AIR QUALITY IMPACT ASSESSMENT FOR THE PROPOSED PLATREEF UNDERGROUND MINE

PLATREEF RESOURCES (PTY) LTD

PLA1677

OCTOBER 2013

Digby Wells & Associates (Pty) Ltd. Co. Reg. No. 1999/05985/07. Fern Isle, Section 10, 359 Pretoria Ave Randburg Private Bag X10046, Randburg, 2125, South Africa

Tel: +27 11 789 9495, Fax: +27 11 789 9498, info@digbywells.com, www.digbywells.com

This document has been prepared by **Digby Wells Environmental**.

Report Title: **Air Quality Impact Assessment for the Proposed Platreef Underground Mine**

Project Number: **PLA1677**

Name	Responsibility	Signature	Date
Matthew Ojelede	Report Writer		02/10/2013
Vladimir Jovic	1st Reviewer		03/10/2013

EXECUTIVE SUMMARY

OUTLINE OF THE PROJECT

Digby Wells Environmental (hereafter Digby Wells) was requested by Platreef Resources (Pty) Ltd (hereafter Platreef), as an independent environmental consultancy to undertake Environmental and Social Impact Assessment (ESIA) encompassing several specialist studies of which Air Quality Impact Assessment (AQIA) forms an integral part for the proposed developments at the proposed Platinum Mine near Mokopane.

The overall objective of this AQIA is to identify the potential impacts and develop management measures to optimise the project benefits and minimise or avoid any adverse impacts that may result from the proposed Platreef Platinum Mine operation.

This Air Quality Impact Assessment (AQIA) study complied with the International Finance Corporation (IFC) Performance Standards, as well as the Equator Principles (EPs), a framework accepted among international project financiers for managing Environmental and Social Risks in developing countries where such aspects are either weak or non-existent (Equator Principles 2013).

KNOWLEDGE GAPS

Monitoring of air quality data is not undertaken by Platreef Platinum Mine in the proposed project area at present (except for the newly commissioned dust monitoring network), however, studies have been conducted in the past where data was sourced in determining the background levels of certain criteria pollutants. It is worth mentioning that air quality data from the South African Air Quality Information System (SAAQIS) monitoring station at Mokopane completed the aforementioned. The air quality and climate assessment was carried out as a desktop study. The information that is presented comprises of gathered (reports and peer-reviewed) information, analyses of modelled meteorological data, knowledge gained from planned site visits and robust discussions with other specialists.

BASELINE ASSESSMENT

The meteorological data set from Lakes Environmental Consultants, historical dust fallout and PM_{10} and $PM_{2.5}$ data from WSP Walmsley (2003/2004), as well as particulate and gaseous monitoring data supplied by SAAQIS were analysed.

Ambient air quality in this region of South Africa is strongly influenced by regional atmospheric movements, together with local climatic and meteorological conditions. The most important of these atmospheric movement routes are the direct transport towards the Indian Ocean and the recirculation over the sub-continents.

The country experiences distinct weather patterns in summer and winter 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. 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 the northern part of South Africa. This inversion layer traps the pollutants in the lower atmosphere, which results in reduced dispersion and a poorer ambient air quality. Preston-Whyte and Tyson (1988) describe the atmospheric conditions in the winter months as highly unfavourable for the dispersion of atmospheric pollutants. The significant variation in the windfield in the Waterberg area is indicative of strong underlying topographical influence on the prevailing meteorological conditions. The Waterberg mountain range exercises its influence on the local scale, with its peaks and valleys.

The predominant wind direction is from the northeast, frequent winds mainly from the NW and SE quadrant. Although wind speeds are generally moderate during the period (average 3.66 m/s), predominant speeds between 3.6-5.4 m/s occurred 42 % of the time. Wind speeds greater than 5.4 m/s (i.e. threshold friction velocity of 0.26 m/s) with ability to generate fugitive dust from open areas occurred 14.4% during the period.

Diurnal variability in the wind fields for the Platreef modelled data reveals that during night time, wind field conditions from the northeast (25.4% of the time) with secondary contributions from east northeast and east prevail. Wind speeds between 3.6-5.4 m/s and 5.4-8.8 m/s occurred 53 % and 18 % of the time. The morning time is dominated by wind fields from the northeast, north northeast and north with secondary components from the east, east southeast directions. Wind speeds between 3.6-5.4 m/s and 5.4-8.8 m/s occurred 37 % and 18 % of the time.

BASELINE DUST MONITORING

Baseline monitoring of dust fallout commenced in August 2013 and will last for the next year. Results will complement the historical data collect previously by WSP Walmsley in 2003/2004 reported in this study. Dust deposition data is crucial as it shows monthly, seasonal, and in some cases inter-annual variability in dust fallout rates – pre and during operational scenarios. The standard procedure accepted internationally - the American Society for Testing and Methods (ASTM) D1739 – 98 (Reapproved 2010) Standard Test Method for Collection and Measurement of Dustfall (Settleable Particulate Matter). South Africa now has its own standard (SANS 1137:2012, which is the identical implementation of ASTM D1739:1998) which was used in current monitoring campaign.

Analysis of previous **pre-mining** dust deposition data reveals that although the permitted frequency of exceedance is twice within a year (not sequential months), the area recorded seven consecutive months of exceedance, with dust deposition rates well over 1 500 $mg/m^2/day$. The above background results from historical data are considered a serious violation of the current standard.

BASELINE PM_{10} and $PM_{2.5}$

Average daily PM_{10} concentrations recorded at the Mokopane Ambient Air Quality Station are presented in the report. The average measured background PM_{10} concentration for the last five months is generally within the current NAAQS for PM_{10} of 120 $\mu g/m^3$. The limit was exceeded once in December as seen in the report. If the future NAAQS ambient standard of 75 $\mu g/m^3$ is considered (which will come into effect on the 1st of January 2015), there are several days exceeding the limit value. However, the WHO Guideline of 50 µg/m³ is actually exceeded on a number of occasions.

Measurements conducted in 2003/2004 by WSP Walmsley confirm historical levels of ambient particulate matter in the proposed Platreef mining area. The $PM_{2.5}$ and PM_{10} levels were measured using Single Striker Filter Units (SSFU) installed at Mahwelereng to continuously monitor ambient concentrations of pollutants. Figure 9-2 shows the PM_{10} concentrations from April 2003 to April 2004 with five of the twelve months of sampling exceeding the South African Standard of 120 µg/m³. If reference is made to the IFC (WHO – Guideline), only one of the twelve months of sampling was within compliance (March 2004).

The National Ambient Air Quality Standard for particulate matter with aerodynamic diameter less than 2.5 microns ($PM_{2.5}$) was promulgated on 29 June 2012 by the Minister of Water and Environmental Affairs. Ever since, ambient $PM_{2.5}$ standard of 65 µg/m³ is in force until 31 December 2015, and a new standard of 40 µg/m³ would take effect from 1 January 2016.

The $PM_{2.5}$ concentration observed over the five months period is observed to be well below the IFC (WHO guideline) value of 25 µg/m^3 and the NAAQS of 65 µg/m^3 (which takes immediate effect from the date of promulgation) as shown in the report.

The results of the monitoring of $PM_{2.5}$ conducted by WSP Walmsley in 2003/2004 are presented in the report. If results obtained are compared to the current standard, two months (August and September) of the twelve months of sampling were not compliant. The values measured were exceeding the 65 µg/m³ recommended by the current standard. On the other hand, nine months recorded values in exceedance of the IFC (WHO) Guideline of 25 µg/m^3.

SENSITIVE RECEPTORS

A domain of 20x20 km was defined, with a reference mid-point within the future mining and plant area. This domain, defined as the zone of potential impact due to air pollution emanating from the proposed Platreef mine stretches 10 kilometres from the reference point to the North, South, East and Western boundaries. This zone of impact encompasses Ga-Magonwa in the northeast, Tshamahansi to the east, Ga-Kgubudi to the west and southwest, Mzumbani to the south, and MAsodi, Ga-Madiba, Masehlaneng Mahlelereng, Mosate and Sekgakgapeng further south.

OTHER SOURCES OF AIR POLLUTION

Mokopane town has a number of small industries within its location, as well as hospital with stack. Angloplatinum operates well established platinum mine The current infrastructure of Mogalakwena platinum mine consists of four open pits, namely the Sandsloot, Zwartfontein, Mogalakwena Central and Mogalakwena North pits. The mining method is open-pit truck and shovel, and the current pit depths vary from 110 metres (Mogalakwena North) to 245 metres (Sandsloot). The ore is milled at the new fully operational North Concentrator and at the older South Concentrator.

EMISSIONS INVENTORY

It is not anticipated that the various construction activities would result in higher off-site impacts than the operational phase mining activities. The temporary nature of the construction activities, and the low likelihood that some of these activities would concur with the first operational mining months would reduce the significance of the potential impacts.

All emission scenarios have been simulated using the USA Environmental Protection Agency's Preferred/Recommended Models: AERMOD modelling system.

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.

Although the Platreef operation is going to be an underground working, there are various sources of emission anticipated at various stages of the mine life cycle: from the construction, operational and decommissioning phases. Emissions from the underground Platinum mine includes:

- Inhalable particulates, with aerodynamic diameters less than or equal to 10 microns (PM_{10}) and 2.5 microns ($PM_{2.5}$)from all mining sources;
- Total suspended particulates (TSP), from all mining sources;
- Gaseous emissions from underground heavy vehicle operations and blasting (from ventilation shafts), includes oxides of nitrogen (NO and NO_2, jointly known as NO_x, SO_2 and CO).

An emissions inventory was established comprising emissions for construction and operational activities at the proposed Platreef Platinum underground mine. The establishment of this emissions inventory is necessary to provide the source and emissions data required as input to the dispersion model simulations. Emissions from the construction phase are considered to be localised and finite, limited to the construction period. Emissions from vehicles were not included in the run as the information regarding these parameters was not available. Gaseous emissions from the underground operations will be released via the ventilation shafts. This inventory calculated emissions from the ventilation shafts, material handling (tipping) processes (underground to RoM via a conveyor, RoM reclamation conveyor to crushers and dumps for topsoil, wasterock and ROM) as well as deposition of tailings to TSF, coupled with the particulate matter load (TSP, PM_{10} and $PM_{2.5}$).coarse particulate matter associated with the ventilation shafts is usually trapped in order to avoid clogging of the surface fans – keeping them in good working condition. It was assumed that the mine will use electricity from the national grid, and no on-site power generators for emergency situations. There will be emergency generator, with debatable size.

For Platreef, the ROM stockpile, waste rock and TSF stockpile sources have been modelled as area sources. Crusher, material handling processes (tipping to RoM stockpile, tipping to waste rock stockpile, conveyor to crusher) have been modelled as volume sources. The ventilation shaft was modelled as a point source. The paved road in the mine project areas and the link road to N11 were modelled as line volume sources. All hours in the meteorological data file have been simulated with an emission rate from the sources. This approach would be considered to be a detailed and conservative assessment.

A rectangular receptor grid of 20 km x 20 km encompassing the entire project area is defined. The grid mesh was 250 metres resulting in a total of 6 561 grid points. Each of the grid points has x and y (Cartesian co-ordinates) values in metres. Terrain effects were imported from NASA Shuttle Topography Radar Mission (STRM3) global database with ~90 m accuracy and processed by the AERMAP module of AERMOD.

This receptor grid has been chosen to include the nearest sensitive receptors (These are mainly surrounding sensitive receptors including residential dwellings and provide an indication of the extent of any air pollution impacts. The 1-hour, 24-hour and annual averaging times have been used for consistency. The modelling has been performed using the meteorological data discussed in previous section and the gaseous, particulate and deposition emissions calculations explained in the emissions inventory section.

The mine's operations are 24 hours per day and 365 days a year. These predicted concentrations and deposition rates are attributed to mine operation only and did not consider cumulative impacts. Any mitigation measure that will be applied will reduce the impact of wind erosion from the ROM stockpile, waste rock stockpile, TSF, crusher, and paved roads to the surrounding area.

The occupational exposure limits as published in the amended Schedule 22.9(2)(a) of the Mine Health and Safety Act (1996, amended 2006) were used for estimating the emissions for gaseous pollutants from the ventilation shafts.

IMPACT ASSESSMENT

Predicted PM10 Concentrations

Isopleth plot of predicted highest daily values for PM_{10} generated by the proposed Platreef Platinum Mine operations is given in Figure 11-1 with a daily highest predicted ground level concentration of 500 µg/m³ mostly within the proposed mine area. The isopleth plots of predicted maximum daily values for PM_{10} for all sources combined without mitigation measures was found to exceed the current daily limit of 120 µg/m³ in the northern, western and southern sections from the mine boundary (at distances ~ 500 to less than 300 m from the boundary). The predicted PM_{10} concentrations around the neighbouring residential areas (sensitive receptors) are predicted and compared against the current SA standards and SANS limit values.

The predicted highest annual values for PM_{10} generated by the proposed Platreef Platinum Mine operations are given in Figure 11-2 with an annual highest predicted ground level concentration of 699 µg/m³ and minimum of 7 µg/m³. With mitigation measures applied, the ground level concentrations of PM_{10} observed at the selected sensitive receptors showed decreases ranging between 33 and 59 %. Annual PM_{10} levels were observed to have decrease by between 25 and 47%.

Predicted PM2.5 Concentrations

Isopleth plot of predicted 4th highest daily values for $PM_{2.5}$ generated by the proposed Platreef Platinum Mine operations show daily highest predicted ground level concentration of 276 µg/m³ and minimum of 3 µg/m³. This isopleth plot of predicted maximum daily values for $PM_{2.5}$ from all sources without mitigation measures anticipated around the operations exceeds the current daily limit of 65 µg/m³ and the future limit of 40 µg/m³ outside the mine boundary to some 200 m. However, exceedances are mainly within the vicinity of the mine. The predicted $PM_{2.5}$ concentrations around the closest neighbouring residential areas (sensitive receptors – PLA 06) is predicted to receive 23 µg/m³ per day which is 35% of the current SA standards and SANS limit values, whilst sensitive receptor furthest away from the operations received lower concentrations of $PM_{2.5}$.

The annual highest predicted ground level concentration of 67 µg/m³ and minimum of 0.7 µg/m³. Exceedances are confined within the mine borders. For $PM_{2.5}$, with mitigation the diurnal concentrations observed at the defined sensitive receptors decreased by between 22 and 83%. The decreases observed for the annual levels ranged between 33 and 54% respectively.

Predicted Dust Deposition Rates

The predicted dust deposition rates before mitigation at the sensitive receptors were all within the SANS limit for residential areas (i.e. 600 mg/m²/day) except for site PLA 06. When mitigation measures are applied, the anticipated deposition decreased at the selected sensitive receptors i.e. PLA 06 – from 629 mg/m^2/day to 317 mg/m^2/day. In general the levels decreased by between 35 and 50% at the selected sensitive receptor sites.

Predicted NO_2 Concentrations

Isopleth plot of predicted hourly values for NO_2 generated by the proposed Platreef Platinum Mine operations from ventilation shafts shows daily highest predicted ground level concentration of 862 µg/m³ and minimum of 9 µg/m³. This isopleth plot in shows predicted maximum hourly values for NO_2 emissions from the vents without mitigation measures. Areas where the recommended current hourly limit of 200 µg/m³ is likely to be violated are clearly indicated in the plot. The predicted NO_2 concentrations around the neighbouring residential areas (sensitive receptors) are evaluated. Based on the simulated values, the sensitive receptors are exposed to hourly levels way below the hourly limit value.

The predicted annual ground level concentration for NO_2 generated by the proposed PlatinumMine operations do not exceed given standards.

Predicted SO_2 Concentrations

Isopleth plot of predicted hourly ground level concentration for SO_2 generated by the proposed Platreef Platinum Mine operations from ventilation shafts show highest predicted ground level concentration of 1564 µg/m³ and minimum of 16 µg/m³. This isopleth plot shows predicted maximum hourly values for SO_2 emissions from the vents without mitigation measures. Areas where the recommended current hourly limit of 350 µg/m³ is likely to be violated are clearly indicated in the plot. The predicted SO_2 concentrations around the neighbouring residential areas (sensitive receptors) are presented in the report. Based on the values, the sensitive receptors are exposed to hourly levels below the recommended limit value of 350 µg/m³.

The isopleths showing the ground level concentration for 24-hour and annual averaging periods depict the areas that are likely to experience levels of SO_2 higher than the recommended limit value of 125 and 50 µg/m³ respectively. The predicted levels of SO_2 at the sensitive receptor sites are presented in the report. The daily and annual values at receptor sites are within the recommended limits.

Predicted CO Concentrations

Isopleth plot of predicted ground level concentrations for 1-hourly and 8-hourly are presented in the report. The predicted CO concentrations around the neighbouring residential areas (sensitive receptors) are reported in the table. The 1-hourly and 8-hourly limit values were not exceeded at any of the sites. Thus CO is not going to be an issue in the area surrounding the proposed mining operation.

MONITORING

Platreef Mine conducted dust monitoring campaign for one year (April 2003 to April 2004) and results are presented in this report. It commissioned a dust monitoring network in August 2013 for a twelve months period. It is advised that such monitoring be continue after the current monitoring period expires, for the project life in order to establish historical repository of data needed to fully understand/address fugitive and airborne dust emissions from the construction, operation and closure activities. The current dust monitoring sites are depicted in Plan 5. Managing dust fallout effectively will result in the reduction of respiratory diseases that are as a result of air pollution, reduced risk of damage to property, improved visibility, and fewer disturbances to existing flora and fauna habitats.

PM10 Monitoring Programme

As reported previously, Platreef conducted a PM_{10} and $PM_{2.5}$ monitoring during the period April 2003 and April 2004. The client should re-establish a fine particulate monitoring programme, which should include one particulate instrument to monitor PM_{10} and preferably $PM_{2.5}$ from the mine operation. PM_{10} instrument should be located to the western section of the mine boundary. This is based on the plots from the air dispersion modelling results. It is advised to install the unit at least one year prior to the construction phase to allow for the collection of an ambient air quality baseline data set.

Gaseous Monitoring Programme

The gaseous pollutants such as NO_2, SO_2 and CO where modelled using default occupational limit values. It is recommended that monitoring programme to measure gaseous pollutants (NO_x, SO_2), and other criteria pollutants be initiated.

CONCLUSION

The findings reported here are a mixture of historical, observed and modelled data and provided the background and predicted scenario of various pollutant in the Platreef mining area. The daily PM_{10} concentrations recorded at the Mokopane Ambient Air Quality Station are presented and generally are within the NAAQS for PM_{10} of 120 µg/m³ for the month considered. If the future NAAQS ambient standard of 75 µg/m³ is considered (which will come into effect on the 1st of January 2015), there are several days exceeding the limit value. However, the WHO Guideline of 50 µg/m³ is actually exceeded on a number of occasions. Records provided from measurements conducted by WSP Walmsley (2003/2004) provide historical levels of ambient particulate matter in the proposed Platreef mining area and confirm five sequential months exceeding the South African Standard of 120 µg/m³ for PM_{10}. If reference is made to the IFC (WHO Guideline - 50 µg/m³), only one of the twelve months of sampling was within compliance. Isopleths of PM_{10} generated from dispersion model for both unmitigated and mitigated scenarios have shown that concentrations above the recommended limit value can reach distances of ~2 km from the mine boundaries, especially for the western and southern section of the mine boundary.

$PM_{2.5}$ data from the Mokopane Ambient Air Quality Station confirm the low levels of this pollutant, with values below the IFC (WHO guideline) value of 25 µg/m^3 and the NAAQS of 65 µg/m^3. Historical records from the monitoring campaign conducted by WSP Walmsley in 2003/2004 confirmed two month of no compliance in a year. Generally, values recorded were within the 65 µg/m³ threshold recommended by the current standard. Isopleths from the dispersion modelling plots have indicated that the area impacted by $PM_{2.5}$ arising from the proposed Platreef mine operation is minimal and greater portion falls within the project area.

The dust monitoring programmes conducted by WSP Walmsley in 2003/2004 in the Platreef mining area confirmed high dust fallout rates in the area. The historical dust fallout data measured are observed to be in violation of the current residential and industrial limits recommended by SANS 1929:2011 "Ambient air quality – limit for common pollutant". Although the permitted Frequency of exceedance is twice within a year (not sequential months), the area recorded seven consecutive months of exceedance, with dust deposition rates observed for each of the months well over 1 500 mg/m^2/day. The above background results from historical data are considered a serious violation of the current standard. The seasonal variability also showed high deposition rates except during summer season, with values within the residential and industrial limits, apart from one site which recorded deposition rates of 740 mg/m^2/day. Results from the dispersion modelling did not corroborate the observed data reported by Walmsley in 2003/2004. From the dispersion model data, only one site was in violation of the residential limit as recommended by SANS 1929:2011. With the commissioning of a monitoring network in August 2013 by Platreef, it will be interesting to see if the results are in line with those reported from historical measurements.

For NO_2, observed data from the Mokopane Ambient Air Quality Station show levels that are generally within the limit for both the South African NAAQS and WHO Guideline, although incidents of one or two peaks exceeding recommended limits are common. Hourly ground level concentration of this pollutant generated with AERMOD dispersion modelling have shown that areas between 400 and 450 m from the vent shaft are likely to experience NO_2

levels above recommended limit. The isopleth of annual ground level concentration are with the recommended limit, with higher values confined to the mine boundary.

The level of SO_2 levels from observed data reported by SAAQIS are generally within the recommended South African NAAQS and WHO Guidelines. The dispersion model data for the 10 Minutes, 1-hour, 24-hour and 1-year averaging periods reveal that from the vents to a distance of 400, 450 and 500 m are likely to experience values above the standard for the various averaging periods.

Carbon monoxide (CO) concentrations measured at the SAAQIS are below the recommended NAAQS 8-hr and 1-hr limit values respectively. The peaks observed in CO concentration are not in exceedance of the standard. Isopleths of ground level concentrations generated from the dispersion model are showing low values. Default occupational limit have been deployed as input data to the dispersion model, as site-specific data was not available.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

ADMS	Advanced Dispersion Modelling System
AEL	Atmospheric Emission Licence
AERMOD	American Meteorological Society/United States Environmental Protection Agency Regulatory Model
AQG	Air Quality Guidelines
AQIA	Air Quality Impact Assessment
APPA	Atmospheric Pollution Prevention Act (Act 45 of 1965)
ASTM	American Society for Testing and Materials
AWS	Automatic Weather Station
CALPUFF	California Puff Model - advanced non-steady-state meteorological and air quality modeling system
CFR	Code of Federal Regulation (USA)
DEA	Department of Environmental Affairs
EHS	Environmental Health and Safety
EIA	Environmental Impact Assessment
EP	Equator Principles
ESIA	Environmental and Social Impact Assessment
FEV	Forced Expiratory Volume
FVC	Forced Vital Capacity
GIIP	Good International Industry Practice
GN	Government Notice
IDP	Integrated Development Plan
IFC	International Finance Corporation
ISCST3	Industrial Source Complex Short-Term, Version 3
km	Kilometre
km^2	Kilometre squared
km	Kilometre

m	Metre
m^2	Metre squared
mamsl	metres above mean sea level
MEC	Member of Executive Council
MM5	Mesoscale model - Fifth generation
MPRDA	Minerals and Petroleum Resources Development Act
NAAQS	National Ambient Air Quality Standards
NEMA	National Environment Management Act, 1998 (Act 107 of 1998)
NEM:AQA	National Environment Management: Air Quality Act (Act No. 39 of 2004)
NFAQM	National Framework for Air Quality Management
NPI	National Pollutant Inventory
PCD	Pollution Control Dam
PEF	Peak Expiratory Flow
PM	Particulate Matter
$PM_{2.5}$	Particulate Matter less than 2.5 microns in diameter
PM_{10}	Particulate Matter less than 10 microns in diameter
PSD	Particle Size Distribution
PSU/NCAR	Pennsylvania State University / National Center for Atmospheric Research
ROM	Run of Mine
SAAQIS	South African Air Quality Information System
SANS	South African National Standards
SPCC	State Pollution Control Commission of New South Wales, Australia
STRM	Shuttle Topography Radar Mission
TSF	Tailings Storage Facility
TSP	Total Suspended Particulates
US EPA	United States Environmental Protection Agency
WBPA	Waterberg-Bojanala Priority Area

WHO	World Health Organisation

1 INTRODUCTION

Platreef Resources (Pty) Ltd (hereafter Platreef) has acquired the mineral prospecting licence on two farms, Turfspruit 241 KR and Macalacaskop 243 KR, with the prospecting rights for the third and adjacent farm - Rietfontein 2 KS belonging to Atlatsa Resources Corporation (previously Anooraq Resources). Platreef intends to apply for a mining right over all three farms.

The proposed Platreef mining area is within the Bushveld Complex (which houses 89% of the world's platinum-group metals reserve). The complex is segmented into three major regions: the Eastern and Western lobes and the Northern Limb. It has been observed that for the Eastern and Western lobes the mineralization is hosted in the interior of the complex, in the Merensky Reef and UG2 Chromite layers. In contrast, in the Northern limb the mineralization is hosted at the lower margin of the complex in the Platreef – making it more economically viable to mine.

Platreef is investigating the construction and operation of an underground Platinum mine. The project is a greenfields project in an area where the current land use is predominantly agriculture. The surface infrastructure planned includes incline shafts, ventilation shafts, a process plant with supporting infrastructure and facilities such as access roads, pipelines and power, as well as a Tailings Storage Facility (TSF). The current infrastructure does not include a smelter. In fulfilment of the requirements stipulated in Section 39 of the Minerals and Petroleum Resources Development Act (MPRDA), an Environmental Impact Assessment (EIA) process for the proposed project is being undertaken.

For the Tailings Storage Facility (TSF), 4 alternative sites were initially identified in the scoping phase, namely:

- Site 1 located on the farm Turfspruit;
- Site 2 located on the farm Rietfontein 2 KS (preferred location);
- Site 3 located on the farm Bultongfontein (preferred location); and
- Site 4 located on the farm Rietfontein 240 KR (eliminated during the scoping phase).

During the EIA investigations, two sites (namely, the Rietfontein 2KS and Bultongfontein) were nominated as preferred locations for the TSF.

These two options were evaluated from the air quality pollution potential, and the preferred option is the site located on the Rietfontein farm. The main reason for site selection is the predominant wind direction in the area, which is northeasterly. TSF in general has potential to generate air pollution. The proposed location of the site at Bultongfontein farm is widely exposed to the predominant winds in the area, which would probably lead to the increased particle load in the air downwind from the site. The site is also in the proximity of the existing TSF at the Mogalakwena Platinum Mine, and there is a possibility of having compounded effects downwind from the two TSF's. On the other hand, the proposed Rietfontein 2 KS site will be constructed as a side-hill type tailings storage facility, which will be mostly lying on the foothills and shielded by the Thabaphaswa hills and mountains from the winds coming from northeasterly direction.

. This study focused on the preferred site on the Rietfontein farm. If Platreef decides to change the preferred TSF site to Bultongfontein farm, new studies will have to be conducted to address the changes, since no detailed information was supplied with regards to footprint or height of alternative TSF.

The project site lies approximately 8 km from the town of Mokopane (previously known as Potgietersrus) in a north westerly direction. The project is situated in the Mogalakwena Local Municipality and within the Waterberg District Municipality. (Plan 1: Regional Setting).

Platreef is required to obtain environmental authorisation for the proposed development in Limpopo Province and has appointed Digby Wells Environmental (South Africa) (Pty) Ltd (hereafter Digby Wells) to undertake Environmental and Social Impact Assessment (ESIA), with an Air Quality Impact Assessment (AQIA) component.

The AQIA component will determine ambient air quality baseline, followed by the development of an air emission inventory that will take into account all the relevant sources of air pollution in the area and cumulative effects of the mine's additive contributions. A dust fallout monitoring network will be commissioned and dust fallout will be monitored and reported for a period of twelve months. Mitigation measures, incorporating best practicable environmental options will be discussed.

2 BRIEF PROJECT DESCRIPTION

2.1 Location of Site

The proposed Platreef prospecting area in its southern edge is approximately 2.5 km northwest of the town of Mokopane (Plan 2 – Local Setting). Currently, the prospecting area comprises of farm portions: Turfspruit 241 KR, Macalacaskop 243 KR and Rietfontein 2 KS in the Mogalakwena Local Municipality within the Waterberg District Municipality of Limpopo Province.

The mine prospecting area encompasses plots with residential land uses – with large urban, middle class and informal settlements. The formal settlement of Ga-Madiba exists to the southwest of the known mineralisation on Macalacaskop farm. The informal settlement of Tshamahansi is located on the Turfspruit farm and northwest of it.

Surrounding settlements in the area include:

- Mahwelereng-A
- Mahwelereng-B
- Tshamahansi
- Ga-Magonwa
- Ga-Kgubudi
- Mzombane

- Ga-Madiba
- Masehlaneng
- Maroteng
- Mosate
- Ga-Mapela
- Masodi
- Sekgakgapeng and
- Sekgoboko.

Makapansgat is an archaeological location within the Makapansgat and Zwartkrans Valleys, northeast of Mokopane. It is situated approximately 23 km east-southeast form the proposed mining and plant area, and it is anticipated that there will be no influence with regards to dust and gaseous pollutants. The Maribashoekberge range that is situated to the west of Makapansgat will act as a barrier to any air pollution or dust from the proposed Platreef operations.

2.2 Other Sources of Air Pollution

Mokopane town has a number of small industries within its location, as well as hospital with stack. Anglo Platinum operates well established platinum mine The current infrastructure of Mogalakwena platinum mine consists of four open pits, namely the Sandsloot, Zwartfontein, Mogalakwena Central and Mogalakwena North pits. The mining method is open-pit truck and shovel, and the current pit depths vary from 110 metres (Mogalakwena North) to 245 metres (Sandsloot). The ore is milled at the new fully operational North Concentrator and at the older South Concentrator.

3 TERMS OF REFERENCE

The Air Quality Impact Assessment (AQIA) for the proposed Platreef Mine will form part of the ESIA being undertaken by Digby Wells. In order to determine the possible impacts from the proposed project on surrounding air quality and on human health, an air quality baseline study has been conducted and air impact assessment is part of this report, which includes recommendations for mitigation of impacts.

The terms of reference for the AQIA included:

- Defining the study area and identifying possible sensitive receptors based on the area that could potentially be affected by the proposed project;
- The assessment of regional climate and site-specific atmospheric dispersion potential;
- The assessment of available ambient air quality;
- The identification of significant information gaps; and
- The analysis of local topography and a discussion of effect it has on the local wind field.

- Assessment of human health impacts;
- Assess the cumulative effects of the mine's additive contributions;
- Mitigation measures incorporating Best Practicable Environmental Option; and
- Set up a dust fallout monitoring network to measure dust fallout for a calendar year accompanied by detailed quarterly reports.

4 ASSUMPTIONS AND LIMITATIONS

The following assumptions and limitations were identified:

- Adequate ambient air quality monitoring data is not available to evaluate the baseline air quality situation at proposed Platreef project area, but data from the South African Air Quality Information System (SAAQIS) database for the air quality monitoring station at Mokopane will be used;
- Use was made of modelled, site-specific meteorological data for the baseline assessment and modelling runs, which complimented available local hourly meteorological data for the study area; and
- Data input into the model has been based on all documentation provided by the Client. It is assumed that the information provided by the Client is accurate and complete.

5 EXPERTISE OF THE SPECIALIST

Vladimir Jovic completed his BSc (Hons) degree at the University of Belgrade, Serbia in 1998. He has more than seven years of experience in Atmospheric Dispersion Modelling and emissions inventories compilation. Working as an Air Quality Specialist since 2006, he has co-authored many dispersion modelling impact assessments and has deployed specialised modelling software suites, including ISCST3, AERMOD, ADMS and CALPUFF. Mr. Jovic has attended three specialised introductory and advanced courses in atmospheric dispersion modelling (AERMOD and CALPUFF) presented by specialists in this field from the United States of America (USA) and Canada. A detailed CV is attached as Appendix B.

6 REGIONAL CLIMATE AND FACTORS INFLUENCING AIR DISPERSION

6.1 Regional Climate

South Africa is located in the sub-tropics where high pressures and subsidence dominate. However, the southern part of the continent can also serve as a source of hot air that intrudes sub-tropics, and that sometimes lead to convective movement of air masses. On average, a low pressure will develop over the southern part of the continent, while the normal high pressures will remain over the surrounding oceans. These high pressures are known as Indian High Pressure Cell and Atlantic High pressure Cell. The intrusion of continents will allow for the development of circulation patterns that will draw moisture (rain) from either tropics (hot air masses over equator) or from the mid-latitude and temperate latitudes.

Southern Africa is influenced by two major high pressure cells, in addition to various circulation systems prevailing in the adjacent tropical and temperate latitudes. The mean circulation of the atmosphere over Southern Africa is anticyclonic throughout the year (except near the surface) due to the dominance of the three high pressure cells, namely South Atlantic High Pressure, off the west coast, the South Indian high pressure off the east coast and the continental high pressure over the interior.

It is these climatic conditions and circulation movements that are responsible for the distribution and dispersion of air pollutants within proposed Platreef area and between neighbouring provinces and countries bordering South Africa.

6.2 Topography

The topography of the prospecting area slopes gently south – from 1172 m to 1073 m above mean seal level (amsl), with elevation of 1572 m (amsl) in the north-eastern part, due to the north-south trending ridge. The south western sections (outside) the prospecting area section have elevation in the range of 1471 m amsl as a result of the northwest southeast trending ridge. This will have implications on the general wind pattern influencing the area and pollutant dispersal (Plan 3 - Topography).

6.3 Vegetation

The natural landscape consists of mainly Savanna/grassland type vegetation cover. Farming activity is not pronounced within the domain. Vegetation communities include secondary grassland and agriculture, degraded bush, degraded ridge, with small portions of riparian and ridge communities, as well as residential areas.

6.4 Climate and 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. The most important of these atmospheric movement routes are the direct transport towards the Indian Ocean and the recirculation over the sub-continents.

The country experiences distinct weather patterns in summer and winter 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. 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 the northern part of South Africa. This inversion layer traps the pollutants in the lower atmosphere, which results in reduced dispersion and a poorer ambient air quality. Preston-Whyte and Tyson (1988) describe the atmospheric conditions in the winter months as highly unfavourable for the dispersion of atmospheric pollutants.

The significant variation in the windfield in the Waterberg area is indicative of strong underlying topographical influence on the prevailing meteorological conditions. The Waterberg mountain range exercises its influence on the local scale, with its peaks and valleys.

The climate is semi-arid, with precipitation occurring as rain. Average annual rainfall is around 300 mm. Over 90% of the annual rainfall occurs between the months of October and March. The highest monthly averages typically occur in November and December, although January also receives precipitation above average. In terms of Koeppen Climate Classification, the area belongs to BSh (Arid Climate, Steppe, hot).

Precipitation reduces erosion potential by increasing the moisture content of materials. This represents an effective mechanism for removal of atmospheric pollutants and is therefore considered during air pollution studies. Rain-days are defined as days experiencing 0.25 mm or more rainfall.

Site specific MM5 modelled meteorological data set for full three calendar years (2009 – 2011) was obtained from the Lakes Environmental Consultants in Canada to determine local prevailing weather conditions. This dataset consists of surface data, as well as upper air meteorological data that is required to run the dispersion model. It is required if site specific surface and upper air meteorological data is not available. The Pennsylvania State University / National Center for Atmospheric Research (PSU/NCAR) meso-scale model (known as MM5) is a limited-area, non-hydrostatic, terrain-following sigma-coordinate model designed to simulate or predict meso-scale atmospheric circulation.

This data has been tested extensively and has been found to be extremely accurate.

Modelled meteorological data for the period January 2009 to December 2011 was obtained for a point near the proposed Platreef site (24.095986 S, 28.968619 E). Data availability was 100%.

Generally, a data set of greater than 90% (Taken to be the same as that stipulated for pollutant data availability (SANS, 2011) is required in order 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.

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 the wind speed. The amount of particulate matter generated by wind is also dependent on the material's surface properties. This includes whether the material is crusted, the amount of non-erodible particles and the particle size distribution of the material.

Wind roses comprise 16 spokes which represent 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 direction categories. The figure given at the bottom of the legend described the frequency with which calms occurred, i.e. periods during which the wind speed was below 0.5 m/s.

The spatial and annual variability in the wind field for the Platreef modelled data is clearly evident in Figure 6-1. The predominant wind direction is from northeast, with the secondary component from the east northeast and east. Contributions from the NW and SE quadrant are observed. Calm conditions (wind speeds < 0.5 m/s) occurred for 4.2 % of the time. Wind class frequency distribution per sector is given in Figure 6-4 and Table 6-1.

The spatial variability in the wind fields for the Platreef modelled data is presented. The predominant wind direction is from the northeast, frequent winds mainly from the NW and SE quadrant (Figure 6-1). Although wind speeds are generally moderate during the period (average 3.66 m/s), predominant speeds between 3.6-5.4 m/s occurred 42 % of the time. Wind speeds greater than 5.4 m/s (i.e. threshold friction velocity of 0.26 m/s) have the ability to generate fugitive dust from open areas and storage piles. Wind speeds greater than 5.4 m/s in the Platreef area account for 14.4% % during the period.

Diurnal variability in the wind fields for the Platreef modelled data is presented in Figure 6-2. At night time, wind field conditions from the northeast (25.4% of the time) with secondary contributions from east northeast and east. Wind speeds between 3.6-5.4 m/s and 5.4-8.8 m/s occurred 53 % and 18 % of the time. The morning time is dominated by wind fields from the northeast, north northeast and north with secondary components from the east, east southeast directions. Wind speeds between 3.6-5.4 m/s and 5.4-8.8 m/s occurred 37 % and 18 % of the time.

In the afternoon, the predominant wind was blowing from the northwest direction (17%), with 13% coming from the north northwest direction. Secondary components were observed from the south east sector. The evening wind field conditions were different from what was observed in the afternoon, with winds from the northeast (18 %) and east northeast (16%) respectively. Wind speeds between 3.6-5.4 m/s and 5.4-8.8 m/s occurred 49 % and 13 % of the time.

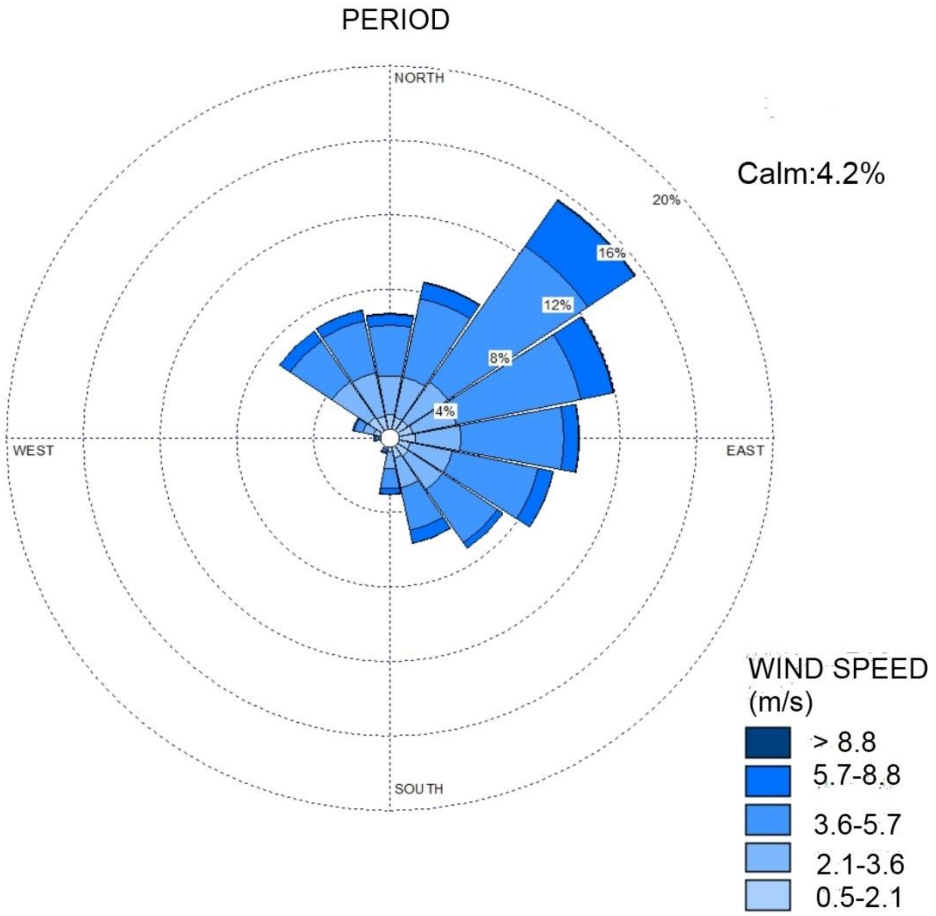

Figure 6-1: Surface wind rose modelled data (01 January 2009 – 31 December 2011)

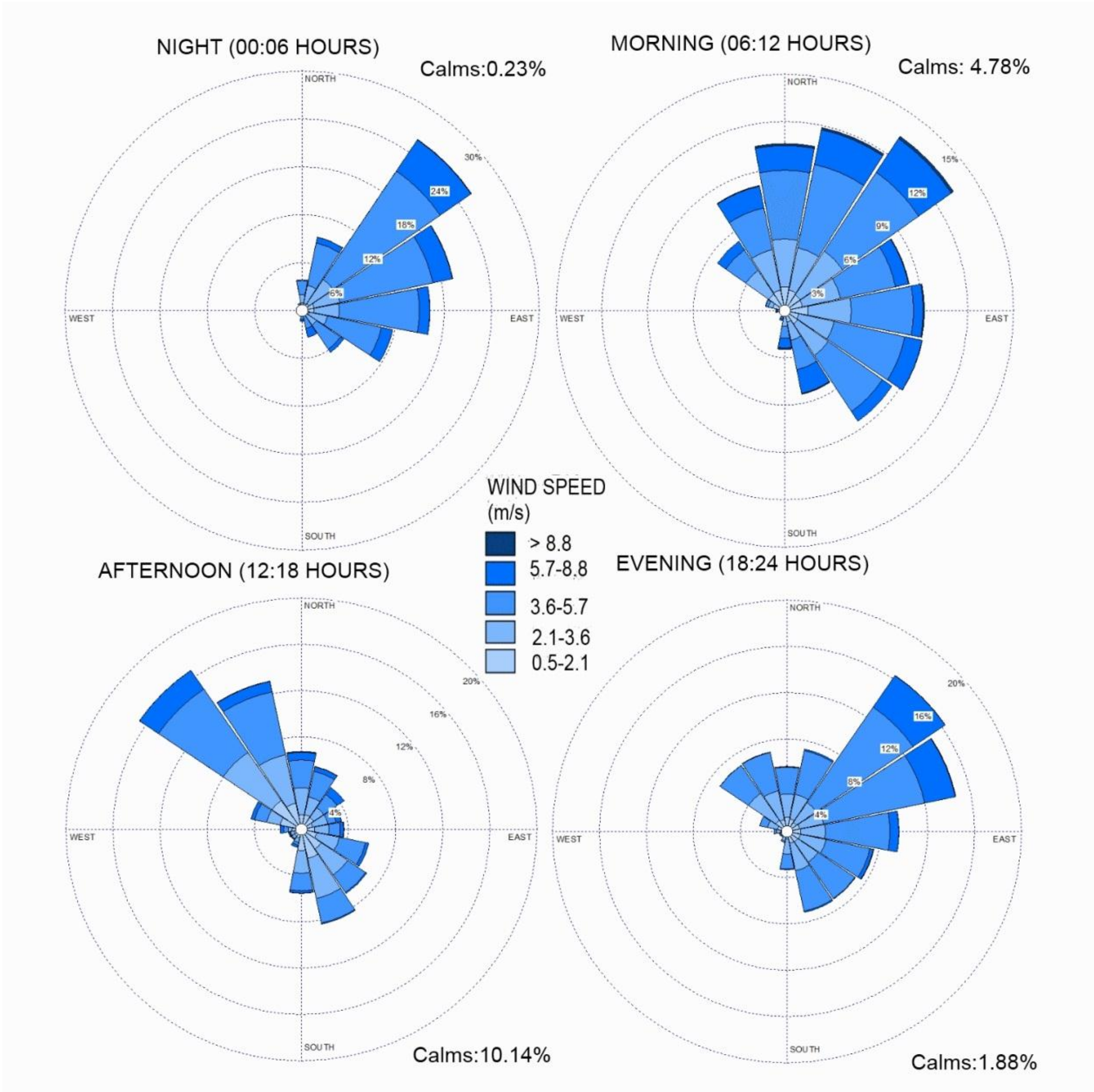

Figure 6-2: Diurnal variation of winds between Night time 00:00 – 06:00 (Top left), Morning 06:00 – 12:00 (top right), Afternoon 12:00 – 18:00 (Bottom left), Evening 18:00 – 24:00 (bottom right) and (modelled data 01 January 2009 – 31 December 2011)

The seasonal variability observed in wind regime is represented by the plots in Figure 6-3. In spring the predominant wind speed comes from the NE with secondary components from the NNE and ENE respectively. Less infrequent winds were observed from the N, NNW and NW. The predominant wind direction did not change significantly in summer. However, there were changes in the frequency of winds from the NE which was observed to have decrease and winds from ENE direction increased slightly.

In autumn, strong winds were coming from the E, ENE, NE, ESE in the order of dominance, with secondary components from the SE and NE respectively. In winter the influence from the NE sector diminished with the wind from the E, ESE, SE and SSE dominating.

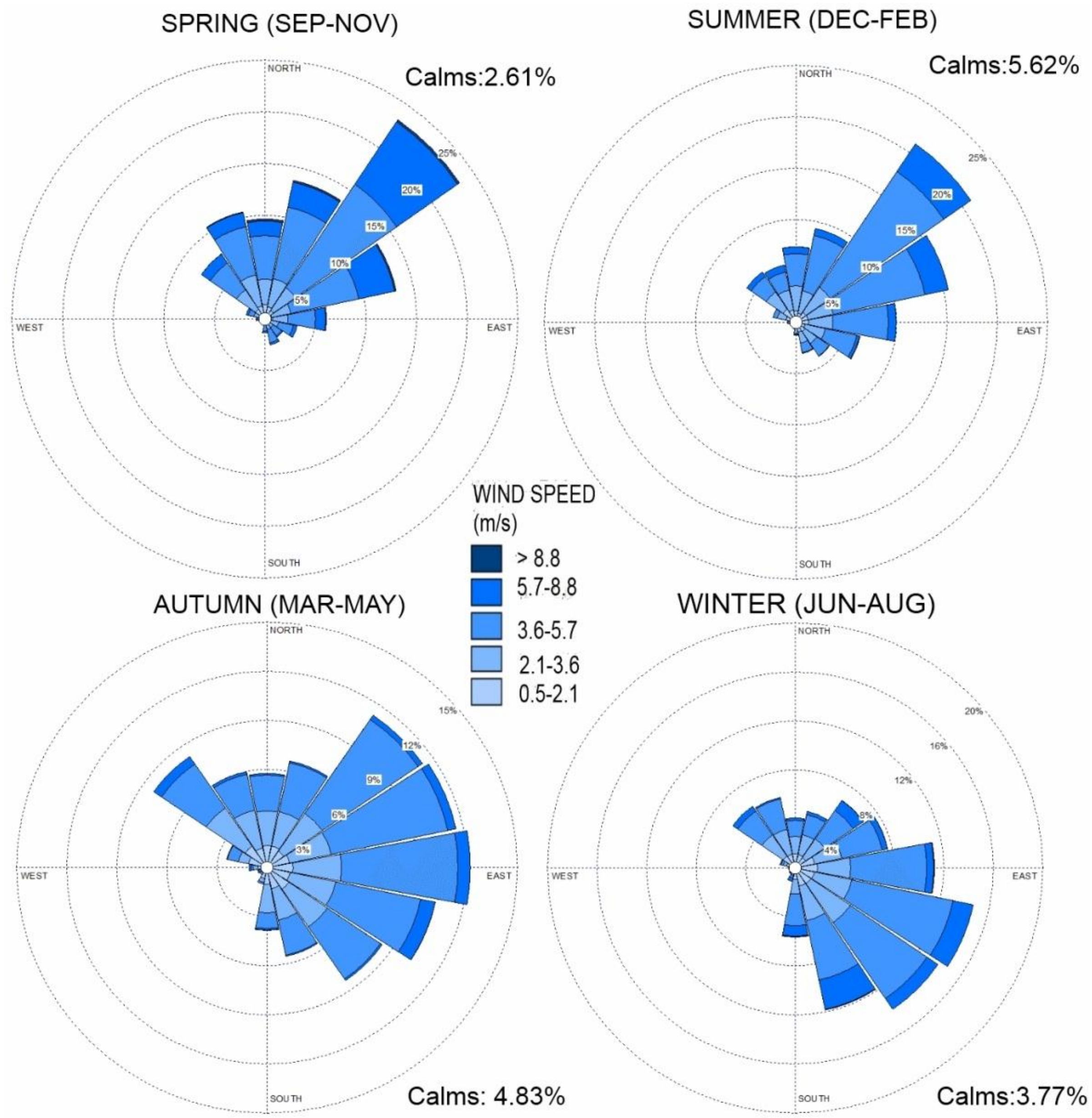

Figure 6-3: Seasonal variation of winds in spring season (September – November) (top left), summer season (December - February) (top right), autumn season (March – May) (bottom left) and winter season (June – August) (bottom right) (modelled data 01 January 2009 – 31 December 2011)

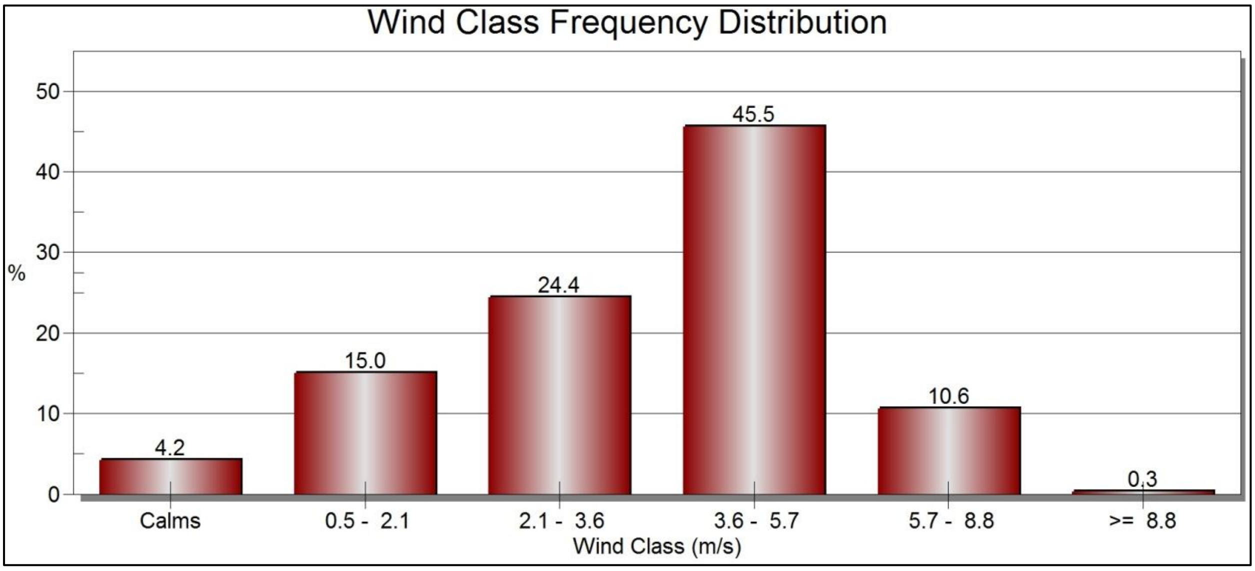

Figure 6-4: Wind Class Frequency Distribution for Platreef modelled data, 01 January 2009 – 31 December 2011

Table 6-1: Wind Class Frequency Distribution per Direction for Platreef modelled data, 01 January 2009 – 31 December 2011

	Directions (m/s)	Wind Classes (m/s)					
		0.5 - 2.1	2.1 - 3.6	3.6 - 5.4	5.4 - 8.8	>= 8.8	Total
1.00	N	1.26	2.09	2.58	0.70	0.05	6.69
2.00	NNE	1.16	2.18	3.99	1.18	0.05	8.56
3.00	NE	1.13	2.53	7.72	4.04	0.07	15.48
4.00	ENE	1.23	2.32	5.87	2.46	0.04	11.92
5.00	E	1.34	2.36	4.91	1.21	0.03	9.86
6.00	ESE	1.09	2.23	4.27	1.09	0.02	8.69
7.00	SE	1.17	2.16	3.25	0.56	0.00	7.14
8.00	SSE	1.09	1.62	2.19	0.86	0.02	5.77
9.00	S	0.72	0.92	0.99	0.38	0.03	3.03
10.00	SSW	0.37	0.26	0.14	0.10	0.00	0.86
11.00	SW	0.30	0.13	0.06	0.02	0.00	0.50
12.00	WSW	0.26	0.14	0.05	0.03	0.00	0.49
13.00	W	0.41	0.19	0.14	0.11	0.00	0.84
14.00	WNW	0.88	0.57	0.41	0.13	0.00	1.99
15.00	NW	1.37	2.30	2.46	0.83	0.00	6.96
16.00	NNW	1.23	2.36	2.69	0.72	0.02	7.02
	Sub-Total	14.99	24.36	41.72	14.40	0.32	95.80
	Calms						4.20
	Missing/Incomplete						0.00
	Total						100.00

6.4.1 Temperature

Air temperature is important, both for determining the effect of plume buoyancy (the larger the temperature difference between the plume and the ambient air, the higher the plume is able to rise), and determining the development of the mixing and inversion layers.

South African Weather Service has an Automatic Weather Station (AWS) within the reasonable distance from the Platreef Project site (Station Code :0633882 7 – Mokopane), approximately 14.5 km south southeast from the proposed plant area). The data collected at this station were not considered to be fully representative of conditions on site, particularly on Rietfontein 2KS, so the use was made of modelled data and trends were observed analysing the three years available (2009-2011).

Three-year averaged maximum, average and minimum temperatures for Platreef are given in Table 6-2. Annual average temperatures for Platreef area are given as 18.3°C. The average daily maximum temperatures range from 22.9°C in December to 8.1°C in July, with daily minima ranging from 21.5°C in December to 7.1°C in July. Annual average temperature for Platreef is given as 16.8°C.

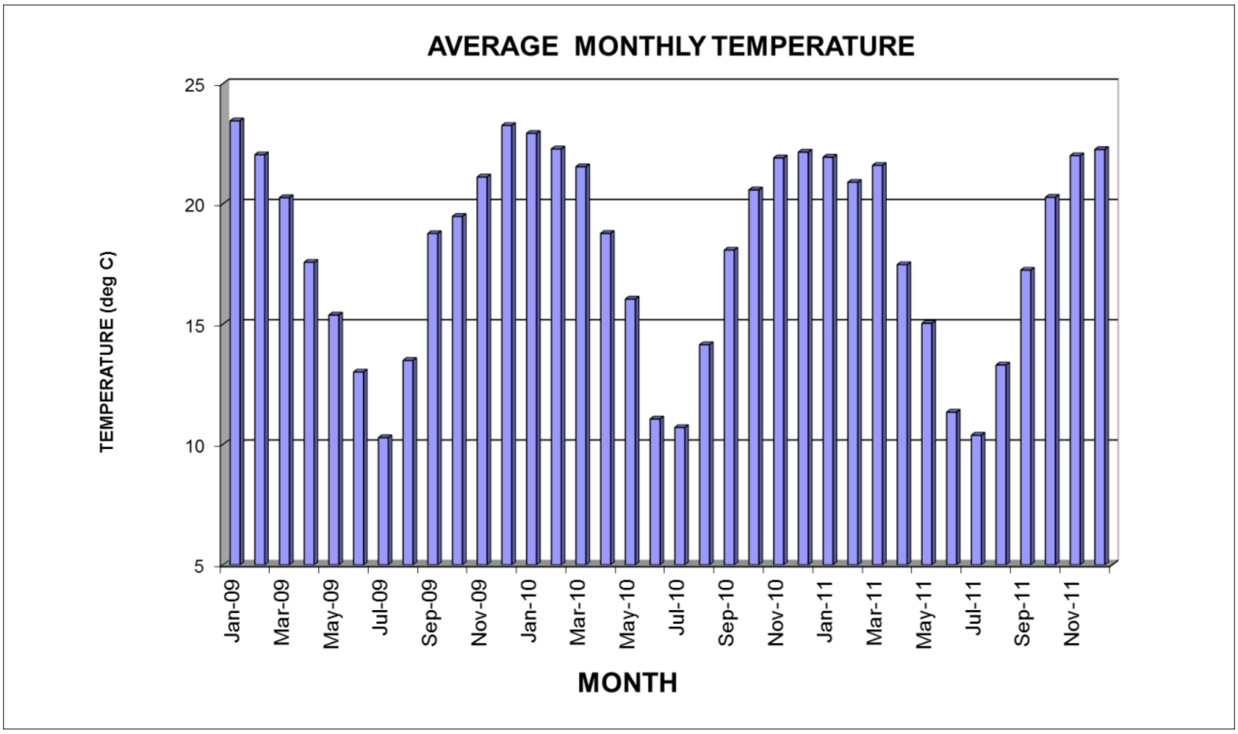

Figure 6-5: Average monthly temperature derived from the Platreef modelled data (2009-2011)

Table 6-2: Averaged monthly minimum, maximum and average temperature values derived from the Platreef modelled data (2009-2011)

Temperature (deg °C)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Monthly Max.	23.5	22.3	21.6	18.8	16.0	13.0	10.7	14.1	18.8	20.6	22.0	23.3	18.7
Monthly Min.	21.9	20.9	20.3	17.5	15.0	11.1	10.3	13.3	17.2	19.5	21.1	22.2	17.5
Monthly Ave.	22.8	21.7	15.5	17.9	15.5	11.8	10.5	13.6	18.0	20.1	21.7	22.6	17.6

6.4.2 Relative Humidity

The data in

Table 6-3 is representative of the relative humidity for the Platreef area. The annual maximum, minimum and average relative humidity is given as 66.9 %, 61.1 % and 63.9 %, respectively. The daily maximum relative humidity remains above 60 % for most of the year (with exception of November and December), and range from 78.5 % in winter (July) to 55.8 % in November. The daily minimum relative humidity on the other hand is less than 70 % throughout the year, with the highest minimum (69.4 %) occurring in June and the lowest (49.4 %) occurring in November.

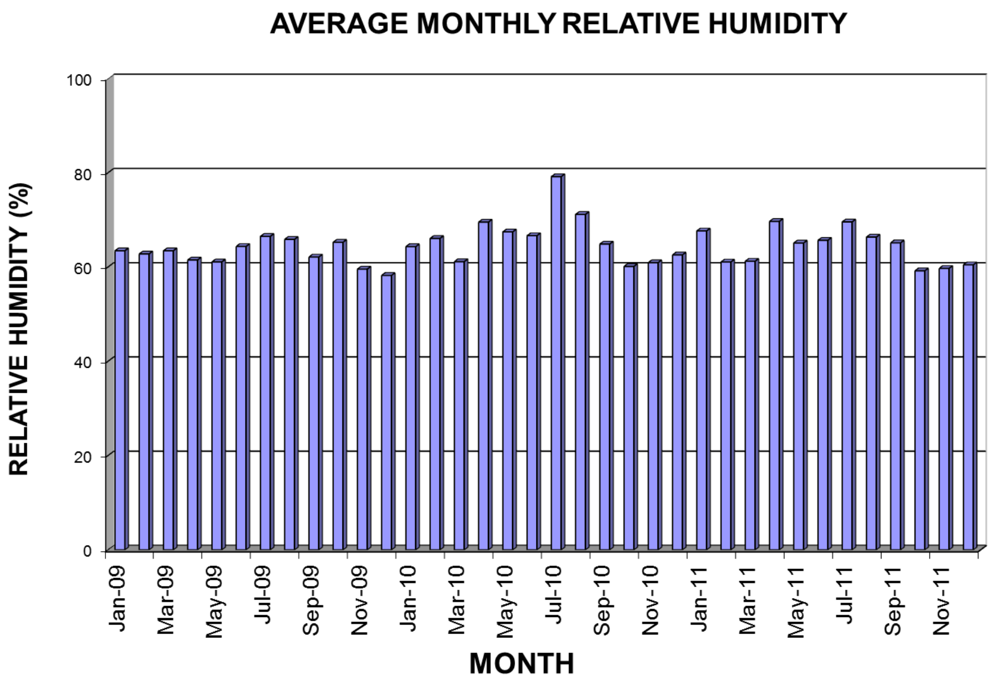

Figure 6-6: Average Monthly Relative Humidity derived from the Platreef modelled data (2009-2011)

Table 6-3: Average Monthly Relative Humidity derived from the Platreef modelled data (2009-2011)

Relative Humidity (%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Monthly Max.	68	66	63	70	67	67	79	71	65	65	61	63	67
Monthly Min.	63	61	61	62	61	64	67	66	62	59	60	58	62
Monthly Ave.	65	63	65	67	65	66	72	68	64	62	60	60	65

6.4.3 Precipitation

As shown in Table 6-4, the three year annual maximum, minimum and average monthly precipitation rates for the Platreef site are 106.9 mm, 47.9 mm and 76.4 mm, respectively. The highest monthly maximum precipitation (266.4 mm) occurs for June. The rate decreases down to 8.1 mm in July. The monthly minimum precipitation ranges between 191.3 mm in January and 0 mm in July and August.

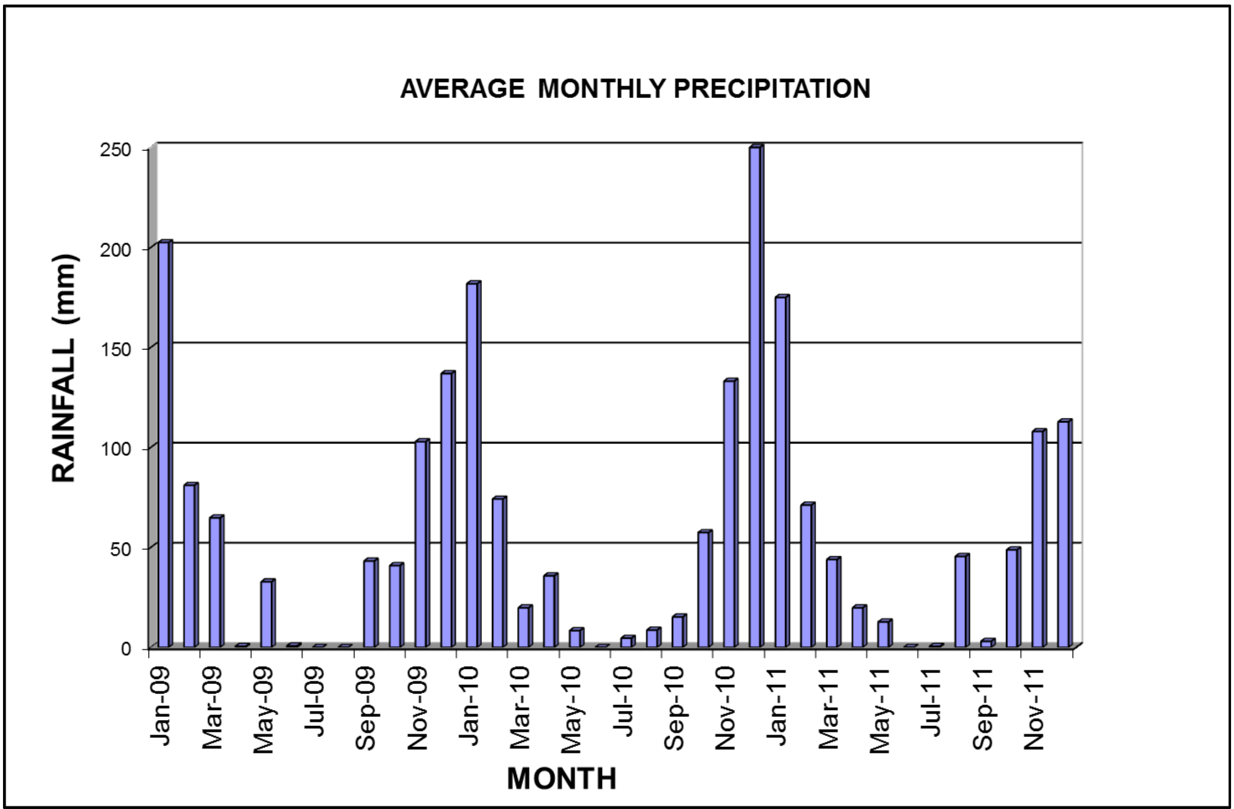

Figure 6-7: Average Monthly Precipitation derived from the Platreef modelled data (2009-2011)

Table 6-4: Average Monthly Precipitation derived from the Platreef modelled data (2009-2011)

Precipitation (mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Monthly Max.	202	81	65	36	33	1	5	45	43	57	133	304	84
Monthly Min.	175	71	20	1	8	0	0	0	3	41	103	113	45
Monthly Ave.	186	75	18	19	18	0	2	18	20	49	115	185	59

6.4.4 Evaporation

As shown in

Table 6-5, the annual maximum, minimum and average monthly evaporation rates for the Potgietersrus (Mokopane) area for the period 1957-1987 are 244 mm, 130 mm and 178 mm, respectively. The highest monthly maximum evaporation (332.2 mm) occurs for November. The rate decreases significantly down to 121.6 mm in June. The monthly minimum evaporation ranges between 200.7 mm in December and 69.9 mm in June.

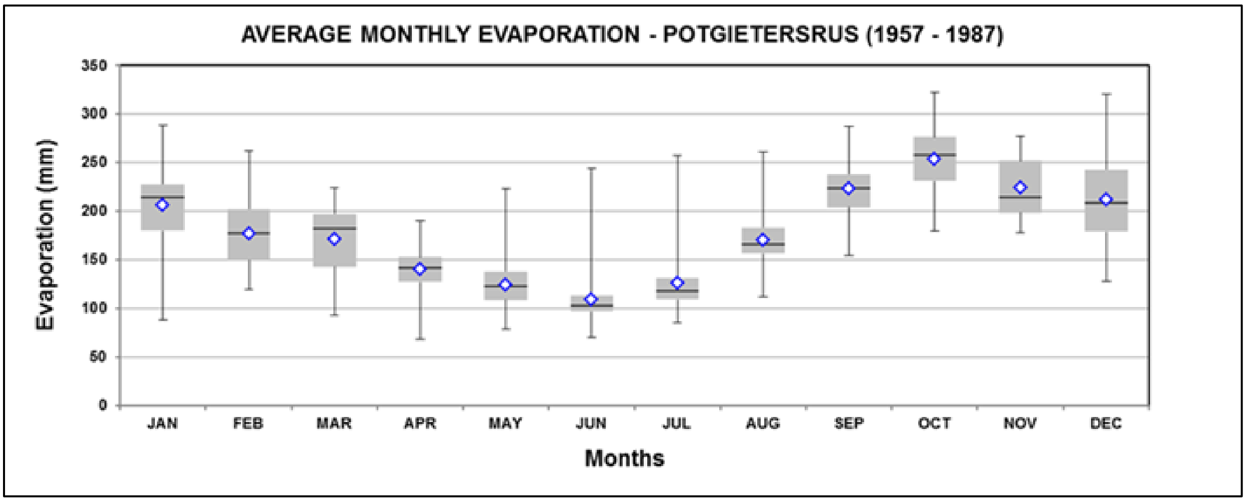

Figure 6-8: Average Monthly Evaporation for Mokopane (Potgietersrus) S-Pan Evaporation Station (1957 – 1987) (Source: South African Weather Service)

Table 6-5: Maximum, minimum and average monthly evaporation rates for the Mokopane (Potgietersrus) (Symon's Pan) S-Pan evaporation station for 1957-1987 period (South African Weather Service)

Evaporation (mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Monthly Max.	289	262	224	190	223	244	257	261	288	322	277	320	289
Monthly Min.	88	120	93	68	79	70	85	111	155	180	178	128	88
Monthly Ave.	206	177	171	141	124	109	126	170	224	253	224	212	206

6.4.5 Boundary Layer Properties and Atmospheric Stability

The region of the atmosphere governing transport and dispersion of the majority of the pollutants is the planetary boundary layer. This layer is defined as the layer where the wind structure is influenced by the surface of the Earth.

The height of the planetary boundary layer varies with the atmospheric stability and this is important for the concentrations of pollutants in the air because the majority of the pollutant mass typically is confined within this layer. During night-time when conditions in most cases are stable, the planetary boundary layer is shallow, down to 20-50 metres and the surface concentration of pollutants can therefore be quite high, especially close to emission sources that are active during the night. Under unstable conditions the planetary boundary layer can be as high as 2 kilometres and pollutants are in this case distributed in the air column mainly by convective turbulence. In the vicinity of the top of the boundary layer, the horizontal winds are typically stronger and the pollutants that end up at these higher levels may be transported far away from the emission sources. In neutral conditions emitted pollutants are quickly mixed in the air by mechanical turbulence and the surface concentration is not particularly high. During neutral conditions the strong horizontal wind speeds can transport pollutants across large distances.

The atmospheric conditions may be divided into three broad classes in terms of stability: neutral, stable and unstable conditions. These major three categories are characterised by the following:

- *Neutral* conditions where the temperature is homogeneous throughout the boundary layer. This situation typically occurs in the transition from day to night and is characterised by strong winds and clouds and large amounts of mechanical turbulence.
- *Stable* conditions where the temperature is lowest close to the surface and increases towards the top of the boundary layer. This situation typically occurs during night-time or in winter situations and is characterised by little turbulence and a strong stratification of the planetary boundary layer which is quite shallow. This class can be further divided into stable and very stable classes.
- *Unstable* conditions where the temperature of the air closest to the surface is higher than the temperature of the air above it. This situation typically occurs during daytime at summer when the sun is shining and it is characterised by large amounts of convective turbulence usually resulting in the formation of cumulus clouds during the day. This class can be further divided into very unstable, moderately unstable and unstable classes.

The refined classes of atmospheric stability classes are further defined in the Table 6-6 and Table 6-7.

Table 6-6: Atmospheric Stability Classes.

Designation	Stability Class	Atmospheric Condition
A	Very unstable	Calm wind, clear skies, hot daytime conditions
B	Moderately unstable	Clear skies, daytime conditions

Designation	Stability Class	Atmospheric Condition
C	Unstable	Moderate wind, slightly overcast daytime conditions
D	Neutral	High winds or cloudy days and nights
E	Stable	Moderate wind, slightly overcast night-time conditions
F	Very stable	Low winds, clear skies, cold night-time conditions

Table 6-7: Meteorological conditions that define the Pasquill stability classes

Surface wind speed	Daytime incoming solar radiation			Night time cloud cover	
m/s	Strong	Moderate	Slight	> 50%	< 50%
< 2	A	A – B	B	E	F
2 – 3	A – B	B	C	E	F
3 – 5	B	B – C	C	D	E
5 – 6	C	C – D	D	D	D
> 6	C	D	D	D	D

*Note: Class D applies to heavily overcast skies, at any wind speed day or night.

7 LEGAL CONTEXT

Guidelines provide a basis for protecting public health from adverse effects of air pollution and for eliminating, or reducing to a minimum, those contaminants of air that are known or likely to be hazardous to human health and wellbeing World Health Organization (WHO, 2000). Once the guidelines are adopted as standards, they become legally enforceable. These standards 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.

The prevailing legislation in the Republic of South Africa with regards to the Air Quality field is the National Environment Management: Air Quality Act (Act No. 39 of 2004) (NEM: AQA). The NEM: AQA serves to repeal the Atmospheric Pollution Prevention Act (45 of 1965) (APPA) and various other laws dealing with air pollution.

According to the Act, the then Department of Environment Affairs and Tourism (now 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.

Section 24 in Chapter 2 (Bill of Rights) of Constitution of the Republic of South Africa, 1996 dealing with the Environment states that:

Everyone has the right:

- to an environment that is not harmful to their health or well-being; and
- to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that –
  - prevent pollution and ecological degradation;
  - promote conservation; and
  - secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

It is this constitutional imperative that underpins the environmental protection laws such as NEM: AQA.

A fundamental aspect of the new approach to the air quality regulation, as reflected in the NEM: AQA, is the establishment of National Ambient Air Quality Standards (NAAQS). These standards provide the goals for air quality management plans and also provide the benchmark by which the effectiveness of these management plans is measured. The NEM:AQA provides for the identification of priority pollutants and the setting of ambient standards with respect to these pollutants.

The Act ensures that air quality planning is integrated with existing activities. The implications of this are that plans that are required in terms of the NEMA must incorporate consideration of air quality. In addition, Integrated Development Plans (IDP's) developed by local and district municipalities, also have to take air quality into account.

The Act describes various regulatory tools that should be developed to ensure the implementation and enforcement of air quality management plans. These include:

- *Priority Areas*, which are air pollution 'hot spots';
- *Listed Activities and Minimum Emission Standards*[1], under Section 21 of the AQA which are 'problem' processes that require an Atmospheric Emission Licence (AEL) in order to operate;
- *Controlled Emitters*, which includes the setting of emission standards for 'classes' of emitters, such as motor vehicles, incinerators, etc., as well as controlled fuels;
- *Control of Dust*;
- *Control of Noise*; and
- *Control of Odours*.

In order to facilitate implementation of and compliance with the NEM: AQA, the Act provides for government to turn down AEL Licence applications from applicants who have a problematic record of air quality management practices. It also provides for government to demand that 'problem' industries appoint qualified air quality practitioners.

The Act also deals with South Africa's international obligations in terms of air quality management. Provision is made for the control of processes impacting on South Africa's neighbours and the global atmosphere in general, as well as trans-boundary air pollution.

The Act further regulates the establishment of the National Framework for Air Quality Management (NFAQM). The Framework was published in September 2007 and under its provisions public was invited to submit comments on proposed amendments in February this year (2013).

The Act as a whole is defined by the adoption of a comprehensive approach to the management of offences and penalties, which includes the provision of transitional arrangements. The Act provides for flexibility and proactive approach, so that permissible emission limits can be amended on a progressive basis in order to achieve set air quality standards. As a consequence, the NEM: AQA came into full effect only on 1 April 2010. Certain sections of the Act came into force on 11 September 2005, but the Minister excluded other sections until such time as local authorities had the capacity and skills to deal with the implementation of the legislation. Significantly, many of the excluded sections related to listed activities and licensing of listed activities. The excluded sections were brought into

---

[1] Minimum Emission Standards are the highest emission standards at which a Listed Activity will be allowed to operate under normal working conditions. If a definition of the process operated on the plant is matching the process description under established Listed Activities, the plant operates a Listed Activity and it must then be in possession of an Atmospheric Emission Licence indicating the specific Listed Activity(s) operated on the facility. Not only must the plant be in possession of an Atmospheric Emission Licence, it must also comply with the conditions within the licence to comply with NEM:AQA.

effect on the 31 March 2010, and the old Atmospheric Pollution Prevention Act (APPA) of 1965 was fully repealed on the same date.

The Act also required the Minister or the Member of Executive Council (MEC) to identify and publish activities which result in atmospheric emissions that require an AEL before they can operate. 1 April 2010 also marked the date when the new list of activities requiring Atmospheric Emissions Licenses to operate was promulgated and, with this, the levelling of the atmospheric emission "playing field" through the setting of minimum emissions standards for all these listed activities was implemented.

Government Notice 248 (GN248:2010) established and identified activities which result in atmospheric emissions for which an AEL must be obtained before operation can take place.

GN248:2010 lists the ten main categories, each with its associated subcategories (more detailed description of the exact activities and minimum emission standards), for which an AEL needs to be obtained. The main categories include:

- Combustion Installations
- Petroleum Industry
- Carbonization and Platinum Gasification
- Metallurgical Industry
- Mineral Processing, Storage and Handling
- Organic Chemicals Industry
- Inorganic Chemicals Industry
- Disposal of Hazardous and General Waste
- Pulp and Paper Manufacturing Activities
- Animal Matter Processing.

The Notice further states that the minimum emission standards will be applicable to both permanently operating plants and for experimental (pilot) plants with a design capacity equivalent to the one of a listed activity. Minimum standards are applicable under normal working conditions, and any normal start-ups, maintenance, upset and shut-down conditions that exceed a period of 48 hours will be subject to Section 30 of the AQA, which deals with control of emergency accidents. Upset conditions means any temporary failure of air pollution control equipment or failure of a process to operate in a normal or usual manner that leads to an emission standard being exceeded.

Any new plant must comply with the new plant minimum emission standards as contained in Part 3 of the Notice (which gives detailed account of minimum emission standards) on the date of publication of the notice, which was 31 March 2010.

Department of Environmental Affairs (DEA) has established the National Ambient Air Quality Standards for the criteria pollutants in the Government Notice - GN1210:2009 (Table 7-1).

Table 8 gives an overview of the established NAAQS, as well reference methods and compliance dates for criteria pollutants.

Table 7-1: National Ambient Air Quality Standards as of 24 December 2009

National Ambient Air Quality Standards for Sulphur Dioxide (SO_2)				
AVERAGING PERIOD	**LIMIT VALUE ($\mu g/m^3$)**	**LIMIT VALUE (ppb)**	**FREQUENCY OF EXCEEDANCE**	**COMPLIANCE DATE**
10 Minutes	500	191	526	Immediate
1 hour	350	134	88	Immediate
24 hours	125	48	4	Immediate
1 year	50	19	0	Immediate
The reference method for the analysis of SO_2 shall be ISO 6767.				

National Ambient Air Quality Standards for Nitrogen Dioxide (NO_2)				
AVERAGING PERIOD	**LIMIT VALUE ($\mu g/m^3$)**	**LIMIT VALUE (ppb)**	**FREQUENCY OF EXCEEDANCE**	**COMPLIANCE DATE**
1 hour	200	106	88	Immediate
1 year	40	21	0	Immediate
The reference method for the analysis of NO_2 shall be ISO 7996.				

National Ambient Air Quality Standards for Particulate Matter (PM_{10})			
AVERAGING PERIOD	**LIMIT VALUE ($\mu g/m^3$)**	**FREQUENCY OF EXCEEDANCE**	**COMPLIANCE DATE**
24 hour	120	4	Immediate – 31 December 2014
24 hour	75	4	1 January 2015
1 year	50	0	Immediate – 31 December 2014
1 year	40	0	1 January 2015
The reference method for the determination of the PM_{10} fraction of suspended particulate matter shall be EN 12341.			

National Ambient Air Quality Standards for Ozone (O_3)				
AVERAGING PERIOD	**LIMIT VALUE ($\mu g/m^3$)**	**LIMIT VALUE (ppb)**	**FREQUENCY OF EXCEEDANCE**	**COMPLIANCE DATE**
8 hours (running)	120	61	11	Immediate
The reference method for the analysis of ozone shall be the UV photometric method as described in SANS 13964.				

National Ambient Air Quality Standards for Benzene (C_6H_6)				
AVERAGING PERIOD	**LIMIT VALUE ($\mu g/m^3$)**	**LIMIT VALUE (ppb)**	**FREQUENCY OF EXCEEDANCE**	**COMPLIANCE DATE**
1 year	10	3.2	0	Immediate – 31 December 2014

1 year	5	1.6	0	1 January 2015
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)				
AVERAGING PERIOD	**LIMIT VALUE ($\mu g/m^3$)**	**LIMIT VALUE (ppb)**	**FREQUENCY OF EXCEEDANCE**	**COMPLIANCE DATE**
1 year	0.5		0	Immediate
The reference method for the analysis of lead shall be ISO 9855.				

National Ambient Air Quality Standards for Carbon Monoxide (CO)				
AVERAGING PERIOD	**LIMIT VALUE (mg/m^3)**	**LIMIT VALUE (ppm)**	**FREQUENCY OF EXCEEDANCE**	**COMPLIANCE DATE**
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 DEA has established National Ambient Air Quality Standards for particulate matter of aerodynamic diameter less than 2.5 micron metres in June 2012 (GN486: 2012) as depicted in Table 9.

Figure 7-1: Established National Ambient Air Quality Standards for Particulate Matter ($PM_{2.5}$)

National Ambient Air Quality Standards for Particulate Matter ($PM_{2.5}$)			
AVERAGING PERIOD	**LIMIT VALUE ($\mu g/m^3$)**	**FREQUENCY OF EXCEEDANCE**	**COMPLIANCE DATE**
24 hours	65	0	Immediate – 31 December 2015
24 hours	40	0	1 January 2016 – 31 December 2029
24 hours	25	0	01 January 2030
1 year	25	0	Immediate – 31 December 2015
1 year	20	0	1 January 2016 – 31 December 2029
1 year	15	0	01 January 2030
The reference method for the determination of PM2.5 fraction of suspended particulate matter shall be EN 14907.			

In December 2012 DEA published the Draft National Dust Control Regulations (GN1007:2012) which relate to ambient dust monitoring and propose dust fall limits at the boundary or beyond the boundary of premises for residential and light commercial areas, as well as areas other than residential and light commercial.

The proposed limits are as follows:

- **600** mg/m^2/day averaged over 30 days in residential and light commercial areas measured using reference method ASTM D1739; or
- **1200** mg/m^2/day averaged over 30 days in areas other than residential and light commercial areas measured using reference method ASTM D1739.

In the above-mentioned notice terms like target, action and alert thresholds have been 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 would require dedicated mitigation plans once it is in force.

The proposed National Dust fallout standard is given in the below.

Table 7-2: 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	D < 600	Two within a year, not sequential months
Non-Residential Area	600 < D < 1200	Two within a year, not sequential months

This project will look at the compliance in respect of prevailing South African standards, as well as guidelines prescribed the World Bank and the International Finance Corporation.

7.1 International Finance Corporation and World Bank Guidelines

As of April 30, 2007, new versions of the International Finance Corporation (IFC) Environmental, Health, and Safety Guidelines (known as the 'EHS Guidelines') are now in use. IFC is a member of the World Bank Group. These guidelines replace those documents previously published in Part III of the Pollution Prevention and Abatement Handbook and on the IFC website.

The IFC EHS Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP). The EHS Guidelines contain the performance levels and measures that are generally considered to be achievable in new facilities by existing technology at reasonable costs. Application of the EHS Guidelines to existing facilities may involve the establishment of site-specific targets, with an appropriate timetable for achieving them. The applicability of the EHS Guidelines should be tailored to the hazards and risks established for each project on the basis of the results of an environmental assessment in which site-specific variables, such as host country context, assimilative capacity of the environment, and other project factors, are taken into account (IFC, 2007).

When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever is more stringent. If less stringent levels or measures are appropriate in view of specific project circumstances, a full and detailed justification for any proposed alternatives is needed as part of the site-specific environmental assessment. This justification should demonstrate that the choice for any alternate performance levels is protective of human health and the environment.

The World Bank has developed a set of guidelines and standards for specific process (including Platinum Mines and Platinum Processing) and for individual pollutants (such as particulates, sulphur dioxide and oxides of nitrogen).

Projects with significant sources of air emissions, and potential for significant impacts to ambient air quality, should prevent or minimize impacts by ensuring that:

- Emissions do not result in pollutant concentrations that reach or exceed relevant ambient quality guidelines and standards by applying national legislated standards, or in their absence, the current WHO Air Quality Guidelines (Table 7-3), or other internationally recognized sources;
- Emissions do not contribute a significant portion to the attainment of relevant ambient air quality guidelines or standards. As a general rule, IFC Guideline suggests 25 percent of the applicable air quality standards to allow additional, future sustainable development in the same airshed.

Table 7-3: World Health Organization Ambient Air Quality Guidelines (used by IFC)

WHO Ambient Air Quality Guidelines[2][3]		
Pollutant	**Averaging Period**	**Guideline value in µg/m[3]**
Sulfur dioxide (SO_2)	24-hour	125 (Interim target-1) 50 (Interim target-2) 20 (guideline)
Sulfur dioxide (SO_2)	10 minute	500 (guideline)
Nitrogen dioxide (NO_2)	1-year	40 (guideline)
Nitrogen dioxide (NO_2)	1-hour	200 (guideline)
Particulate Matter PM10	1-year	70 (Interim target-1) 50 (Interim target-2) 30 (Interim target-3) 20 (guideline)
Particulate Matter PM10	24-hour	150 (Interim target-1) 100 (Interim target-2) 75 (Interim target-3) 50 (guideline)
Particulate Matter PM2.5	1-year	35 (Interim target-1) 25 (Interim target-2) 15 (Interim target-3) 10 (guideline)
Particulate Matter PM2.5	24-hour	75 (Interim target-1) 50 (Interim target-2) 37.5 (Interim target-3) 25 (guideline)
Ozone	8-hour daily maximum	160 (Interim target-1) 100 (guideline)

8 HEALTH EFFECTS OF THE IDENTIFIED POLLUTANTS

8.1 Particulates

The main pollutant of concern identified as a result of the construction and operational phases of the mining development will be the particulate matter, whether in the form of total suspended particulates (TSP), PM_{10} or $PM_{2.5}$.

---

[2] 7 World Health Organization (WHO). Air Quality Guidelines Global Update, 2005. PM 24-hour value is the 99th percentile.

[3] Interim targets are provided in recognition of the need for a staged approach to achieving the recommended guidelines.

Particles 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). The fine particles contain the secondarily formed aerosols such as sulphates and nitrates, combustion particles and recondensed organic and metal vapours. The coarse particles contain earth crust materials and fugitive dust from roads and industries (Fenger, 2002).

In terms of health effects, particulate air pollution is associated with complaints of the respiratory system (WHO, 2000). Particle size is important for health because it controls where in the respiratory system a given particle deposits. 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 extrathoracic part of the respiratory tract while smaller particles are deposited into the smaller airways leading to the respiratory bronchioles (WHO, 2000).

Particulate matter (PM) is a type of air pollution that is present wherever people live. It is generated mainly by human activities: transport, energy production, domestic fuel combustion and by a wide range of industries. There is no evidence of a safe level of exposure or a threshold below which no adverse health effects occur.

The range of adverse health effects of PM is broad, involving respiratory and cardiovascular systems in children and adults. Both short- and long-term exposures lead to adverse health effects. Very young children, probably including unborn babies, are particularly sensitive to the adverse effects of PM. The evidence is sufficient to infer a causal relationship between exposure to PM 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. Increased mortality from cardiovascular and respiratory diseases and from lung cancer has been observed in residents of more polluted areas.

Based on the existing evidence of adverse health effects at low levels of exposure, WHO revised its Air Quality Guidelines (AQG) for PM in 2005. For $PM_{2.5}$, the new AQG values are 10 $\mu g/m^3$ for the annual average and 25 $\mu g/m^3$ for the 24-hour mean (not to be exceeded for more than 3 days/year). The corresponding guidelines for PM_{10} were set as 20 $\mu g/m^3$ and 50 $\mu g/m^3$.

Ambient PM_{10} concentrations are a good approximation of population exposure to PM from outdoor sources. 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 8-1.

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 (PEF) 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 FEV_1 (Forced Expiratory Volume over one second) for each 100 µg/m^3 increase in the daily PM_{10} average.

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).

Studies have indicated an association between lung function and chronic respiratory disease and airborne particles. Older studies by Chestnut *et al* (1991) found that FVC (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 by Dockery *et al* (1993) 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 8-1: Short-term and long-term health effects associated with exposure to PM (after 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

9 BASELINE ASSESSMENT

Baseline monitoring and assessment of atmospheric pollutants was appraised using data from the SAAQIS database. The Air Quality Monitoring Station in Mokopane is one of the three air quality monitoring stations commissioned for the Waterberg-Bojanala Priority Area (WBPA) in 2012. The other two stations are in Lephalale and Thabazimbi. The National Priority Area covers the Bojanala District in the North West Province and the Waterberg District in the Limpopo Province. The database contains measurement for known priority pollutants, recording data based on the recommended averaging period. Archived measurements for the past five months are discussed below to emphasize the background conditions.

Further, results from ambient air quality monitoring conducted in 2003/2004 by WSP Walmsley are presented and discussed as additional background information.

9.1 Measured Concentrations

9.1.1 PM_{10} Concentration

In literature, particulate matter (specifically $PM_{2.5}$ and PM_{10}) represents danger to the receiving population as it can penetrate into indoor environment increasing the exposure period to such pollutants. The PMs have the ability to penetrate the trachea-bronchial and alveolar regions of the human respiratory system leading to respiratory diseases. If the PM contains heavy metals, the risk to human is exacerbated based on the exposure period, age and wellbeing of the individual.

Average daily PM_{10} concentrations recorded at the Mokopane Ambient Air Quality Station are presented in Figure 9-1. The average measured background PM_{10} concentration for the last five months is generally within the current NAAQS for PM_{10} of 120 µg/m³. The limit was exceeded once in December as seen in the figure below. If the future NAAQS ambient standard of 75 µg/m³ is considered (which will come into effect on the 1st of January 2015), there are several days exceeding the limit value. However, the WHO Guideline of 50 µg/m³ is actually exceeded on a number of occasions (red dotted line - Figure 9-1).

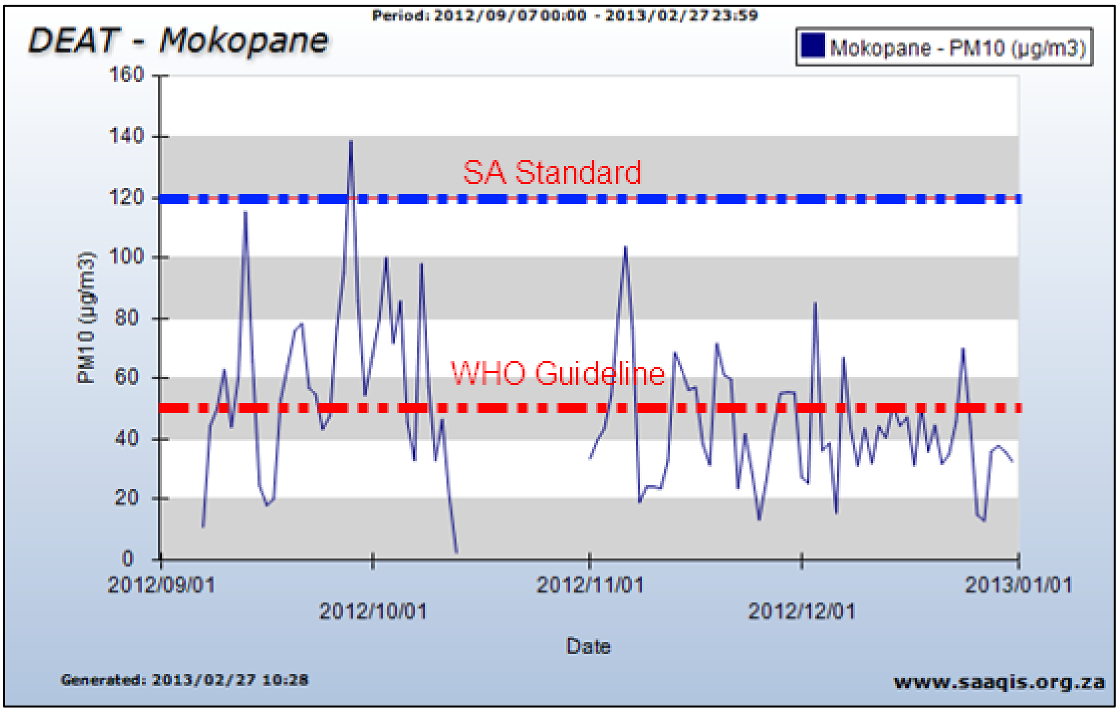

Figure 9-1: PM10 concentrations from the WBPA air quality monitoring station in Mokopane

Measurements conducted in 2003/2004 by WSP Walmsley confirm historical levels of ambient particulate matter in the proposed Platreef mining area. The $PM_{2.5}$ and PM_{10} levels were measured using Single Striker Filter Units (SSFU) installed at Mahwelereng to continuously monitor ambient concentrations of pollutants. Figure 9-2 shows the PM_{10} concentrations from April 2003 to April 2004 with five of the twelve months of sampling exceeding the South African Standard of 120 µg/m³. If reference is made to the IFC (WHO – Guideline), only one of the twelve months of sampling was within compliance (March 2004).

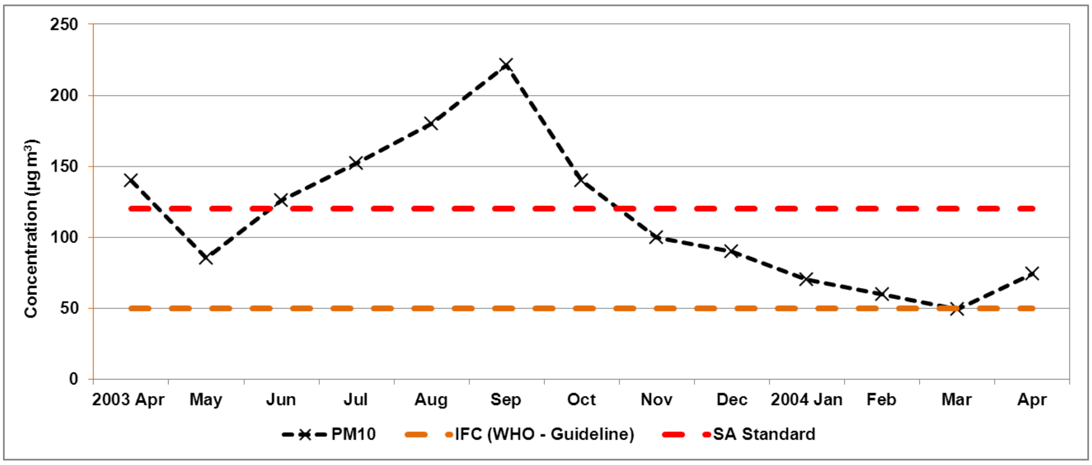

Figure 9-2: PM_{10} concentration measured in the Platreef Mining Area (April 2003 - April 2004)

9.1.2 $PM_{2.5}$ Concentrations

The National Ambient Air Quality Standard for particulate matter with aerodynamic diameter less than 2.5 microns ($PM_{2.5}$) was promulgated on 29 June 2012 by the Minister of Water and Environmental Affairs. Ever since, ambient $PM_{2.5}$ standard of 65 µg/m³ is in force until 31 December 2015, and a new standard of 40 µg/m³ would take effect from 1 January 2016.

The $PM_{2.5}$ concentration observed over the five months period is observed to be well below the IFC (WHO guideline) value of 25 µg/m^3 and the NAAQS of 65 µg/m^3 (which takes immediate effect from the date of promulgation) as shown Figure 9-3.

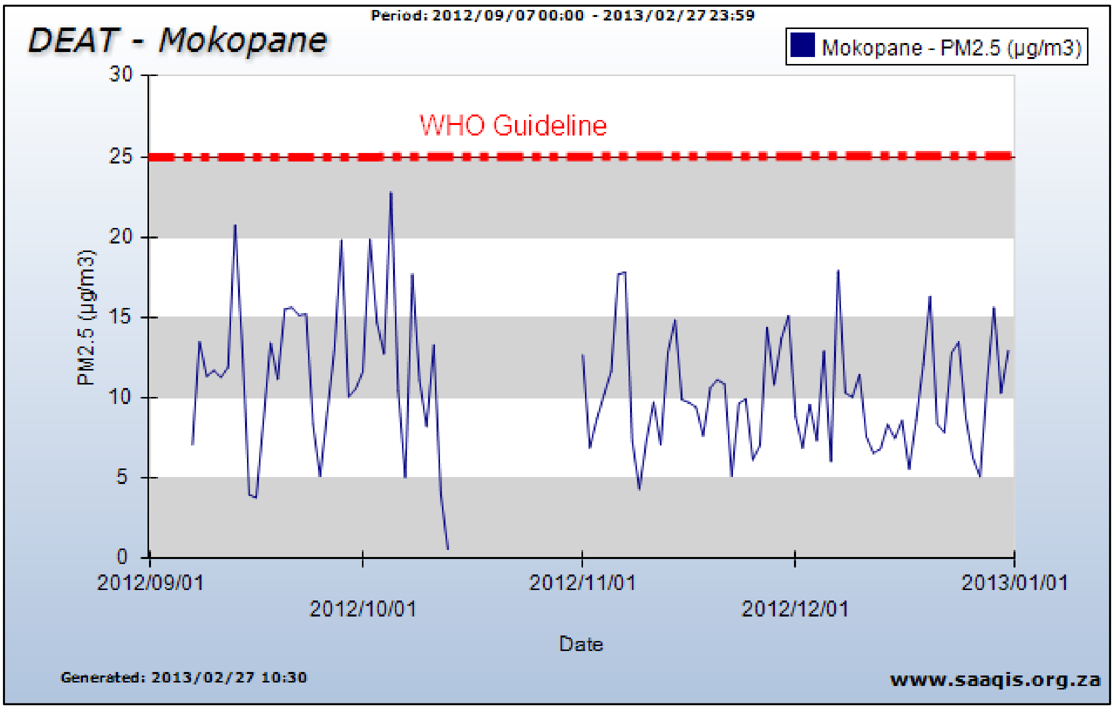

Figure 9-3: $PM_{2.5}$ concentrations from the WBPA air quality monitoring station in Mokopane

The results of the monitoring of $PM_{2.5}$ conducted by WSP Walmsley in 2003/2004 are presented below (Figure 9-4). If results obtained are compared to the current standard, two months (August and September) of the twelve months of sampling were not compliant. The values measured were exceeding the 65 µg/m³ recommended by the current standard. On the other hand, nine months recorded values in exceedance of the IFC (WHO – Guideline) of 25 µg/m^3.

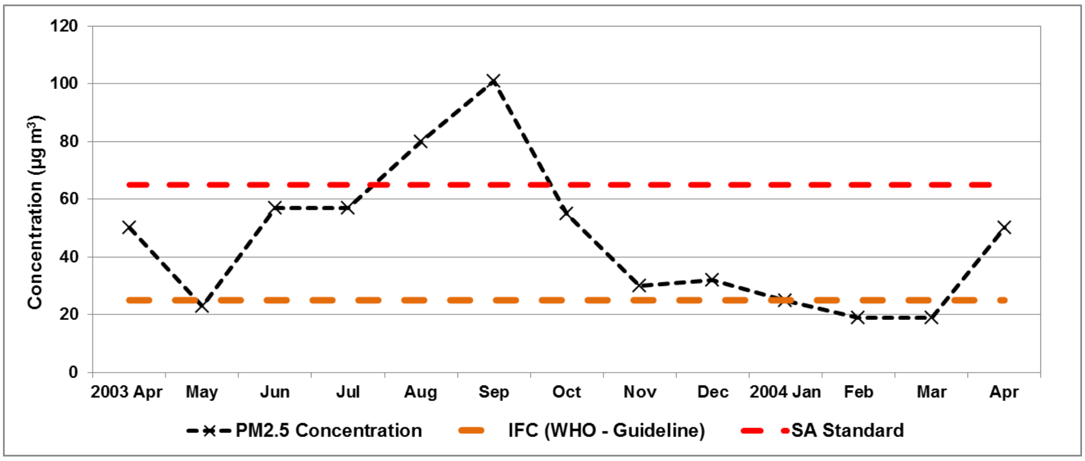

Figure 9-4: PM2.5 concentration measured in the Platreef Mining Area (April 2003 - April 2004)

9.1.3 Carbon Monoxide

The Carbon Monoxide (CO) concentration measured is below the recommended NAAQS 8-hr and 1-hr limit values of 8.7 ppm and 26 ppm respectively (Figure 9-5 and Figure 9-6). The peaks observed in CO concentration are not in exceedance of the standard. The pollutant is known to contribute to greenhouse effect and global warming.

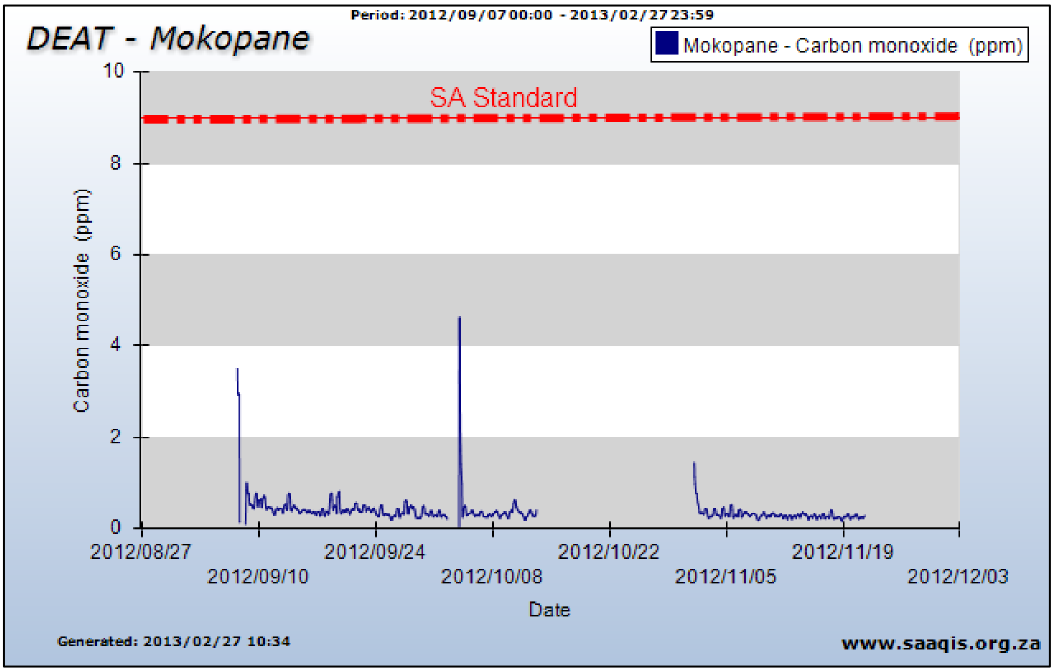

Figure 9-5: Carbon Monoxide from the WBPA air quality monitoring station in Mokopane (8 hourly average)

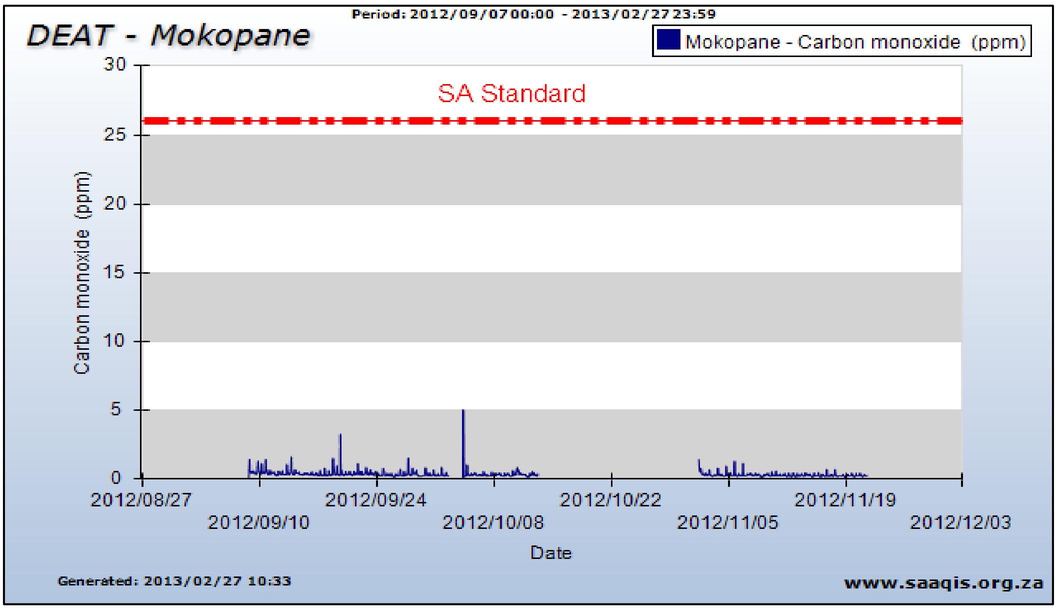

Figure 9-6: Carbon Monoxide concentrations from the WBPA air quality monitoring station in Mokopane (Hourly average)

9.1.4 NO_2/NO_x Concentration

The NO_2 standard specified by the WHO and South African NAAQS are the same - 200 µg/m^3 (106 ppm). It is assumed that the complete conversion of all emitted NO to NO_2 has occurred, as per US EPA's Guideline on Air Quality Models, Appendix W to 40 CFR Part

51, for Tier 1 screening approach. As seen in Figure 9-7, the recorded values for NO_x are generally below this limit, except an incident in October with a peak that exceeded the limit slightly.

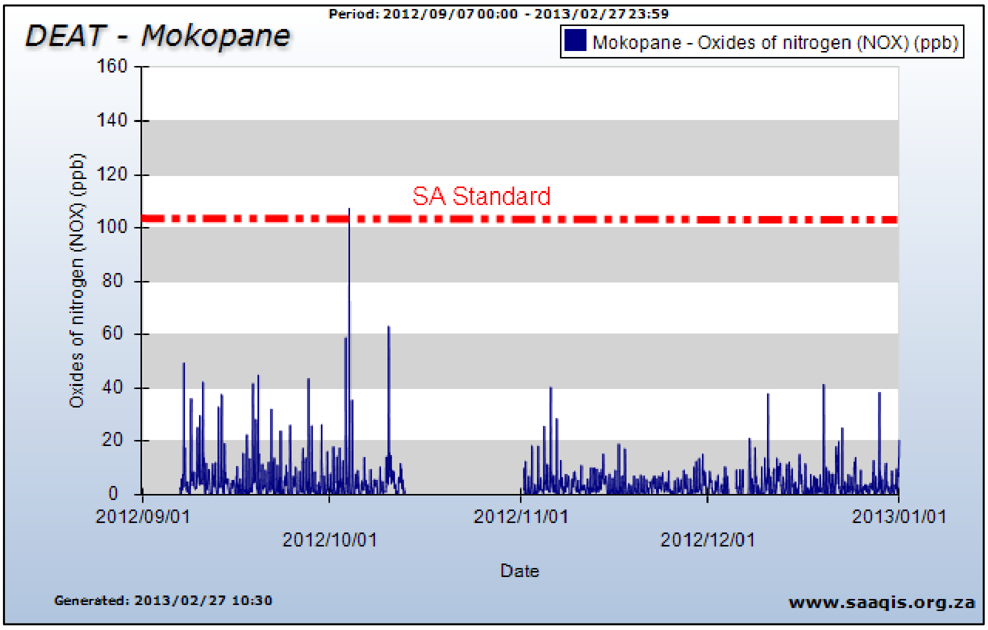

Figure 9-7: Nitrogen dioxide concentrations from the WBPA air quality monitoring station in Mokopane (Hourly average)

9.1.5 Sulfur Dioxide

The SO_2 concentration observed over the five months period is seen to be very low with values generally below 10 ppb, a factor of 4 below the prescribed SA 24 hours limit of 48 ppb (Figure 9-8). The values are also within WHO recommended guideline value of 20 ppb.

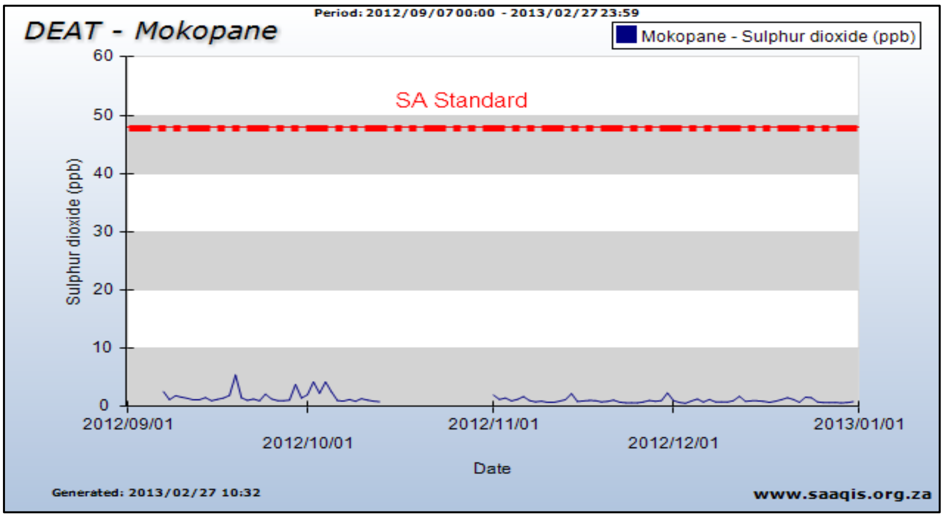

Figure 9-8: SO_2 concentrations from the WBPA air quality monitoring station in Mokopane (daily average)

Measurements observed over a 10-minutes averaging period were within SA NAAQS value of 191 ppb, except on one occasion when the recommended limit value was violated as seen in the Figure 9-9, but below the WHO guideline value of 500 ppb.

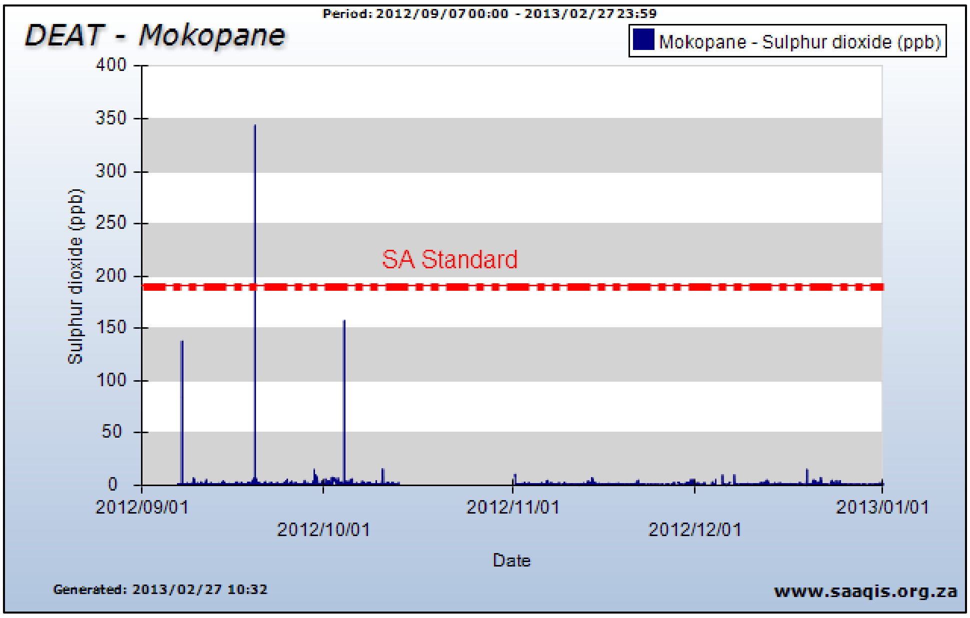

Figure 9-9: SO_2 concentrations from the WBPA air quality monitoring station in Mokopane (10 minute averages)

9.1.6 Benzene

The plot depicted in Figure 9-10 indicates the levels of Benzene observed over the five months period. From the measurements, there are a number of times when the NAAQS limit of 3.2 ppb was exceeded slightly. Once in September, ambient concentration went above 16 ppb.

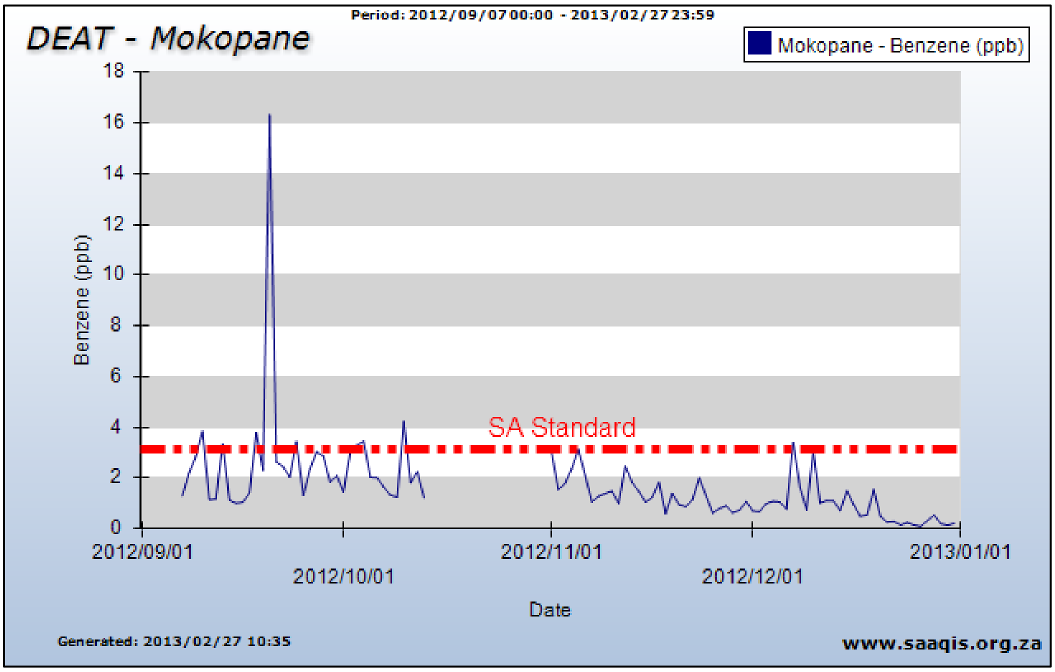

Figure 9-10: Benzene concentrations from the WBPA air quality monitoring station in Mokopane (daily average)

9.1.7 Ozone

Ozone (O_3) formed in the atmosphere by the reaction of nitrogen oxides, hydrocarbons and sunlight. In Figure 9-11, O_3 levels are within the recommended South African standard of 61 ppb (120 µg/m^3), with some exceedances observed during the first few days of February 2012. If WHO guideline value is considered, several exceedances can be seen in Figure 9-11.

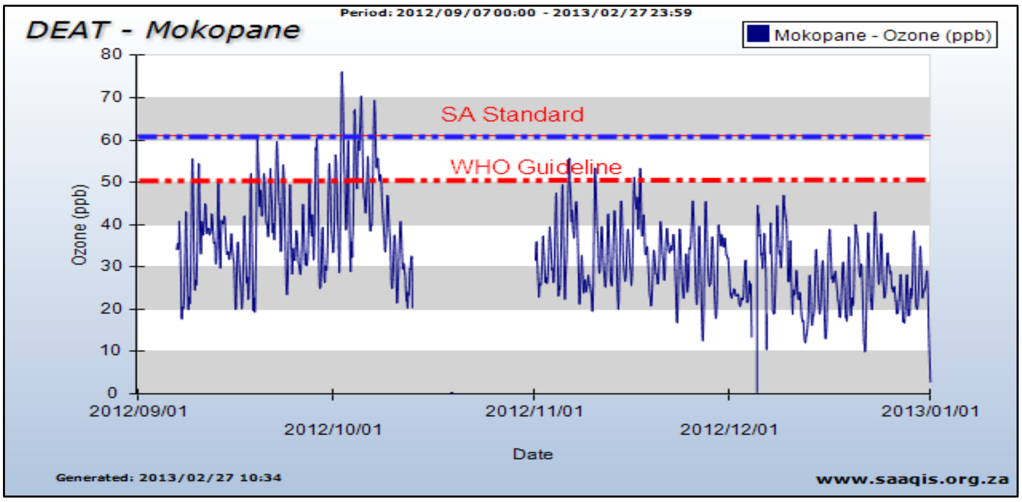

Figure 9-11: Ozone concentrations from the WBPA air quality monitoring station in Mokopane (8-hourly average)

9.2 Measured Dust Fallout Levels

Dust fallout monitoring network was commissioned in August 2013 to monitor the ambient dust deposition rates in the Platreef area. The network was commissioned at the selected sensitive receptor areas around the proposed mine area. Dust fall out monitoring will be conducted over 30 day periods and quarterly reports prepared for the mine to submit to relevant authorities.

During the monitoring window, exposure will comply with the standard operating procedure of 30±2 days. The dust deposition records observed are compared against the relevant standard. Since the current monitoring just commenced, reference will be made to the measurements conducted by WSP Walmsley in 2003/2004 in the Platreef mining area (Figure 9-12). If monthly dust fallout rates measured in 2003/2004 are compared to the current dust fallout limits spelt out in the proposed National Dust Control Regulation, soon to take effect, the area will be in violation of the residential and industrial limits 92 % and 67 % of the sampling period. Although the permitted Frequency of exceedance is twice within a year (not sequential months), the area recorded seven consecutive months of exceedance, with dust deposition rates well over 1 500 mg/m^2/day. The above background results from historical data are considered a serious violation of the current standard.

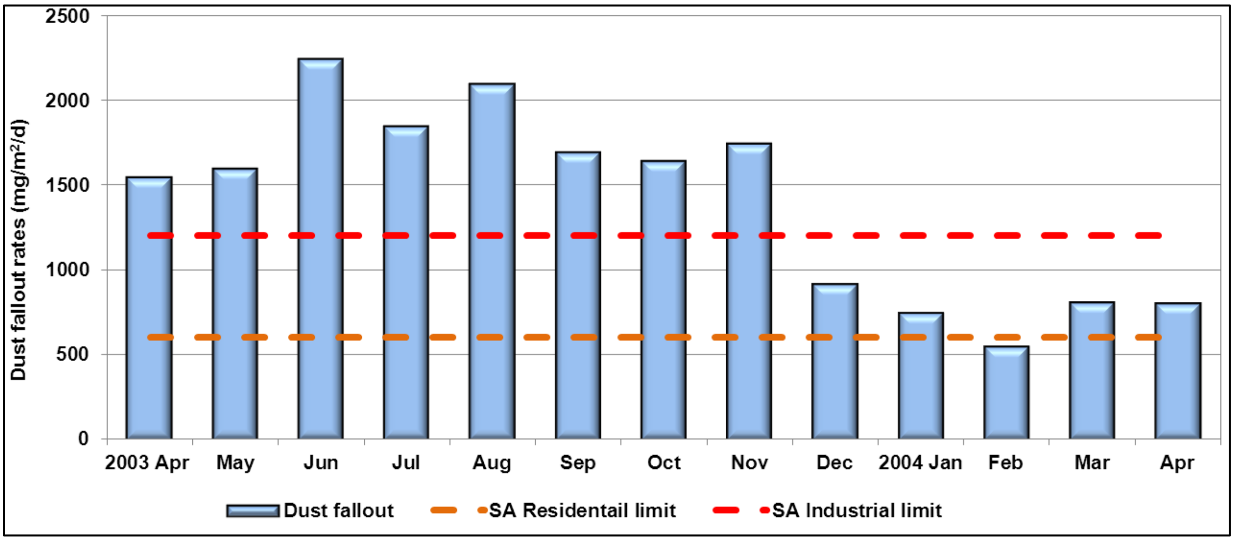

Figure 9-12: Monthly dust fallout rates observed in the Platreef Mining Area (April 2003 - April 2004)

The seasonal average dust deposition rates per site confirm the variability from season to season in the area (Figure 9-13). In autumn, all the sites (seven in total) exceeded the residential and industrial limit values of 600 mg/m^2/day and 1200 mg/m^2/day – with the highest value reaching 2760 mg/m^2/day (site – Ga-Madiba). In winter, only one site was within compliance – as the other sites exceeded residential and industrial limit values. The highest value was observed to be above 3 350 mg/m^2/day in winter. In the spring, majority of the sites were in violation of the residential and industrial standards as in previous season.

Lastly, the values recorded in summer were within the residential and industrial limits, except at the site Moholerwe with dust deposition rates of 740 mg/m^2/day.

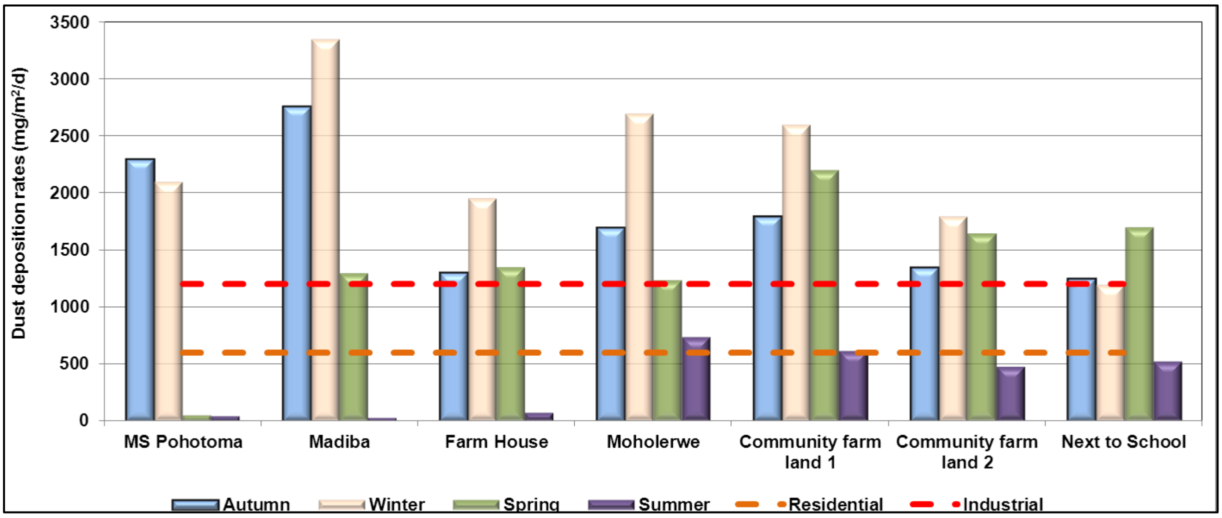

Figure 9-13: Seasonal average dust fallout rate per monitoring site (April 2003 - April 2004)

10 EMISSIONS INVENTORY METHODOLOGY AND RESULTS

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 (NPI) Emission Estimation Technique Manuals.

Although the Platreef operation is going to be an underground working, there are various sources of emission anticipated at various stages of the mine life cycle: from the construction, operational and decommissioning phases. Emissions from the underground Platinum mine includes:

- Inhalable particulates, with aerodynamic diameters less than or equal to 10 microns (PM_{10}) and 2.5 microns ($PM_{2.5}$)from all mining sources;
- Total suspended particulates (TSP), from all mining sources;
- Gaseous emissions from underground heavy vehicle operations and blasting (from ventilation shafts), includes oxides of nitrogen (NO and NO_2, jointly known as NO_x, SO_2 and CO).

An emissions inventory was established comprising emissions for construction and operational activities at the proposed Platreef Platinum underground mine (Table 10-1). The establishment of this emissions inventory is necessary to provide the source and emissions data required as input to the dispersion model simulations. Emissions from the construction phase are considered to be localised and finite, limited to the construction period. Emissions from vehicles were not included in the run as the information regarding these parameters was not available. Gaseous emissions from the underground operations will be released via the ventilation shafts. This inventory calculated emissions from the ventilation shafts, material handling (tipping) processes (underground to RoM via a conveyor, conveyor to secondary crusher and dumps for topsoil, wasterock and ROM) as well as deposition of tailings to TSF, coupled with the particulate matter load (TSP, PM_{10} and $PM_{2.5}$).coarse particulate matter associated with the ventilation shafts is usually trapped in order to avoid clogging of the underground fans – keeping them in good working condition. It was assumed that the mine will use electricity from the national grid, and no on-site power generators for emergency situations.

Table 10-1: Activity and source of of emmissions for the proposed Platreef Platinum mine

Source	Activity
Construction You are missing the wet plant portion Also potential dust at Dried Concentrate Storage	• Berm • Roads
Drilling and Blasting	Adit area
Material handling	Front end loader to truck ▪ Topsoil (infrastructural area) ▪ Soft (adit or incline area) ▪ Hard (adit or incline area) Conveyor to RoM stockpile ▪ ROM
Vehicle activity on paved roads	Transport of concentrate to smelter via paved road
Wind erosion	Topsoil storage (Negligible) pile
	ROM stockpile
	Wasterock stockpile
	TSF stockpile
Crushing	Secondary/Tertiary Crushing and Screening
Tipping	▪ Underground to RoM ▪ Conveyor to crusher

Ventilation shafts	▪ Underground to ambient atmosphere

10.1.1 Material handling operations

During this process, the topsoil is removed using scrappers, soft and hard (blasting) of the adit area. Platinum ore are removed from the underground operation using blasting and subsequent hoisting to the surface. Thereafter, waste rock is transported to dumps and the Platinum ore to ROM Pad. From the ROM Pad it is understood that Platinum will be transported via conveyor to the secondary/tertiary crushing facilities and milling. The secondary/tertiary crusher will reduce the size of the Platinum ore which will be transported by conveyor to the milling portion of the concentrator plant. Emissions from material operations depend on various factors such as wind speed, wind direction and precipitation. The higher the moisture content of the material, the less fugitive dust will be released during the process. To calculate the emissions from the material handling operations, equations from US-EPA AP42 and Australian NPI emission factors were utilised.

10.1.2 Vehicle activity on haul roads

Activities of mine trucks will be limited to the transport of concentrate from the processing and concentrator plant to the smelter (which is outside the mine property). Transportation from ROM stockpile to crusher will be via conveyor. The ore will later be transported by conveyor from the crushing/screening to the milling portion of the concentrator plant, where the concentrate is produced. From the processing plant, a 30 tonne articulate trucks will be used to transport the concentrate to designated smelters outside the mine property. Emissions from operations associated with the use of paved roads inside the mine (Table 10-2) to the road N11 using the route given are estimated. The distances covered while transporting the concentrate have been calculated and present in below (Table 10-2).

Table 10-2: Parameters for the paved roads while transporting ore concentrate for the proposed operation

Road	Length (m)	Width (m)
Ore concentrate	3 049	10

10.1.3 Wind erosion from Waste stockpile, RoM and TSF

The topsoil and waste rock stockpiles generated during the construction phase will be minimal and probably used for construction purposes on site (berm and foundations for buildings), reason being that this will be limited to the adit areas – since the project is an underground operation.

At the ROM stockpile, there will be constant transfer of ore from underground using a conveyor to the stockpile and then to the crushing/screening. During milling the ore is ground into wet pulp, and pumped through the flotation circuit. During flotation the ore is split into two streams: Concentrate and Tails.

The Tails stream is pumped to the TSF, the Concentrate is filtered and dried, and ready for transport to smelter. The following are the specifications of the different stockpiles which are identified as sources of wind erosion (Table 10-3).

Table 10-3: Parameters for the different stockpiles

ID	Volume (tons)	Volume (m³)	Height (m)	Area (m²)	Area (ha)	x-length	y-length
ROM STOCKPILE	1 200 320	600 160	8	75 020	7.50	310	242
WASTE STOCKPILE (South)	3 504 600	2 190 375	15	146 025	14.60	531	275
WASTE STOCKPILE (West)	3 500 640	2 187 900	17	128 700	12.87	468	275
TSF STOCKPILE	3 810 807	2 540 538	77	32 994	3.30	234	141

10.1.4 Material handling (Tipping)

Material handling (tipping) as a process is known to have influence on dust generation. With the different kind of materials – topsoil, soft, and hard, tipping will be negligible. The tipping is mostly associated with the ROM – and two tipping points were assigned within the mining area: underground to ROM and conveyor to crusher. In this case, being an underground operation - conveyor will be used, and the surrounding wind regime, the material tipping rate, and the moisture content of the material all have a bearing on the dust generation at the tipping transfer points.

10.1.5 Crushing/Screening

There will be a primary crusher underground, and crushing/screening (which is located on the surface) will be used to further reduce the size of the ore for processing at the processing plant. In most cases, the crushing and screening process represents a significant source of fugitive dust with high quantities of respirable fractions released to the atmosphere. The crusher will be working 24 hours per day and 365 days per year. The amount of ROM processed per day for the secondary crusher is approximately 11 000 tonnes. The parameters used in the calculations of the emissions from the crushers are given below (Table 10-4).

Table 10-4: Parameters for the crusher

Source	ROM per annum	Tonnes per annum	Moisture content (%)
Secondary crusher	1,200 000	10 958. 90	10*

*The ore is considered to be high moisture ore

10.2 Predictive Emission Factors

An emission factor is a representative value that attempts to relate an activity associated with the release of a pollutant to the quantity of that pollutant released into the atmosphere. Emission factors and emission inventories are fundamental tools for air quality management. The emission factors are frequently the best or only method available for estimating emissions produced by varying sources. Emission estimates are important, amongst others, for developing emission control strategies; determining applicability of permitting and control programmes; and ascertaining the effects of sources and appropriate mitigation measures.

In order to determine the significance of the potential for impacts, it is necessary to quantify atmospheric emissions and predicted airborne pollutant concentrations occurring as a result of each emission source. Empirically derived *predictive emission factor equations* are available for the quantification of TSP, PM_{10} and $PM_{2.5}$, for sources such as aeolian erosion from open areas, haul roads, paved roads, crushers and several other sources.

The State Pollution Control Commission of New South Wales, Australia (SPCC, 1983) states published a number of emission factors i.e. the average value for wind erosion from open areas is 0.4 kg/ha/h (3,504 kg/ha/year).It is suggested that this value be adopted as a default in the absence of other information. The same applies to all other activities with inadequate information to assess associated pollution load.

AP-42 (USEPA, 1998) states that 50% of the TSP is emitted as PM_{10}. Therefore, the default emission factor for PM_{10} is 0.2 kg/ha/h.

Default values:

$$EF_{TSP(kg/ha/hr)} = 0.4\ kg/ha/hr$$

$$EF_{PM_{10}}(kg/ha/hr) = 0.2\ kg/ha/hr$$

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, such as Platinum or metallic ore piles. Examples would include open storage piles at mining operations (USEPA, 2006). Emission factors from some sources are specified below (Table 10-5).

Table 10-5: Wind erosion from exposed areas and derived emission factors

Activity	Unit	TSP emission factors	PM_{10} emission factors	$PM_{2.5}$ emission factors
Wind erosion of exposed area – ROM stockpiles	$g/m^2/s$	1.1E-05	5.5E-06	8.3E-07
Wind erosion of exposed waste rock – stockpiles	$g/m^2/s$	1.1E-05	5.5E-06	8.3E-07
Wind erosion of exposed area – TSF	$g/m^2/s$	1.1E-05	5.5E-06	8.3E-07

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 of material from the surface, the nature of dispersion of the dust plume, and the rate of deposition which may be anticipated.

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 speeds are exceeded, particulate emission rates tend to decay rapidly due to the reduced availability of erodible material (Cowherd *et al.*, 1988).

It is anticipated that dust will be eroded from the crushers at the Platreef operational area, especially when wind speed conditions are greater than 5.4 m/s (i.e. threshold friction velocity of 0.26 m/s). Fugitive dust generation usually results with high wind speed conditions (i.e. > 5.4 m/s). Wind speeds of 5.4 m/s and stronger occur in the area ~14.4 % of the time. An average wind speed of 3.66 m/s was calculated from the Platreef modelled data.

10.3 Emissions Values

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

PSD is a key parameter determining the entire process of wind erosion, from entrainment through transport to deposition.

Table 10-6 gives the PSD adopted from Airshed Planning Professionals report for a platinum mine, used as input parameters into the dispersion model for dust deposition.

Table 10-7 gives an overview of annual emissions from ROM stockpile, Waste rock stockpile, TSF, crusher, transfer points (tipping), paved roads and ventilation shafts.

Table 10-8 shows the emissions when mitigation measures have been implemented.

Table 10-6: Particle size distribution for the proposed Karee Tailings Dam supplied by the Airshed Planning Professionals (2006)

SOURCE	PERCENTAGES UNDER PARTICLE SIZE FRACTION (µm)							
	75	45	30	15	10	5	2.5	1
Waste rock stockpiles	0.3	0.19	0.2	0.07	0.098	0.05	0.05	0.05
Run of Mine	0.28	0.16	0.2	0.07	0.1	0.05	0.07	0.07

TSF	0.12	0.14	0.21	0.09	0.14	0.1	0.13	0.07

Table 10-7: Estimated annual emissions for the wind erosion sources

Activity	Annual emissions (t/year)		
	TSP	PM_{10}	$PM_{2.5}$
Wind erosion of exposed area – ROM stockpile	51.0	13.1	2.0
Wind erosion of exposed area – Waste rock South stockpile	51.0	25.5	3.8
Wind erosion of exposed area – Waste rock West stockpile	51.0	22.5	3.4
Wind erosion of exposed area – TSF	51.0	5.8	0.9
Wind erosion of exposed area – paved roads	1.0	0.2	-
Wind erosion from Crusher	120	48	-
Wind erosion from tipping	3.1	1.44	-
Total emissions	**328.1**	**116.4**	**10.1**

Table 10-8: Estimated annual emissions for the wind erosion sources after mitigation

Activity	Annual emissions (t/year)		
	TSP	PM_{10}	$PM_{2.5}$
Wind erosion of exposed area – ROM stockpile	15.7	7.9	1.2
Wind erosion of exposed area – Waste rock South stockpile	30.6	15.3	2.3
Wind erosion of exposed area – Waste rock West stockpile	27.0	13.5	2.0
Wind erosion of exposed area – TSF	6.9	3.5	0.5

Activity	Annual emissions (t/year)		
	TSP	PM_{10}	$PM_{2.5}$
Wind erosion of exposed area – paved roads	0.62	0.12	-
Wind erosion from Crusher	30	12	-
Wind erosion from tipping	1.22	0.57	-
Total emissions	**112.04**	**52.89**	**6**

11 METHODOLOGY, RESULTS AND DISCUSSION FOR DISPERSION MODELLING

11.1 Dispersion Model

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 11-1 gives an overview of meteorological parameters and basic setup options for the AERMOD model runs.

Table 11-1: Summary of meteorological and AERMET parameters used for this study

Number of grids (spacing)	1 (250 m)*
Number of grids points	81x81
Years of analysis	Jan 2009 to Dec 2011
Centre of analysis	Platreef Mine (24.095986 S, 28.968619 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	1264 m
MM5-Processed Grid Cell (Grid Cell Centre) - UTM Coordinates	699900 m E, 7333300 m S
Anemometer Height	14 m
Surface meteorological stations	1 site at the future Platreef Platinum Mine using data generated by AERMET
Upper air meteorological stations	1 site at the future Platreef Platinum Mine using data generated by AERMET
Simulation length	26280 hours (Jan 2009 to Dec 2011)
Sectors	The surrounding area land use type was considered to be residential *land use*
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 (The regional setting showed ridges in the area)

*

11.1.1 Source data requirements

The infrastructure layout utilised during the dispersion model was provided by the client as shown in Plan 4. AERMOD can model area, volume and point sources. Input into the dispersion model includes prepared meteorological data, source data, information on the nature of the receptor grid and emissions input data. Model inputs were verified before the model was executed.

For Platreef, the ROM stockpile, waste rock and TSF stockpile sources have been modelled as area sources. Crusher, material handling processes (tipping to RoM stockpile, tipping to waste rock stockpile, conveyor to crusher) have been modelled as volume sources. The ventilation shaft was modelled as a point source. The paved road in the mine project areas and the link road to N11 were modelled as line volume sources. All hours in the meteorological data file have been simulated with an emission rate from the sources. This approach would be considered to be a detailed and conservative assessment.

A rectangular receptor grid of 20 km x 20 km encompassing the entire project area is defined. The grid mesh was 250 metres resulting in a total of 6 561 grid points. Each of the grid points has x and y (Cartesian co-ordinates) values in metres. Terrain effects were imported from NASA Shuttle Topography Radar Mission (STRM3) global database with ~90 m accuracy and processed by the AERMAP module of AERMOD.

This receptor grid has been chosen to include the nearest sensitive receptors (These are mainly surrounding sensitive receptors including residential dwellings and provide an indication of the extent of any air pollution impacts. The 1-hour, 24-hour and annual averaging times have been used for consistency. The modelling has been performed using the meteorological data discussed in previous section and the gaseous, particulate and deposition emissions calculations explained in the emissions inventory section.

The mine’s operations are 24 hours per day and 365 days a year. These predicted concentrations and deposition rates are attributed to mine operation only and did not consider cumulative impacts. Any mitigation measure that will be applied will reduce the impact of wind erosion from the ROM stockpile, waste rock stockpile, TSF, crusher, and paved roads to the surrounding area.

The occupational exposure limits as published in the amended Schedule 22.9(2)(a) of the Mine Health and Safety Act (1996, amended 2006) were used for estimating the emissions for gaseous pollutants from the ventilation shafts.

11.2 Results and Discussion

The AERMOD model predicts the one-hour average concentration at each receptor specified, for each hour of the year’s meteorological data. The highest ground level concentration is established for each hour and is referred to as the peak hourly concentration.

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 distributions of concentrations follow closely the main wind directions (wind roses generated for the site on Figure 6-1 to Figure 6-3). Numerical values of maximum depend on the emission rate and the meteorological data used. Simulations were undertaken to determine concentrations of particulate matter with a particle size of less than 10 microns (µm) in size (PM_{10}), particle size of less than 2.5 microns (µm) in size ($PM_{2.5}$), and of deposition of total suspended particulates (TSP) from operations at the proposed Platreef Platinum Mine. Scenarios with mitigation measures were simulated using the control factors from Australian NPI V3.1 as shown in Table 11-2.

Table 11-2: Estimated control factors for Platreef Mining Operations

Operation / Activity	Control method and emission reduction
ROM stockpile	40% for dust reduction
Waste rock stockpile	40% for telescopic chute with water sprays
TSF	40% vegetation cover
Paved road	40% for water sprays
Crusher	75% water sprays (enclosed)

*Assumed mitigation measures will be implemented by client

11.2.1 Isopleth Plots and Evaluation of Modelling Results

Summary of isopleth plots generated in the current section are presented in Table 11-3.

Table 11-3: Evaluation of results for particulate matter, deposited nuisance dust and gaseous pollutants during the operational phase

Pollutant	Averaging period	Standard (µg/m³)	Figure
PM_{10}	24 Hours	120(1) 75 (2)	11-1
	1 Year	50(1) 40(2)	11-2
$PM_{2.5}$	24 Hours	65(3) 40(4)	11-3
	1 Year	25(3) 20(4)	11-4
Dust Deposition	Maximum 24 Hours	600(5)	11-5
Mitigated concentrations			
PM_{10}	24 Hours	120(1) 75 (2)	11-6
	1 Year	50(1) 40(2)	11-7
$PM_{2.5}$	24 Hours	65(3) 40(4)	11-8
	1 Year	25(3) 20(4)	11-9
Dust Deposition	Maximum 24 Hours	600(5)	11-10

Pollutant	Averaging period	Standard (µg/m³)	Figure
Gaseous Pollutants concentrations			
NO_2	1 Hours	200(1)	11-11
	1 Year	40(1)	11-12
SO_2	10 Minutes	500(1)	11-13
	1 Hour	350(1)	11-14
	24 Hour	125(1)	11-15
	1 Year	50(1)	11-16
CO	1 Hour	30000(1)	11-17
	8 Hours	10000(1)	11-18

(1) South African- Current National Ambient Air Quality Standards (NAAQS)
(2) South African- Future (from 1 January 2015) National Ambient Air Quality Standards (NAAQS)
(3) South African- Proposed current National Ambient Air Quality Standards (NAAQS)
(4) South African- Proposed future (from 1 January 2016) National Ambient Air Quality Standards (NAAQS)
(5) SANS 1929:2011: "Ambient Air Quality – Limits for common pollutants"

11.2.2 PM_{10} Predicted impacts

Isopleth plot of predicted highest daily values for PM_{10} generated by the proposed Platreef Platinum Mine operations is given in Figure 11-1 with a daily highest predicted ground level concentration of 500 µg/m³ mostly within the proposed mine area. The isopleth plots of predicted maximum daily values for PM_{10} for all sources combined without mitigation measures was found to exceed the current daily limit of 120 µg/m³ in the northern, western and southern sections from the mine boundary (at distances ~ 500 to less than 3000 m from the boundary). The predicted PM_{10} concentrations around the neighbouring residential areas (sensitive receptors) are predicted and compared against the current SA standards and SANS limit values (Table 11-4). With mitigation measures applied, the ground level concentrations of PM_{10} observed at the selected sensitive receptors showed decreases ranging between 33 and 59 %. Annual PM_{10} levels were observed to have decrease by between 25 and 47%.

It should be noted that isopleth plots reflecting daily averaging periods contain only the highest predicted ground level concentrations for that averaging period, over the entire period for which simulations were undertaken. These isopleths are likely concentrations that the proposed Platreef Platinum Mine would have on ambient air quality and not cumulative impact from all the existing sources in the area. *It is therefore possible that even though a high daily concentration is predicted to occur at certain locations, that this may only be true for one day during the entire period.*

The predicted highest annual values for PM_{10} generated by the proposed Platreef Platinum Mine operations are given in Figure 11-2 with an annual highest predicted ground level concentration of 699 µg/m³ and minimum of 7 µg/m³. Areas with exceedances of the annual standard of 50 µg/m³ are depicted in Figure 11-2, showing the ground level concentrations.

Table 11-4: Predicted PM_{10} concentrations at sensitive receptors (Unmitigated)

Site ID	X	Y	24-h (µg/m^3)	Annual (µg/m^3)
PLA 01	699539.5	7331241	62	4
PLA 02	699055.5	7329973	58	2.4
PLA 03	701472.2	7330663	44	3.0
PLA 04	702644.9	7334128	6	1.2
PLA 05	701048.5	7335911	17	1
PLA 06	698128.1	7334883	**242**	**40**
PLA 07	699930.1	7333306	101	10
PLA 08	701180.5	7337723	6	0.4

Table 11-5: Predicted PM_{10} concentrations at sensitive receptors (Mitigated)

Site ID	X	Y	24-h (µg/m^3)	Annual (µg/m^3)
PLA 01	699539.5	7331241	34	2.2
PLA 02	699055.5	7329973	33	1.4
PLA 03	701472.2	7330663	20	2.0
PLA 04	702644.9	7334128	4	0.7
PLA 05	701048.5	7335911	7	0.6
PLA 06	698128.1	7334883	**143**	**24**
PLA 07	699930.1	7333306	58	5.3
PLA 08	701180.5	7337723	3	0.3

11.2.3 $PM_{2.5}$ Predicted impacts

Isopleth plot of predicted 4th highest daily values for $PM_{2.5}$ generated by the proposed Platreef Platinum Mine operations is given in Figure 11-3 with a daily highest predicted ground level concentration of 276 µg/m³ and minimum of 3 µg/m³. This isopleth plot of predicted maximum daily values for $PM_{2.5}$ from all sources without mitigation measures anticipated around the operations exceeds the current daily limit of 65 µg/m³ and the future limit of 40 µg/m³ outside the mine boundary to some 200 m. However, exceedances are mainly within the vicinity of the mine. The predicted $PM_{2.5}$ concentrations around the closest neighbouring residential areas (sensitive receptors – PLA 06) is predicted to receive 23 µg/m³ per day which is 35% of the current SA standards and SANS limit values, whilst sensitive receptor furthest away from the operations received lower concentrations of $PM_{2.5}$ (Table 11-6). For $PM_{2.5}$, with mitigation the diurnal concentrations observed at the defined sensitive receptors decreased by between 22 and 83%. The decreases observed for the annual levels ranged between 33 and 54% respectively.

The isopleth depicting the annual ground level concentrations for $PM_{2.5}$ that will be generated by the proposed Platinum Mine operations is presented (Table 11-6). The annual highest predicted ground level concentration of 67 µg/m³ and minimum of 0.7 µg/m³. Exceedances are confined within the mine borders. The exact values at the selected sensitive receptors are presented (Table 11-6).

Table 11-6: Predicted $PM_{2.5}$ concentrations at sensitive receptors (unmitigated)

Site ID	X	Y	24-hours (µg/m³)	Annual (µg/m³)
PLA 01	699539.5	7331241	17	0.6
PLA 02	699055.5	7329973	14	0.5
PLA 03	701472.2	7330663	9	0.5
PLA 04	702644.9	7334128	2	0.2
PLA 05	701048.5	7335911	4.5	0.2
PLA 06	698128.1	7334883	51	**6.3**
PLA 07	699930.1	7333306	28	1.6
PLA 08	701180.5	7337723	1.8	0.08

Table 11-7: Predicted $PM_{2.5}$ concentrations at sensitive receptors (Mitigated)

Site ID	X	Y	24-hours (µg/m³)	Annual (µg/m³)
PLA 01	699539.5	7331241	4.0	0.40
PLA 02	699055.5	7329973	2.4	0.23
PLA 03	701472.2	7330663	3.0	0.27
PLA 04	702644.9	7334128	1.2	0.14
PLA 05	701048.5	7335911	1.0	0.10
PLA 06	698128.1	7334883	40.0	**4.0**
PLA 07	699930.1	7333306	10.0	0.8

PLA 08	701180.5	7337723	0.4	0.05

11.2.4 Dust deposition predicted impacts

Dust predicted dust deposition rates exceeding the recommended SANS limit values are mainly confined to within the mine boundary. The predicted dust deposition rates at the sensitive receptors of Platreef exceeding the SANS action criteria for residential areas (i.e. 600 mg/m²/day) was observed at site PLA 06 only.

When mitigation measures are applied, the anticipated deposition decreased at the selected sensitive receptors i.e. PLA 06 – from 629 mg/m²/day to 317 mg/m²/day. In general the levels decreased by between 35 and 50% at the selected sensitive receptor sites.

It should be noted that isopleth plots reflecting daily averaging periods contain only the highest predicted ground level concentrations for that averaging period, over the entire period for which simulations were undertaken. These isopleths are likely concentrations that the proposed Platreef Platinum Mine would exert on ambient air quality and not cumulative impact from all the sources. *It is therefore possible that even though a high daily concentration is predicted to occur at certain locations, that this may only be true for one day during the entire period.*

When the mitigation measures provided in Table 11-2 are implemented simultaneously, the anticipated deposition decreased at the selected sensitive receptors i.e. PLA 06 – from 629 mg/m²/day to 317 mg/m²/day (Table 11-8). Once mitigation measures are applied the footprint also decreases as seen in Figure 11-10, with areas most likely to be non-compliant limited to within the mine boundary (> 2 400 mg/m²/day).

Table 11-8: Predicted monthly dust deposition rates at sensitive receptors

Site ID	X	Y	Unmitigated (mg/m²/day)	Mitigated (mg/m²/day)
PLA 01	699539.5	7331241	22	13
PLA 02	699055.5	7329973	15	9
PLA 03	701472.2	7330663	21	12
PLA 04	702644.9	7334128	94	58
PLA 05	701048.5	7335911	113	68
PLA 06	698128.1	7334883	629 (1)	317
PLA 07	699930.1	7333306	88	49
PLA 08	701180.5	7337723	68	44

(1) The figure in bracket indicates the number of times the site is in violation of the limit value recommended by the South African National Ambient Air Quality Standards (NAAQS). Currently for dust deposition, the frequency of exceedance is two but not sequential months.

11.2.5 NO_X

In ambient air, NO reacts with oxygen to form the toxic nitrogen dioxide (NO_2). Human activities have increased the production of NO_2 in combustion chamber i.e. engines. NO_2 primarily can have effects on the lungs and other organs – spleen and liver. In the human blood it can lead to creation of metahemoglobin, which cannot transport oxygen. NO_2 in air can convert to nitric in acid rain.

Isopleth plot of predicted hourly values for NO_2 generated by the proposed Platreef Platinum Mine operations is given in Figure 11-11 with a daily highest predicted ground level concentration of 862 µg/m³ and minimum of 9 µg/m³. This isopleth plot in Figure 11-11 shows predicted maximum hourly values for NO_2 emissions from the vents without mitigation measures. Areas where the recommended current hourly limit of 200 µg/m³ is likely to be violated are clearly indicated in the plot. The predicted NO_2 concentrations around the neighbouring residential areas (sensitive receptors) are presented (Table 11-9). Based on the values in Table 11-9, the sensitive receptors are exposed to hourly levels way below the hourly limit value.

The predicted annual ground level concentration for NO_2 generated by the proposed Platinum Mine operations is given in Figure 11-2. The estimated NO2 levels at the different receptors are presented in Table 11-9.

Table 11-9: Predicted NO_2 concentrations at sensitive receptors

Site ID	X	Y	1-hours (µg/m³)	1 Year (µg/m³)
PLA 01	699539.5	7331241	7.3	0.06
PLA 02	699055.5	7329973	10.2	0.04
PLA 03	701472.2	7330663	8.4	0.05
PLA 04	702644.9	7334128	12	0.04
PLA 05	701048.5	7335911	21	0.05
PLA 06	698128.1	7334883	49	**0.3**
PLA 07	699930.1	7333306	46	0.16
PLA 08	701180.5	7337723	4	0.02

11.2.6 SO_2

SO_2 is pungent smelling and toxic gas, with major source being heat and power generation facilities that utilize poor quality oil containing sulphur. It increases breathing resistance and symptoms such wheezing and chest tightness. Sulphur dioxide is also a precursor of acid rain, leading to corrosion of buildings, soils, lakes and streams.

Isopleth plot of predicted hourly ground level concentration for SO_2 generated by the proposed Platreef Platinum Mine operations is given in Figure 11-3, with hourly highest predicted ground level concentration of 1564 µg/m³ and minimum of 16 µg/m³. This isopleth plot in Figure 11-3 shows predicted maximum hourly values for SO_2 emissions from the vents without mitigation measures. Areas where the recommended current hourly limit of 350 µg/m³ is likely to be violated are clearly indicated in the plot. The predicted SO_2 concentrations around the neighbouring residential areas (sensitive receptors) are presented (Table 11-10). Based on the values in Table 11-10, the sensitive receptors are exposed to hourly levels below the recommended limit value of 350 µg/m³.

The isopleths showing the ground level concentration for 24-hour and annual averaging periods depict the areas that are likely to experience levels of SO_2 higher than the recommended limit value of 125 and 50 µg/m³ respectively (Figure 11-15 and Figure 11-16). The predicted levels of SO_2 at the sensitive receptor sites are presented in Table 11-10. The daily and annual values at receptor sites are within the recommended limits.

Table 11-10: Predicted SO_2 concentrations at sensitive receptors

Site ID	X	Y	1-hour (µg/m³)	24-hours (µg/m³)	Annual (µg/m³)
PLA 01	699539.5	7331241	16	1.1	0.05
PLA 02	699055.5	7329973	17	0.9	0.04
PLA 03	701472.2	7330663	15	0.9	0.05
PLA 04	702644.9	7334128	16	1.1	0.04
PLA 05	701048.5	7335911	27	1.6	0.05
PLA 06	698128.1	7334883	120	**5.4**	**0.32**
PLA 07	699930.1	7333306	143	6.4	0.21
PLA 08	701180.5	7337723	6.5	0.4	0.02

11.2.7 CO

Carbon monoxide is high toxic and flammable gas, and formed from incomplete combustion processes. It is reported that sufficient exposure may reduce the amount of oxygen the brain leading unconsciousness and brain damage.

Isopleth plot of predicted ground level concentrations for 1-hourly and 8-hourly are presented in Figure 11-17 and Figure 11-18 respectively. The predicted CO concentrations around the neighbouring residential areas (sensitive receptors) are reported (Table 6-1). The 1-hourly and 8-hourly limit values were not exceeded at any of the sites. Thus CO is not going to be an issue in the area surrounding the proposed mining operation.

Table 11-11: Predicted CO concentrations at sensitive receptors

Site ID	X	Y	1-hours (µg/m^3)	8-hour (µg/m^3)
PLA 01	699539.5	7331241	121	22
PLA 02	699055.5	7329973	118	18
PLA 03	701472.2	7330663	104	18
PLA 04	702644.9	7334128	111	19
PLA 05	701048.5	7335911	191	36
PLA 06	698128.1	7334883	836	**106**
PLA 07	699930.1	7333306	991	130
PLA 08	701180.5	7337723	44	7

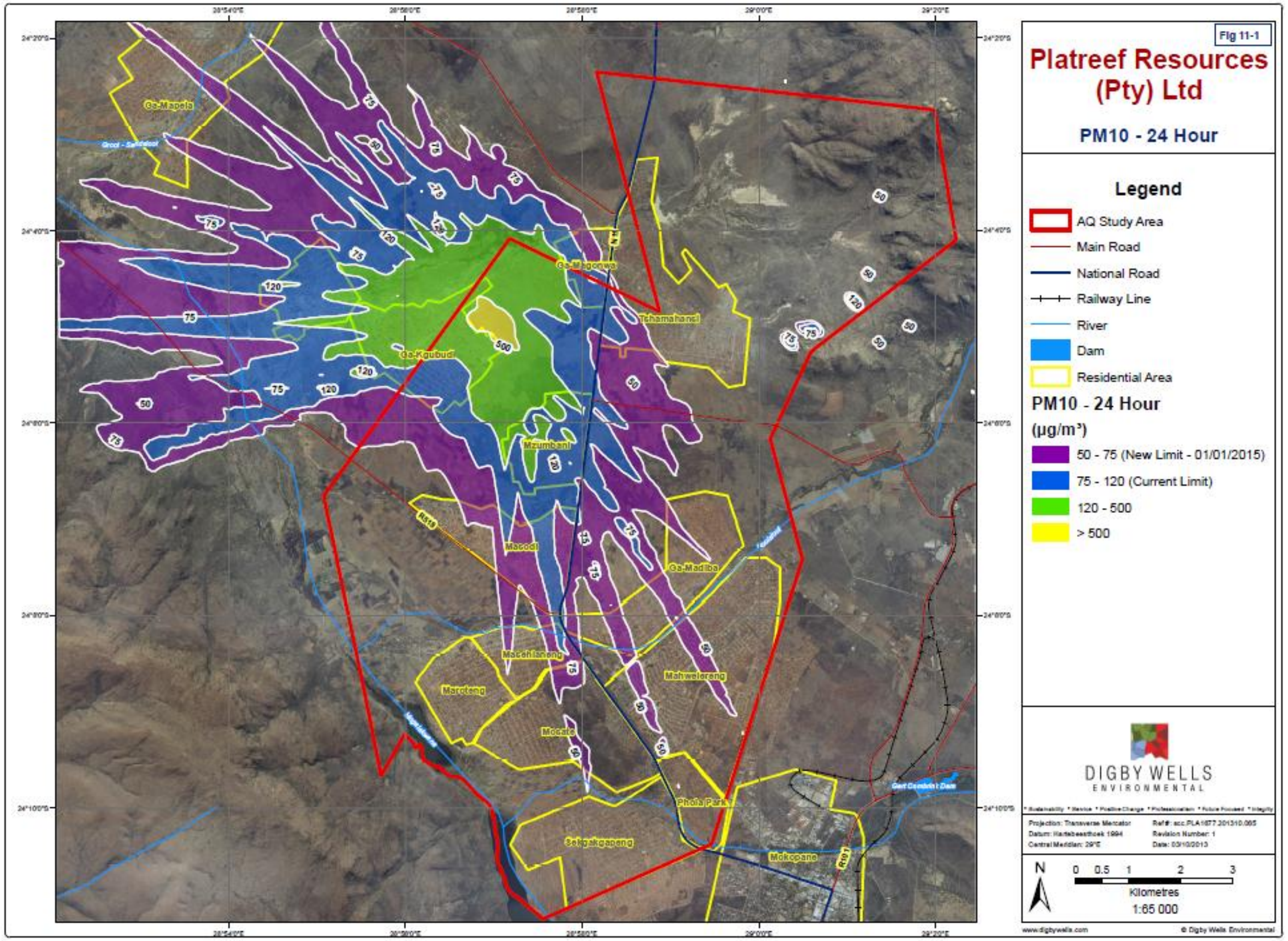

Figure 11-1: Predicted 4th highest (99th percentile) daily PM_{10} concentrations (µg/m³) due to the proposed Platreef Platinum Mine

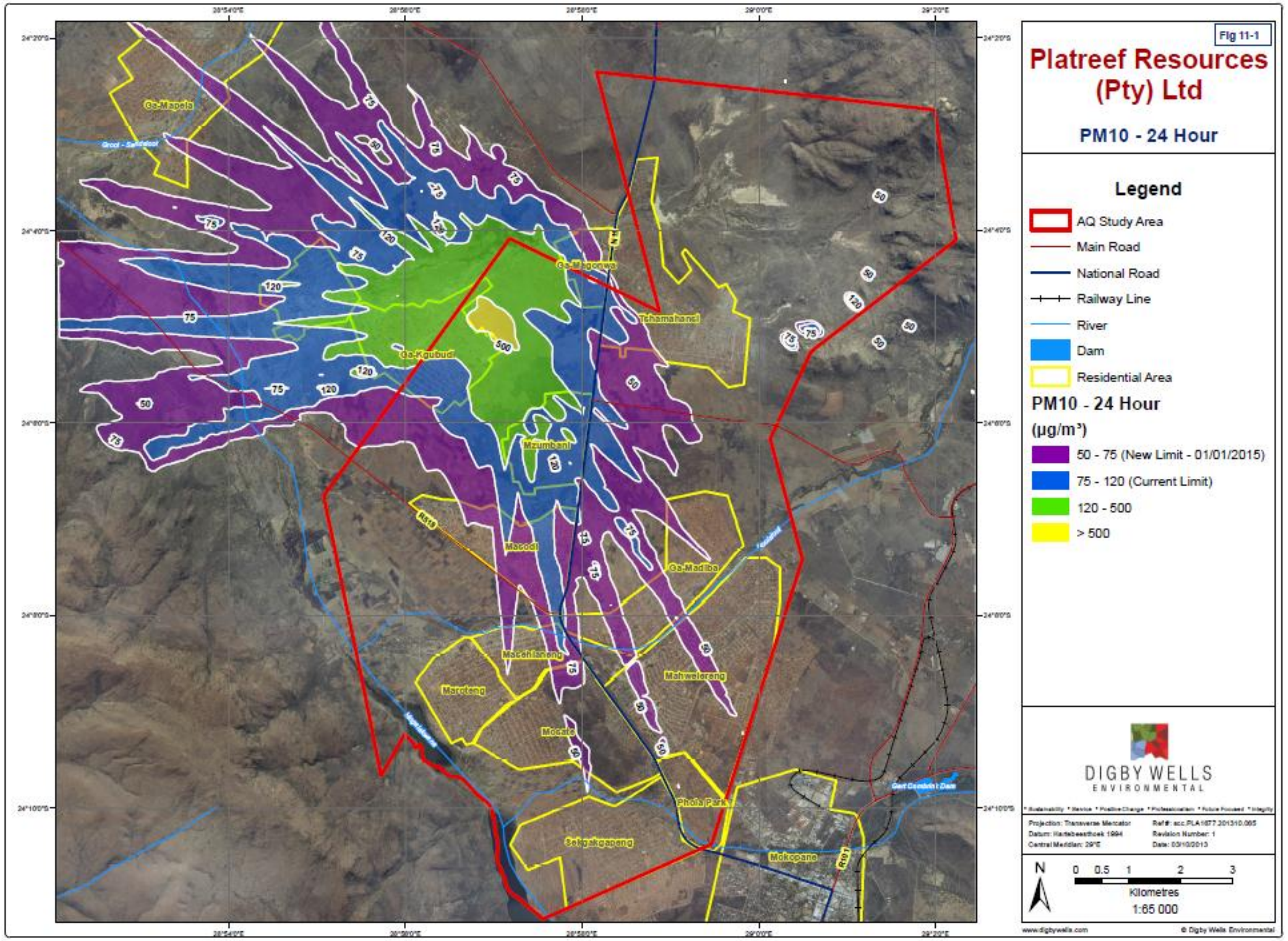

Figure 11-2: Predicted 1st highest (100th percentile) annual average PM_{10} concentrations (µg/m^3) due to the proposed Platreef Platinum Mine

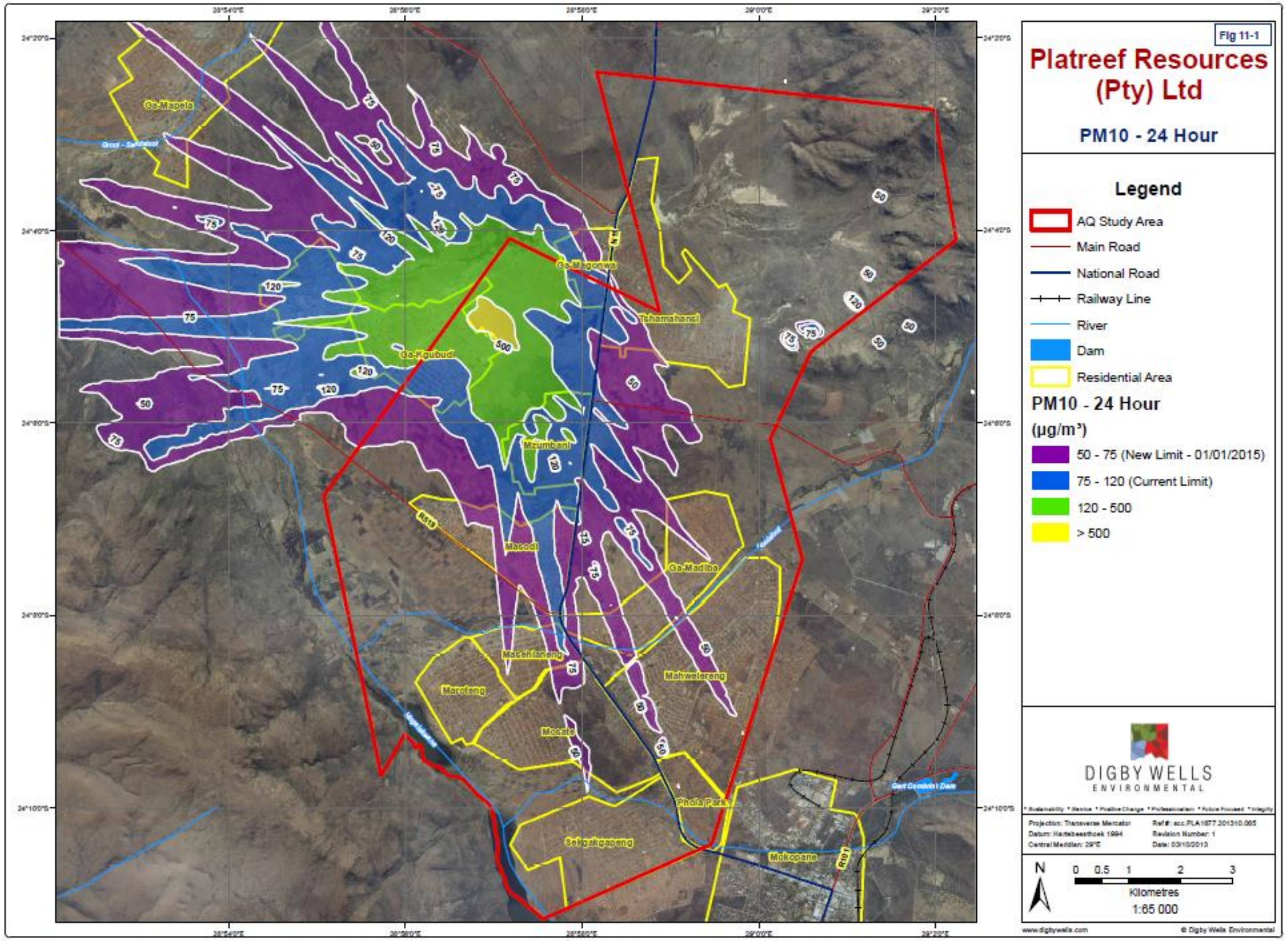

Figure 11-3: Predicted 4th highest (99th percentile) daily $PM_{2.5}$ concentrations ($\mu g/m^3$) due to the proposed Platreef Platinum Mine

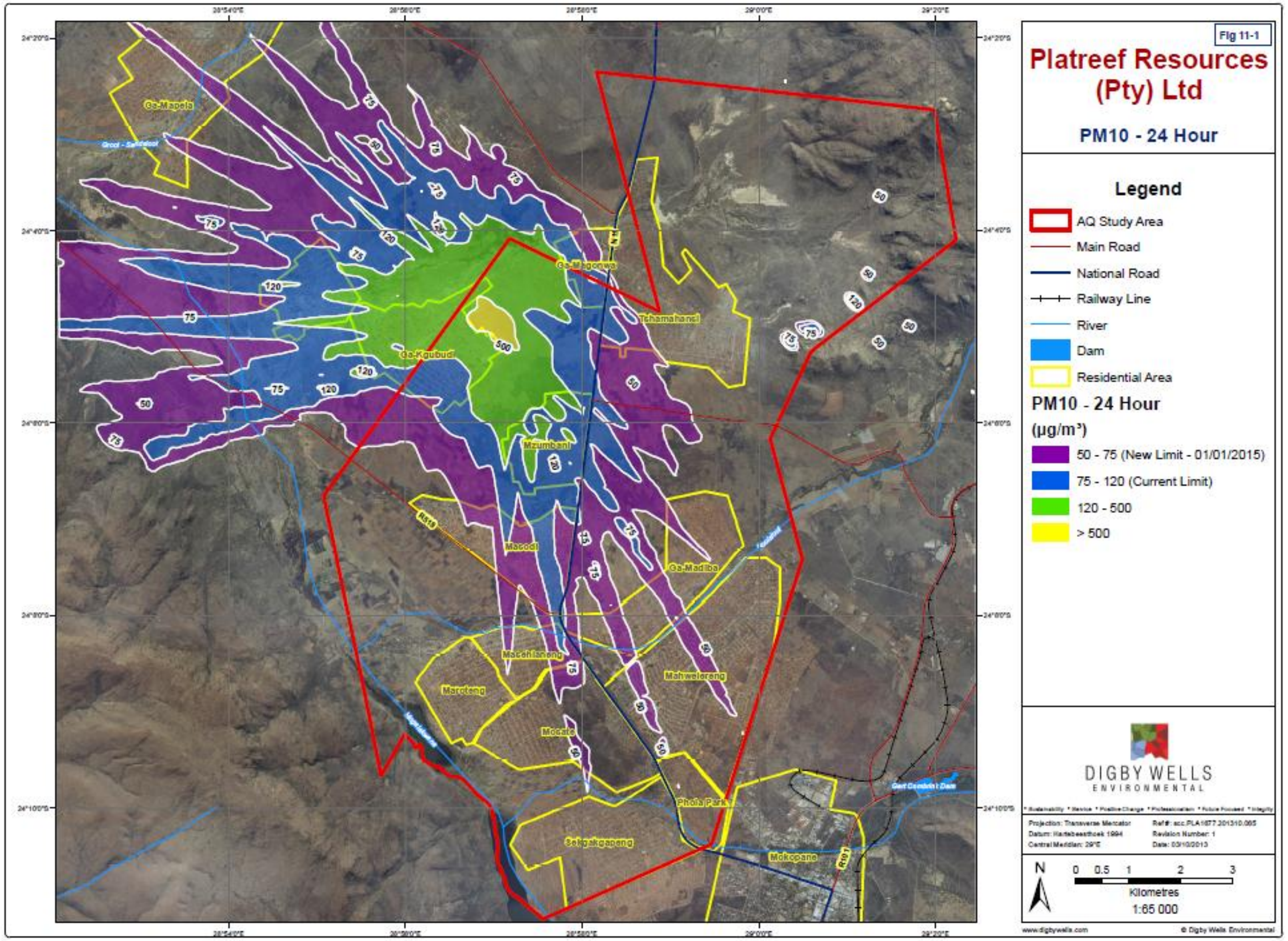

Figure 11-4: Predicted 1st highest (100th percentile) annual average $PM_{2.5}$ concentrations (µg/m^3) due to the proposed Platreef Platinum Mine

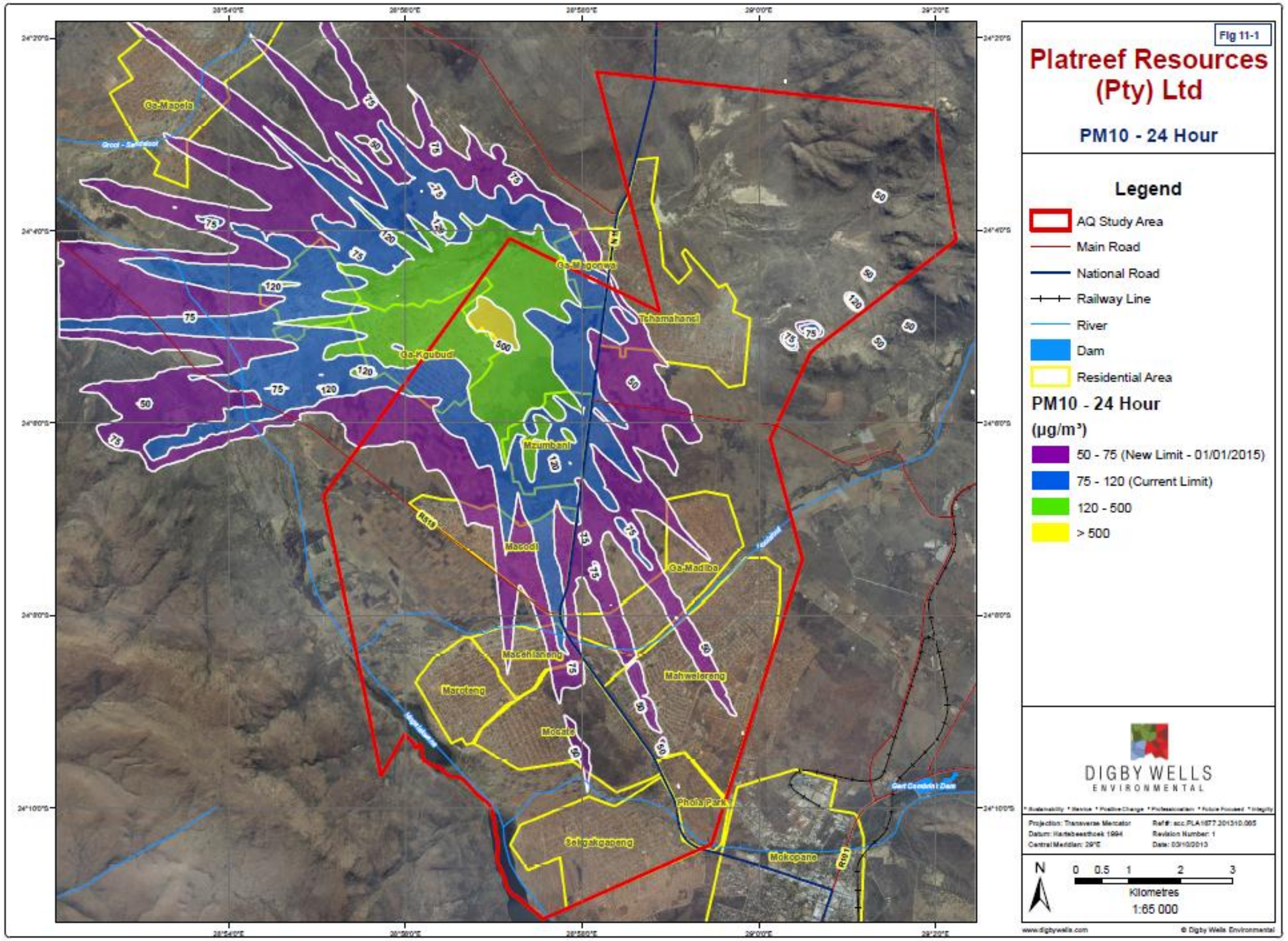

Figure 11-5: Predicted maximum daily average (100th percentile) dust deposition (mg/m²/day) due to the proposed Platreef Platinum Mine without mitigation

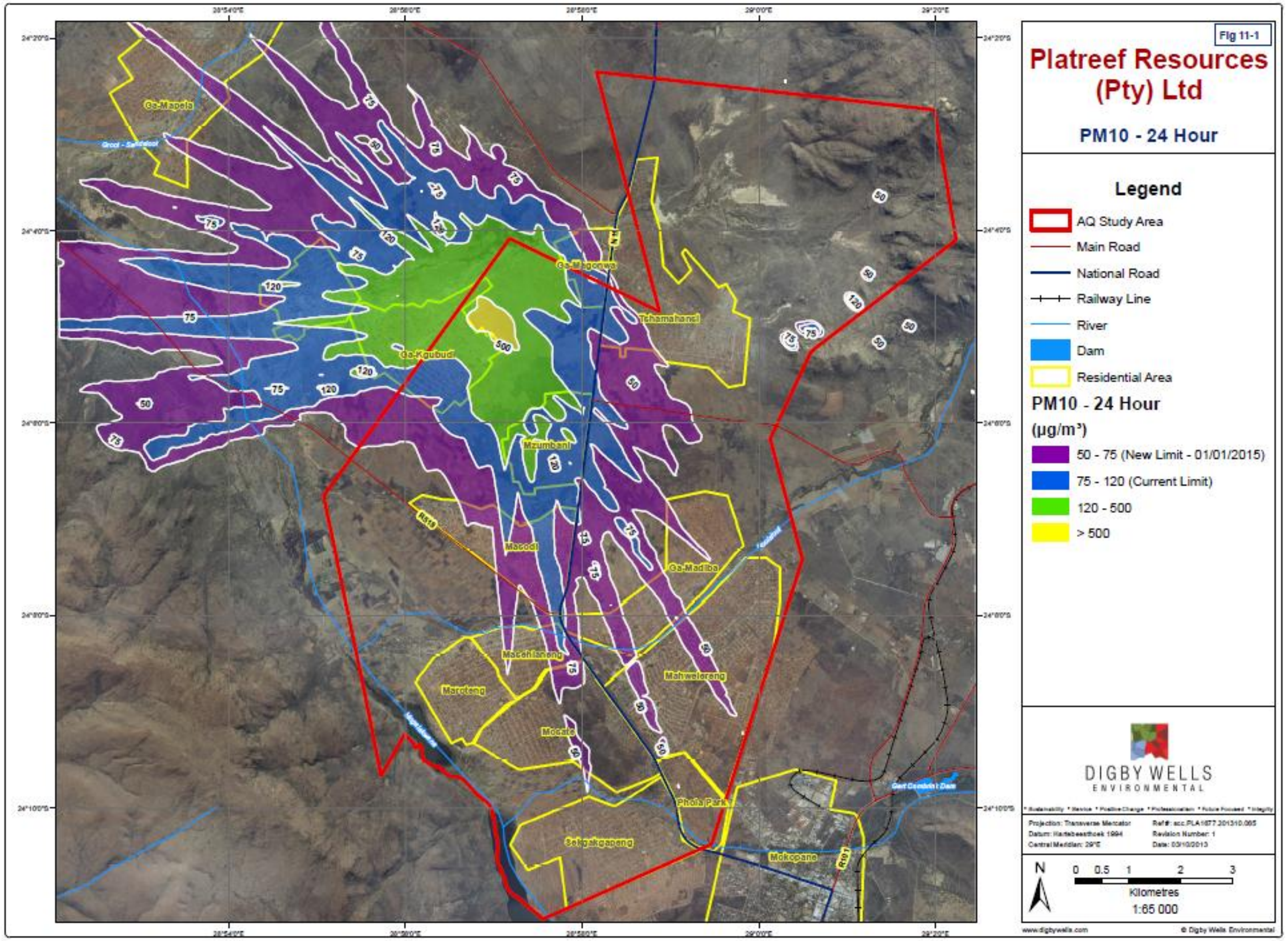

Figure 11-6: Predicted 4th highest (99th percentile) daily PM_{10} concentrations ($\mu g/m^3$) due to the proposed Platreef Platinum Mine with mitigation in place

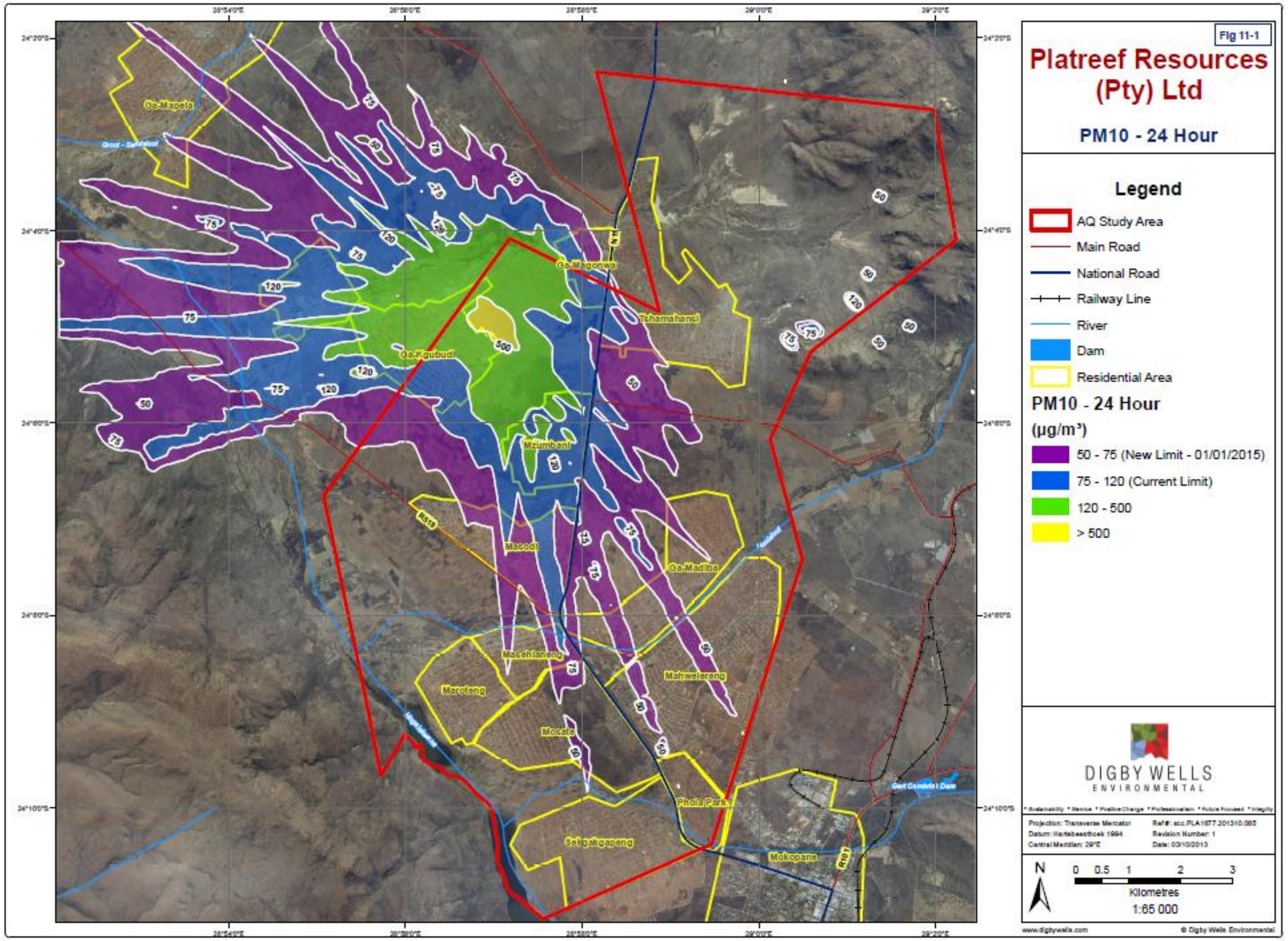

Figure 11-7: Predicted 1st highest (100th percentile) annual average PM_{10} concentrations (µg/m³) due to the proposed Platreef Platinum Mine with mitigation in place

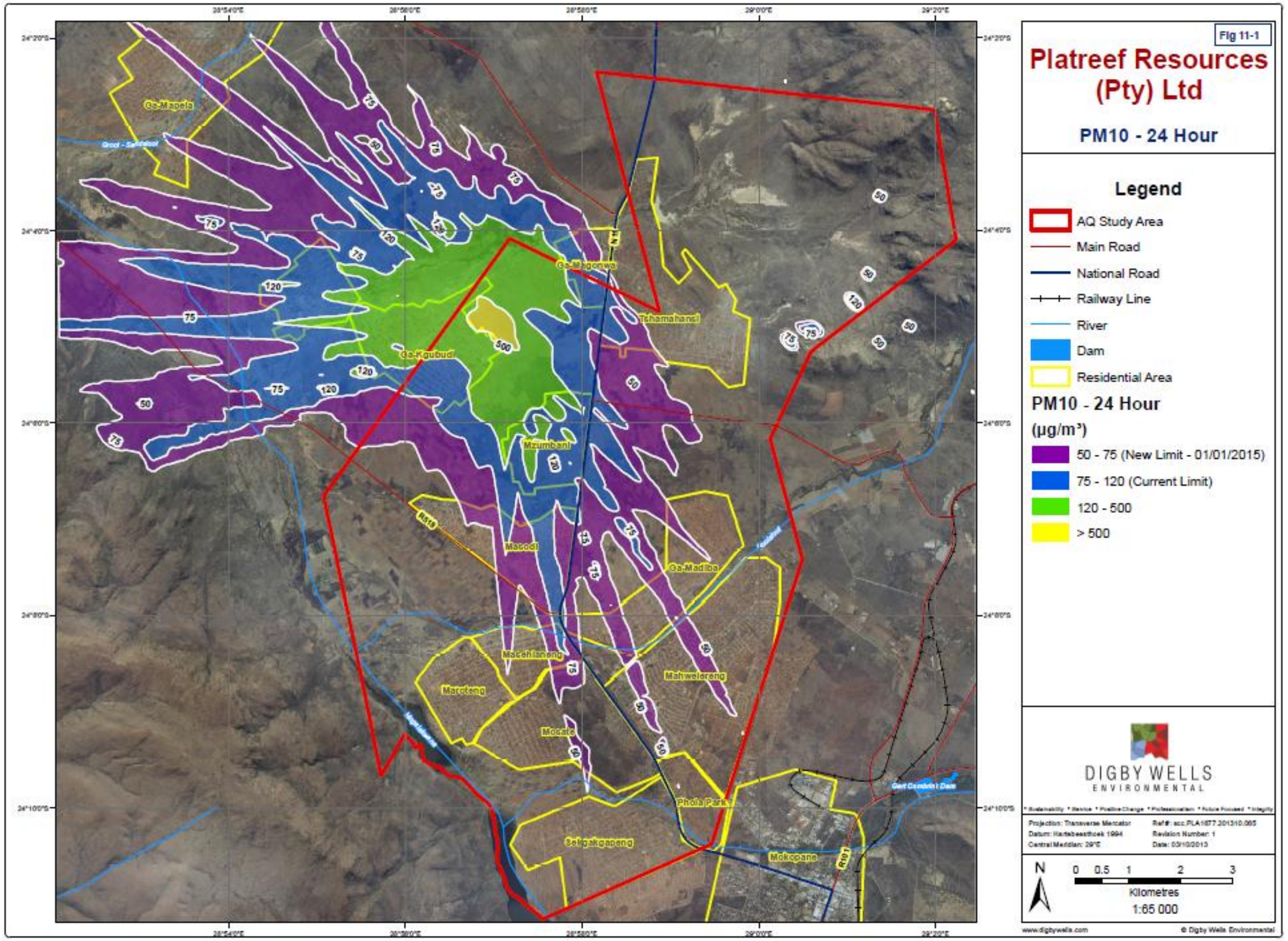

Figure 11-8: Predicted 4th highest (99th percentile) daily $PM_{2.5}$ concentrations ($\mu g/m^3$) due to the proposed Platreef Platinum Mine with mitigation in place

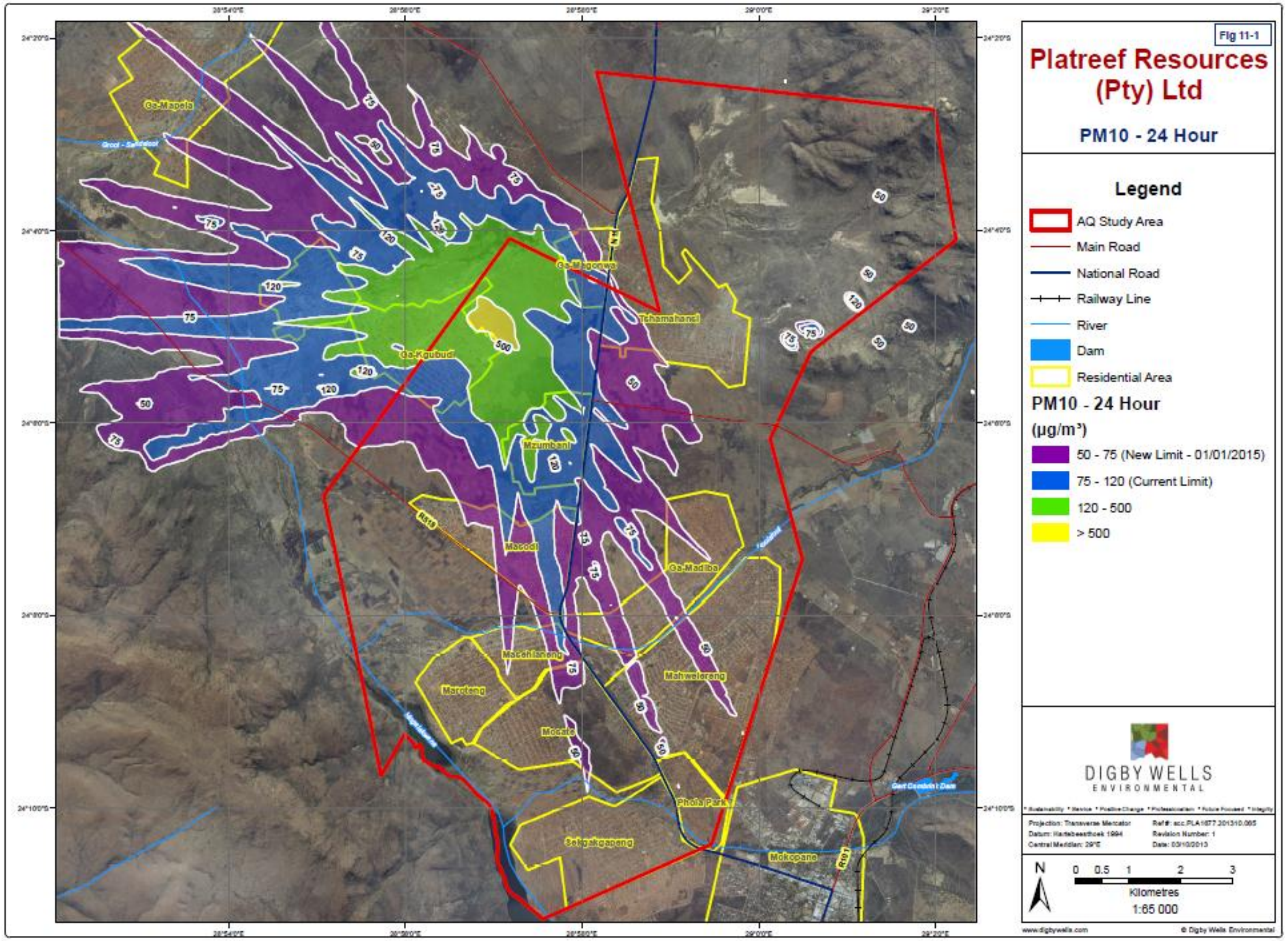

Figure 11-9: Predicted 1st highest (100th percentile) annual average $PM_{2.5}$ concentrations ($\mu g/m^3$) due to the proposed Platreef Platinum Mine with mitigation in place

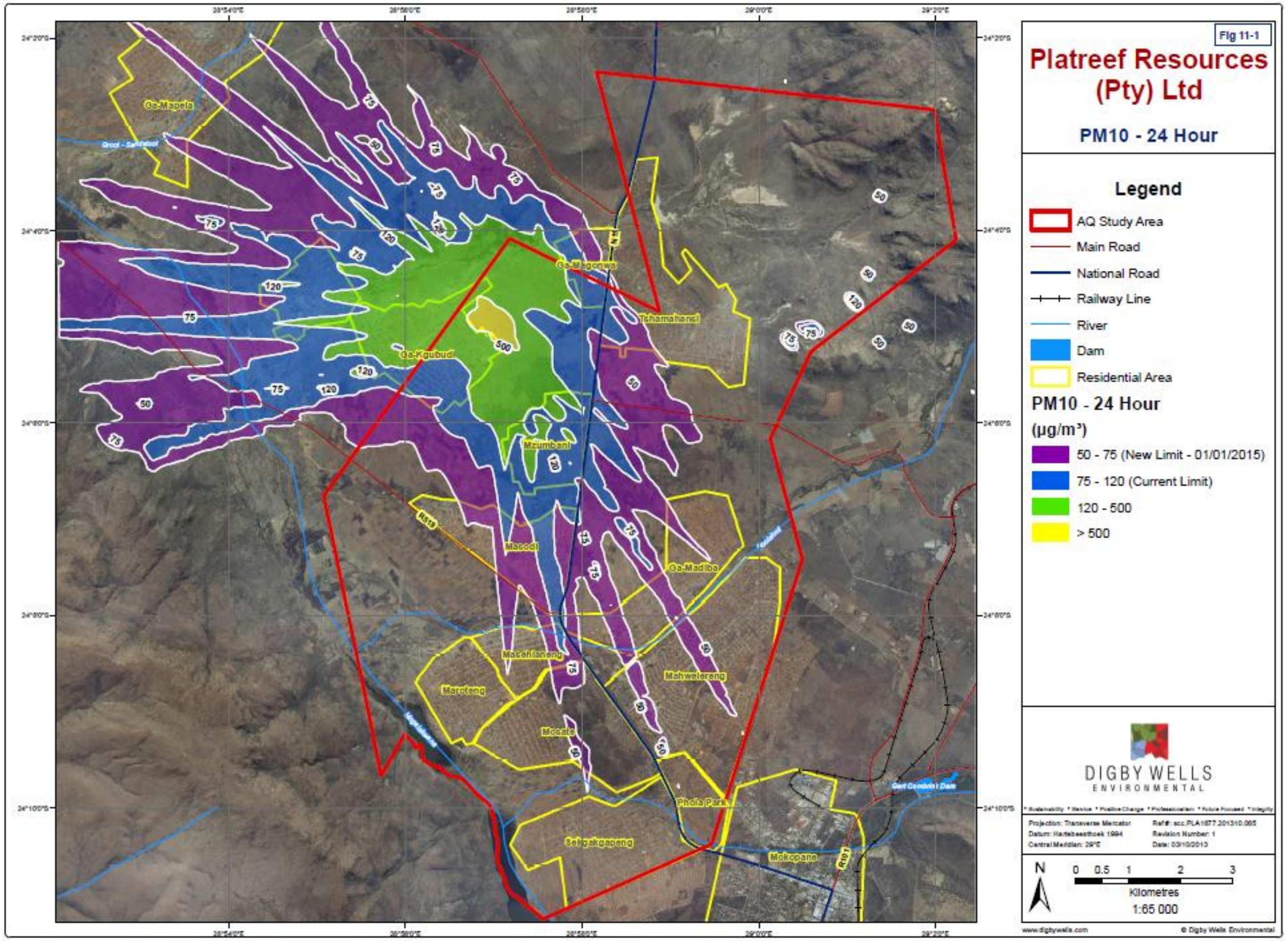

Figure 11-10: Predicted maximum daily average (100th percentile) dust deposition (mg/m²/day) due to the proposed Platreef Platinum Mine with mitigation in place

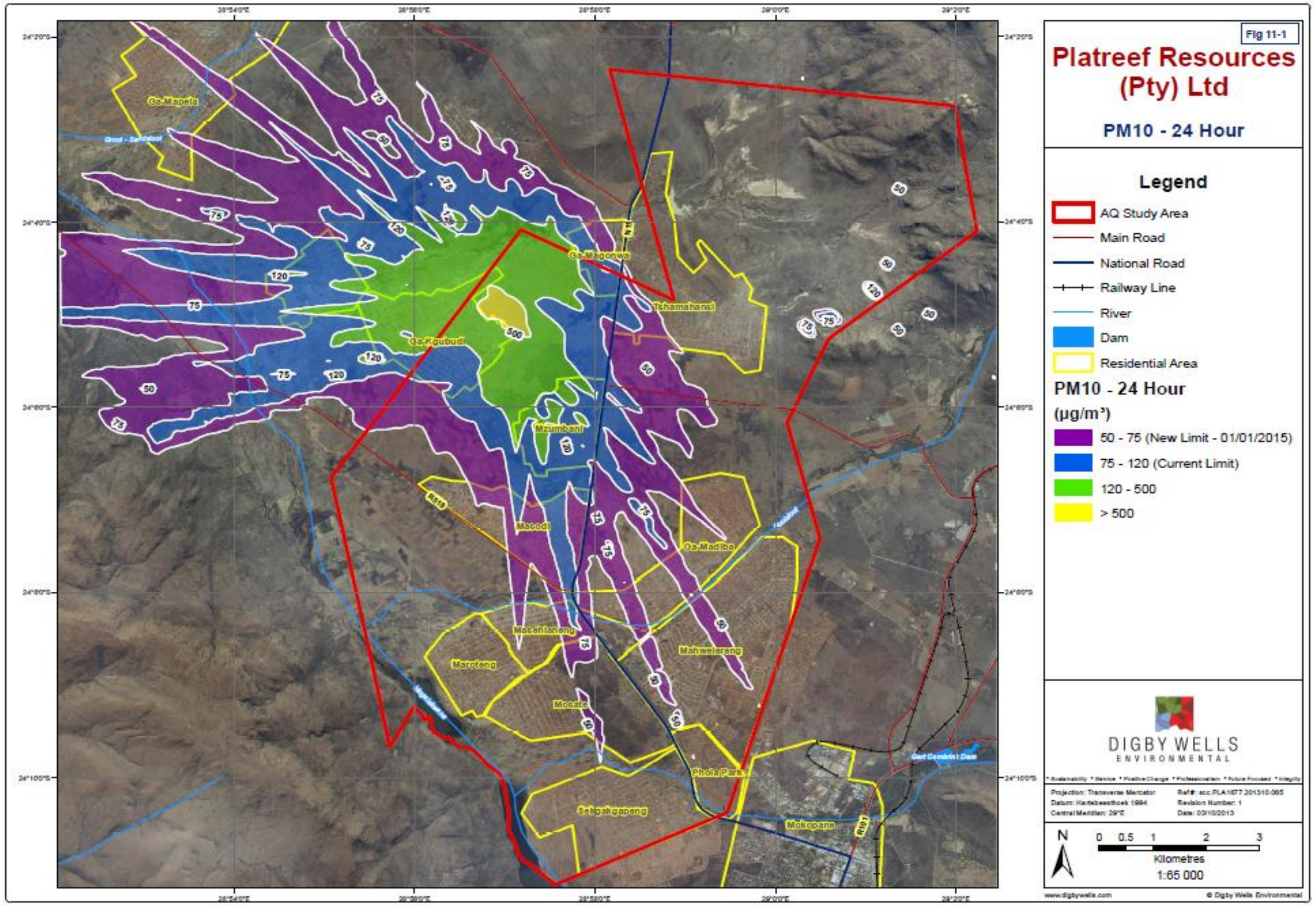

Figure 11-11: Predicted 4th highest hourly average (99th percentile) NO_2 concentrations (µg/m^3) due to the proposed Platreef Platinum Mine operation

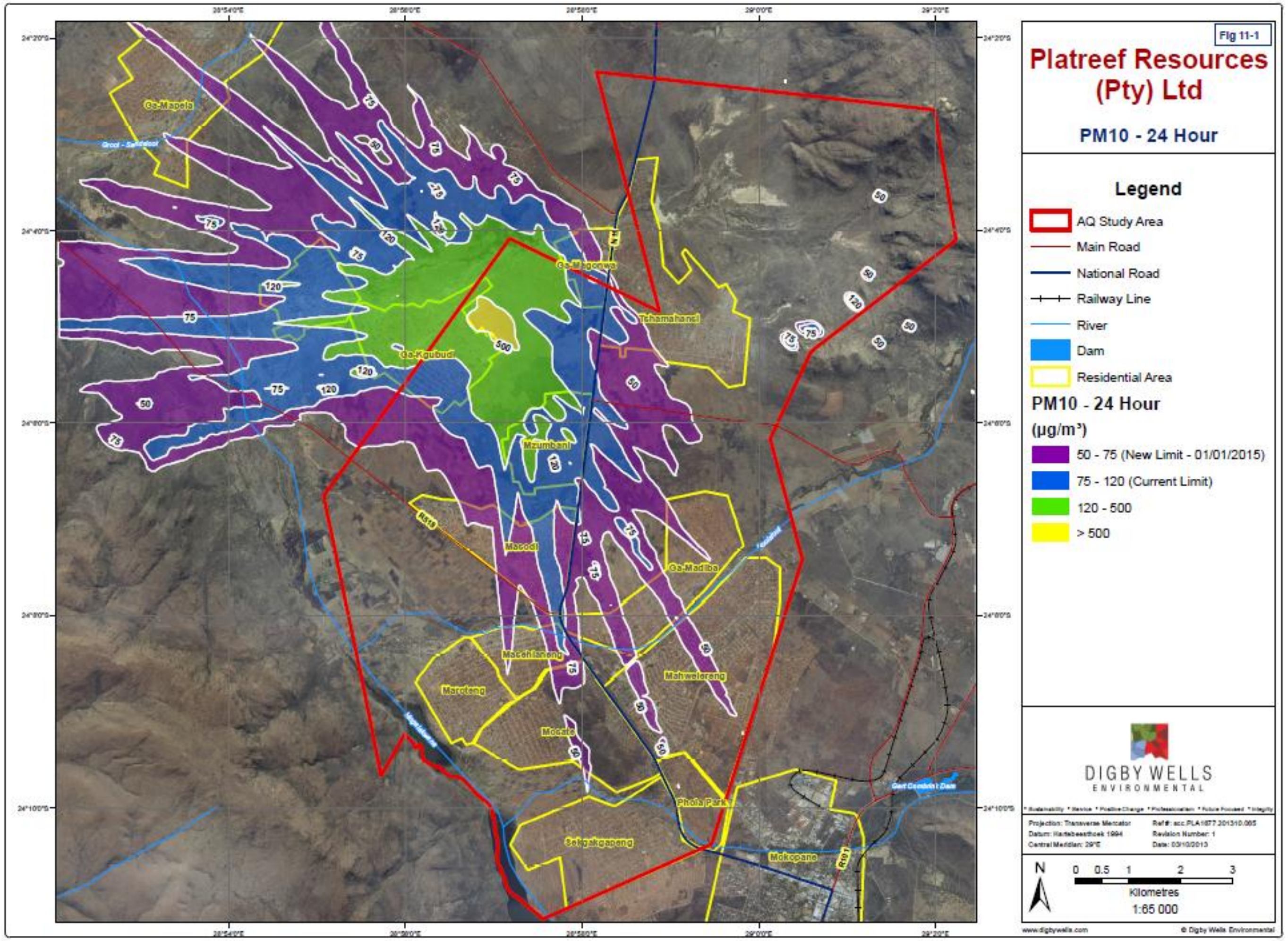

Figure 11-12: Predicted annual (100th percentile) NO_2 concentrations (mg/m^2/day) due to the proposed Platreef Platinum Mine operation

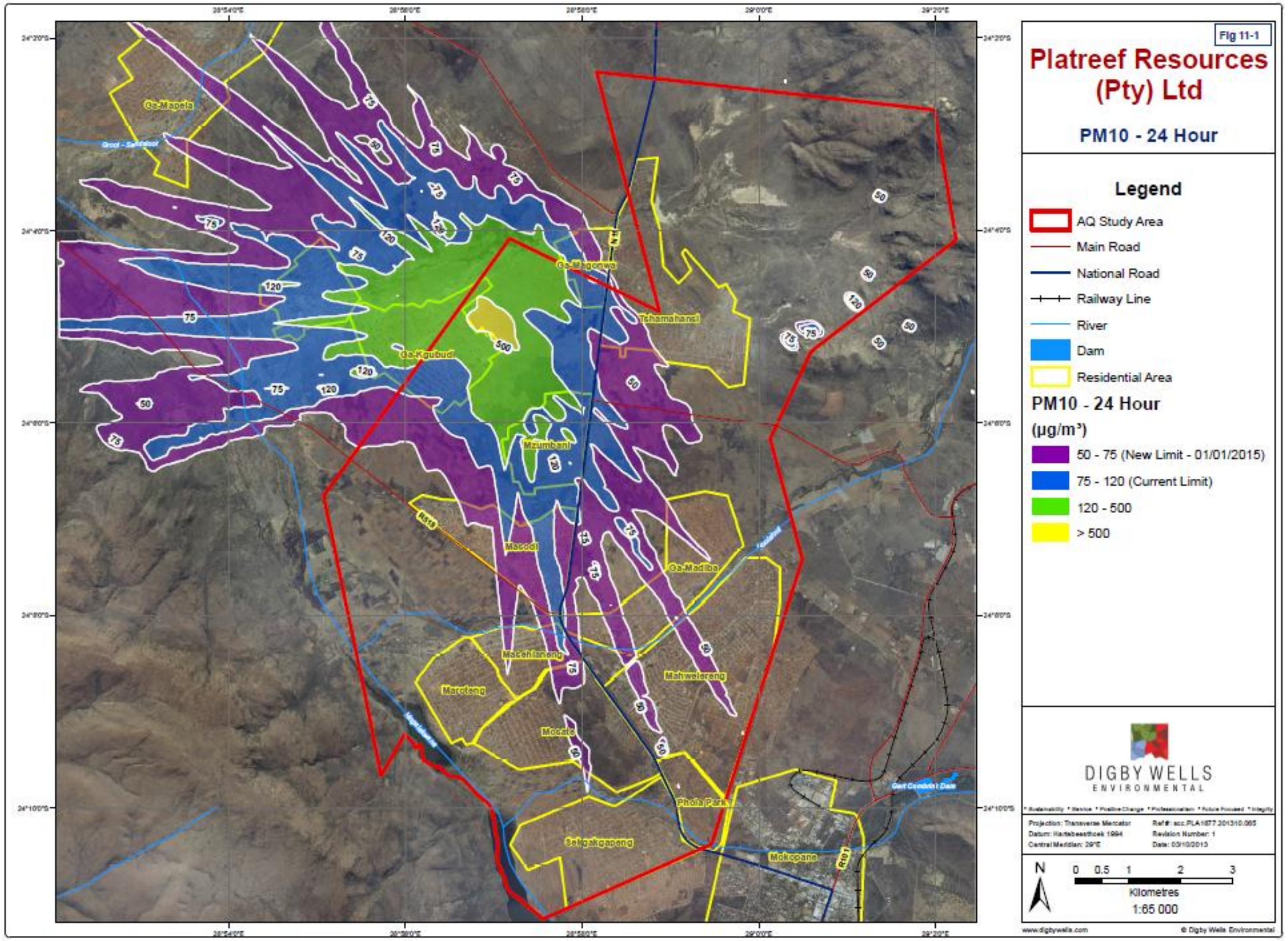

Figure 11-13: Predicted 4th highest 10 minutes average (99th percentile) SO_2 concentrations ($mg/m^2/day$) due to the proposed Platreef Platinum Mine.

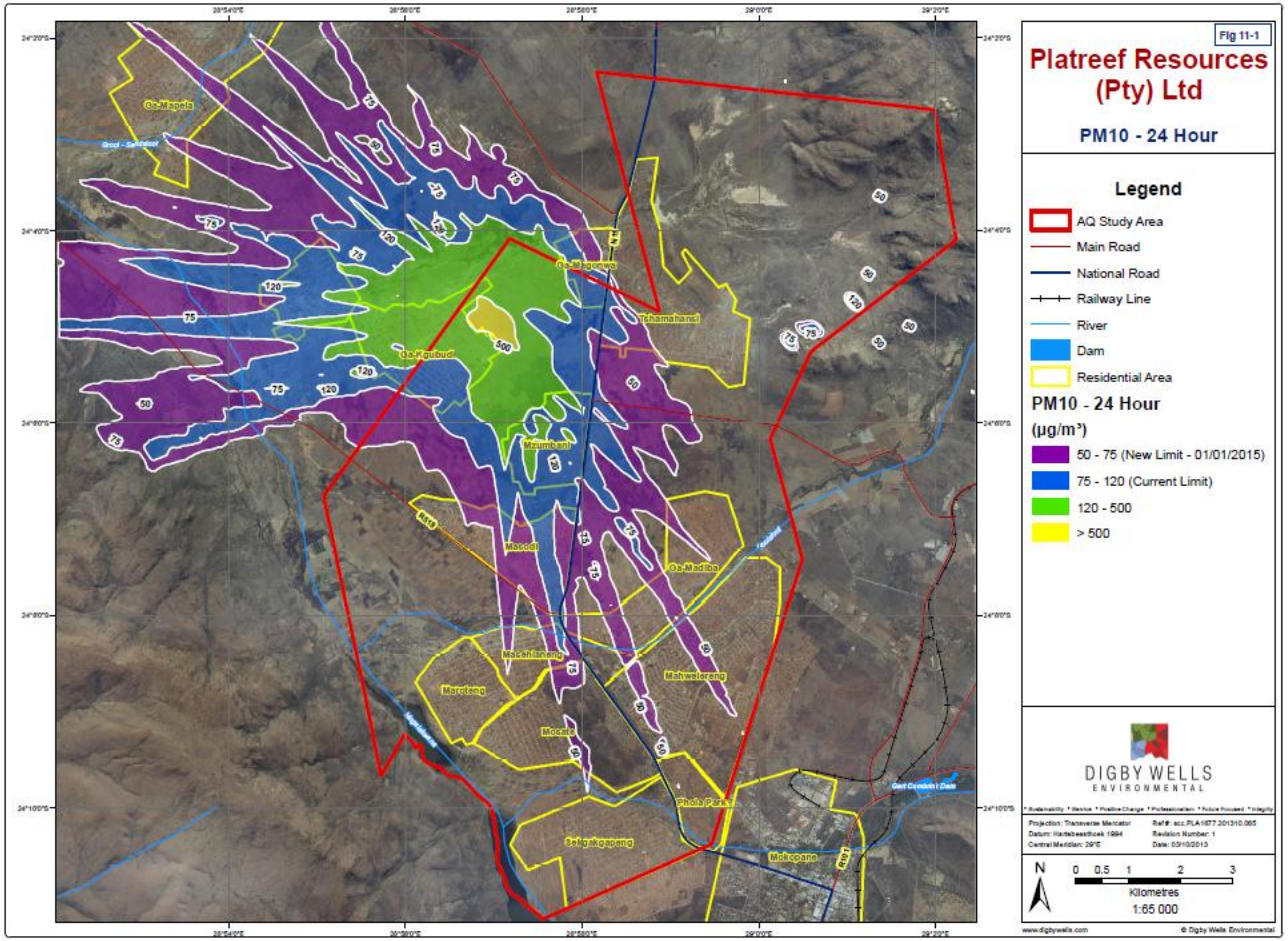

Figure 11-14: Predicted 4th highest hourly average (99th percentile) SO_2 concentrations (mg/m²/day) due to the proposed Platreef Platinum Mine.

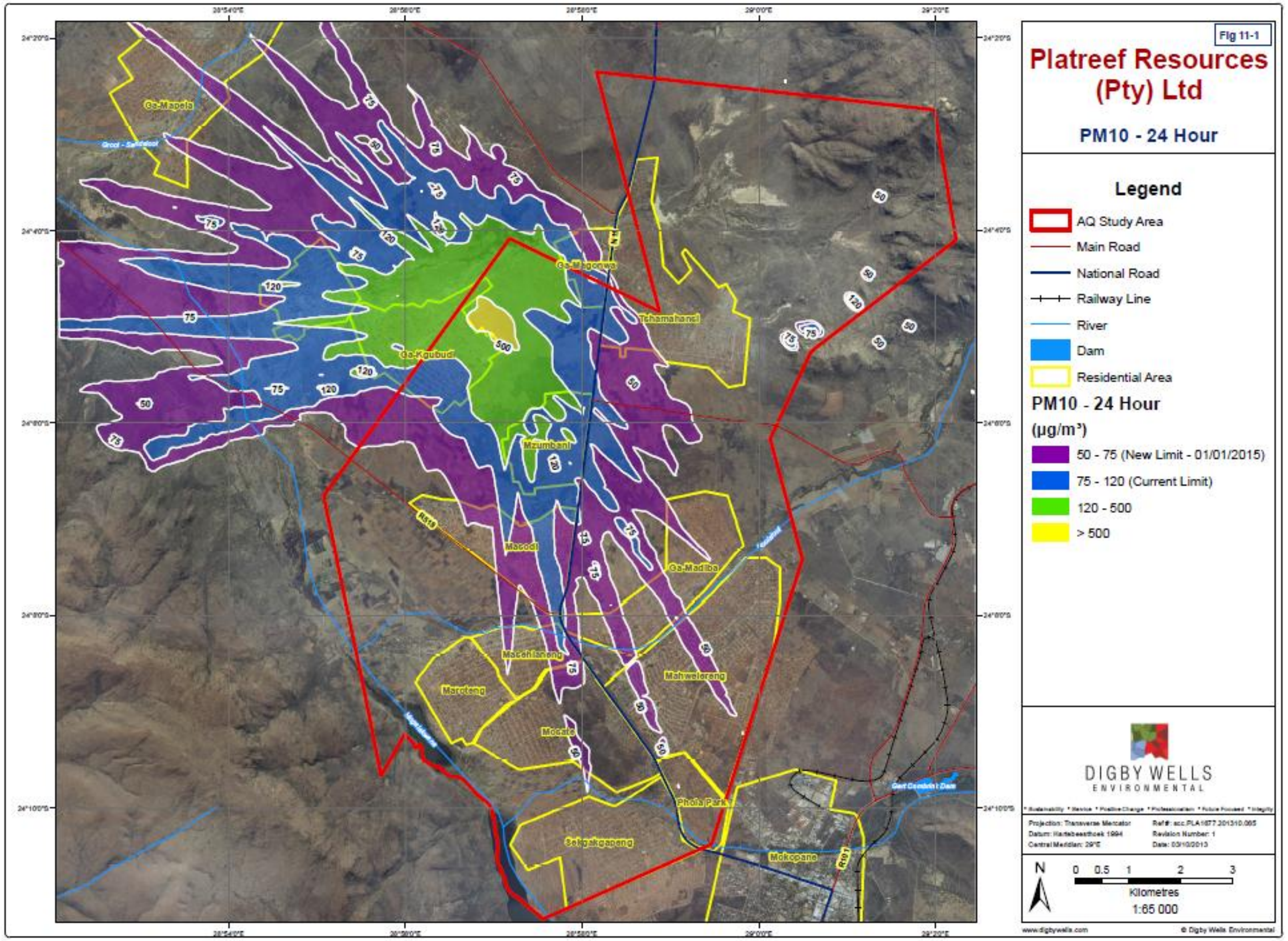

Figure 11-15: Predicted 4th highest maximum daily average (99th percentile) SO_2 concentrations (µg/m^3) due to the proposed Platreef Platinum Mine operation.

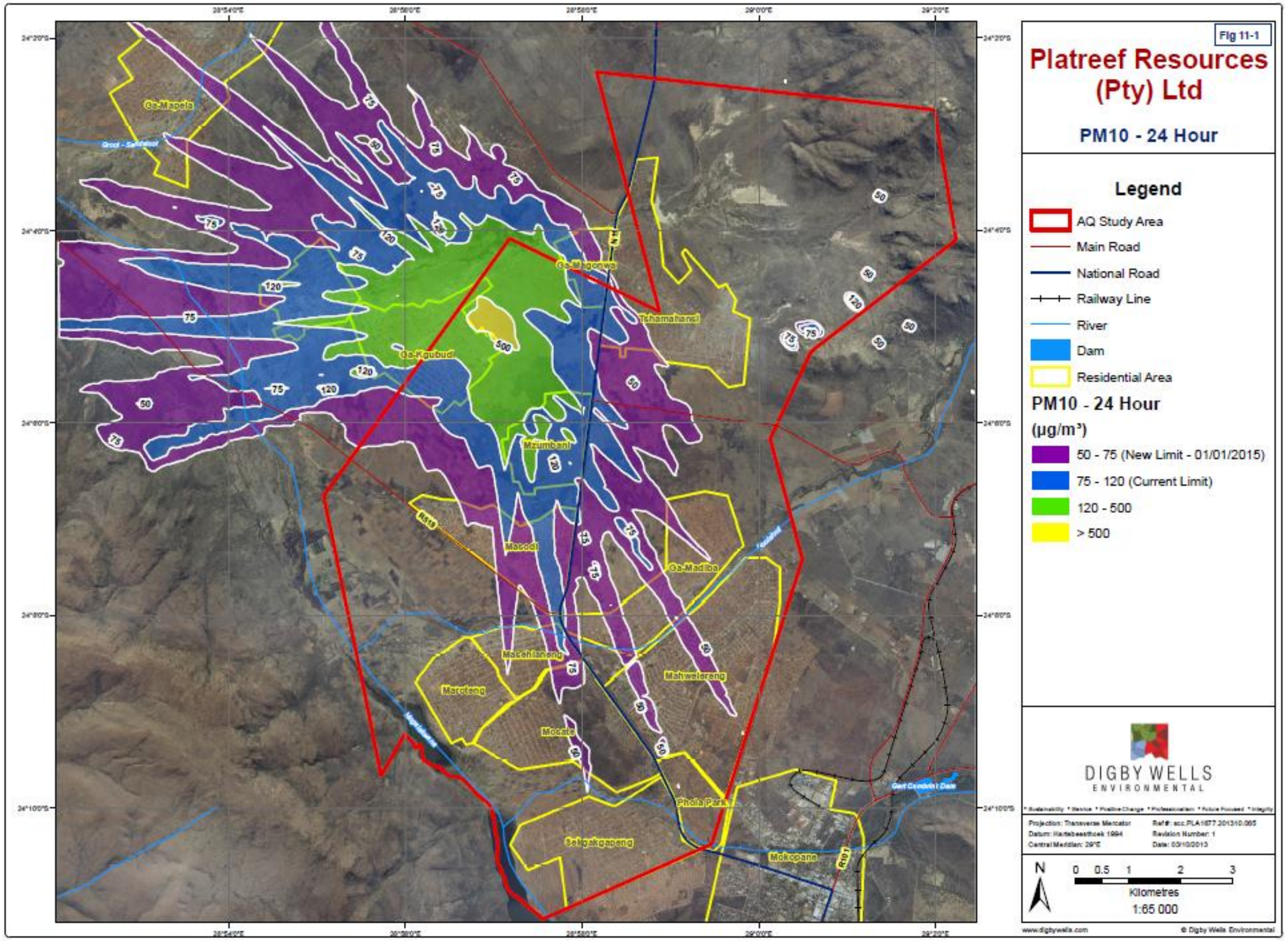

Figure 11-16: Predicted 1st highest annual average (100th percentile) SO_2 concentrations (µg/m^3) due to the proposed Platreef Platinum Mine operation.

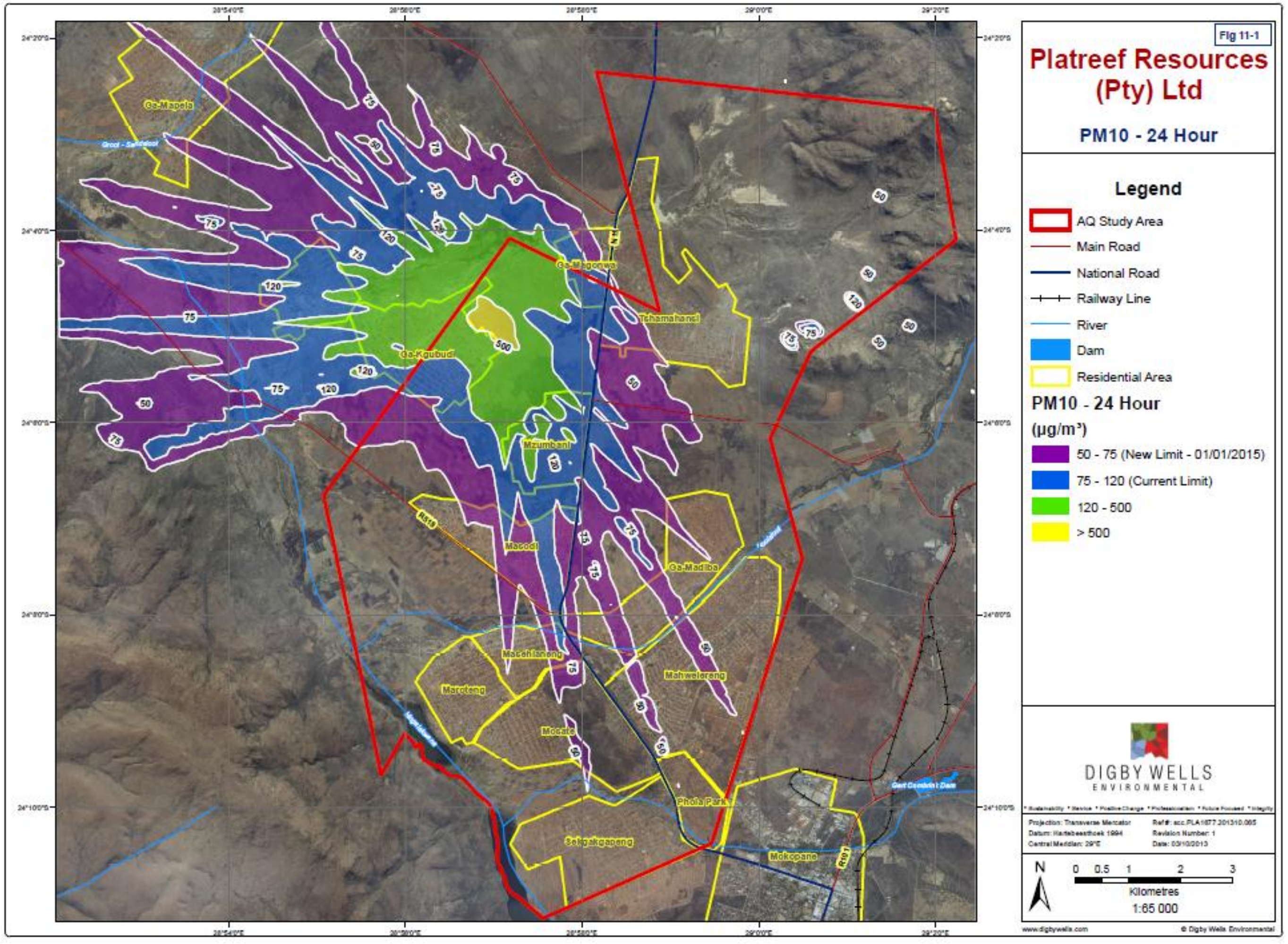

Figure 11-17: Predicted 4th highest hourly average (99th percentile) CO concentrations (µg/m^3) due to the proposed Platreef Platinum Mine operation.

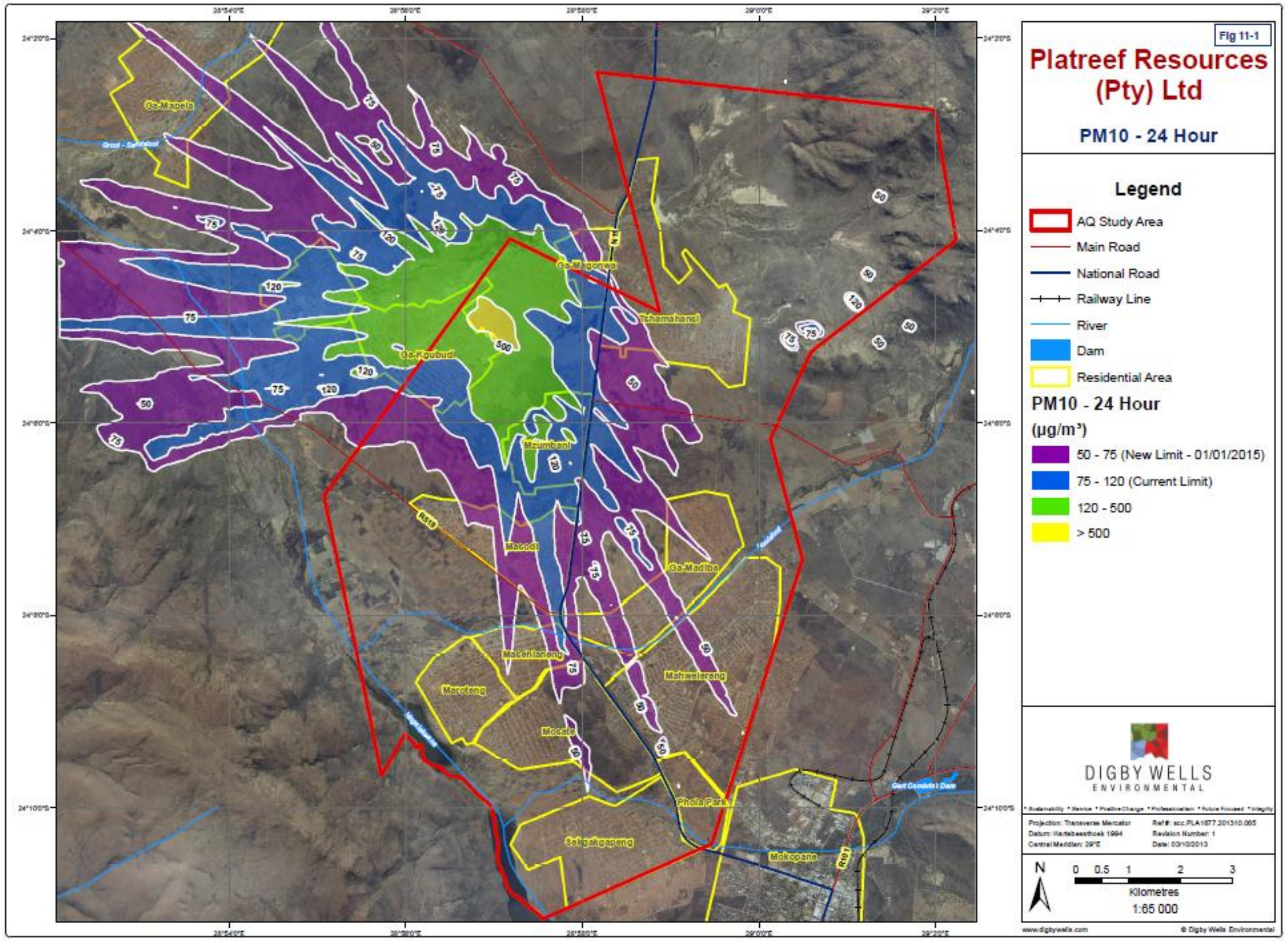

Figure 11-18: Predicted 4th highest 8-hour average (99th percentile) CO concentrations (µg/m³) due to the proposed Platreef Platinum Mine operation.

12 IMPACT ASSESSMENT

12.1 Impact rating and assessment

The list of activities used for the Platreef Air Quality Study is given in Table 12-4.

The method provides an indication in relative terms of the significance of potential impact on the atmospheric environment.

The system is based on ordinal data where a number is used to represent a category. Ordinal data allows for an increase or decrease in the scoring to provide a relative indication which cannot be interpreted on a linear scale.

The methodology determines the environmental significance using the following equation:

Significance of environmental impact = Consequence X Probability

The consequence of an impact can be derived from the following factors:

- Spatial extent;
- Duration of impact; and
- Severity / magnitude

Duration is defined by how long the impact may be prevalent and spatial scale is the physical area which could be affected by an impact. The severity of an impact relates to how severe the impact will be. The overall probability of the impact can be determined, and is related to the likelihood of such an impact occurring. The spatial extent, duration, severity and probability are ranked using the criteria indicated in Table 12-1, and then the overall consequence is determined by adding the individual scores.

Environmental impacts are obtained by multiplying the consequence of the impact with the probability of occurrence, as follows:

Significance = Consequence x Probability

Where

Consequence = Severity (1-7) + Extent (1-7) + Duration (1-7)

And

Probability = Likelihood of an impact occurring (1-7)

The maximum score that can be obtained is 147 significance points.

The impact rating process is designed to provide a numerical rating (scores from 1 to 7) of the various environmental impacts identified for various project activities. The matrix calculates the rating out of 147 (Table 12-2). The significance of an impact is then determined and categorised into one of four categories (Table 12-3). The assessment is done for all activities that were predicted to have an air quality impact.

Environmental impacts are rated as Major, Moderate, Minor and Negligible based on the significance scoring (Table 12-3).

- More than 108 points indicate Major environmental significance;
- Between 73 and 108 points indicate Moderate environmental significance;
- Between 33 and 73 points indicate Minor environmental significance; and
- Less than 33 points indicate Negligible environmental significance.

Table 12-1: Descriptions and scales of the terms used to define the impact significance

Rating	Severity	Spatial scale	Duration	Probability
7	Very significant impact on the environment. Irreparable damage to highly valued species, habitat or eco system. Persistent severe damage.	International The effect will occur across international borders	Permanent: No Mitigation No mitigation measures of natural process will reduce the impact after implementation.	Certain/ Definite. The impact will occur regardless of the implementation of any preventative or corrective actions.
6	Significant impact on highly valued species, habitat or ecosystem.	National Will affect the entire country	Permanent: Mitigation Mitigation measures of natural process will reduce the impact.	Almost certain/Highly probable It is most likely that the impact will occur.
5	Very serious, long-term environmental impairment of ecosystem function that may take several years to rehabilitate	Province/ Region Will affect the entire province or region	Project Life The impact will cease after the operational life span of the project.	Likely The impact may occur.
4	Serious medium term environmental effects. Environmental damage can be reversed in less than a year	Municipal Area Will affect the whole municipal area	Long term 6-15 years	Probable Has occurred here or elsewhere and could therefore occur.
3	Moderate, short-term effects but not affecting ecosystem	Local Local	Medium term 1-5 years	Unlikely Has not happened yet but

Rating	Severity	Spatial scale	Duration	Probability
	function. Rehabilitation requires intervention of external specialists and can be done in less than a month.	extending only as far as the development site area		could happen once in the lifetime of the project, therefore there is a possibility that the impact will occur.
2	Minor effects on biological or physical environment. Environmental damage can be rehabilitated internally with/ without help of external consultants.	Limited Limited to the site and its immediate surroundings	Short term Less than 1 year	Rare/ improbable Conceivable, but only in extreme circumstances and/ or has not happened during lifetime of the project but has happened elsewhere. The possibility of the impact materialising is very low as a result of design, historic experience or implementation of adequate mitigation measures
1	Limited damage to minimal area of low significance, (eg ad hoc spills within plant area). Will have no impact on the environment.	Very limited Limited to specific isolated parts of the site.	Immediate Less than 1 month	Highly unlikely/None Expected never to happen.

Table 12-2: Impact significance matrix as a product of Consequence and Probability

Significance										
		Consequence (severity + scale + duration)								
		1	3	5	7	9	11	15	18	21
Probability / Likelihood	1	1	3	5	7	9	11	15	18	21
	2	2	6	10	14	18	22	30	36	42
	3	3	9	15	21	27	33	45	54	63
	4	4	12	20	28	36	44	60	72	84
	5	5	15	25	35	45	55	75	90	105
	6	6	18	30	42	54	66	90	108	126
	7	7	21	35	49	63	77	105	126	147

Table 12-3: Impact significance classification based on the Significance scoring

Significance		
High (Major)	**108- 147**	
Medium-High (Moderate)	**73 - 107**	
Medium-Low (Minor)	**36 - 72**	
Low (Negligible)	**0 - 35**	

Table 12-4: Activity List

Activity No.	**Activity**
Construction Phase	
1	Site Clearing: Removal of topsoil and vegetation
2	Construction of surface infrastructure (e.g. access roads, pipes, storm water diversion berms, change houses, admin blocks, drilling, blasting and development of adits for mining, etc)
3	Transportation of materials & workers on site

4	Temporary storage of hazardous chemicals and fuels.
Operational Phase	
5	Removal PGM's (underground mining process).
6	Operation of surface infrastructure such as the operation of the mining shaft, crusher, pipelines, the TSF and processing plant (includes water use and storage on site, including pollution control dams).
7	Storage, handling and treatment of hazardous products (fuel, explosives, oil) and waste activities (waste, sewage, discards, PCD).
	Decommissioning Phase
8	Demolition & removal of all infrastructures (incl. transportation off site).
9	Rehabilitation (spreading of soil, re-vegetation & profiling/contouring) (includes sealing of adit and ventilation shaft entrances).
10	Storage, handling and treatment of hazardous products (fuel, explosives, oil) and waste activities (waste and sewage).
Post-closure Phase	
11	Post-closure monitoring and rehabilitation.

12.2 Construction Phase

12.2.1 Activity 1: Site Clearing: Removal of topsoil and vegetation.

Description of impact

During this activity, a number of operations take place such as land clearing, topsoil removal, loading of material, hauling, grading, stockpiling, bulldozing and compaction. Initially, topsoil and subsoil will be removed with large scrapers. The topsoil will be stockpiled for rehabilitation in the berm that will surround mining area. It is anticipated that each of the above mentioned operations will have its own duration and potential for dust generation. Fugitive dust (containing TSP (total suspended particulate, will give rise to nuisance impacts as fallout dust), as well as PM_{10} and $PM_{2.5}$ (dust with a size less than 10 microns, and dust with a size less than 2.5 microns giving rise to health impacts)) It is anticipated that the extent of dust emissions would vary substantially from day to day depending on the level of activity, the specific operations, and the prevailing meteorological conditions. This activity will be short-term and localised, seizing after construction activities.

Impact assessment

Parameter	Impact Pre-Mitigation		Impact Post-Mitigation	
Duration (7)	Short-Term	2	Short-Term	2
Scale (7)	Local	3	Local	3
Severity (7)	Minor	2	Minor	2
Likelihood (7)	Certain / Definite	7	Highly Probable	6
Significance	Medium – Low	49	Medium – Low	42

Mitigation measures

There are various measures that can be implemented to mitigate the impacts of construction activities on atmospheric environment. Topsoil should not be removed during windy months (August, September and October) due to associated wind erosion heightening dust levels in the atmosphere. The area of disturbance must be kept to a minimum and no unnecessary clearing of vegetation must occur. Topsoil should be re-vegetated to reduce the exposure areas. During the loading of topsoil onto trucks or stockpiles, the dropping heights should be minimised. Water or other binding agents such as (petroleum emulsions, polymers and adhesives) can be used for dust suppression on earth roads. When using bulldozers and graders, there is need to minimise travel speed and distance and volume of traffic on the roads.

12.2.2 Activity 2: Construction of surface infrastructure (e.g. access roads, pipes, storm water diversion berms, change houses, admin blocks, drilling, blasting and development of adits for mining, etc)

Description of impact

During this phase, it is anticipated there will be construction of infrastructure. This will include ventilation shafts, incline shaft portal, access roads, pipes, storm water diversion berms, change houses, admin blocks, drilling, blasting and development of adits for mining, etc. Activities of vehicles on access roads, levelling and compacting of surfaces, as well localised drilling and blasting will have implications on ambient air quality. The above mentioned activities will result in fugitive dust emissions containing TSP (total suspended particulate, giving rise to nuisance impacts as fallout dust).

Impact assessment

Parameter	Impact Pre-Mitigation		Impact Post-Mitigation	
Duration (7)	Short-Term	2	Short-Term	2
Scale (7)	Local	3	Local	3
Severity (7)	Low	2	Low	2
Likelihood (7)	Certain / Definite	7	Highly Probable	5
Significance	Medium – Low	49	Low	35

Mitigation measures

To mitigate the impact of construction activities on atmospheric environment, the following measures should be applied: topsoil should not be removed during windy periods (August, September and October), as dust levels will increase as a result of wind erosion. The area of disturbance must be kept to a minimum and no unnecessary clearing of vegetation must occur. Drop heights when loaders dump soil into trucks or on topsoil stockpile should be reduced.

12.2.3 Activity 3: Transportation of materials and workers on site

Description of impact

Transportation of the workers and materials in and out of mine site will be a constant feature during the construction phase. This will however results in the production of fugitive dust (containing TSP, as well as PM_{10} and $PM_{2.5}$) due to suspension of friable materials from earth roads. It is anticipated this activity will be short-term and localised and will seize once the construction activities are finalised.

Impact assessment

Parameter	Impact Pre-Mitigation		Impact Post-Mitigation	
Duration (7)	Short-Term	2	Short-Term	2
Scale (7)	Local	3	Local	3
Severity (7)	Moderate	3	Low	2
Likelihood (7)	Certain / Definite	7	Highly Probable	5

Significance	Medium – Low	56	Low	35

Mitigation measures

In order to mitigate the impacts of the activity, the speed limit should be kept to the low as more dust will be generated at higher wind speeds. Speed limits need to be observed and erecting speed humps. Management should fit roads with speed humps to ensure adherence. Application of wetting agents or application of dust suppressant to bind soil surfaces to avoid soil erosion. The drop heights should be minimised when depositing materials to the ground. Encourage car-pool and bulk delivery of materials in order to reduce the number of trip per day.

12.2.4 Activity 4: Temporary storage of hazardous chemicals and fuels.

Description of impact

These hazardous products include fuel for the trucks, explosives used in drilling and waste or sewage. The impacts of the hazardous materials and waste management are related to the types and amount of equipment and machinery used during construction and the waste produced. Impacts anticipated include evaporation of diesel fuel and heavy fuel from temporary storage tanks and possible spills on site during re-fuelling of heavy machinery and trucks can lead to a reduction in the quality of air in the immediate vicinity. Damage to containers of bags holding powdery chemicals during material handling can lead to release and subsequent erosion with implication on ambient air quality.

Impact assessment

Parameter	Impact Pre-Mitigation		Impact Post-Mitigation	
Duration (7)	Short-Term	2	Short-Term	2
Scale (7)	Local	3	Local	3
Severity (7)	Low	2	Low	2
Likelihood (7)	Highly Probable	6	Likely	4
Significance	Medium – Low	42	Low	28

Mitigation measures

A hazardous products and waste management plan must be developed and applied. This plan will identify anticipated waste streams, addressing determination, inspection and waste minimisation procedures, storage locations, waste-specific management and disposal requirements. Also, a recycling strategy to be applied by workers during the construction phase is vital.

12.3 Operational Phase

12.3.1 Activity 5: Removal PGM's (underground mining process).

Description of impact

In order to transport mined PGM material to surface a number of activities are conducted simultaneously, including the transportation of machinery underground, as well as materials and workforce. This will be followed by followed by subsequent drilling and blasting activities underground, crushing and hauling of materials to the surface. Drilling is an intermittent exercise that emits fugitive dust. There will be fumes from diesel trucks transporting ore to the conveyor belt. The conveyor belts deposit the Platinum into the crusher, the crushing process releases fugitive dust. Activities by machinery underground will lead to exhaust fumes from vehicles and dust from drilling and blasting processes. Fugitive dust (containing TSP, as well as PM_{10} and $PM_{2.5}$) occurs as a result of the aforementioned processes.

Description of impact

Parameter	Impact Pre-Mitigation		Impact Post-Mitigation	
Duration (7)	Project life	6	Project life	5
Scale (7)	Local	3	Local	3
Severity (7)	Moderate	3	Minor	2
Likelihood (7)	Likely	6	Likely	4
Significance	Medium – Low	72	Medium – Low	40

Mitigation measures

To mitigate the impact of using and maintaining underground machinery and other mining activities such as drilling, blasting and crushing on atmospheric environment, the following measures should be applied: there is need to have water sprays, filtration systems can be utilised to remove the pollutants from the air prior to their release to the surface via the vent, use of efficient diesel fuel for heavy underground machinery.

12.3.2 Activity 6: Operation of surface infrastructure such as the operation of the mining shaft, crusher, pipelines, the TSF and processing plant (includes water use and storage on site, including pollution control dams).

Description of impact

In this activity, the use of the secondary crusher and TSF are the most likely to have implications on ambient air quality. The crushing process releases fugitive dust, especially if there are no enclosure and water sprays. Dust contained within the RoM ore can be released into the atmosphere during this process i.e. fugitive dust (containing TSP, as well as PM_{10} and $PM_{2.5}$). Wind erosion from TSF can be a perennial source of dust if not properly managed during and post mining operations.

Impact assessment

Parameter	Impact Pre-Mitigation		Impact Post-Mitigation	
Duration (7)	Project Life	5	Project Life	5
Scale (7)	Local	3	Limited	2
Severity (7)	Very Serious	5	Serious	4
Likelihood (7)	Highly Probable	6	Likely	5
Significance	Medium – High	78	Medium – Low	55

Mitigation measures

During crushing, it is advised to install water sprays around the crushing area and will be better if the crusher is enclosed to reduce its impact on ambient air quality. The TSF should undergo routine maintenance throughout the lifespan of the mine – with on-going revegetation to avoid exposed surface amenable to wind erosion.

12.3.3 Activity 7: Storage, handling and treatment of hazardous products (fuel, explosives, oil) and waste activities (waste, sewage, discards, PCD).

Description of impact

Most significant waste is produced from the operational phase as there is a significant amount of waste rock removed. Since this is going to be an underground operation, the topsoil generated will be minimal. However, there will be waste rock stockpiles generated from the underground process. Hazardous products include fuel, explosives and waste or sewage. Hazardous materials and waste impacts are related to the types, amount of equipment and machinery used for the phase. It includes 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 chemicals.

Impact assessment

Parameter	Impact Pre-Mitigation		Impact Post-Mitigation	
Duration (7)	Project Life	5	Project Life	5
Scale (7)	Local	3	Local	3
Severity (7)	Very Serious	5	Serious	3
Likelihood (7)	Likely	5	Probable	4
Significance	Medium – Low	65	Medium – Low	44

Mitigation measures

There is a need to develop a waste management plan. This will identify anticipated liquid and solid waste streams and will ensure thorough inspection and waste minimisation procedures, storage locations, and waste-specific management and disposal requirements. Optimum material handling and recycling strategy should be enforce by management and strict adherence on the part of workers during the operation phase. There is need for the provision of secondary containment for fuel storage. Hazardous substances should be stored and handled in accordance with the local regulations and chemicals must be stored in clearly labelled containers. Employees should be trained on hazards of handling and storing hazardous chemicals. There is need to understand the process that generates waste and monitoring constantly to observe if there are changes in the waste or the waste characteristics. It is essential to ensure regular training and exercise for the staff on the emergency procedures.

12.4 Decommissioning Phase

12.4.1 Activity 8: Demolition & removal of all infrastructures (incl. transportation off site).

Description of impact

During this activity, there is demolition of buildings and foundation and subsequent removal of rubbles generated. There is cleaning-up of workshops, fuels and reagents, removal of power and water supply, removal of haul and access roads. Potential for impacts during this phase will depend on the extent of demolition and rehabilitation efforts during closure as well as features which will remain. The impacts on the atmospheric environment during the decommissioning phase will be similar to the impacts during the construction phase. The process includes dismantling and demolition of existing infrastructure, transporting and handling of topsoil on unpaved roads in order to bring the site to its initial/rehabilitated state. Demolition and removal of all infrastructureswill cause fugitive dust emissions. The impacts will be short-term and localised. Any implication or implications this phase will have on ambient air quality will seize once the activities are finalised.

Impact assessment

Parameter	Impact Pre-Mitigation		Impact Post-Mitigation	
Duration (7)	Short-Term	2	Short-Term	2
Scale (7)	Local	3	Local	3
Severity (7)	Low	2	Low	2
Likelihood (7)	Highly Probable	6	Likely	5
Significance	Medium – Low	42	Low	35

Mitigation measures

In order to mitigate the impacts of demolition and removal of rubbles on the atmospheric environment, the following measures should be applied: demolition should not be performed during windy periods (August, September and October), as dust levels and the area affected by dust fallout will increase. The area of disturbance must be kept to a minimum, as demolition should be done judiciously avoid the exposure of larger areas to wind erosion .

12.4.2 Activity 9: Rehabilitation (spreading of soil, re-vegetation and profiling/contouring) (includes sealing of adit and ventilation shaft entrances).

Description of impact

During this activity, there is the reshaping and restructuring of the landscape. Since this is an underground operation, the area to be reconstructed will be limited to the adit area(s). Topsoil can be imported to reconstruct the soil structure. There is less transfer of soil from one area to other therefore negligible chances of dust through wind erosion. Profiling of TSF ans waste rock dump to enhance vegetation cover and reduce wind erosion from such surfaces post mining. Adits and vent shafts will be sealed to avoid the release of gases from underground from several reactions that might take place once mining stops, as this would have implications on ambient air quality.

Impact assessment

Parameter	Impact Pre-Mitigation		Impact Post-Mitigation	
Duration (7)	Short-Term	2	Short-Term	2
Scale (7)	Local	3	Local	3
Severity (7)	Serious	4	Minor	2
Likelihood (7)	Highly Probable	6	Likely	4
Significance	Medium – Low	54	Low	28

Mitigation measures

Spreading of soil must be performed on less windy days. The bare soil will be prone to erosion there is need to reduce the velocity near the surface of the soil by re-vegetation. Leaving the surface of the soil in a coarse condition reduces wind erosion and ultimately reduces the dust levels. Additional mitigation measures include keeping the soil moist using sprays or water tanks, using wind breaks. The best time to re-vegetate the area must be linked to the distribution and reliability of the rainfall.

12.4.3 Activity 10: Storage, handling and treatment of hazardous products (fuel, explosives, oil) and waste activities (waste and sewage).

Description of impact

This includes fuel, explosives and solid waste from the destruction of structures. Hazardous materials and waste impacts are related to the types, amount of equipment and machinery used for the phase. The impacts include waste produced and material generated during the decommission phase. It includes evaporation of diesel fuel and heavy fuel from temporary storage tanks on site that are used for re-fuelling of heavy machinery and trucks. Some of the wastes include waste oils, chemicals and hazardous chemicals.

Impact assessment

Parameter	Impact Pre-Mitigation		Impact Post-Mitigation	
Duration (7)	Short Term	1	Short Term	1
Scale (7)	Local	3	Local	3
Severity (7)	Very Serious	5	Serious	4

Parameter	Impact Pre-Mitigation		Impact Post-Mitigation	
Likelihood (7)	Highly Probable	6	Likely	5
Significance	Medium –Low	54	Medium –Low	40

Mitigation measures

There is a need to develop a hazardous products and waste management plan that identifies anticipated waste streams, addresses determination, inspection and waste minimisation procedures, storage locations, waste-specific management and disposal requirements. Include a recycling strategy to be practiced by workers during the decommissioning phase. The hazardous substances should be stored and handled in accordance with the local regulations. The chemicals must be stored in clearly labelled containers. Employees should be trained on hazards of handling and storing hazardous chemicals. There is need to understand the process that generates waste and monitor constantly to see if there is any changes in the waste or the waste characteristics. Regular training and exercise for the staff about the handling and adequate disposal of hazardous waste procedures is crucial.

12.4.4 Post-closure phase

12.4.5 Activity 11: Post-closure monitoring and rehabilitation.

Description of impact

Re-vegetation of the remaining footprint of the mine must be done after the reclamation. The impacts on the atmospheric environment during rehabilitation will be limited to the vehicular activity during spreading of soil and profiling/contouring. The impact will be medium-term, very limited on spatial scale, with limited implication on ambient air quality.

Impact assessment

Parameter	Impact Pre-Mitigation		Impact Post-Mitigation	
Duration (7)	Medium-Term	3	Medium-Term	3
Scale (7)	Very Limited	1	Very Limited	1
Severity (7)	Minor	2	Minor	2
Likelihood (7)	Highly Probable	6	Highly Probable	6
Significance	Medium – Low	36	Medium – Low	36

It is recommended that the rehabilitation by vegetating should begin during the operational phase. The objective is to minimise the erosion. These measures should reduce the potential for fugitive dust generation and render the impacts on ambient air quality negligible.

13 SUMMARY OF SIGNIFICANT IMPACTS

The significant impacts for the proposed mine includes the storage of ROM stockpile, TSF, waste rock stockpiles, use of the secondary crusher and the release of gaseous pollutants from the ventilation shafts. The mitigation and management measures discussed below detail how these significant impacts can be managed and mitigated.

14 MITIGATION MEASURES AND MANAGEMENT PLAN

The following mitigation and management measures detailed below will reduce fugitive dust and by implication respirable fractions from identified sources (includes crusher, material handling (tipping) processes and transportation of ore), paved roads and stockpiles.

14.1 Material handling operations

As the secondary crusher is a known source of emissions, generated dust can be mitigated by housing the crusher in an enclosure and using water sprays. To manage the fugitive dust, the feed side of the crusher must be enclosed (USBM, 1974). With other sources of dust, use of water to dampen dust generating areas such as ROM stockpile, wasterock stockpile or exposed soil (i.e. have a spray at the beginning of a dust source, in this case the stockpile - use of fan sprays nozzles to minimise the volume of water utilised), use of chemical dust suppressant, wind breaks and rapid vegetation of exposed areas will reduce the amount of dust generated. Conveyor will be employed for transporting the ore and it should be covered, while the ore material should be sprayed to increase moisture content and reduce dust. Lowering the fall heights of the transfer points through the use of velocity breaking chutes will also reduce the amount of dust generated.

The magnitude of ore dust emissions is dependent on a number of factors, such as the level of exposure of the open surface to air moving at high speeds and the inherent dustiness of the material. Measures that can be applied include: enclosed conveyor belt to reduce wind contact with ore during transport and deployment of water spray.

14.2 Berm Construction

What dust control needed for building of Berm

14.3 Paved roads

The fugitive dust generated from paved roads is anticipated to be minimal, but needs to be controlled in line with good practice. Since this is an underground operation, the paved roads will mainly be used for the transportation of ore concentrate from the plant for smelting out the mine premises.

14.3.1 Speed controls on paved road

Reducing speed on haul roads is an effective way to manage fugitive dust. However reducing speed may lower the production of mines. Studies by Watson et al., 1996 showed that reducing speed reduces the generation of particles less than 10 micro meters by about 58% when speed controls are reduced from 25 mph (40 km/h) to 15 mph (24 km/h). Also, it was reported that decreasing the volume of traffic on the haul roads reduces the impacts of dust entrainment. Transportation of ore material will be conducted by conveyor belt hence the expected levels of dust associated with this source will be negligible.

14.4 Wind erosion from stockpiles and open areas

There are two main types of stockpiles: long term and short term. A topsoil stock pile is a long term stockpile is a stockpile that is not disturbed for a long period; it is stored until reclamation of the mine will be done. Topsoil will be used to raise berm around the mining area that will act as a barrier and will have screening function. The latter is not applicable to Platreef operation being an underground operation. The only places where topsoil will be removed are the adit areas and are limited in scale. However, the ore, waste rock and TSF stockpiles will be exposed to wind erosion during the operational life of the mine. Wind erosion of stock piles and open areas is reduced when soils are left as clods which are dense, thereby resisting erosion. Other measures to manage erosion from stockpiles are to ensure the soils are roughened, compacted and kept moist. Wetting the soils leads to materials forming a crust that resists erosion. Cementation can be used as a means of controlling dust. This is done by alternate wetting and drying of the soils thus firming the crust. Wind barriers can be created using plants, shrubs and trees. Vegetation can be grown on the edges of the stockpile to reduce erosion, especially after the cessation deposition on the stockpile. Vegetation prevents high winds from getting in contact with the loose materials thereby preventing entrainment of particles. Mulching of recently disturbed areas can reduce the amount of wind erosion by 80% (Smolen et al., 1988; USEPA 1995; Woodruff 1977).

As the amount of soil exposed is directly proportional to the amount of dust generated and the amount of dust transported, it is not advised to construct during the windy periods. In order to determine the windy periods, a wind anemometer needs to be installed on site. Wind speed will be recorded daily and when wind speeds exceed 5.4 m/s, extra dust control measures need to be carried out. Mitigation efficiencies for wind erosion as prescribed by the Australian NPI Emission Estimation Technique Manual for Mining Version 3.1 are reported in Table 14-1.

Table 14-1: Mitigation efficiencies for wind erosion (After Australian NPI Emission Estimation Technique Manual).

Description	Mitigation efficiency (%)
Wind erosion from stockpiles	50% for water sprays. 30% for wind breaks. 99% for total enclosure.

Description	Mitigation efficiency (%)
	30% for primary earthworks (reshaping/profiling, drainage structures installed). 30% for rock armour and/or topsoil applied.
Wind erosion	30% for primary rehabilitation 40% for vegetation established, but not demonstrated to be self-sustaining. Weed control and grazing control. 60% for secondary rehabilitation. 90% for re-vegetation. 100% for fully rehabilitated (release) vegetation.

15 MONITORING PROGRAMME

15.1 Dust Monitoring Programme

Platreef Mine conducted dust monitoring campaign for one year (April 2003 to April 2004) and results are presented in this report. It commissioned a dust monitoring network in August 2013 for a twelve months period. It is advised that such monitoring be continue after the current monitoring period expires, for the project life in order to establish historical repository of data needed to fully understand/address fugitive and airborne dust emissions from the construction, operation and closure activities. The current dust monitoring sites are depicted in Plan 5. Managing dust fallout effectively will result in the reduction of respiratory diseases that are as a result of air pollution, reduced risk of damage to property, improved visibility, and fewer disturbances to existing flora and fauna habitats.

15.2 PM_{10} Monitoring Programme

As reported previously, Platreef conducted a PM_{10} and $PM_{2.5}$ monitoring during the period April 2003 and April 2004. The client should re-establish a fine particulate monitoring programme, which should include one particulate instrument to monitor PM_{10} and preferably $PM_{2.5}$ from the mine operation. PM_{10} instrument should be located to the western section of the mine boundary. This is based on the plots from the air dispersion modelling results. It is advised to install the unit at least one year prior to the construction phase to allow for the collection of an ambient air quality baseline data set.

15.3 Gaseous Monitoring Programme

The gaseous pollutants such as NO_2, SO_2 and CO where modelled using default occupational limit values. It is recommended that monitoring programme to measure gaseous pollutants (NO_x, SO_2), and other criteria pollutants be initiated.

16 CONCLUSION

The findings reported here are a mixture of historical, observed and modelled data and provided the background and predicted scenario of various pollutant in the Platreef mining area. The daily PM_{10} concentrations recorded at the Mokopane Ambient Air Quality Station are presented and generally are within the NAAQS for PM_{10} of 120 µg/m³ for the month considered. If the future NAAQS ambient standard of 75 µg/m³ is considered (which will come into effect on the 1st of January 2015), there are several days exceeding the limit value. However, the WHO Guideline of 50 µg/m³ is actually exceeded on a number of occasions. Records provided from measurements conducted by WSP Walmsley (2003/2004) provide historical levels of ambient particulate matter in the proposed Platreef mining area and confirm five sequential months exceeding the South African Standard of 120 µg/m³ for PM_{10}. If reference is made to the IFC (WHO Guideline - 50 µg/m³), only one of the twelve months of sampling was within compliance. Isopleths of PM_{10} generated from dispersion model for both unmitigated and mitigated scenarios have shown that concentrations above the recommended limit value can reach distances of ~2 km from the mine boundaries, especially for the western and southern section of the mine boundary.

$PM_{2.5}$ data from the Mokopane Ambient Air Quality Station confirm the low levels of this pollutant, with values below the IFC (WHO guideline) value of 25 µg/m^3 and the NAAQS of 65 µg/m^3. Historical records from the monitoring campaign conducted by WSP Walmsley in 2003/2004 confirmed two month of no compliance in a year. Generally, values recorded were within the 65 µg/m³ threshold recommended by the current standard. Isopleths from the dispersion modelling plots have indicated that the area impacted by $PM_{2.5}$ arising from the proposed Platreef mine operation is minimal and greater portion falls within the project area.

The dust monitoring programmes conducted by WSP Walmsley in 2003/2004 in the Platreef mining area confirmed high dust fallout rates in the area. The historical dust fallout data measured are observed to be in violation of the current residential and industrial limits recommended by SANS 1929:2011 “Ambient air quality – limit for common pollutant”. Although the permitted Frequency of exceedance is twice within a year (not sequential months), the area recorded seven consecutive months of exceedance, with dust deposition rates observed for each of the months well over 1 500 mg/m^2/day. The above background results from historical data are considered a serious violation of the current standard. The seasonal variability also showed high deposition rates except during summer season, with values within the residential and industrial limits, apart from one site which recorded deposition rates of 740 mg/m^2/day. Results from the dispersion modelling did not corroborate the observed data reported by Walmsley in 2003/2004. From the dispersion model data, only one site was in violation of the residential limit as recommended by SANS 1929:2011. With the commissioning of a monitoring network in August 2013 by Platreef, it will be interesting to see if the results are in line with those reported from historical measurements.

For NO_2, observed data from the Mokopane Ambient Air Quality Station show levels that are generally within the limit for both the South African NAAQS and WHO Guideline, although incidents of one or two peaks exceeding recommended limits are common. Hourly ground level concentration of this pollutant generated with AERMOD dispersion modelling have shown that areas between 400 and 450 m from the vent shaft are likely to experience NO_2 levels above recommended limit. The isopleth of annual ground level concentration are with the recommended limit, with higher values confined to the mine boundary.

The level of SO_2 levels from observed data reported by SAAQIS are generally within the recommended South African NAAQS and WHO Guidelines. The dispersion model data for the 10 Minutes, 1-hour, 24-hour and 1-year averaging periods reveal that from the vents to a distance of 400, 450 and 500 m are likely to experience values above the standard for the various averaging periods.

Carbon monoxide (CO) concentrations measured at the SAAQIS are below the recommended NAAQS 8-hr and 1-hr limit values respectively. The peaks observed in CO concentration are not in exceedance of the standard. Isopleths of ground level concentrations generated from the dispersion model are showing low values. Default occupational limit have been deployed as input data to the dispersion model, as site-specific data was not available.

17 REFERENCES

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

Chestnut et al (1991). Pulmonary function and ambient particulate matter: epidemiological evidence from NHANES I. Arch Environ Health 46(3):135-144.

Cowherd et al (1998*).* Control of Open Fugitive Dust Sources, EPA-450/3-88-008, United States Environmental Protection Agency, Research Triangle Park, North Carolina.

Dockery D.W., C.A. Pope, III, X. Xu, *et al*. 1993. An association between air pollution and mortality in six U.S. cities. *N. Engl. J. Med*. 329:1753-1759.

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

Ferguson, J.H. et al., (1999): "Fugitive Dust: Nonpoint Sources." Agricultural MU Guide, University of. Missouri-Columbia, Agricultural Publication G1885.Government of the Republic of South Africa - Government Notice 1210:2009 – National Ambient Air Quality Standards – December 2009.

Government of the Republic of South Africa - Government Notice 1007: 2012 - Draft National Dust Control Regulations – December 2012.

Government of the Republic of South Africa - Mine Health and Safety Act, Act 29 of 1996, Amendment to the Regulations in Respect of Occupational Hygiene, GN No. R 989, 2006.

Government of the Republic of South Africa - National Environmental Management: Air Quality Act, Act 36 of 2004.

Government of the Republic of South Africa - National Environmental Management Act, Act 107 of 1998.

Harrison, Roy M., 1948- & Grieken, R. van (René) (1998). Atmospheric particles. Wiley, Chichester; New York

Manahan, S.E., (1991): *Environmental Chemistry*, Lewis Publishers Inc, United States of America.

Maroni, M., Seifert, B. and Lindvall, T. (eds) (1995), *Indoor Air Quality - A Comprehensive Reference Book*, Elsevier Science & Technology, Amsterdam, Netherlands.

Pope C. A., Schwartz J., Ransoms M. R. (1992). Daily mortality and PM10 pollution in the Utah valley. Arch. Environ. Health 47, 211–217.

Pope, C.A., Dockery, D.W., (1992). Acute health effects of PM10 pollution on symptomatic and asymptomatic children. *American Journal of Respiratory and Critical Care Medicine*. Vol 145(5), 1123-1128.

Pope C. A., Kanner R. E. (1993) Acute effects of PM 10 pollution on pulmonary function of smokers with mild to moderate chronic obstructive pulmonary disease. Am. Rev. Respir. Dis. 147:1336–1340.

Preston-Whyte R.A. and Tyson P.D. (1988). *The Atmosphere and Weather over South Africa,* Oxford University Press, Cape Town.

Scorgie Y., Mudeme L. (2006). Air quality impact assessment for Lonmin Platinum's proposed Karee tailings dam No's 4, 5 & 6 Marikana District, Report No.: APP/05/NSS-01 Rev 1.0. for Airshed Planning Professionals (Pty) Ltd.

Smolen, M.D., D.W. Miller, L.C. Wyatt, J. Lichthardt, and A.L. Lanier, (1988). *Erosion and Sediment Control Planning and Design Manual*. North Carolina Sedimentation Control Commission; North Carolina Department of Environment, Health, and Natural Resources; and Division of Land Resources, Land Quality Section, Raleigh, NC.

Smolen, M.D., D.W. Miller, L.C. Wyatt, J. Lichthardt, and A.L. Lanier. (1988). *Erosion and Sediment Control Planning and Design Manual*. North Carolina Sedimentation Control Commission; North Carolina Department of Environment, Health, and Natural Resources; and Division of Land Resources, Land Quality Section, Raleigh, NC.

SPCC (State Pollution Control Commission of New South Wales) (1983) - Air Pollution from Platinum Mining and Related Developments, ISBN 0 7240 5936 9.

Standards South Africa - South African National Standard (SANS) - code of practice, SANS 1929:2011, 2nd Edition, "*Ambient Air Quality – Limits for common pollutants*."

Standards South Africa - South African National Standard (SANS) SANS 1137:2012 "*Standard test method for collection and measurement of dustfall (settleable particulate matter*".

Schwartz, J. (1993). Particulate air pollution and chronic respiratory disease, *Environmental Research*, *62*(1): 7-13

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

US EPA (1998) *National Air Pollutants Emission Trends Report Procedures, 1900 - 1996*. Office of Air Quality and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC, 1998.

US EPA (2006b) *Revision of Emission Factors for AP-42*. Chapter 13: Miscellaneous Source. Section 13.2.4: Aggregate Handling and Storage Piles (Fugitive Dust Sources). http://www.epa.gov/ttn/chief/ap42/index.html. Accessed 2 June 2013.

USBM, (1974). Survey of past and present methods used to control respirable dust in nonPlatinum mines and ore processing mills—final report. U.S. Department of the Interior, Bureau of Mines Contract No. H0220030. NTIS No. PB 240 662.

Watson JG, Rogers CF, Chow JC, DuBois D, Gillies JA, Derby J, Moosmüller H, (1996).Effectiveness demonstration of fugitive dust control methods for public unpaved roads and unpaved shoulders on unpaved roads. Final Report, DRI Document No. 685–5200.1F1,Prepared for California Regional Particulate Air Quality Study, Sacramento, California: California Air Resources Board.

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

WHO (2004). WHO Air Quality Guidelines Global Update, World Health Organisation, October 2005, Germany.

Woodruff NP, Lyles L, Siddoway FH, Fryrear DW ,(1977). How to control wind erosion. U.S. Department of Agriculture, Agricultural Research Service, Agriculture Information Bulletin No. 354.

Appendix A: Declaration of Independence & Curriculum Vitae

SPECIALIST DECLARATION OF INDEPENDENCE

I, Vladimir Jovic, declare that I –

- Act as the independent specialist for the undertaking of a specialist section for the project;
- Do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the Environmental Impact Assessment Regulations, 2006;
- Do not have nor will have a vested interest in the proposed activity proceeding;
- Have no, and will not engage in, conflicting interests in the undertaking of the activity; and
- Undertake to disclose, to the competent authority, any information that have or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the Environmental Impact Assessment Regulations, 2006.

Vladimir Jovic

Name of the specialist

Signature of the specialist

Digby Wells Environmental

Name of company

03/10/13

Date

CURRICULUM VITAE

Mr. Vladimir Jovic
Air Quality Specialist
GIS & Air Quality Department
Digby Wells Environmental

EDUCATION

Matriculation/National Certificate Equivalent - Nuclear Physics Technician, 1985

BSc (Hons) Urban & Regional Planning University of Belgrade, 1998

COURSES

UJ - CALPUFF Advanced techniques in Dispersion Modelling October 2010

UJ – AERMOD Air Dispersion Modelling March 2010

NACA – Introduction to Atmospheric Dispersion Modelling February 2010

NACA & UJ – CALPUFF Modelling Course October 2008

Geographic Information Management Systems –

Understanding Projections in GIS July 2006

Geographic Information Management Systems –

Introduction to ArcGIS 1 March 2006

Computer Foundation – Advanced GIS Course May 2011

PROFESSIONAL AFFILIATIONS

National Association for Clean Air - Member

EMPLOYMENT

November 2011 – Present Digby Wells Environmental: Unit Manager: Atmospheric Science

2010 Dec – October 2011 South African Weather Service: Unit Manager: Air Quality Information

2010 Sept – 2010 Nov Gijima Human Capital Management Division

Occupational Hygiene and Environmental Service: Environmental Specialist

2007 – 2010- Gondwana Environmental Solutions Senior Air Quality Scientist/Project Manager

2006 – 2007 Airshed Planning Professionals Air Quality Scientist

2004 – 2006 Annegarn Environmental Research Environmental Scientist

EXPERIENCE

- Air dispersion modelling.
- Air quality impact assessments.
- Air quality management plans.
- Preparation of tender proposals, quotes and technical documents.
- Assisting with project management.
- Processing meteorological data.
- Compiling emissions inventories.
- Corporate Governance & Strategic Management.

Air quality information unit operational activities: development, implementation, maintenance and support.

Appendix B: Plans

Plan 1: Regional Setting

Plan 2: Local Setting

Plan 3: Topography

Plan 4: Proposed Mine Infrastructure

Plan 5: Dust Monitoring Points