mitigation

Activities	Potential impacts	Aspects affected	Mitigation type	Time period for implementation	Compliance with standards
Site clearing	▪ Reduction in air quality due to dust generation	▪ Air Quality	▪ The use of dust suppressants and binders on haul roads to reduce dust generation; ▪ Limit activity to non-windy days; ▪ There is need to set maximum speed limits on haul 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 i.e. cessation of individual activity ▪ 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).

Activities	Potential impacts	Aspects affected	Mitigation type	Time period for implementation	Compliance with standards
Drilling, blasting, hauling, stockpiles, crushing, power generation and handling of hazardous material	▪ Poor air quality due to dust generation	▪ Air Quality	▪ Wet drilling; and ▪ Limit blasting activity to non-windy days; ▪ The drop heights when offloading at the stockpiles and at conveyor tipping points should be minimised; ▪ The use of dust suppressants and binders on haul roads to reduce dust generation; ▪ There is need to set maximum speed limits on haul roads and to have these limits enforced; and ▪ Routine maintenance and vegetation of storage facilities i.e. topsoil and overburden stockpiles throughout the lifespan of the mine to avoid exposing surfaces to wind erosion. ▪ Selective catalytic reduction technology; and ▪ Use of electrostatic precipitators; ▪ Gas scrubbers; ▪ Handled, stored and disposed hazardous substances in accordance with the local regulations; ▪ Store hazardous substances in clearly labelled containers; ▪ Deal with emergency situations promptly i.e. spills; ▪ Provision of secondary containment for fuel storage.	▪ Must be carried out concurrently with the day to day operation of the mine	▪ 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).
Dismantling and rehabilitation of Project area	▪ Reduced air quality	▪ Air Quality	▪ The area of disturbance during rehabilitation must be kept to a minimum; ▪ Drop heights when loading and offloading rubble and topsoil material should be minimised; ▪ Limit demolition activities to non-windy days.	▪ Must be carried out concurrently i.e. cessation of individual activity	▪ South African National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004), National Dust Control Regulations (2013).

Table 10-5: 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
	National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) - National Dust Control Regulations (2013)

11 Monitoring Plan

11.1 Dust Monitoring Programme

The monitoring of dust deposition rates has been ongoing since September 2016 to date in the vicinity of the proposed Palmietkuilen Mine. It is advised that such monitoring be continued during the project life. This will ensure historical data needed to fully understand and address particulate emissions from the proposed operation. If sources of fugitive dust are managed effectively at the proposed Palmietkuilen Mining Project, there will be overall reduction in ambient concentration at surrounding receptors.

11.2 PM_{10} Monitoring Programme

In accordance with the National Dust Control Regulation promulgated in terms of the NEM: AQA 39 of 2004, dust monitoring is vital if a facilities envisage its activities will impact the ambient air quality. However, if the results from the dust monitoring indicate non-compliance with the dust fallout standard, the air quality officer will request continuous monitoring of PM10. Some facilities though adopt a proactive approach and start monitoring once they realise that they are non-compliant. If the latter is the case, data collected can be useful should the mine come under scrutiny from regulatory agencies (proactive approach).

12 Summary of Significant Impacts

The impact assessment for the proposed Palmietkuilen Mining Project took into cognisance the emissions associated with the construction and operational phases of the project. Activities such as clearing and stockpiling of topsoil, drilling and blasting and hauling of ROM coal and overburden were considered in detail. Findings from this study show the activity of transporting ROM coal and overburden via haul roads and NO_2 emissions from diesel generators constituted the most significant sources of emission, with an impact rating of Moderate (negative).

13 Mitigation and Management Measures

The mitigation and management measures discussed are recommended to maintain the quality of air near the proposed mine and beyond. The mitigation and management measures are very similar irrespective of the phase.

14 Recommendations

Based on the results presented in this report, the following recommendations should be applied during the course of mining at proposed Palmietkuilen Mining ProjectPalmietkuilen Mining ProjectPalmietkuilen Mining Project:

- Continue operation of the dust fallout monitoring network for life of mine;

- Designate a qualified person to act as the Air Quality Officer as required in terms of the Act;
- Ensure air quality information is incorporated into the environmental management information system. Establish an annual reporting structure to the DEA as required by regulations currently in force;
- Procure and operate water spray trucks to spray the haul roads on a regular schedule;
- Invest in fixed water sprays at all coal tipping and transfer points in line with current best engineering practice;
- Adopt measures for demarcating roadways and boundaries of dormant areas not to be used by vehicles;
- Establish codes of practice for good housekeeping with respect to dust management and mitigation, including regular cleaning of spillage and runways, spraying of stockpiles, open areas and roads, appropriate restrictions on vehicle movements and speeds;
- Housing of crushers and screens to contain emissions; and
- Monitor the air quality management measures and information to ensure that adopted measures are sufficient to achieve current air quality standards at the closest receptors for the duration of the project.

15 Conclusion

The conclusions reached in this reported are informed by a combinations of modelled and measured data, providing the background and predicted concentration of some pollutants likely to be emitted when the mine become fully operational.

Dust deposition data were available from a network of monitoring setup by the mine. However PM_{10}, $PM_{2.5}$ and gaseous pollutants data were not available to assess background scenario. For the dust deposition data, deposition rates measured showed that the area sometime experience level higher than the residential and non-residential limits. As such, contributions from the mine may result in exceedances of the regulatory limits in the area.

The main outcome of this AQIA is that particulate pollution from the proposed mine has the potential to exacerbate ambient concentrations during the operational phase. However, with mitigation measures in place, emissions can be contained to within regulatory standards.

It is highly recommended that mine management commit to emission reduction strategies aimed at ameliorating potential impacts and ensure compliance with regulatory requirements.

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