AIR QUALITY IMPACT ASSESSMENT STUDY:

PROPOSED BRAKFONTEIN THERMAL COAL MINE,

MPUMALANGA PROVINCE

21 September 2012

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Report Title:	Specialist Air Quality Assessment Study (including dispersion modelling) for the proposed Brakfontein Thermal Coal Mine, Mpumalanga Province
Project Number	2012DWE-0319
Report Number:	RN_120294_DWE
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Date Submitted:	21 September 2012
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Executive Summary

Gondwana Environmental Solutions (GES) was appointed by Digby Wells Environmental to undertake an air quality impact assessment of the proposed Brakfontein Thermal Coal Mine in Mpumalanga Province. The main objective of the assessment was to assess the potential impact on ambient air quality and human health risks associated with the proposed mining operations.

The scope of work used to evaluate the potential impact that emissions from the proposed Brakfontein coal mining operations will have on the surrounding environment were as follows:

- Literature review of emissions from coal mines and associated processes,
- Identification of pollutants released from coal mines and associated activities,
- Review of potential health effects associated with these emissions,
- Description of the general surroundings of the site, as well as the relevant site specific environment,
- Evaluation of meteorological data to determine the prevailing meteorological conditions,
- Air dispersion modelling using a steady-state plume dispersion model (AERMOD) to assess maximum ground level concentrations for the contaminants of concern,
- Evaluation of the results of the air dispersion modelling against acceptable standards as set out by the Department of Environmental Affairs (DEA), and
- Provision of recommendations to limit the impacts of the proposed Brakfontein coal mining operation on the ambient air quality of the area.

The impact assessment was limited to the impact of airborne particulates. Although the mining activities would also emit other gases, primarily by haul trucks and mining vehicles, it was established that the impact of these compounds would be insignificant and were therefore not included.

Construction phase

Information on activities in the construction phase was largely unavailable. The time scale and order of erection of the beneficiation plant as well as the time scale for initial stockpiling of soil and overburden was not available. Too many assumptions would therefore have to be made in order to model the emissions in this phase of the proposed Brakfontein Thermal Coal Mine operation in

order to predict air pollution effects, and a conservative estimate of this nature is likely to produce results that would unrealistically exceed the National Ambient Air Quality Standards.

Based on the expected particulate pollution for the kinds of activities associated with the preparation and construction of an opencast mining operation of this nature, it is recommended that a comprehensive mitigation programme be implemented to reduce the impact on the receiving environment.

Operational phase

The main conclusions can be summarised as follows:

- PM_{10} (24-hour Average Concentrations) – Without any mitigation measures, the predicted maximum daily concentrations only exceed the national daily standard of 75µg/m^3 (Compliance date: January 2015) in the near vicinity of the operational open pit, haul roads from the pit to the ROM pads, and around the ROM pads.
- PM_{10} (Annual Average Concentrations) – Without any mitigation measures, the predicted maximum annual average concentrations are well within the national annual average standard of 40µg/m^3 (Compliance date: January 2015).

Fugitive emissions from the Proposed Brakfontein Thermal Coal Mine do result in an impact on the nearby surrounding areas; however, concentrations fall off rapidly, moving away from the mining area, and therefore have a relatively localized impact. Because all haul roads, from the coal loading areas to the Kangala processing plant will be tarred (Digby Wells, 2012a), a very large potential emission source has been reduced at the proposed Brakfontein Thermal Coal Mine.

Whilst care has been taken to assess the potential air pollution impact from the proposed development, changes to the proposed design after this assessment may result in different conclusions. Furthermore, no ambient air monitoring was available to aid the assessment of cumulative impacts.

Table of Contents

List of Figures

List of Tables

List of Abbreviations

APPA	-	Atmospheric Pollution Prevention Act, No. 45 of 1965
AQA	-	National Environmental Management: Air Quality Act (Act No. 39 of 2004)
CO	-	Carbon monoxide
CPP	-	Coal Processing Plant
DEA	-	Department of Environmental Affairs
DEAT	-	Department of Environmental Affairs and Tourism
DMR	-	Department of Mineral Resources
DME	-	Department of Minerals and Energy
EIA	-	Environmental Impact Assessment
EMP	-	Environmental Management Plan
FEV_1	-	Forced Expiratory Volume over one second
FVC	-	Forced Vital Capacity
MPRDA	-	Mineral and Petroleum Resources Development Act (Act No. 28 of 2002)
NEMA	-	National Environmental Management Act (Act No. 107 of 1998) as amended
NO_2	-	Nitrogen dioxide
NO_x	-	Oxides of nitrogen
OB	-	Overburden
PEF	-	Peak Expiratory Flow
PM_{10}	-	Particulate matter with an aerodynamic diameter of less than 10 µm
$PM_{2.5}$	-	Particulate matter with an aerodynamic diameter of less than 2.5 µm
ppb	-	Parts per billion
ppm	-	Parts per million
ROM	-	Run of Mine
SAWS	-	South African Weather Service
SO_2	-	Sulphur dioxide
SO_x	-	Oxides of sulphur
TSP		Total Suspended Particulates
$\mu g/m^3$	-	Micrograms per cubic meter
U.S. EPA	-	United States Environmental Protection Agency
VKT		Vehicle Kilometre Travelled
VOC	-	Volatile Organic Compounds
WHO	-	World Health Organisation

1 Introduction

Gondwana Environmental Solutions (GES) was appointed by Digby Wells Environmental to undertake a specialist air quality investigation of the proposed Brakfontein Thermal Coal Mine in Mpumalanga Province as part of the process of preparing an Environmental Impact Assessment (EIA) for the proposed Brakfontein Thermal Coal Mine. The main objective of the project is to provide an assessment of the impact, from the proposed coal mine, on the ambient air quality of the surrounding areas.

An initial baseline assessment was undertaken which included a review of available meteorological data and general regional air quality data. From a review of available literature, it was established that the most significant pollutant that is generated from a coal mine is particulate matter (PM). These particulate emissions will initially consist of dust generated during the construction of the beneficiation plant; the construction and use of access roads; and the preparation of the opencast mining area by stripping of topsoil and overburden. During the operational phase particulate emissions will be generated from drilling and blasting; materials handling operations; vehicle entrainment from unpaved roads; as well as wind erosion from exposed areas of the site.

Although the mining activities would also emit other gases, primarily by haul trucks and mining vehicles, the impacts of these compounds were not included. The sulphur content of South African diesel is too low (0.05% for Sasol Turbodiesel™) and mining equipment is usually too widely dispersed over the mine site to cause sulphur dioxide (SO_2) levels to exceed the national standards, even in mines that use large quantities of diesel. For this reason, no detailed study of SO_2 emissions from the mine has been undertaken. For the same reason, nitrous oxides (NO_x) and carbon monoxide (CO) emissions have not undergone a detailed modelling assessment.

2 Scope of Work

2.1 Terms of Reference

Universal Coal Development IV (Pty) Ltd proposes to remove the coal reserves on the farm Portions 6, 8, 9, 10, 20, 26, 30 and the Remaining Extent of the Farm Brakfontein 264 IR. The project area lies within the jurisdiction of the Victor Khanye local and Nkangala district municipalities in Mpumalanga Province.

Gondwana Environmental Solutions (GES) was appointed by Digby Wells Environmental to undertake an air quality assessment of the proposed development of the Brakfontein Thermal Coal Mine. The main objective of the project is to provide an assessment of the potential impact on ambient air quality from the coal mine, on the surrounding areas. The following tasks were completed in order to achieve the broad objective of the project:

- Literature review of emissions from coal mines and associated processes,
- Identification of pollutants released from coal mines and associated activities,
- Review of potential health effects associated with these emissions,
- Description of the general surroundings of the site, as well as the relevant site specific environment,
- Identification of potential air emission sources,
- Evaluation of meteorological data to determine the prevailing meteorological conditions,
- Preparation of emission rate estimates,
- Air dispersion modelling using a steady-state plume dispersion model (AERMOD) to assess maximum ground level concentrations for the contaminants of concern,
- Evaluation of the results of the air dispersion modelling against acceptable standards as set out by the Department of Environmental Affairs (DEA), and
- Provision of recommendations to limit the impacts of the proposed Brakfontein Thermal Coal Mine on the ambient air quality of the area.

2.2 Outline of Report

An introduction to the coal mine and associated activities and an outline of the scope of this report are provided in **Sections 1 and 2.** Brief CVs of the specialists running the AERMOD model and compiling the report are given in **Section 3**. An overview of the site location and meteorology overview are provided in **Section 4.** The background information of **Section 4** is completed with the South African air quality legislation and ambient air quality standards for particulate pollutants, the health effects of particulate pollutants and an overview of the mining process at the Proposed Brakfontein Thermal Coal Mine. **Section 5** presents the baseline ambient air quality assessment, which assesses local winds in preparation for the modelling process. In **Section 6** an overview of the model and its data requirements are outlined. Thereafter, the emissions inventory is compiled, and the site specific emission factors used as inputs into the model are discussed. Dispersion model results are presented and the main findings of the air quality compliance and impact assessments as required by the National Environmental Management Act, EIA regulations (2006) are documented in **Section 7**. Mitigation measures are recommended in **Section 8.** The conclusions and recommendations are discussed in **Section 9**.

3 Expertise of the Specialists

3.1 Roelof Burger

Roelof Burger completed his BSc (hons) degree at the University of Pretoria in 1998. He has more than 10 years of experience in Atmospheric Science and computer programming. His research interests include precipitation processes and modelling atmospheric process. In 2002 he did an introductory U.S. EPA course in dispersion modelling. Mr Burger worked at the South African Weather Service until 2004 and after that was an associate researcher at the University of the Witwatersrand until early 2012. He is currently working as an atmospheric scientist at North-West University in Potchefstroom. Working as an independent atmospheric consultant since 2005, he has co-authored many dispersion modelling impact assessments. Mr Burger has taught introductory and intermediate courses in atmospheric dispersion modelling at university and industry level.

3.2 Dr Martin van Nierop

Dr Martin van Nierop has a doctorate in Chemical Engineering from the University of the Witwatersrand, Johannesburg. While studying for his doctorate, Dr van Nierop was employed at the University as a research officer. Dr van Nierop became interested in Research management, and managed a number of large contract research projects at the University. One of these was a study of the Brown Haze air pollution problem over Cape Town. The project was conducted by the Climatology Research Group under the leadership of Dr Stuart Piketh during 2003. Dr van Nierop has been involved in several atmospheric impact assessment studies since then.

3.3 Anja van Basten

Anja van Basten completed her BA (Hons) degree in Physical Geography cum laude at Wits University in 1988. She taught high school Geography between 1989 and 1994. She has worked for Gondwana Environmental Solutions since June 2009. She completed an AERMOD course in March 2010.

4 Background

4.1 Site Location

The proposed Brakfontein Thermal Coal Mine is situated on the farm farm Portions 6, 8, 9, 10, 20, 26, 30 and the Remaining Extent of the Farm Brakfontein 264 IR. The area is situated roughly 16 km south-east of Delmas town, and 14 km and 17 km north of Devon and Leandra respectively (Figure 1).

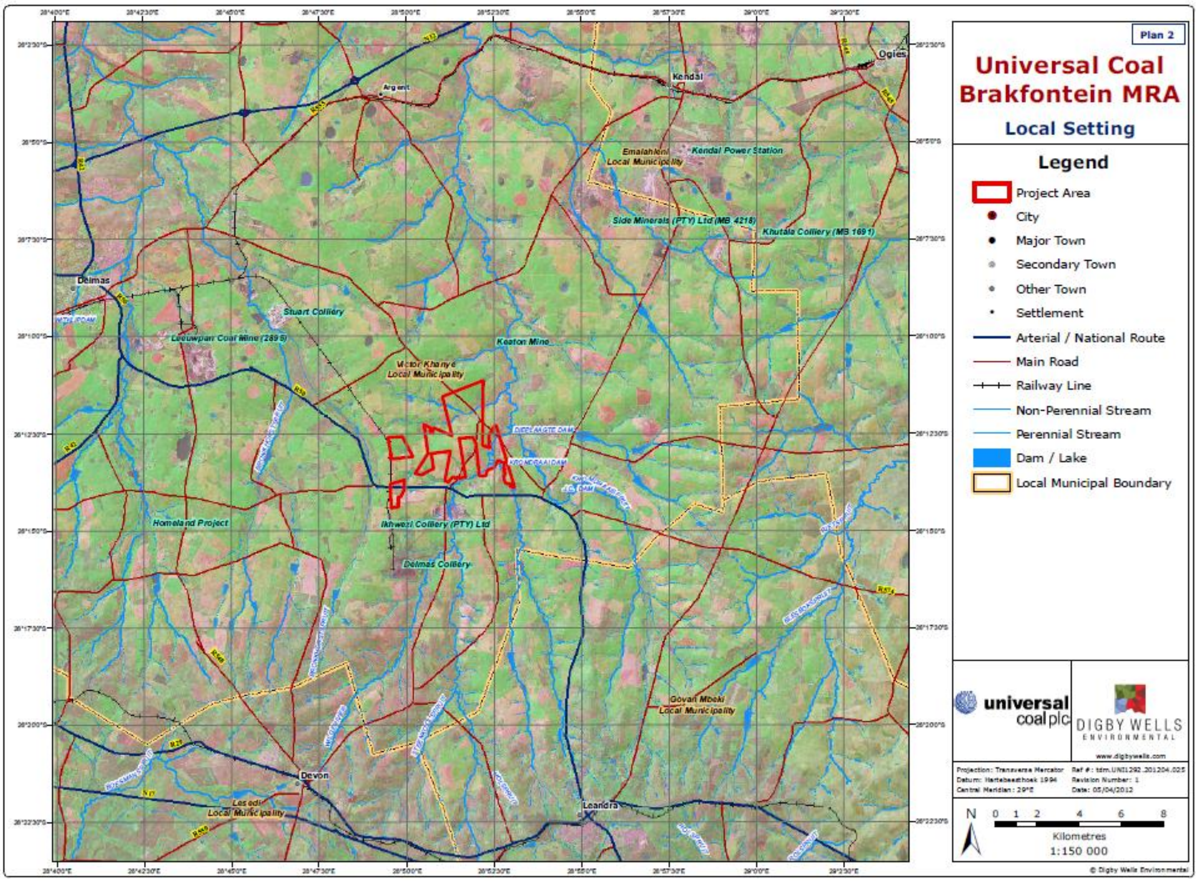

Figure 1: Location of the Proposed Brakfontein Thermal Coal Mine Project Area (Digby Wells, 2012a).

4.2 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 is the direct transport towards the Indian Ocean and the recirculation over the sub-continents around a continental high pressure system (Scholes, 2002). The seasonal shifts of this regional upper-air high pressure system, northwards during winter and southwards during summer, have a pronounced influence on the airflow and atmospheric stability of the area. During winter, the high-pressure belt moves northwards, allowing circumpolar westerlies to displace tropical easterlies, resulting in a succession of cold fronts.

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 Highveld. The 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.

Mpumalanga Province experiences a wide range of both natural and anthropogenic sources of air pollution ranging from veld fires and wind erosion of exposed areas to industrial processes, agriculture, mining activities, power generation, paper and pulp processing, vehicle use and domestic use of fossil fuels. Different pollutants are associated with each of the above activities, ranging from volatile organic compounds and heavy metals to dusts and odours. The proposed Brakfontein Thermal Coal Mine falls within the declared National Highveld Priority Area for Air Quality. As such the ambient levels of particulate matter are high, and often exceed the national standards.

4.3 Air Quality Legislation and Standards

The National Environmental Management: Air Quality Act 39 of 2004 (NEM: AQA) has shifted the approach of air quality management from source-based control to receptor-based control. The basis of this approach is the control of all major sources, including mining, industrial, vehicles and domestic sources in terms of ambient air concentrations, and is the responsibility of Local Government.

The Act makes provision for the minister or MEC to prescribe '*measures for the control of dust in specified places or areas, either in general or by specified machinery or in specified instances*'. This can take the form of guidelines or standards. 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 (WHO, 2000). Once the guidelines are adopted as standards, they become legally enforceable. These guidelines/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 National Ambient Air Quality Standards for the criteria pollutants were published in December 2009 (Government Notice No. 1210, 2009). The values of the National Ambient Air Quality Standards, as well as reference methods and compliance dates for PM_{10} (particulate matter with an aerodynamic diameter of less than 10 µm) are presented in Table 1.

Table 1: National Standards for Ambient Air Quality for PM_{10} (Government Notice No. 1210, 2009).

National Ambient Air Quality Standards for Particulate Matter (PM_{10})			
Averaging Period	**Limit Value (µg/m^3)**	**Frequency of Exceedance**	**Compliance Date**
24 hours	120	4	Immediate – 31 December 2014
24 hours	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.			

The South African guidelines for Total Suspended Particulates (as measured by a high volume sampler) stipulate a 24 hour average of 300 µg/m^3 and an annual average of 100 µg/m^3.

The Draft National Dust Control Regulations were published in May 2011 (Government Notice No. 309, 2011). They include the following prohibitions:

'No person may conduct any activity in such a way as to give rise to dust in such quantities and concentrations that –

1) The dust, or dust fall, has a detrimental effect on the environment, including health, social conditions, economic conditions, ecological conditions or cultural heritage, or has contributed to the degradation of ambient air quality beyond the premises where it originates; or
2) The dust remains visible in the ambient air beyond the premises where it originates; or
3) The dust fall at the boundary or beyond the boundary of the premises where it originates exceeds –

(a) 600 mg/m^2/day averaged over 30 days in residential and light commercial areas, measured using reference method ASTM D1739; or

(b) 1200 mg/m^2/day averaged over 30 days in areas other than residential and light commercial areas, measured using reference method ASTM D1739.'

4.4 Health Effects of Particulate Pollutants

There are an increasing number of research studies highlighting the impact of gases and air pollutants on humans. Many of these emissions, even in small quantities, have adverse effects on workers and neighbouring residents alike. These adverse effects include a wide range of problems that include respiratory, neurological and carcinogenic effects, while others have been noted to cause birth defects in unborn babies.

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 re-condensed 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 is deposited. 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).

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 365µg/m^3 was recorded with effects on mortality observed at concentrations of <100µg/m^3. The increase in total daily mortality was 16% per 100µg/m^3 increase in the 24 hour average. Studies by Schwartz (1993) in Birmingham recorded daily concentrations of 163µg/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 – 1000µg/m^3 whereas in more recent times, daily concentrations are between 10 – 100µg/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).

Health 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 – 251µg/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 100µg/m^3 increase in the daily PM_{10} average.

Long-term exposure

Long-term exposure to low concentrations (~10µg/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, 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 60µg/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. The Harvard Six Cities Study (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 10µg/m^3 increase in annual average particulate concentrations.

Table 2: Short-term and long-term health effects associated with exposure to PM (WHO, 2004).

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

4.5 Overview of the Mining Process

4.5.1 Opencast Mining

Opencast mining involves the stripping of usable soil and soft overburden material using a fleet of diesel trucks and shovels. This topsoil and overburden is stockpiled (stockpile positions at Brakfontein are indicated in the proposed mine plan (Figure 6)) for use in the rehabilitation of the area once the mining is completed. A process of roll-over or strip mining is then followed in which the overburden of each strip is drilled and blasted and then placed in the excavation produced by the previous strip. Once the hard rock overburden has been removed, the coal zones are exposed. Individual coal benches are then created by drilling and blasting. The coal zones are mined and then, at Brakfontein, the raw material will be off-loaded onto the ROM pads, from where it will be transported in 40 m^3 trucks, by tarred road, to Kangala for processing (Digby Wells, 2012a). The final void will be backfilled with the overburden from the initial boxcut.

4.5.2 Underground Mining

There will be a period when there will be an overlap of underground and open pit mining. The underground mining sections will be developed via the highwall of the open pit operations. This will enable a shorter lead time to get the underground sections started, eliminate hoisting requirements, as well as reduce upfront capital costs (Digby Wells, 2012b). From there, the bord and pillar method of extracting the coal will be used. Miners first extract coal along a regular grid of tunnels or bords throughout the entire area to be mined, while the coal in between the bords acts as pillars holding up the roof. Miners then start to remove the coal from the pillars in order to mine as much coal from the coal seam as possible. In shortwall mining, a continuous mining machine with movable roof supports is used. Once the pillars furthest from the entrance are mined, the roof is left to collapse in a controlled way as miners work back towards the entrance (Digby Wells, 2012b).

It is anticipated that the Brakfontein Thermal Coal Mine will produce approximately 1.44 Mt per annum (ROM), over a period of approximately 21.8 years from the opencast mining operations, and 0.72 Mt per annum (ROM) from the underground mining operations (Digby Wells, 2012a).

5 Baseline Ambient Air Quality Assessment

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 downwind 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 predominant wind directions (as given by the South African Weather Service weather station, located at OR Tambo, for the year 2010) are between north-westerly and northerly for about 36% of the time **(**Figure 2).

The average hourly wind speed is about 4 m/s. Wind speeds of over 8 m/s were only recorded approximately 3% of the time, and wind speeds of over 11 m/s were only recorded approximately 0.09% of the time. Calm conditions (wind speeds below 1 m/s) were experienced about 2% of the time.

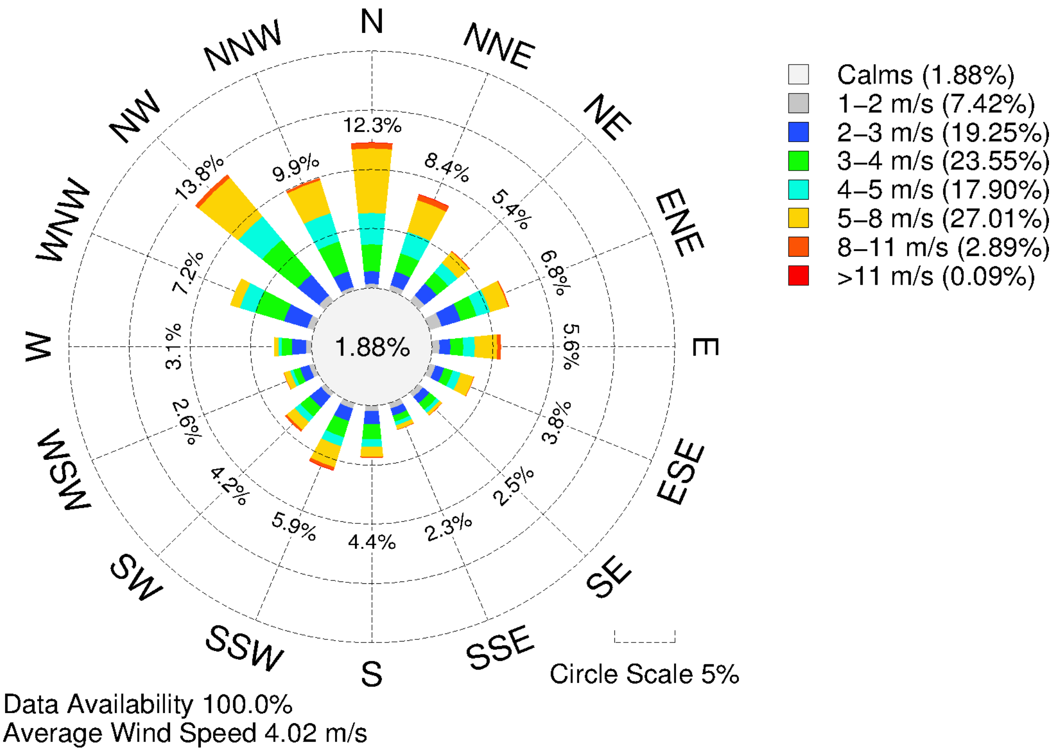

Figure 2: A wind rose of the recorded average hourly wind statistics at the South Africa Weather Service weather station located at OR Tambo for the year 2010.

Winds from a north-westerly to a northerly direction tend to dominate throughout the year (Figure 4).

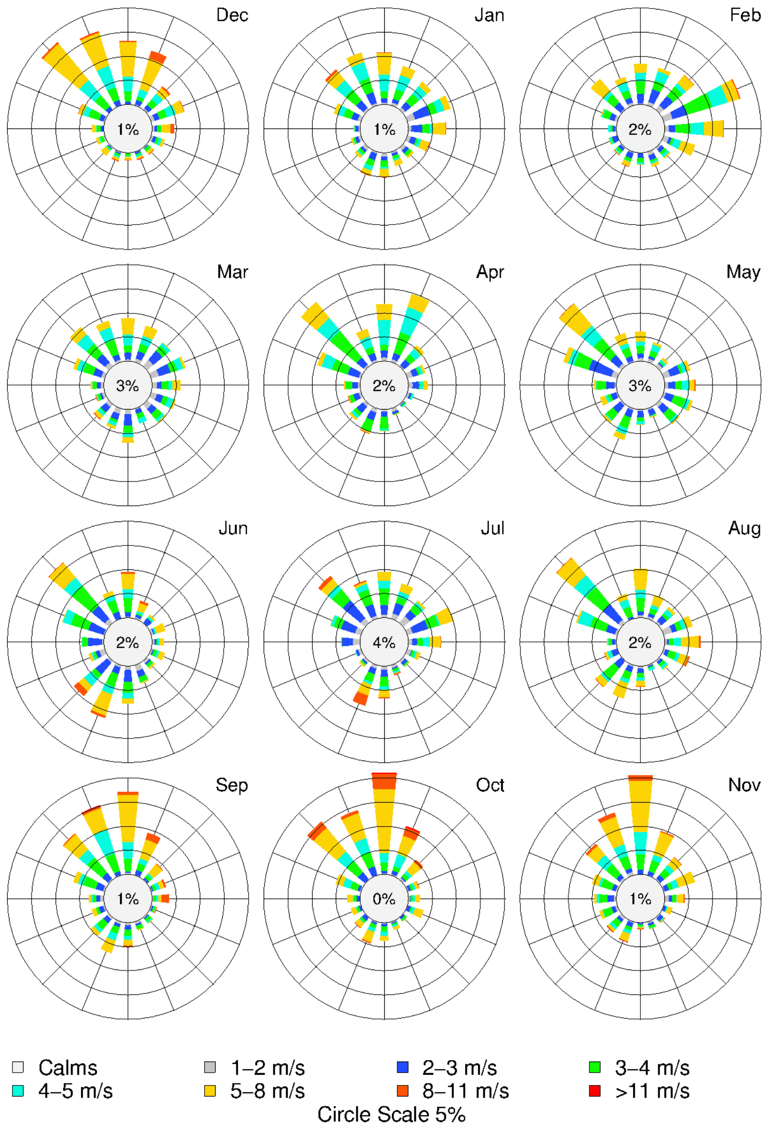

Figure 3: Monthly wind roses of hourly data from the South Africa Weather Service weather station located in OR Tambo for the year 2010.

There is a slight diurnal variation in wind direction. During the warmest hours of the day winds from a north-westerly direction tend to dominate, while in the colder hours winds from a northerly direction tend to be dominant (Figure 4).

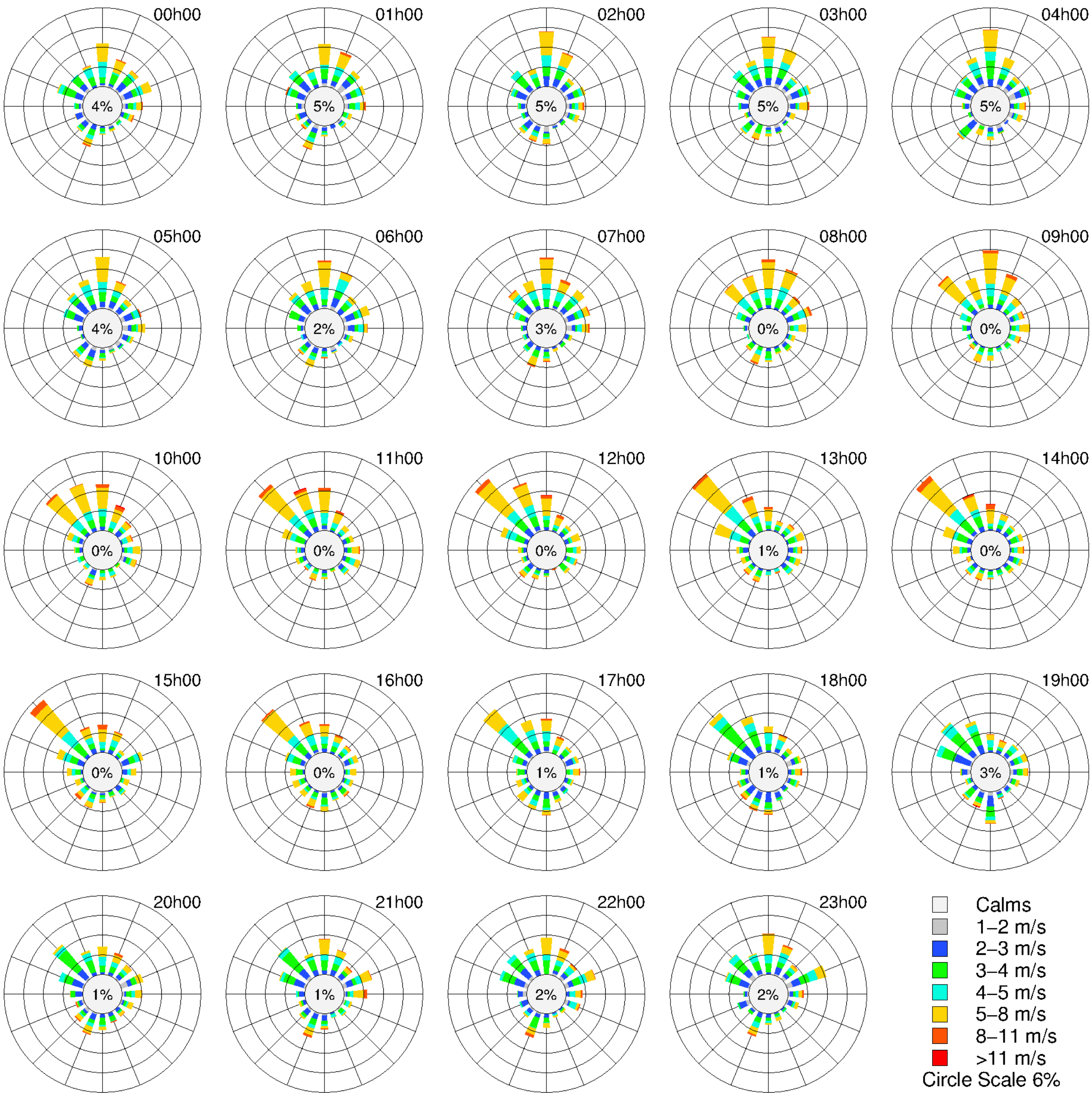

Figure 4: Diurnal variation in hourly wind measurements at the South Africa Weather Service weather station located at OR Tambo for the year 2010.

During the day strong convective mixing brings higher momentum air to the ground, where drag at the surface acts as a momentum sink. The mixing process is vigorous enough to maintain substantial wind speeds at the anemometer height of 10 m. This mixing process also impacts the mixing height (Figure 5). Mixing heights below 400 m above ground level are common during the night, but start to rise during the day as heating increases and reach a median of almost 3 km above ground level during the late afternoon. As the sun sets the convective boundary layer breaks up and the stable, nocturnal boundary layer forms around 200 m above ground level. The remainder of the convective boundary layer will form the residual layer that will be re-entrained into the convective boundary layer during the next day.

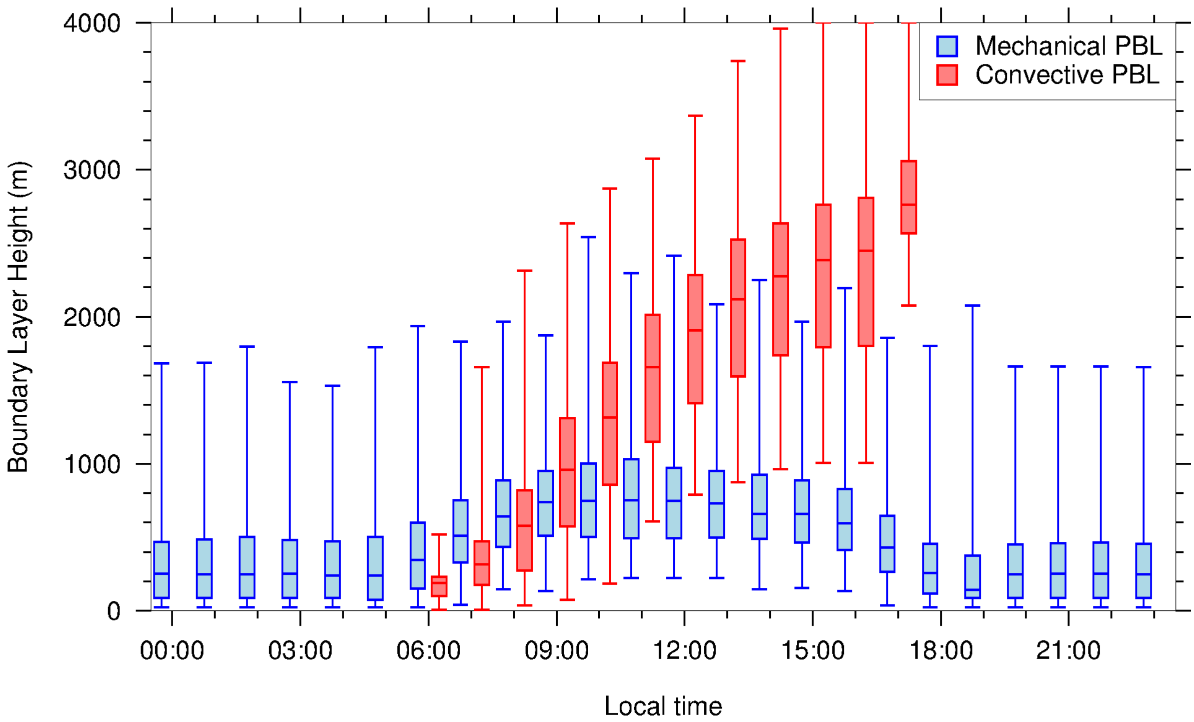

Figure 5: Diurnal variations in mixing height. The box-and-whiskers plot denotes the minimum, 25% percentile, the median, 75% percentile and the maximum values as a function of local time.

6 Model Overview and Data Requirements

Emission limits are not applicable to fugitive sources and are therefore not stipulated for mining operations. Mining operations are however subject to meeting ambient air quality limits and are required to demonstrate compliance with such limits. Ambient air pollutant concentrations are also of significance in terms of their potential to impact human health and the broader environment. In order to project ambient air pollutant concentrations arising due to mining operations, it is necessary to undertake air dispersion modelling.

The selection and population of an applicable dispersion model suited to the environment and the nature of the mining operations is documented below. Dispersion simulations of highest daily as well as annual average PM_{10} concentrations were undertaken for the opencast mining at the proposed Brakfontein Thermal Coal Mine. Isopleth plots depicting predicted spatial variations in air pollutant concentrations, occurring due to the opencast mining at the Brakfontein Thermal Coal Mine, are presented in Section 7.2. Comparison of the predicted concentrations was then made with the relevant National Ambient Air Quality Standards and the Draft National Dust Control Regulations.

6.1 Model Overview

Dispersion models are used to predict the ambient concentration in the air of pollutants emitted to the atmosphere from a variety of processes (SANS 1929, 2005). 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.

AERMOD is a steady-state plume dispersion model developed by The American Meteorological Society/Environmental Protection Agency Regulatory Model Improvement Committee (AERMIC). It has been adopted as the EPA's preferred regulatory model for both simple and complex terrain.
AERMOD incorporates air dispersion based on planetary boundary layer (PBL) turbulence structure and scaling concepts, including treatment of both surface and elevated sources, and both simple and complex terrain.

The modelling system consists of one main program (AERMOD) and two pre-processors (AERMET and AERMAP). The basic purpose of AERMET is to use meteorological measurements, representative of the modelling domain, to compute certain boundary layer parameters used to estimate profiles of wind, turbulence and temperature. AERMET uses these parameters to generate profiles of the needed meteorological variables. In addition, AERMET passes all meteorological observations to AERMOD. Surface characteristics in the form of albedo, surface roughness and Bowen ratio, plus standard meteorological observations (wind speed, wind direction, temperature, and cloud cover), are input to AERMET. AERMET then calculates the PBL parameters: friction velocity, Monin-Obukhov length, convective velocity scale, temperature scale, mixing height, and surface heat flux. AERMOD is designed to run with a minimum of observed meteorological parameters. For the purposes of this project, both weather data provided by the South African Weather Service and modelled data from the MM5 regional scale model were used to initialize the AERMET pre-processor.

The AERMOD terrain pre-processor, AERMAP, uses gridded terrain data to calculate a representative terrain-influence height, also referred to as the terrain height scale. The terrain height scale, which is uniquely defined for each receptor location, is used to calculate the dividing streamline height. The gridded data needed by AERMAP is selected from Digital Elevation Model (DEM) data. AERMAP is also used to create receptor grids. The elevation for each specified receptor is automatically assigned through AERMAP. For each receptor, AERMAP passes the following information to AERMOD: the receptor's location, its height above mean sea level, and the receptor specific terrain height scale (Cimorelli et al, 2004).

6.2 Methodology

Particulate matter is the only significant emission of concern into the air during coal mining. This is normally separated into total suspended particulates (TSP) and particulate matter with an aerodynamic diameter smaller than 10µm (PM_{10}). TSP is primarily a nuisance factor where PM_{10} is a health concern. Although the proposed Brakfontein Thermal Coal Mine is comprised of an opencast and an underground mining area, it is assumed that the underground activities will not have significant atmospheric emissions.

In order to assess the area and size of impact of particulate emissions, from the proposed Brakfontein Thermal Coal Mine operation, on the ambient air quality of its surroundings, a series of steps was followed. First, an emissions inventory was compiled, which identified all the potential sources of air pollutants (Section 6.3). Secondly, in order to quantify TSP and PM_{10} emissions, a set of predictive emission factors was established – one for each source identified in the emissions inventory, using site specific parameters. For this purpose, use was made of the comprehensive set of emission factors published by the U.S. Environmental Protection Agency (U.S. EPA) in its AP-42 document *Compilation of Air Pollution Emission Factors* as well as emission factor equations from the U.S. EPA's Factor Information and Retrieval Data Systems (FIRE) version 6.25 (Section 6.4). Finally, surface data, upper air data, land-use data, topography data and the site specific emission factors were used to run the AERMOD model (Section 7). The predicted air pollutant concentrations were then evaluated against local guidelines and standards. The outline of mine activities is indicated in (Figure 6).

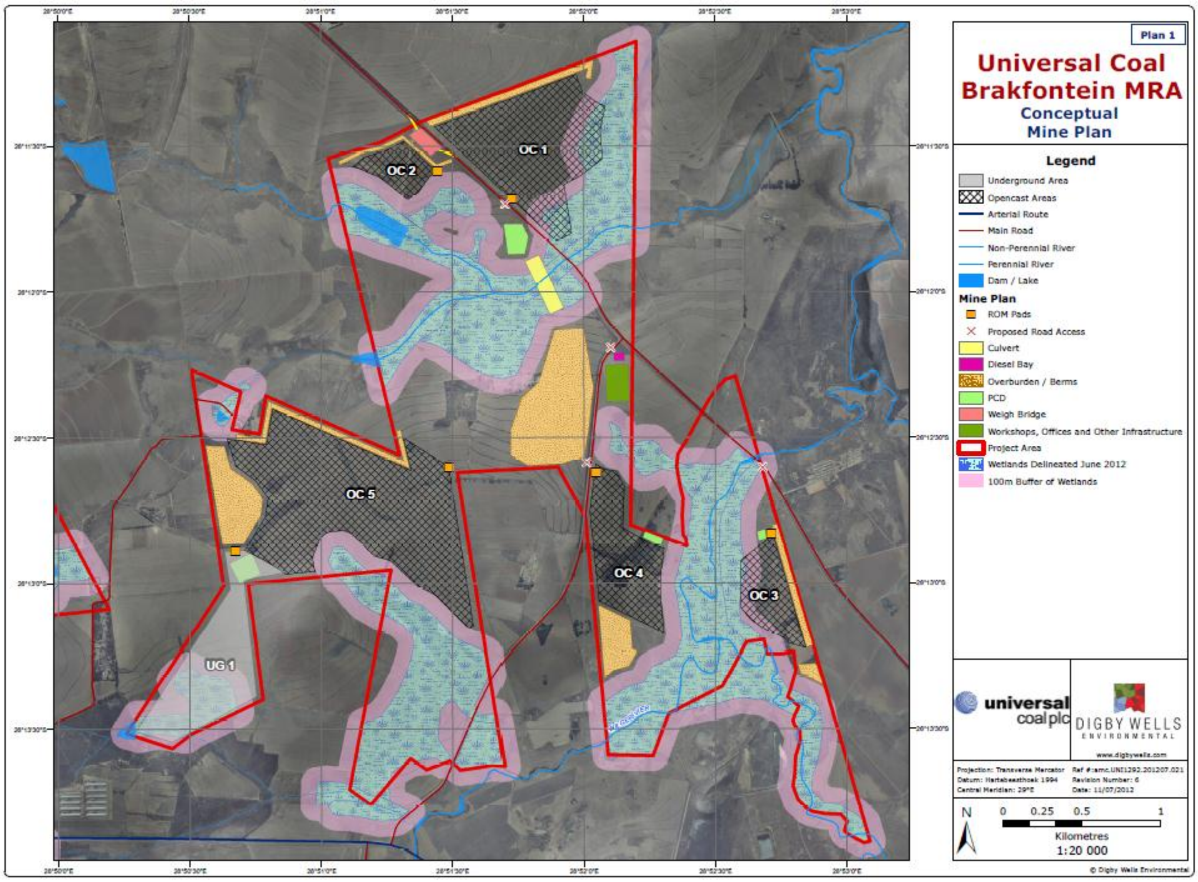

Figure 6: Proposed Brakfontein Thermal Coal Mine Site Layout (Digby Wells, 2012c).

6.3 Emissions Inventory

The following sections will discuss the various emissions associated with the different phases of the project. An emissions inventory was established based on the activities associated with the mine. The establishment of an emissions inventory for the proposed Brakfontein Thermal Coal Mine was necessary to provide the source and emissions data required as input into the dispersion simulations. The release of particulates represents the most significant emission and is the focus of the current study. This emission is the pollutant of concern during the construction, operational and decommissioning phases of the project.

6.3.1 Fugitive Dust Emissions during the Construction Phase

The construction phase will comprise site preparation and construction of the workshops, offices and other infrastructure. This usually entails a series of different operations including land clearing, topsoil removal, material loading and hauling, stockpiling, grading, bulldozing, compaction, etc. Each of these operations has its own duration and potential for dust generation. It is anticipated therefore 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 is in contrast to most other fugitive dust sources where emissions are either relatively steady or follow a discernible annual cycle.

Due to the lack of detailed information on activities e.g. number of dozers to be used, size and locations of stockpiles and temporary roads, rate of on-site vehicle activity and the lack of a specified schedule for construction, modelling of this phase of the mine was not undertaken. Modelling, based on all the assumptions that would have to be made under the circumstances given, would result in estimated emissions that are conservatively high. However, it is anticipated that the emissions from this phase of the project will be significantly lower than during the operational phase.

An overview of activities during the construction of a typical opencast mine and the associated environmental impacts are presented in Table 3.

Table 3: Environmental Impacts and Associated Activities during Construction.

Impact	Source	Activity
Generation of TSP and PM_{10}	Workshops and Offices	Clearing of groundcover
		Levelling of area
		Building construction
		Wind erosion from building materials storage piles
	Preparation of the opencast mining pit	Clearing of vegetation and topsoil
		Blasting and removal of overburden from three or four initial strips
		Loading and unloading of topsoil and overburden
		Wind erosion from topsoil and overburden storage piles
		Tipping onto topsoil and overburden storage piles
		Vehicle entrainment on unpaved road surfaces
	Stockpile sites	Clearing of groundcover
		Levelling of area
		Surface preparation of proposed stockpile areas
	Transport infrastructure Unpaved / gravel roads	Clearing of vegetation and topsoil
		Levelling of proposed transportation route area
Gases and particulates	Vehicles	Tailpipe emissions from construction and haul vehicles at the construction sites.
	Blasting	Emissions released from blasting activities.

6.3.2 Fugitive Dust Emissions during the Operational Phase

Sources that would generate pollutants of concern were identified by firstly utilising the inputs and outputs of the operational processes and secondly considering the disturbance to the environment. The activities and the emissions associated with the operational phase of the opencast mining operations are outlined in Table 4.

Table 4: Activities and Aspects Identified for the Operational Phase of the Brakfontein Thermal Coal Mine.

Impact	Source	Activity
Generation of TSP and PM_{10}	Mining operations within open pit area	Waste rock removal by shovel and truck
		Ore removal by shovel and truck
	Materials handling operations	Loading of topsoil, soft overburden and waste rock onto trucks; and offloading/tipping onto stockpiles
		Loading ore onto trucks and tipping onto ROM pads
		Loading of coal onto trucks for transport off site
	Vehicle activity on unpaved roads	Vehicles transporting topsoil to stockpile
		Haul trucks transporting overburden and waste from open pit to stockpiles
		Haul trucks transporting ore from open pit to ROM pads
	Wind erosion	Topsoil and overburden stockpiles
		Waste rock dumps
		ROM storage piles
	Drilling and blasting	Drilling and blasting of overburden
		Drilling and blasting of ore
Gases and Particulates	Vehicle activity	Tailpipe emissions from haul vehicles
		Tailpipe emissions from water tankers
		Tailpipe emissions from further transport mediums (buses for employees, private motor vehicles, mine personnel movement, etc.)

6.4 Predictive Emission Factors

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. In the quantification of TSP and PM_{10}, empirically derived *predictive emission factor equations* are available for sources such as vehicle entrained dust from unpaved and paved roadways, aeolian erosion from open areas, materials handling operations, drilling, blasting, and crushing and screening activities etc. 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. Each equation requires inputs of parameters that are specific to the site being evaluated. The parameters used for the Brakfontein Thermal Coal Mine mining operation are documented in Table 5 and the resulting emission factors used to quantify emissions from the different activities at the Brakfontein Thermal Coal Mine are documented in Table 6. Some of the factors taken into consideration when applying emission factor equations are outlined below.

Table 5: Site Specific Parameters for the proposed Brakfontein Thermal Coal Mine.

Site parameters	Units	Pits 1-5
Annual topsoil	m^3	195 034
Annual overburden	Mtonne	5.7
Overburden density	t/m^3	4
Annual overburden	t /year	5 472 000
Annual ROM	t /year	1 440 000
Annual ROM to CPP	t /year	1 440 000
Moisture (estimate)	%	7
Silt content (estimate)	%	2
Number of drills per year	n	5 200
Number of bulldozers	n	1
Number of coal bulldozers	n	1
Area of pits (Total)	m^2	2 145 377
Depth of pit (estimate average between 6 m and 45 m)	m	25
Annual hours bulldozing overburden	h/year	4 800
Annual hours bulldozing coal	h/year	3 024
Blast area	m^2	2 500
Blasts per year	n/year	52
Grader travel distance	km/year	936
Grader speed	km/h	11.4
Mean wind speed	m/s	4.02
Overburden Stockpile	m^2	211 891
ROM Stockpile	m^2	70 000
Discard Dump	m^2	185 211
Haul road width	m	7
ROM truck trips per year	n/year	19 200
ROM Haul road length (Total unpaved)	km	1.2
OB Haul road length (Total)	km	0.6
OB truck trips per year (estimate)	n/year	730
Pit Haul truck mean weight (estimate)	t	175
Pit Haul truck load	t	150

Table 6: Mining Activities at the proposed Brakfontein Thermal Coal Mine with Emission Factors.

Mining Operations	Unit	PM_{10}	TSP
Bulldozing overburden	kg/hr	0.05	0.48
Bulldozing coal	kg/hr	0.95	6.52
Truck loading – coal	kg/Mg	0.01	0.06
Truck loading overburden	kg/Mg	0.00936	0.018
Drilling overburden	kg/hole	0.3068	0.59
Drilling coal	kg/hole	0.052	0.1
Topsoil removal by scraper	kg/Mg	0.01508	0.029
Wind erosion of exposed area	Mg/ha/year	0.442	0.85
Blasting	kg/blast	14.30	27.50
Overburden replacement	kg/Mg	0.00312	0.006
Crushing	kg/Mg	0.02268	0.01
End dump truck coal unloading	kg/Mg	0.00208	0.004
Grading	kg/VKT	0.44	1.49
Active coal storage pile	t/ha/year	18.85853	36.2664
Raw coal unloading (ROM pads)	kg/Mg	0.00052	0.001
Haul truck emissions	kg/VKT	0.53	2.46

6.4.1 Vehicle Activity on Unpaved Roads

Vehicle-entrained dust emissions from the unpaved haul roads within the proposed Brakfontein Thermal Coal Mine mining area potentially represent one of the most significant sources of fugitive dust. This includes hauling coal from the pit to the ROM pads; hauling overburden from the pit to the overburden stockpile; and maintenance of these temporary roads. Such sources have been found to account for the greatest portion of fugitive emissions from many mining operations. Because all haul roads, from the coal loading areas to the Kangala processing plant will be tarred (Digby Wells, 2012a), a very large potential emission source has been reduced at the proposed Brakfontein Thermal Coal Mine**.**

The quantification of the release of fugitive dust from the unpaved roads was calculated for unpaved surfaces in industrial sites that were un-mitigated. In addition to traffic volumes, emissions also depend on a number of parameters which characterise the condition of a particular road and the associated vehicle traffic. Such parameters include average vehicle speed, mean vehicle weight, average number of wheels per vehicle, road surface texture, and road surface moisture (U.S. EPA, 1995). The site-specific parameters used for modelling emissions from the proposed Brakfontein Thermal Coal Mine are recorded in Table**.**

6.4.2 Materials Handling

Materials handling operations associated with mining which are predicted to result in significant fugitive dust emissions include the transfer of material by means of tipping, loading and offloading trucks. The quantity of dust which will be generated from such loading and off-loading operations will depend on various climatic parameters, such as wind speed and precipitation, in addition to non-climatic parameters such as the nature (moisture content) and volume of the material handled (Table 5). Fine particulates are more readily disaggregated and released to the atmosphere during the material transfer process as a result of exposure to strong winds. Increase in the moisture content of the material being transferred would decrease the potential for dust emission, since moisture promotes the aggregation and cementation of fines to the surfaces of larger particles.

6.4.3 Wind Erosion from Exposed Areas

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; U.S. EPA, 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). Any factor which binds the erodible material or otherwise reduces the availability of erodible material on the surface thus decreases the erosion potential of the surface. 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 significant amounts of dust will be eroded from the open areas at the proposed Brakfontein site under wind speeds of greater than 5.4 m/s (i.e. threshold friction velocity of 0.26 m/s). Fugitive dust generation resulting from wind erosion under high winds (i.e. > 5.4 m/s) is directly proportional to the wind speed. Wind speeds of more than 5 m/s are expected to occur in the area about 30% of the time (Figure 2). An average wind speed of 4.02 m/s was taken for the proposed Brakfontein site.

6.4.4 Drilling and Blasting

Drilling and blasting operations represent intermittent sources of fugitive dust emissions. Emissions from drilling are a relatively minor component of the overall emission from an opencast mine. The only available emission equation for drilling is a simple uncontrolled TSP emission factor of 0.59kg/hole (U.S. EPA, 1998). Clearly, other variables such as the depth of the holes, diameter of the holes, and moisture content of the material being drilled would also be relevant and it might be supposed that an emission factor equation should take account of these variables. However, in the absence of other data (and given the relatively minor contribution of this source to overall emissions from mining operations), it is reasonable to accept the 0.59 kg/hole factor for TSP.

U.S. EPA (1998) does not provide an emission factor for the PM_{10} component. However, some measurements were obtained during the Hunter Valley studies (State Pollution Control Commission, 1986). The mean fraction of PM_{10}/TSP for the four available samples was 0.52 (with a standard deviation of 0.10). These relate to drilling of overburden, and probably, there will be a difference for ore or coal. However, in the absence of other information, the best estimate of the emission factor for drilling for PM_{10} is 0.31kg/hole.

Estimating the TSP emission from blasting is difficult, given the complex and variable nature of each blast. Clearly, there are other factors that may also be relevant, such as the degree of fragmentation achieved and whether the blast is a 'throw-blast'. Typically at open pit operations blasting is done in the early afternoons between 12h00 and 17h00. It is assumed that blasting will occur on average, 52 times per annum at the proposed Brakfontein Thermal Coal Mine (Table 5). For blasting, the U.S. EPA estimates that the PM_{10} fraction constitutes 52% of the TSP (U.S. EPA, 1998).

6.5 Emissions Values

Emissions from each of the activities at the proposed Brakfontein Thermal Coal Mine were quantified by using the comprehensive set of emission factor equations published by the US Environmental Protection Agency (U.S. EPA) in its AP-42 document *Compilation of Air Pollution Emission Factor;* as well as emission factor equations from FIRE version 6.25; in combination with site specific parameters for the mine area (Table 5).The emission values which were calculated for all the mining activities are presented in Table 7. The emission values are also summarised in pie chart format in Figure 7 and Figure 8**.** From these figures it can be seen that open pit operations and the ROM stockpiles are the largest causes of particulate emissions. Because of the tarring of most of the haul roads, emissions from hauling have been radically reduced.

Table 7: Estimated annual emissions for the different mining activities at the proposed Brakfontein Thermal Coal Mine without mitigation.

Description	Annual Emissions (t/year)			
	TSP	%	PM_{10}	%
Open pit operations	234	34.6%	141	45.0%
ROM Stockpile	340	50.2%	146	46.5%
Overburden and Waste Stockpile	44	6.4%	13	4.2%
Hauling from the pit	58	8.6%	13	4.0%
Blasting	1	0.2%	1	0.2%
TOTAL	***678***		***314***	

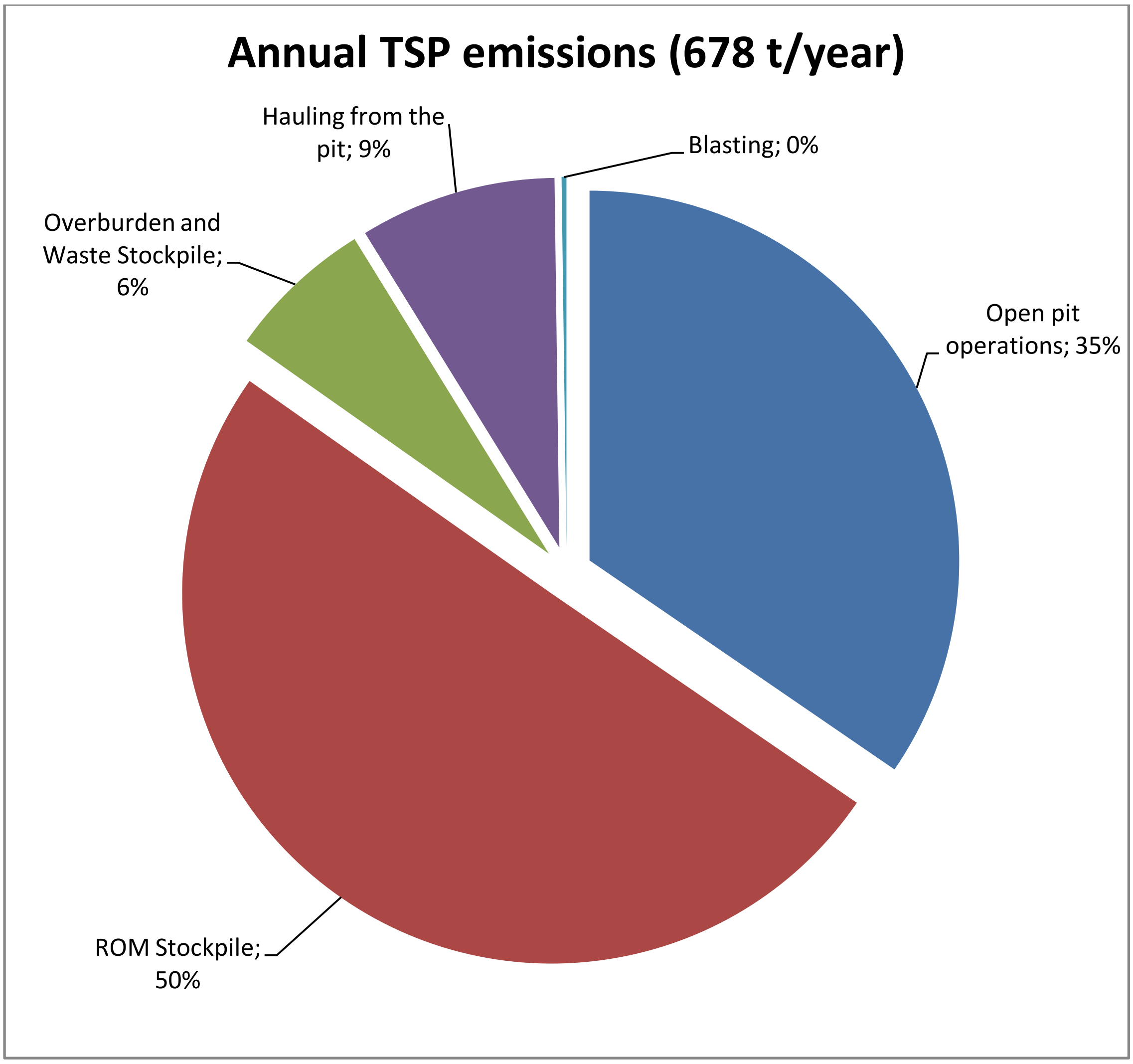

Figure 7: Annual Total Suspended Particulate Emissions from the Different Activities at the Proposed Brakfontein Thermal Coal Mine.

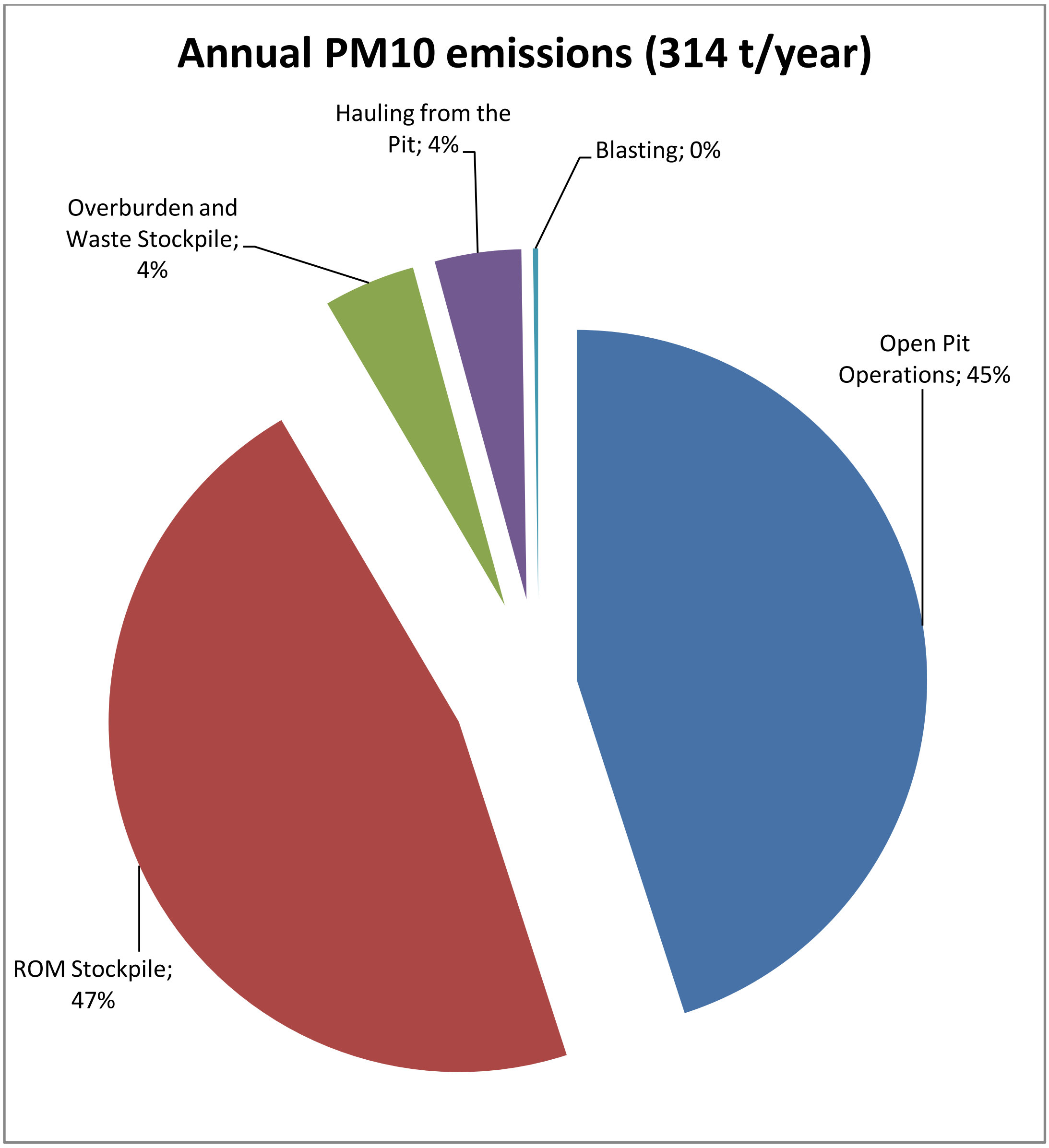

Figure 8: Annual PM_{10} Emissions from the Different Activities at the Proposed Brakfontein Thermal Coal Mine.

7 Air quality impact assessment

7.1 Assumptions and Limitations

The purpose of this modelling effort is not to simulate reality, but to estimate worst possible scenarios. Considering the mandate for regulatory modelling, conservative estimates were made for every input to the model. This should result in overestimation of expected ambient concentrations. Where these estimates exceed ambient guidelines and standards, the different inputs could be further refined.

Whilst care has been taken to assess the potential air pollution impact from the proposed development, changes to the proposed design after this assessment may result in different conclusions.

No ambient air monitoring was available to aid the assessment of cumulative impacts.

Tailpipe particulate emissions were not included. Although the activities at the proposed Brakfontein Thermal Coal Mine would emit gases, primarily by haul trucks and mining vehicles, the impact of these compounds were not included in this assessment. The sulphur content of South African diesel is too low (0.05% for Sasol Turbodiesel™) and mining equipment is too widely dispersed over mine sites to cause sulphur dioxide (SO_2) levels to be exceeded even in mines that use large quantities of diesel. For the same reason, nitrous oxides (NO_x) and carbon monoxide (CO) emissions have also not undergone a detailed modelling assessment.

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. It is therefore possible that, even though a high daily concentration is predicted to occur at certain locations, this may only be true for one day during the entire period.

The scope of the work only covers ambient concentration impacts beyond the mine's boundaries, occupational health issues were not addressed.

7.2 Modelling

Simulations were undertaken to determine concentrations of particulate matter with a particle size of less than 10 microns (μ) in size (PM_{10}) from operations at the proposed Brakfontein Thermal Coal Mine.

Dispersion simulations were executed incorporating all significant sources for the mining area. Stockpiles and hauling were simulated as area sources. Activities in the pit were simulated as Open Pit sources, with the advantage that an area below ground level could be simulated by AERMOD. Blasting was simulated as a volume source.

The modelling was done on a 500 m resolution. The isopleths are given in Figure 9 and Figure 10. The dispersion of pollutants was modelled up to a distance of 20 km from the proposed site; however, isopleths exceeding 120% of the National Standard have not been included in the figures below.

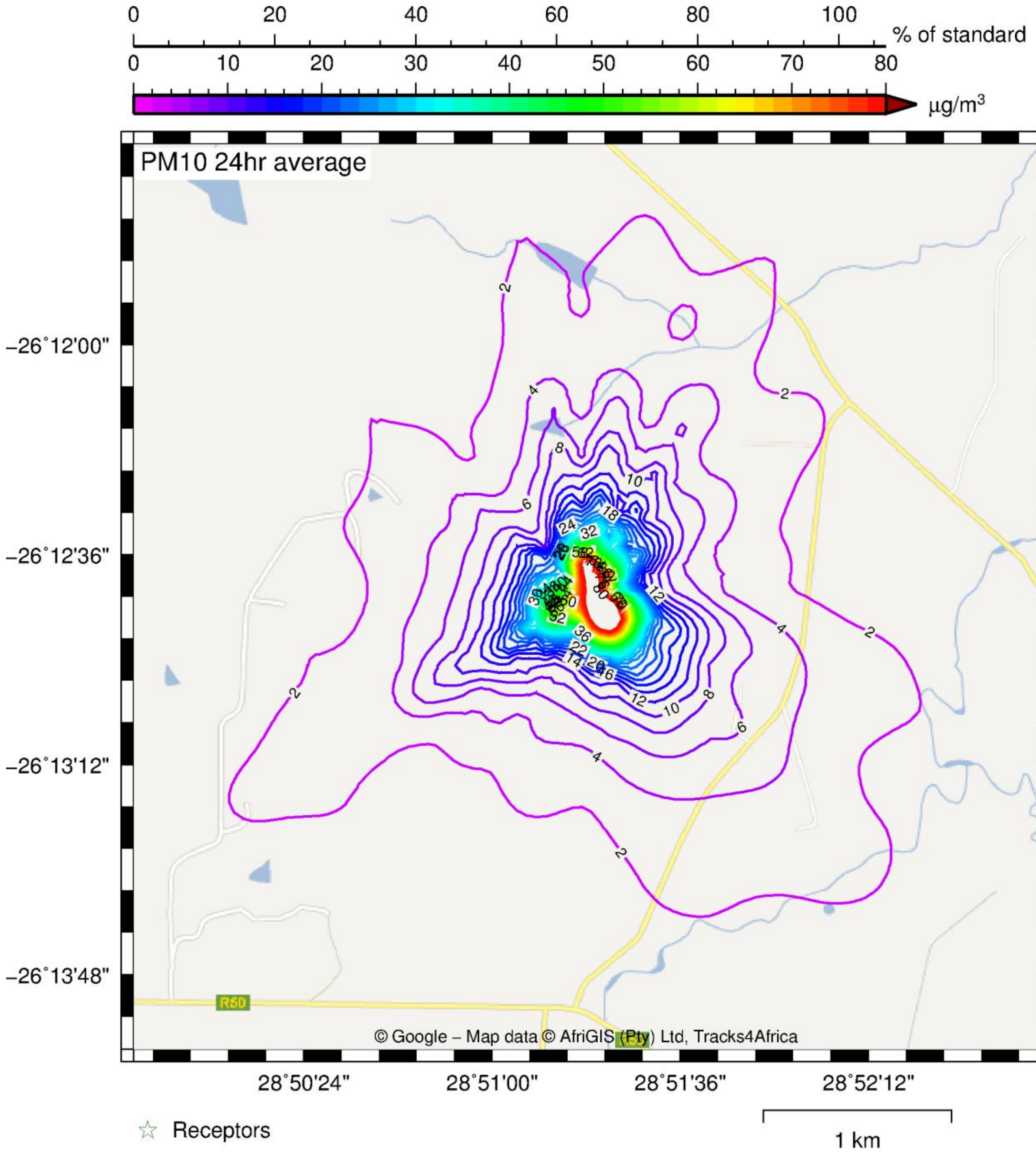

Figure 9: Modelled prediction of daily average PM_{10} concentrations without mitigation measures.

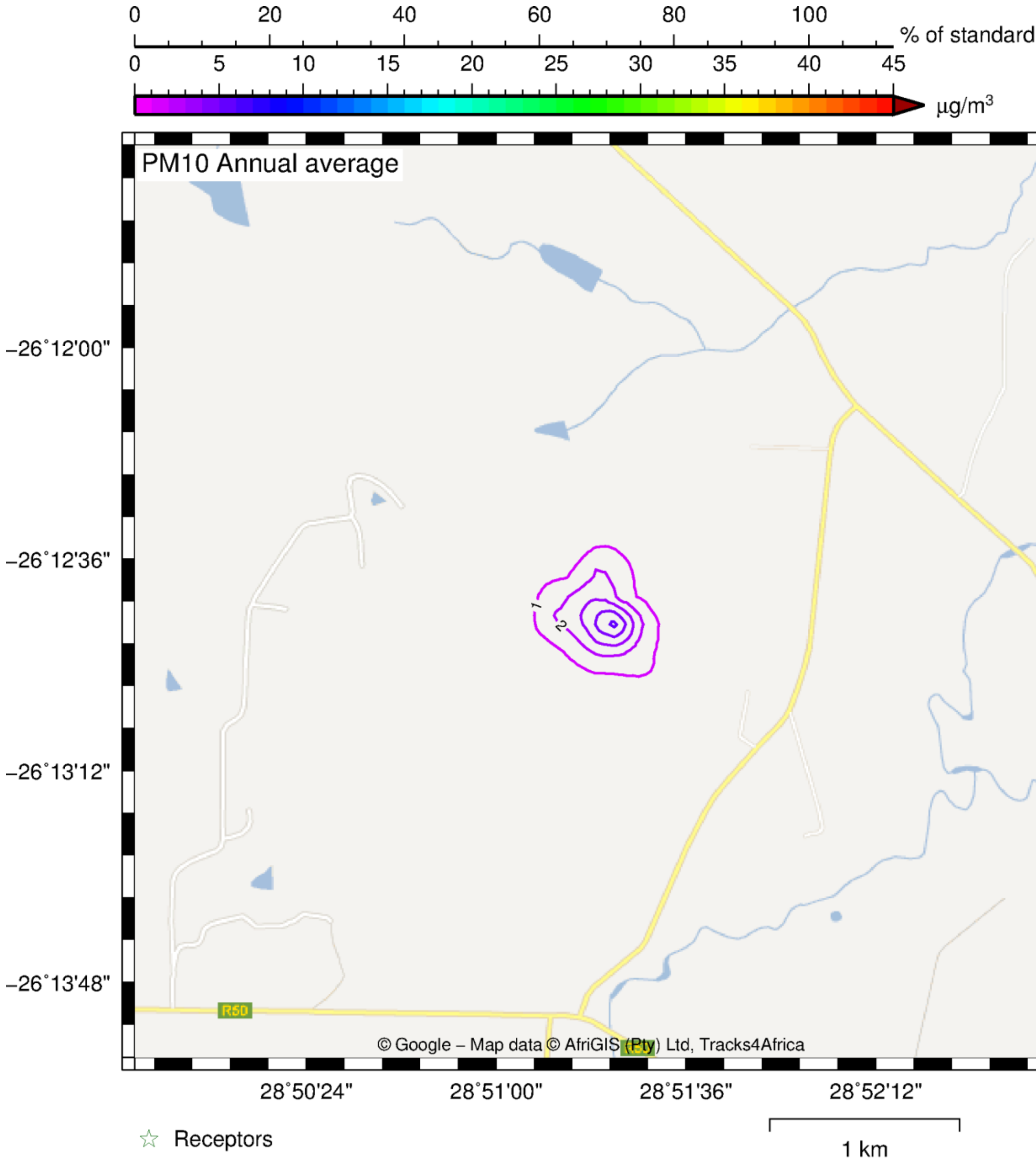

Figure 10: Modelled prediction of annual average PM_{10} concentrations without mitigation measures.

7.3 Evaluation of Modelling Results

The main conclusions can be summarised as follows:

- PM_{10} (24-hour Average Concentrations) – Without any mitigation measures, the predicted maximum daily concentrations only exceed the national daily standard of 75µg/m^3 (Compliance date: January 2015) in the near vicinity of the operational open pit, haul roads from the pit to the ROM pads, and around the ROM pads.
- PM_{10} (Annual Average Concentrations) – Without any mitigation measures, the predicted maximum annual average concentrations are well within the national annual average standard of 40µg/m^3 (Compliance date: January 2015).

Chapter 8 gives an overview of mitigation measures that can be put in place to reduce the impact on the surrounding environment.

7.4 Impact Assessment Matrix

The impact assessment methodology follows that specified by Digby Wells Environmental.

7.4.1 Assessment methodology

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

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 matrix calculates the rating out of 147. The significance of an impact is then determined and categorised into one of four categories (Table 8). The assessment is done for all activities that were predicted to have an air quality impact (Table 9).

Table 8: Assessment impact categories

Category	Colour
<35	Negligible
36 - 72	Minor
73 - 108	Moderate
>108	Major

7.4.2 Assessment results

Table 9: Air Quality Impact Assessment per activity.

Activity	Parameter	Description	Rating
Construction Phase			
Transport of construction material	Duration	Short-term	2
	Extent	Local	3
	Severity	Low	2
	Likelihood	Certain	7
	Significance	Minor	49
Site Clearing and topsoil removal	Duration	Short-term	2
	Extent	Local	3
	Severity	Low	2
	Likelihood	Certain	7
	Significance	Minor	49
Construction of surface infrastructure	Duration	Short-term	2
	Extent	Local	3
	Severity	Low	2
	Likelihood	Certain	7
	Significance	Minor	49
Establishment of initial boxcut and access ramps	Duration	Short-term	2
	Extent	Local	3
	Severity	Low	2
	Likelihood	Certain	7
	Significance	Minor	49
Operational Phase			
Topsoil and overburden removal and stockpiling	Duration	Project Life	5
	Extent	Local	3
	Severity	Medium	3
	Likelihood	Certain	7
	Significance	Moderate	77

Activity	Parameter	Description	Rating
Drilling and blasting of hard overburden	Duration	Project Life	5
	Extent	Local	3
	Severity	Medium	3
	Likelihood	Certain	7
	Significance	Moderate	77
Coal removal	Duration	Project Life	5
	Extent	Local	3
	Severity	Medium	3
	Likelihood	Certain	7
	Significance	Moderate	77
Vehicular activity on haul roads	Duration	Project Life	5
	Extent	Local	3
	Severity	Medium	3
	Likelihood	Certain	7
	Significance	Moderate	77
Discard dumps	Duration	Project Life	5
	Extent	Local	3
	Severity	Medium	3
	Likelihood	Certain	7
	Significance	Moderate	77
Concurrent replacement of overburden and topsoil and re-vegetation	Duration	Project Life	5
	Extent	Local	3
	Severity	Medium	3
	Likelihood	Certain	7
	Significance	Moderate	77
Decommissioning Phase			
Demolition of infrastructure no longer required	Duration	Short-term	2
	Extent	Local	3
	Severity	Low	2
	Likelihood	Certain	7
	Significance	Minor	49
Final replacement of overburden and topsoil and re-vegetation	Duration	Short-term	2
	Extent	Local	3
	Severity	Low	2
	Likelihood	Certain	7
	Significance	Minor	49
Post-closure phase			
Post-closure monitoring and rehabilitation	Duration	Permanent mitigated	6
	Extent	Very limited	1
	Severity	Limited	1
	Likelihood	Rare	2
	Significance	Negligible	16

8 Mitigation Measures

Control measures which should be adopted to reduce the potential for fugitive dust emissions in opencast coal mines are presented in Table 10 and Table 11. Techniques for fugitive dust sources generally involve watering, chemical stabilisation and the reduction of surface wind speed through the use of wind breaks and source enclosures. Because of the tarring of most of the haul roads at the Proposed Brakfontein Thermal Coal Mine (Digby Wells, 2012a), the main area in which mitigation could be undertaken during the operational phase, would be in area of materials handling.

Table 10: Mitigation measures to control dust emissions during construction (U.S. EPA, 1995).

Source	Suggested Control Method
Debris handling	Wind speed reduction, Wet suppression
Truck transport	Wet suppression, Paving, Chemical stabilisation
Cut/fill materials handling	Wind speed reduction, Wet suppression
Cut/fill haulage	Wet suppression, Paving, Chemical stabilization
General construction	Wind speed reduction, Wet suppression, Early paving of permanent roads
Bulldozers	Wet suppression
Pan scrapers	Wet suppression

Table 11: Dust control measures which can be implemented during the operational phase (U.S. EPA, 1995).

Activity	Recommended Control Measure(s)
Material handling (soil, waste rock, ore)	Mass transfer reduction
	Drop height reduction
	Wind speed reduction through sheltering
	Wet suppression
	Enclosures
Vehicle entrainment from unpaved roads	Wet suppression or chemical stabilisation of unpaved roads
	Reduction of unnecessary traffic
	Strict speed control
	Avoid track-on onto neighbouring paved roads
	Design haul roads as far from fence line as possible
Open areas – wind erosion	Reduction of extent of open areas through careful planning and progressive vegetation
	Reduction of frequency of disturbance
	Compaction and stabilisation (chemical or vegetative) of disturbed soil
	Introduction of wind-breaks

Surface treatments such as wet suppression use water, but this is considered to be an expensive option. Other surface treatments include the use of chemicals such as calcium chloride or magnesium chloride. These chemicals attract moisture – drawing moisture out of the air during periods of high humidity, and also reducing the evaporation rate of water during hot periods. Another approach to dust control involves the application of organic or synthetic compounds that physically bind the dust particles together. Calcium lignosulphonate, a by-product of the pulp and paper industry, is a commonly available dust suppressant. Another locally developed, commercial product, Sasbind, can significantly reduce fugitive dust emissions from gravel roads because of its gluing and waterproofing action on soil particles. It is a water based emulsion of modified acrylic polymers suitable for the binding and stabilisation of layers for use in construction of all types of roads (Road Material Stabilisers, 2005). Other locally available products, produced by Dust-a-side, act as surfactants which act as wetting agents which not only reduce the amount of water required for wetting the roads, but also have slight binding properties (DAS, 2010). A decrease of about 50-80% can be achieved by surface treatments.

Limiting the number of vehicles, vehicle weight, distance, or speed travelled is another option.

Positioning haul roads as far into the property from the fence line as possible will also have a huge impact on dust deposition - the largest portion of dust deposition occurs within 20 m of the road.

Rock cladding or armouring of the sides of discard dumps has been shown in various international studies to be effective in various instances in reducing wind erosion of slopes. Cases in which rock cladding has been found to be effective in this regard generally involve rock covers of greater than 0.5 m in depth (Ritcey, 1989; Jewell and Newson, 1997).

10 Conclusions and Recommendations

An air quality impact assessment was undertaken for the Proposed Brakfontein Thermal Coal Mine. Particulate matter represents the main pollutant associated with coal mining operations. Pollutants quantified and evaluated in the assessment include fine particulates and total suspended particulates.

The predicted maximum daily concentrations of PM_{10} only exceed the National Daily Standards of 75µg/m^3 (Compliance date: January 2015) in the near vicinity of the operational open pit, haul roads from the pit to the ROM pads, and around the ROM pads.

The air quality impact on the environment surrounding the proposed mine is therefore quite low. Although fugitive emissions from the Proposed Brakfontein Thermal Coal Mine do result in a negative impact on the nearby surrounding areas, concentrations fall off rapidly, moving away from the mining area, and therefore have a relatively localized impact.

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