Air Quality Impact Assessment

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Abbreviations

ARI	Acute respiratory illness
CO	Carbon monoxide
EIA	Environmental impact assessment
IAP	Indoor Air pollution
LOM	Life of mine
Mtpa	Million tonnes per annum
PM	Particulate matter
ROM	Run of Mine
SANS	South African National Standards

Glossary

Ambient air	The air of the surrounding environment.
Baseline	The current and existing condition before any development or action.
Boundary layer	In terms of the earth's planetary boundary layer is the air layer near the ground affected by diurnal heat, moisture or momentum to or from the surface.
Concentration	When a pollutant is measured in ambient air it is referred to as the concentration of that pollutant in air. Pollutant concentrations are measured in ambient air for various reasons, i.e. to determine whether concentrations are exceeding available health risk thresholds (air quality standards); to determine how different sources of pollution contribute to ambient air concentrations in an area; to validate dispersion modelling conducted for an area; to determine how pollutant concentrations fluctuate over time in an area; and to determine the areas with the highest pollution concentrations.
Condensation	The change in the physical state of matter from a gaseous into liquid phase.
Dispersion potential	The potential a pollutant has of being transported from the source of emission by wind or upward diffusion. Dispersion potential is determined by wind velocity, wind direction, height of the mixing layer, atmospheric stability, presence of inversion layers and various other meteorological conditions.
Emission	The rate at which a pollutant is emitted from a source of pollution.
Emission Factor	A representative value, relating the quantity of a pollutant to a specific activity resulting in the release of the pollutant to atmosphere.
Evaporation	Process by which water changes from a liquid to a gaseous or vapour phase.
Inversion	An increase of atmospheric temperature with an increase in height.
Life of mine	Number of years that an operation is planning to mine and treat ore, taken from the current mine plan.
Mixing layer	The layer of air within which pollutants are mixed by turbulence. Mixing depth is the height of this layer from the earth's surface
Particulate matter (PM)	The collective name for fine solid or liquid particles added to the atmosphere by processes at the earth's surface and includes dust, smoke, soot, pollen and soil particles. Particulate matter is classified as a criteria pollutant, thus national air quality standards have been developed in order to protect the public from exposure to the inhalable fractions. PM can be principally characterised as discrete particles spanning several orders of magnitude in size, with inhalable particles falling into the following general size fractions: * PM10 (generally defined as all particles equal to and less than 10 microns in aerodynamic diameter; particles larger than this are not generally deposited in the lung); * PM2.5, also known as fine fraction particles (generally defined as those particles with an aerodynamic diameter of 2.5 microns or less) ;

* PM10-2.5, also known as coarse fraction particles (generally defined as those particles with an aerodynamic diameter greater than 2.5 microns, but equal to or less than a nominal 10 microns); and
* Ultra fine particles generally defined as those less than 0.1 microns.

Precipitation Ice particles or water droplets large enough to fall at least 100 m below the cloud base before evaporating.

Relative Humidity The vapour content of the air as a percentage of the vapour content needed to saturate air at the same temperature.

1 INTRODUCTION

Royal HaskoningDHV was commissioned by Jacana Environmentals CC to undertake an Air Quality Impact assessment for the proposed The Duel Coal Project located 54km north of Louis Trichardt, Limpopo Province (Figure 1-1).

The Duel Coal Project will be a combination of open pit and underground mining and has a potential life of mine (LOM) of 24 years (Figure 1-2). The envisaged mining methodology for the open pit area is the conventional drill and blast operation with truck and shovel, load and haul. Underground mining will commence from year 10 onwards for a period of 5 years. The land coverage in the vicinity of the The Duel Coal Project area is mixed between rural settlement, hunting and ecotourism. The Mining Right application (MRA) area is located roughly 12km to the east of the N1 highway and situated west to the Nzhelele Nature Reserve.

As part of the air quality impact assessment, a baseline assessment was undertaken which includes a review of available meteorological data to evaluate the prevailing meteorological conditions within the area. The baseline air quality situation was assessed through a review of meteorological data which was obtained from the South African Weather Services for the period of Jan 2008 – Dec 2012. During the impact assessment phase, the potential impact of emissions from the proposed project on the surrounding environment was evaluated through the compilation of an emissions inventory and subsequent dispersion modelling simulations using the AERMOD dispersion model. Comparisons with the South African and relevant international ambient air quality standards were made to determine exposure risks.

Figure 1-1: Proposed location of The Duel Project

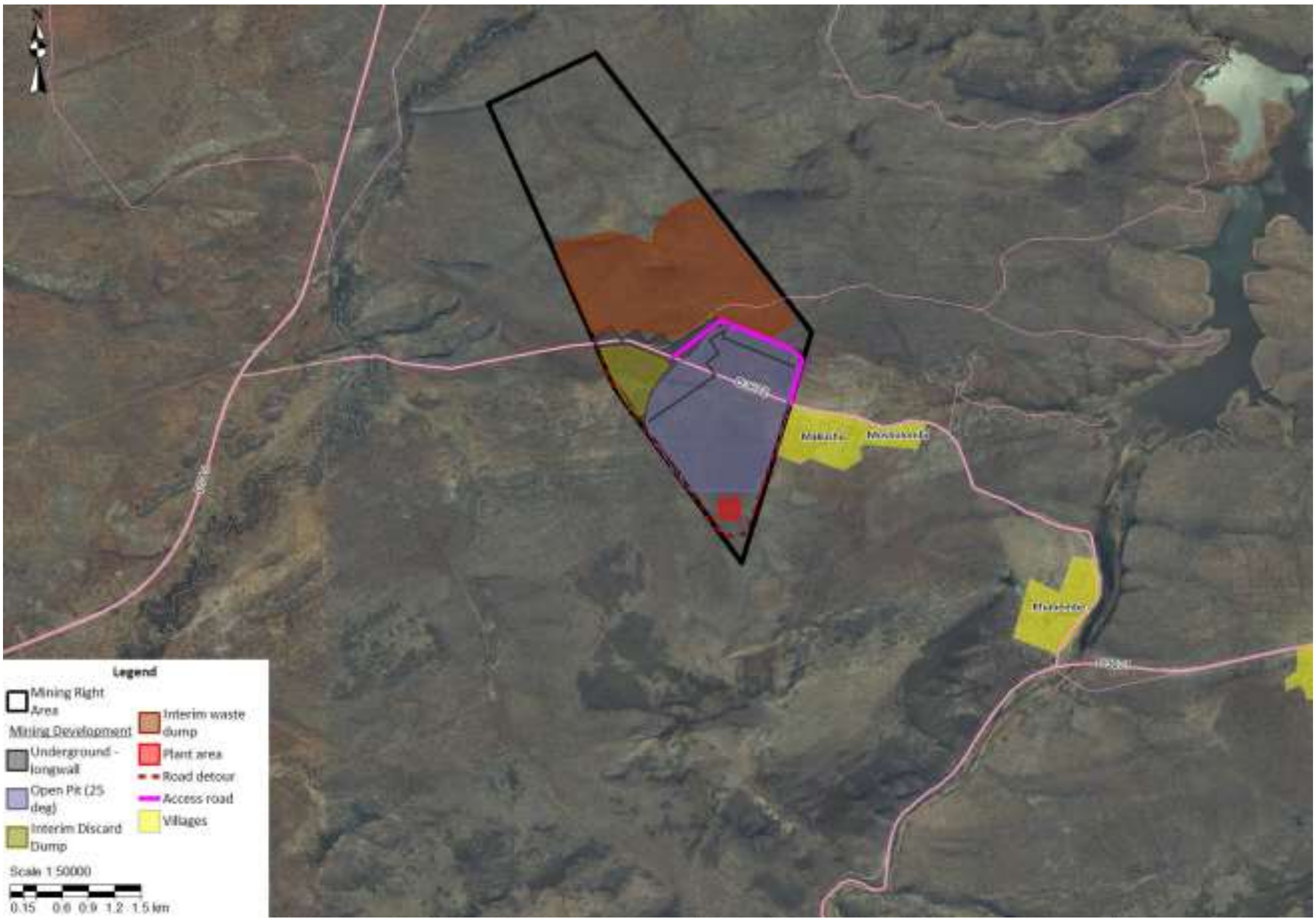


Figure 1-2: The Duel Project

1.1 Project Description

The type of methodology which will be employed at the open pit will be the conventional truck and shovel method (Figure 1-3). The conventional truck and shovel method involves stripping, drilling, blasting, loading and hauling of overburden to the waste dumps and ROM stockpile or PPA (processing plant area). Access will be from selected positions in the open pit and the coal will be mined through the long-wall methodology.

- Drilling and blasting
  - Drilling of blast holes will be carried out by pneumatic or hydraulic crawler mounted drills;
  - Blasting will take place using commercial emulsion type explosives;
  - The slope angle and vertical benches for drilling and blasting will be as per design.
- Loading and hauling
  - Loading and hauling operations are done by means of shovels and front end loaders into off road haul trucks;
  - Ramps will be constructed from 20m to 30m at a gradient of 1:10.

Underground mining operations will commence from year 10 onwards for a period of 5 years. The type of mining methodology employed for the extraction of coal is based on a selected cut method using log wall mining equipment. Seam thickness varies between 2m and 4m. The process for mining involve access development of a tunnel, intake and return roadway around the periphery of the mining black to establish a working face that varies between 150m to 300m. After underground activities have been completed, the access to the underground areas will be closed followed by the final rehabilitation of the open pit. The washed coal will be transported via roads to a nearby siding.

The proposed infrastructure to be developed includes:

- Coal handling processing plant;
- Overburden waste dump;
- Temporary discard dump;
- Haul roads;
- Pollution control dams;
- Raw water storage facility and distribution systems;
- Access roads; and
- Auxiliary infrastructure including a workshop and store, office and change house, electrical power supply and security fencing.

The final discard material from the plant will be disposed of in the mined-out open pit. In the event that the pit is unavailable due to existing mining activities, the discard material will be placed on an interim surface discard dump. The interim discard dump will be reclaimed and dumped into the mined open pit towards the end of LOM as part of the rehabilitation of the mining site.

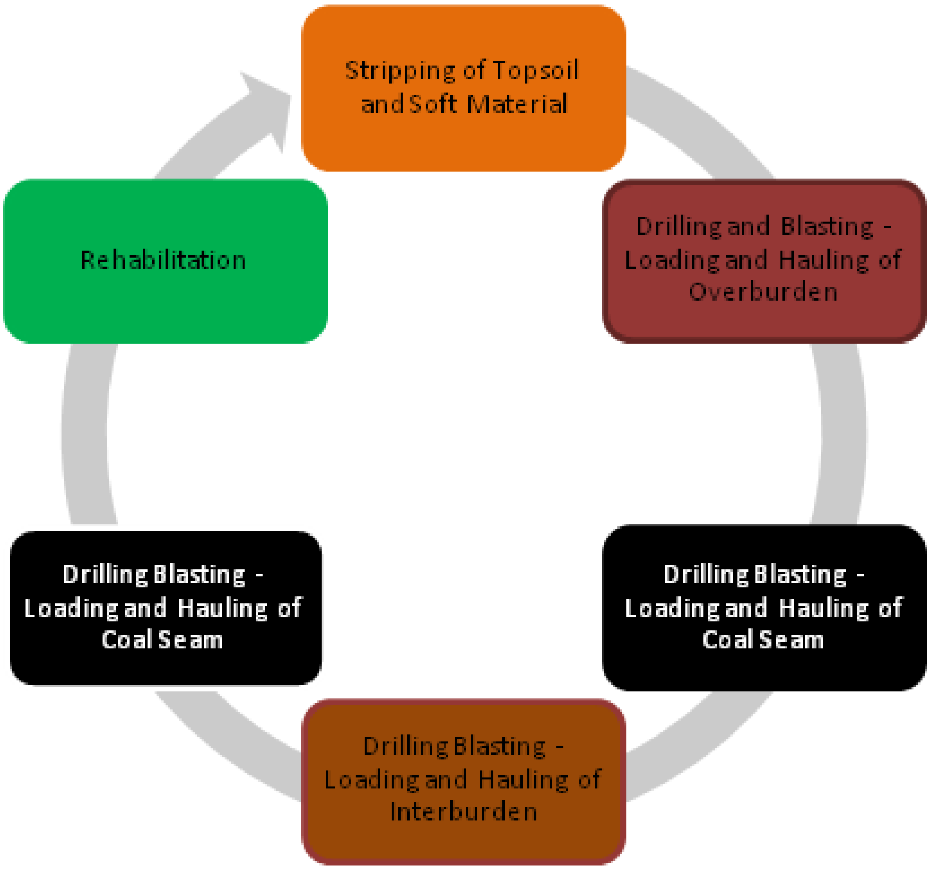


Figure 1-3: Open pit mining cycle

1.2 Terms of Reference

An overview of the Air Quality Impact Assessment is outlined in the section which follows.

- **Baseline assessment**
  - Provide an overview of the prevailing meteorological conditions in the area;
  - Review applicable legislation and policies related to air quality management which are applicable to the proposed operations;
  - Review potential health effects associated with emissions released from the proposed operations;
  - Identification of existing sources of emission and surrounding sensitive receptors, such as local communities, surrounding the plant;
  - Assess the baseline air quality using available ambient air quality monitored data.

- **Impact assessment**
  - Compilation of an emissions inventory for the proposed air quality related sources identified on site;
  - Dispersion modelling simulations undertaken using AERMOD to determine the potential air quality impacts of the proposed activities on the surrounding area;
  - Comparison of the modelled results to the National ambient air quality standards to determine compliance;
  - Provide recommendations for the implementation of appropriate mitigation measures and a monitoring programme (if required);
  - Compilation of a draft and final Air Quality Impact Assessment Report.

1.3 Methodology

The methodology for the proposed project is detailed in the sections below. The assessment which was carried out is a level 2 assessment which is in line with the objectives of the study. Level 2 assessments are used for air quality impact assessments where:

- The distribution of pollutant concentration and deposition are required in time and space;
- The respective dispersion modelling can be treated by a steady state Gaussian Plume model with first order chemistry;
- Emissions assessed are from sources where the greatest impacts are in the order of a few kilometres (less than 50 km downwind).

The two phases of the project; baseline and impact assessment are discussed below.

1.3.1 Baseline assessment

During the baseline assessment, a qualitative approach was used to assess the baseline conditions in the project area. Local meteorological data was obtained from the South African Weather Services (-22.6179 S; 29.8500 E) for the period Jan 2008 – Dec 2012 to determine the atmospheric dispersion potential of the area. Applicable air quality legislation such as the National Environmental Management: Air Quality Act 39 of 2004 (GN163: 2005) and the Listed Activities and Associated Minimum Emission Standards (GN248: 2010) were reviewed. Criteria pollutants relevant to the project and their potential human health effects are also discussed. Existing sources of air pollution surrounding the site were qualitatively assessed. Sensitive receptors, such as local communities in close proximity to the proposed project site were identified via a site visit and through satellite imagery.

1.3.2 Impact assessment

During this phase, an emissions inventory was compiled to estimate emissions from the identified emission sources associated with the proposed activities. Where information is not available, use was made of available United States Environmental Protection Agency (USEPA) emission factors, or emission models to estimate emissions released from mining operations. Dispersion modelling simulations were undertaken using the AERMOD dispersion model and presented graphically as isopleths plots. Comparison with the National ambient air quality standards (GN263; 2009) was made to determine compliance. Based on the predicted results, recommendations for appropriate mitigation measures were provided.

1.4 Report Structure

Section 1 of the report provides background description of the Duel Project. A review of the baseline meteorological conditions is provided in **Section 2**. Applicable air quality legislation, pollutants and their potential health effects are presented in **Section 3**. The emissions inventory, impact assessment, general conclusion and recommendations are presented in **Section 4**.The references are provided in **Section 5.**

2 BASELINE DESCRIPTION OF THE AREA

2.1 Meso-Scale Meteorology

The nature of the local climate will determine what will happen to particulates when released into the atmosphere (Tyson & Preston-Whyte, 2000). Concentration levels fluctuate daily and hourly, in response to changes in atmospheric stability and variations in mixing depth. Similarly, atmospheric circulation patterns will have an effect on the rate of transport and dispersion.

The release of atmospheric pollutants into a large volume of air results in the dilution of those pollutants. This is best achieved during conditions of free convection and when the mixing layer is deep (unstable atmospheric conditions). These conditions occur most frequently in summer during the daytime. This dilution effect can however be inhibited under stable atmospheric conditions in the boundary layer (shallow mixing layer). Most surface pollution is thus trapped under a surface inversion (Tyson & Preston-Whyte, 2000).

Inversion occurs under conditions of stability when a layer of warm air lies directly above a layer of cool air. This layer prevents a pollutant from diffusing freely upward, resulting in an increased pollutant concentration at or close to the earth's surface. Surface inversions develop under conditions of clear, calm and dry conditions and often occur at night and during winter (Tyson & Preston-Whyte, 2000). Radiative loss during the night results in the development of a cold layer of air close to the earth's surface. These surface inversions are however, usually destroyed as soon as the sun rises and warm the earth's surface. With the absence of surface inversions, the pollutants are able to diffuse freely upward; this upward motion may however be prevented by the presence of an elevated inversion (Tyson & Preston-Whyte, 2000).

Elevated inversions occur commonly in high pressure areas. Sinking air warms adiabatically to temperatures in excess of those in the mixed boundary layer. The interface between the upper, gently subsiding air is marked by an absolutely stable layer or an elevated subsidence inversion. This type of elevated inversions is most common over Southern Africa (Tyson & Preston-Whyte, 2000).

2.1.1 Wind

Wind roses comprise of 16 spokes which represents the direction from which the winds blew during the period under review. 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.

Based on an evaluation of the site specific MM5 meteorological data obtained from the South African Weather Services Limpopo Province for The Duel Coal Project (-22.6179 S; 29.8500 E), the following deductions regarding the prevailing wind direction and wind frequency can be presented.

Based on Figure 2-1 below, the predominant wind direction for the area under review is mainly from the south eastern region. Secondary winds occurred mainly from the eastern region. Calms wind (<0.5 m/s) were experienced 0.1 % of the time. The most frequent wind speed of 0.5-2.1 m/s occurred 40.7% of the time. Wind speeds between 2.1 -3.6 m/s were experienced 34.6% of the time, while wind speeds between 3.6 -5.7 m/s was experienced 22.9% of the time. High wind speeds of 5.7 -8.8 m/s occurred less frequently at 1.7% of the time.

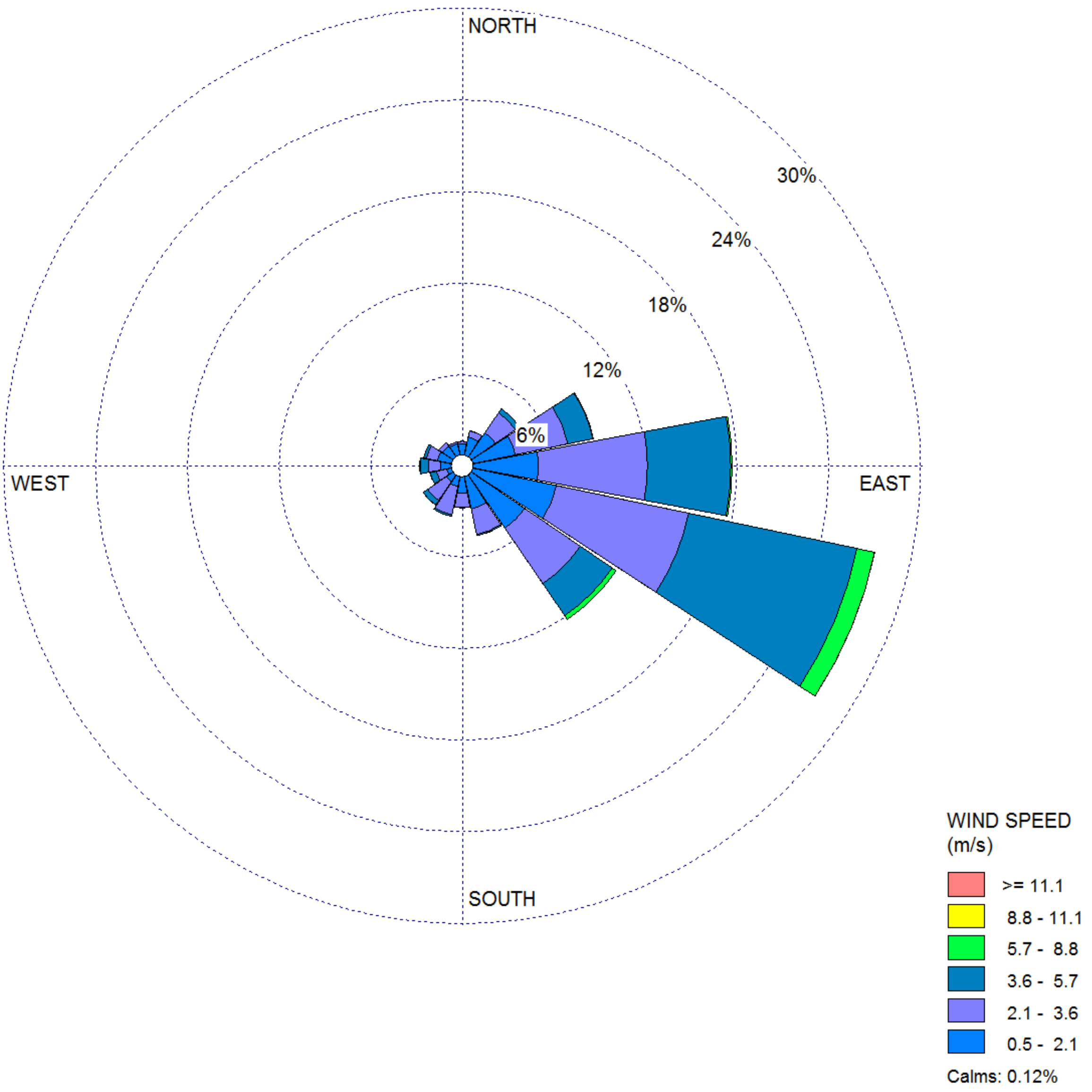
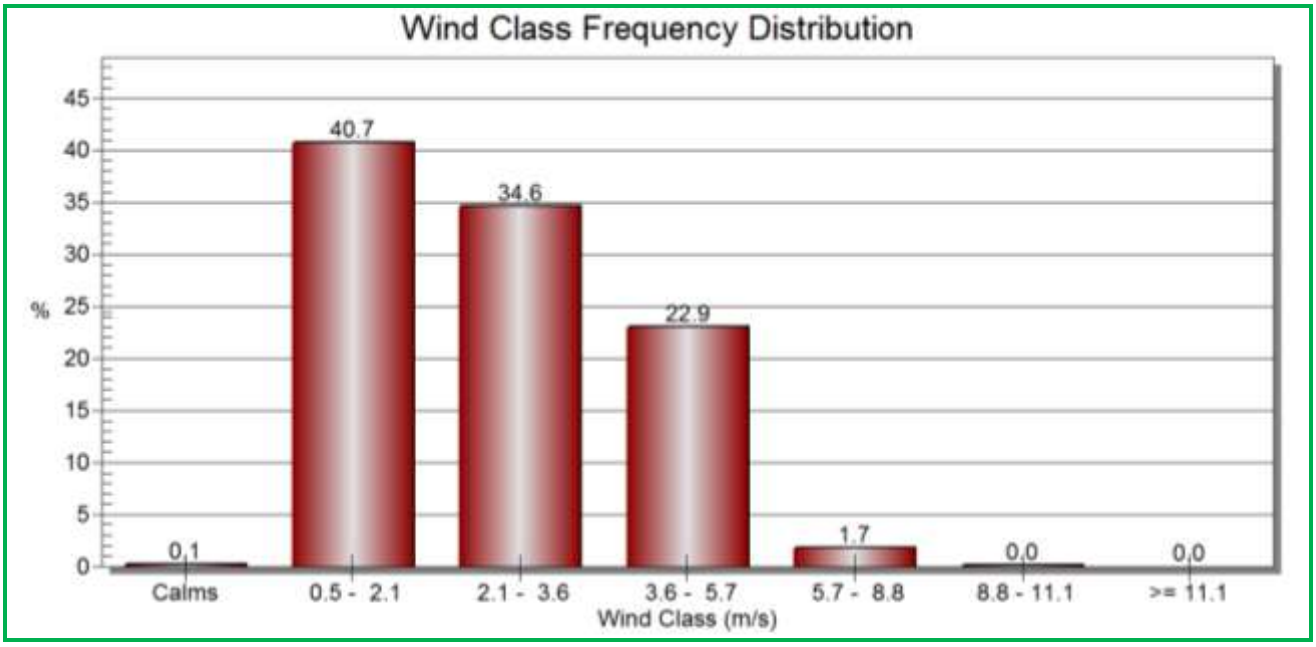


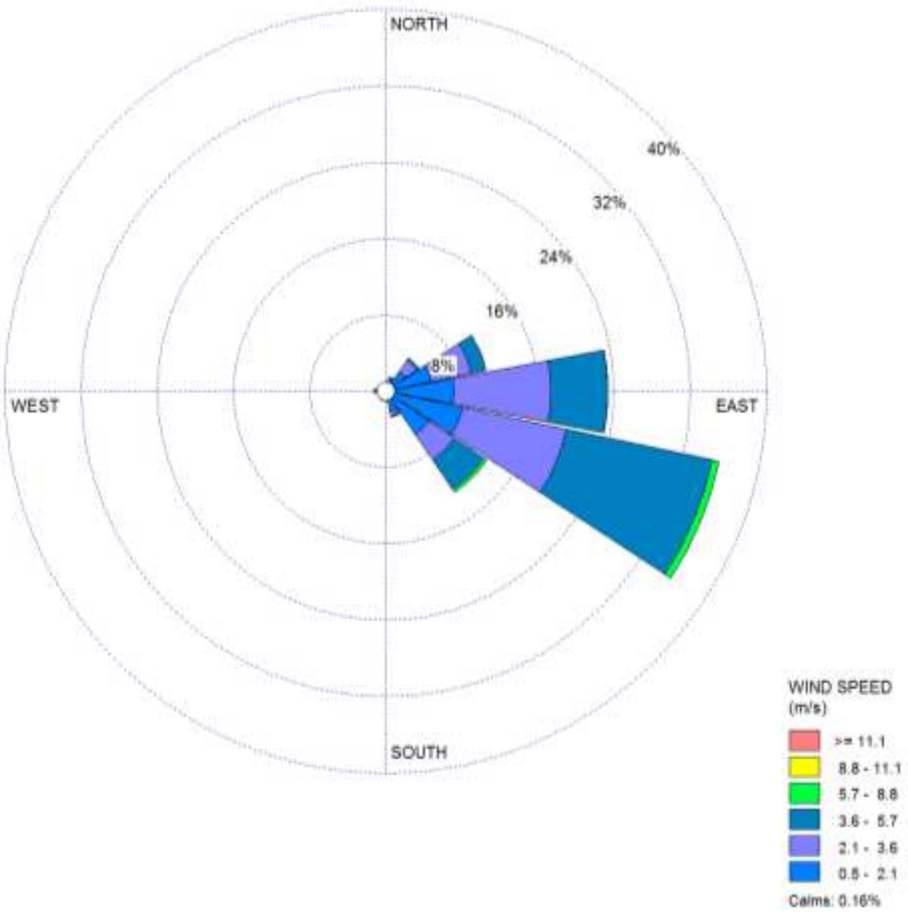
Figure 2-1: Period wind rose for the Jan 2008 – Dec 2012 monitoring period.



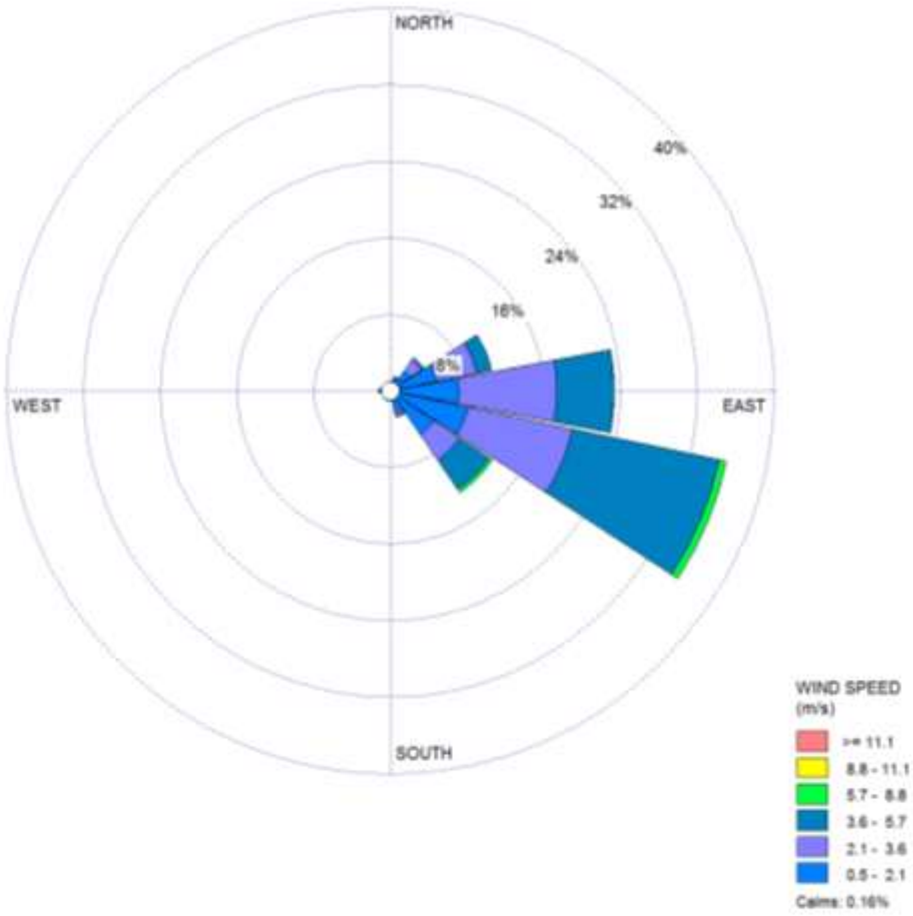
Seasonal variability in the wind field at the proposed site is shown in Figure 2-2 and Figure 2-3 below. The spring (September, October and November) and summer months (December, January and February) experience a similar wind profile, with a predominant wind direction originating from the south eastern region.

The autumn (March, April and May) months has a wind profile with a predominant wind direction originating from the south eastern region. A slight shift in the wind field occurs during the winter months (June, July and August) with a predominant wind direction from the south eastern region and secondary winds from the south western region.

Diurnal trends in the wind field for the proposed The Duel Coal Project is presented in Figure 2-4 and Figure 2-5 below. Between 00:00 -06:00, the winds originate predominately from the south eastern region. During the morning hours of 06:00 – 12:00, the predominant wind direction is from the south east and eastern region with secondary winds from the north east region. During the afternoon and early evenings (12:00 -18:00), the wind profile is similar to that of the morning hours with a predominant wind direction from the south east and eastern regions and secondary winds from the north eastern region. Slow to moderate winds were observed during the night time hours (18:00 -00:00) with a predominant wind direction from the south eastern region.

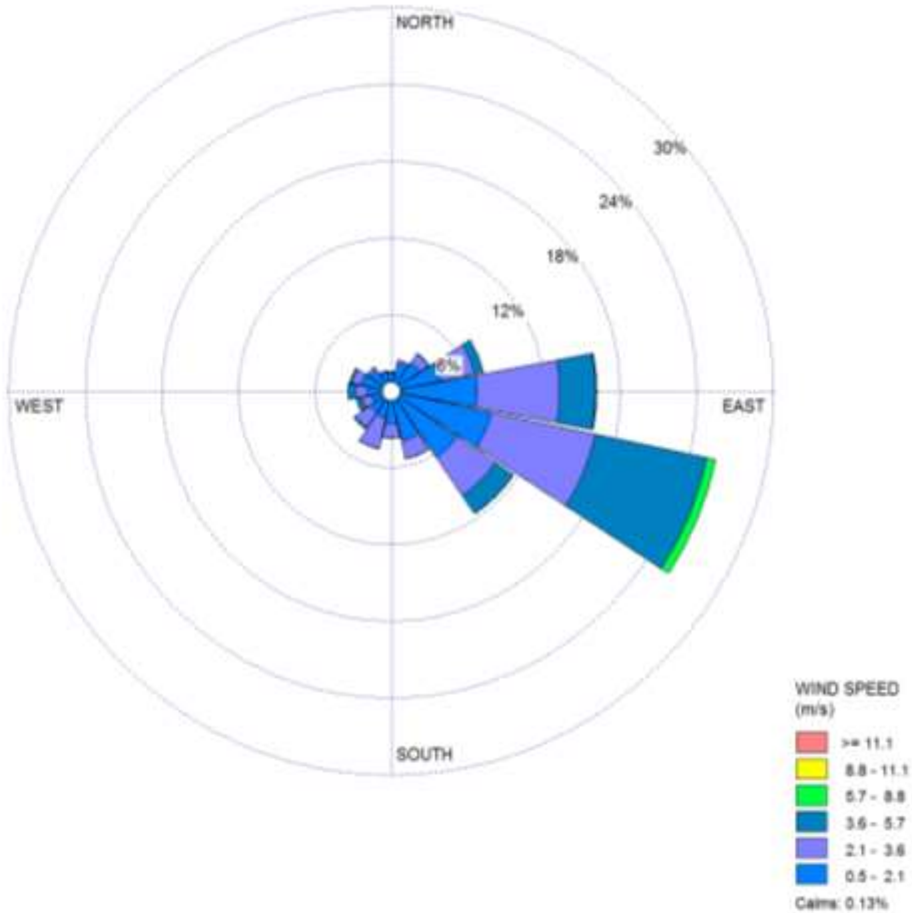


Spring

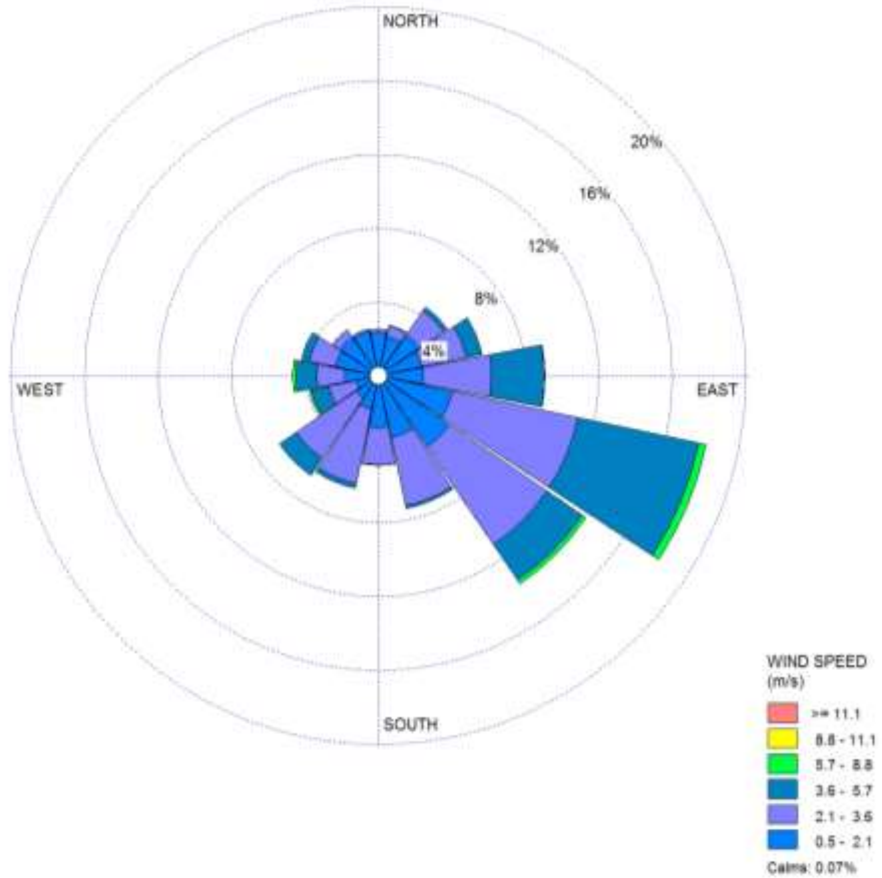


Summer

Figure 2-2: Seasonal wind roses (spring and summer) for the Jan 2008 – Dec 2012 monitoring period.

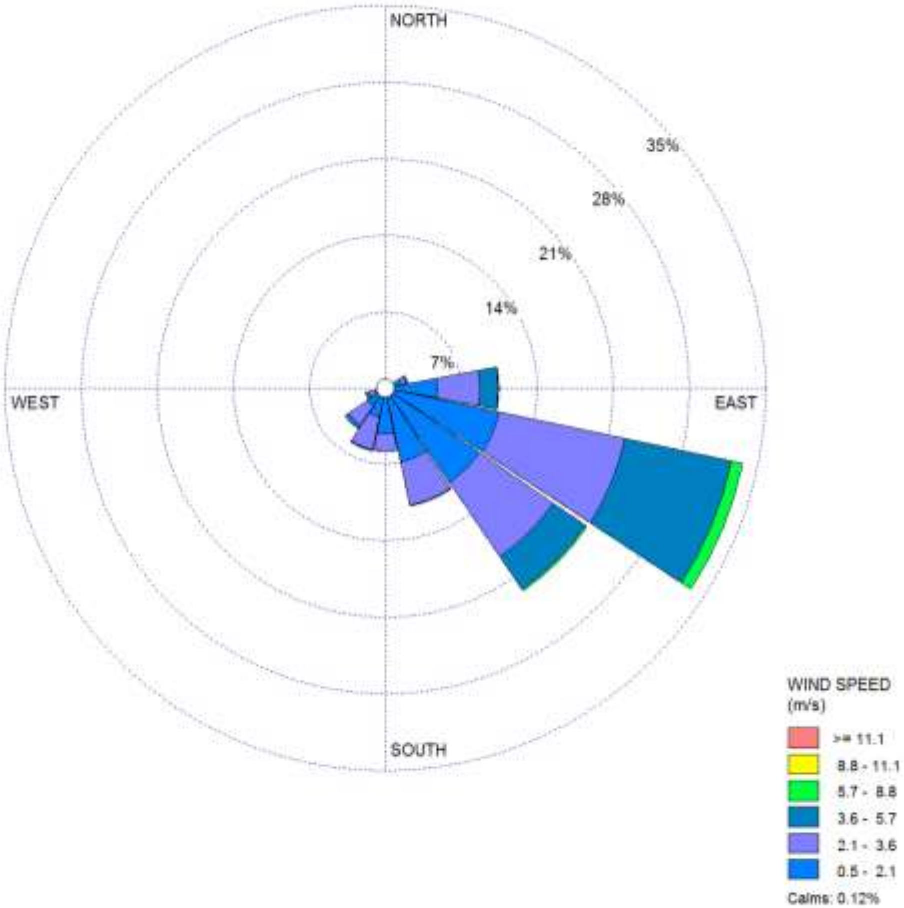


Autumn

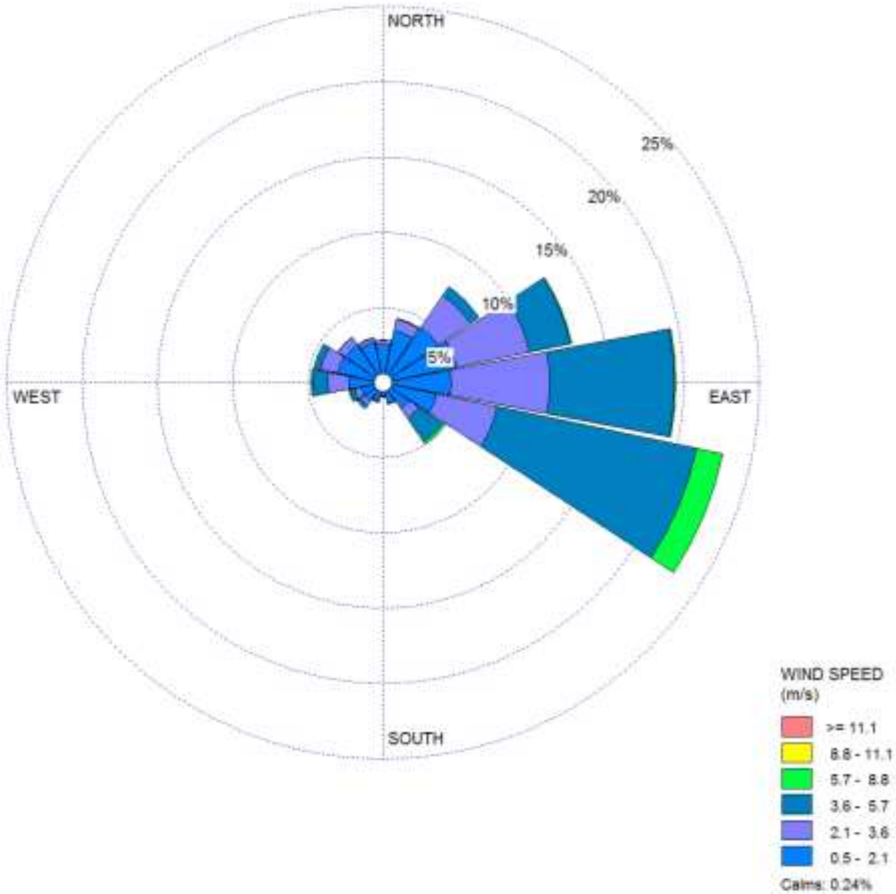


Winter

Figure 2-3: Seasonal wind roses (autumn and winter) for the Jan 2008 – Dec 2012 monitoring period.

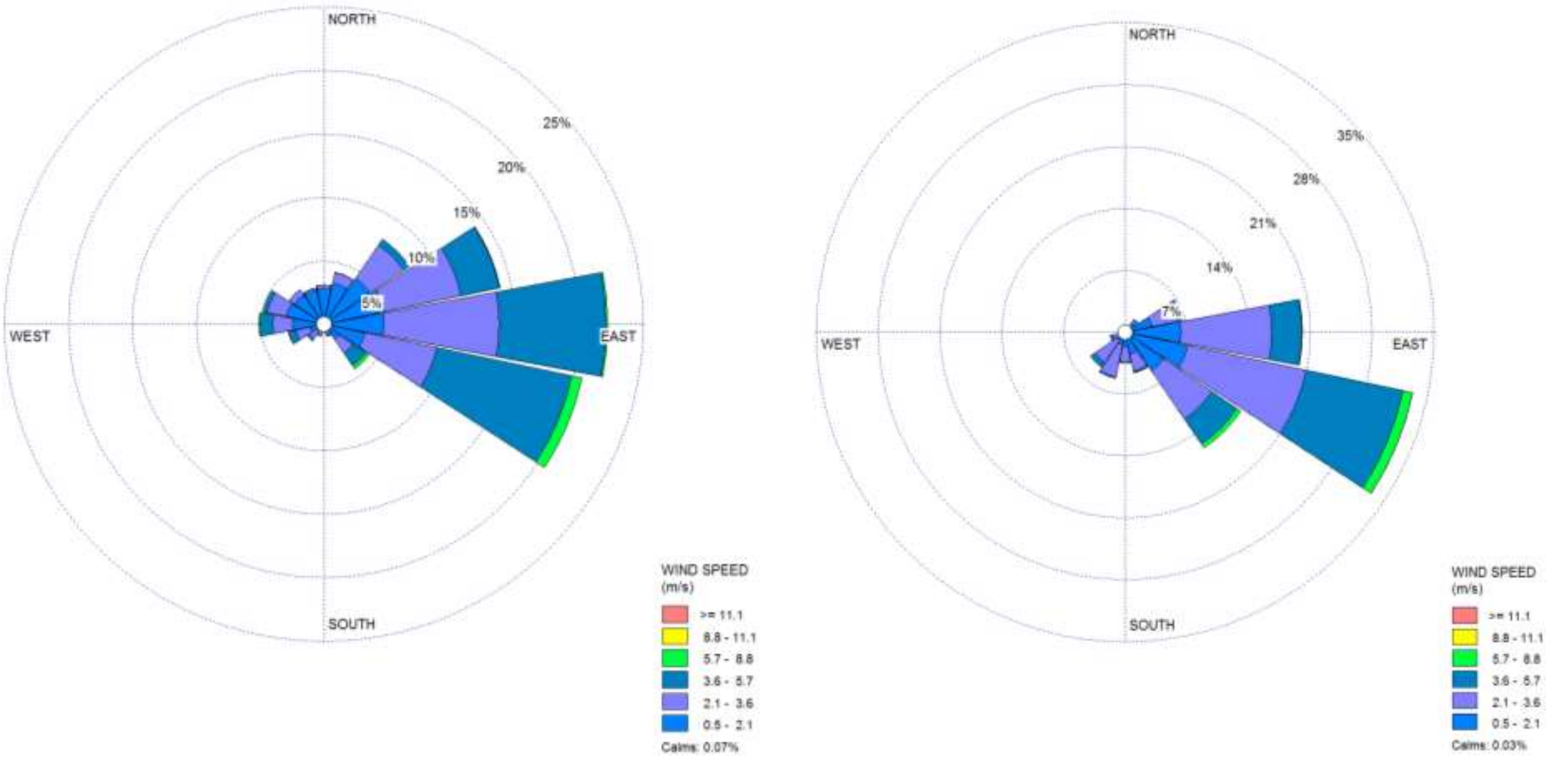


00:00 -06:00



06:00 – 12:00

Figure 2-4: Diurnal wind roses (00:00 -06) – (06:00 – 12:00) for the Jan 2008 – Dec 2012 monitoring period.



12:00 -18:00

18:00-24:00

Figure 2-5: Diurnal wind roses (12:00-18:00) – (18:00-24:00) for the Jan 2008 – Dec 2012 monitoring period.

2.1.2 Atmospheric stability

Atmospheric stability is commonly categorised into one of seven stability classes. These are briefly described in Table 2-1 below. The atmospheric boundary layer is usually unstable during the day due to turbulence caused by the sun's heating effect on the earth's surface. The depth of this mixing layer depends mainly on the amount of solar radiation, increasing in size gradually from sunrise to reach a maximum at about 5-6 hours after sunrise. The degree of thermal turbulence is increased on clear warm days with light winds. During the night a stable layer, with limited vertical mixing, exists. During windy and/or cloudy conditions, the atmosphere is normally neutral. A neutral atmospheric potential neither enhances nor inhibits mechanical turbulences. An unstable atmospheric condition enhances turbulence, whereas a Stable atmospheric condition inhibits mechanical turbulence.

Table 2-1: Atmospheric stability class

A	Very unstable	calm wind, clear skies, hot daytime conditions
B	Moderately unstable	clear skies, daytime conditions
C	Slightly Unstable	moderate wind, slightly overcast daytime conditions
D	Neutral	high winds or cloudy days and nights
E	Slightly Stable	moderate wind, slightly overcast night-time conditions
F	Moderately stable	low winds, clear skies, cold night-time conditions
G	Very stable	Calm winds, clear skies, cold clear night-time conditions

The site experienced mostly moderately stable atmospheric conditions (31.1%) which are characteristic of low winds, clear skies and cold night time conditions. 17.5% of the time was attributed to moderately unstable atmospheric condition which are characteristic of clear skies.

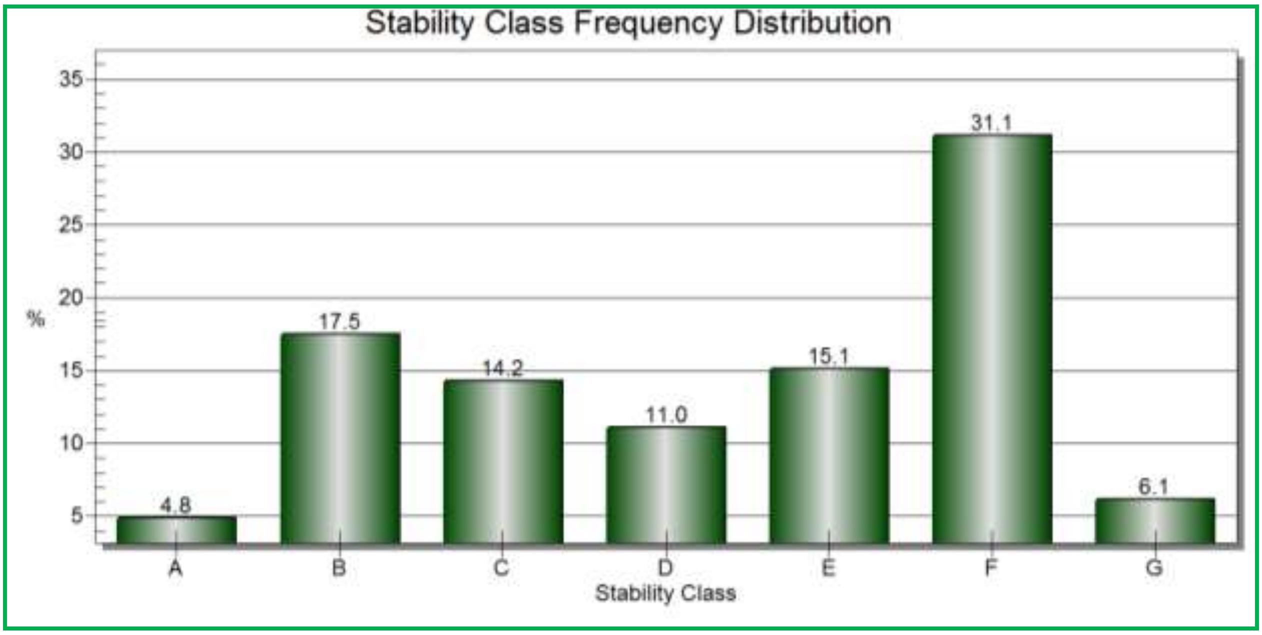


Figure 2-6: Stability class frequency distribution

2.1.3 Temperature and Humidity

Temperature affects the formation, action, and interactions of pollutants in various ways (Kupchella & Hyland, 1993). Chemical reaction rates tend to increase with temperature and the warmer the air, the more water it can hold and hence the higher the humidity.

Temperature also provides an indication of the rate of development and dissipation of the mixing layer as well as determining the effect of plume buoyancy; the larger the temperature difference between the plume and ambient air, the higher the plume is able to rise. Higher plume buoyancy will result in an increased lag time between the pollutant leaving the source, and reaching the ground. This additional time will allow for greater dilution and ultimately a decrease in the pollutant concentrations when reaching ground level.

Figure 2-7 below illustrates the average temperature and relative humidity profile for the area under investigation for the Jan 2008 – Dec 2012 monitoring period. Daily average summer temperatures ranged between 23 -24 ºC, while the average winter temperatures ranged between 13 -15 ºC. The maximum average temperature recorded for the period under review was 24 ºC with a minimum of 13 ºC.

Humidity is the mass of water vapour per unit volume of natural air. When temperatures are at their highest the humidity is also high, the moisture is trapped inside the droplets of the water vapour. This makes the moisture content of the air high. When relative humidity exceeds 70%, light scattering by suspended particles begins to increase, as a function of increased water uptake by the particles (CEPA/FPAC Working Group, 1999). This results in decreased visibility due to the resultant haze. Many pollutants may also dissolve in water to form acids, as well as secondary pollutants within the atmosphere. The highest levels of humidity was recorded during the summer months with an average of 75%, while the lowest levels of humidity was recorded during the springs and winter months with 70% and 72% respectively.

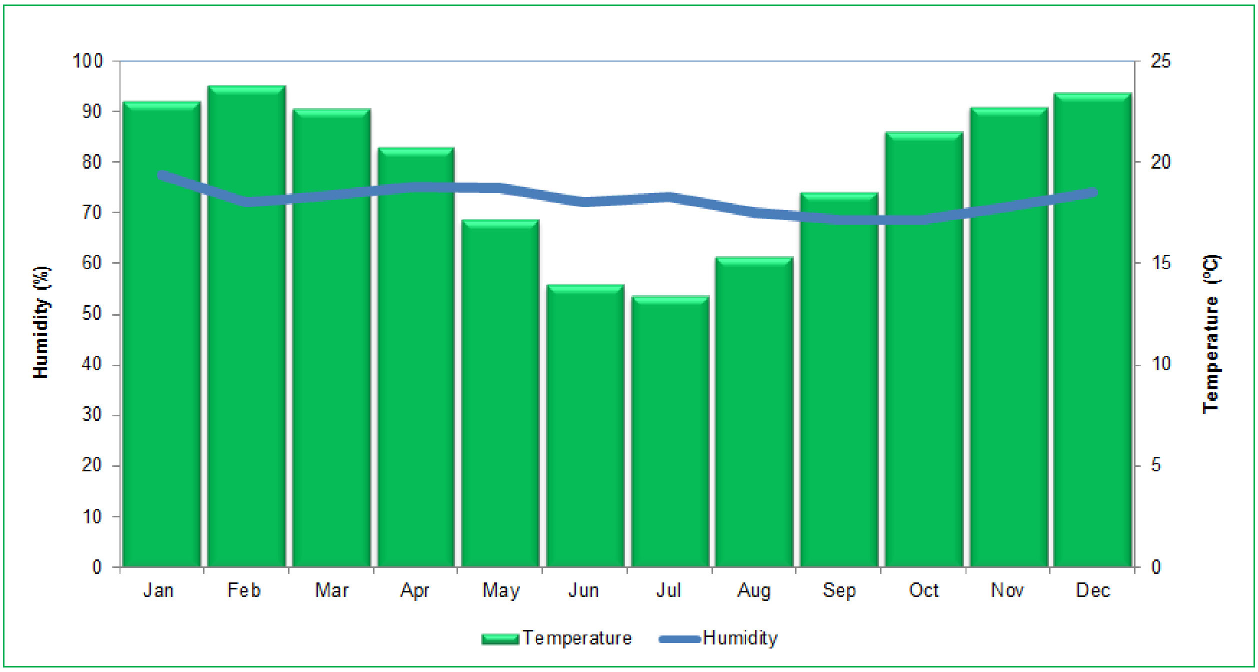


Figure 2-7: Temperature and relative humidity for the Jan 2008 – Dec 2012 monitoring period.

2.1.4 Precipitation

Precipitation cleanses the air by washing out particles suspended in the atmosphere (Kupchella & Hyland, 1993). It is calculated that precipitation accounts for about 80-90% of the mass of particles removed from the atmosphere (CEPA/FPAC Working Group, 1999).

Summary of the average monthly rainfall is illustrated in Figure 2-8 below. The information used in the section below is extracted from the WR2005 study on catchments for The Duel Project Area (Middleton and Bailey, 2009).

The total rainfall observed for the period under review was recorded at 386 mm. The highest period of rainfall was recorded during the summer months (Dec, Jan and Feb) with 209mm while the lowest rainfall was occurred during the winter months (Jun, Jul and Aug) with 14mm.

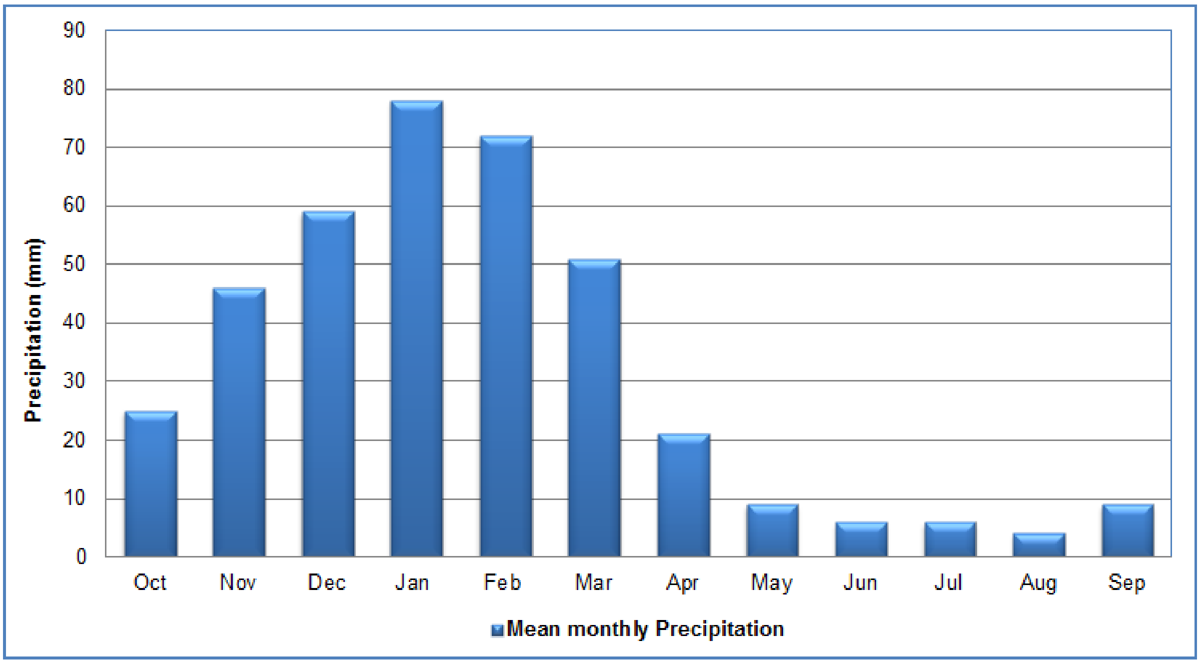


Figure 2-8: Mean monthly precipitation recorded for The Duel Coal Project area.

3 APPLICABLE LEGISLATION

3.1 National Environmental Management: Air Quality Act 39 of 2004

The National Environmental Management: Air Quality Act 39 of 2004 has shifted the approach of air quality management from source-based control to receptor-based control. The main objectives of the Act are to:

- Give effect to everyone's right 'to an environment that is not harmful to their health and well-being'
- Protect the environment by providing reasonable legislative and other measures that (i) prevent pollution and ecological degradation, (ii) promote conservation and (iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development

The Act makes provision for the setting and formulation of national ambient air quality standards for 'substances or mixtures of substances which present a threat to health, well-being or the environment'. More stringent standards can be established at the provincial and local levels.

The control and management of emissions in AQA relates to the listing of activities that are sources of emission and the issuing of emission licences. Listed activities are defined as activities which 'result in atmospheric emissions and are regarded to have a significant detrimental effect on the environment, including human health'. Listed activities have been identified by the minister of the Department of Environmental Affairs and atmospheric emission standards have been established for each of these activities. These listed activities now require an atmospheric emission licence to operate. The issuing of emission licences for Listed Activities is the responsibility of the metropolitan and district municipalities.

In addition, the minister may declare any substance contributing to air pollution as a priority pollutant. Any industries or industrial sectors that emit these priority pollutants will be required to implement a Pollution Prevention Plan. Municipalities are required to 'designate an air quality officer to be responsible for co-ordinating matters pertaining to air quality management in the Municipality'. The appointed Air Quality Officer is responsible for the issuing of atmospheric emission licences.

3.2 National Ambient Air Quality Standards

Air quality guidelines and standards are fundamental to effective air quality management, providing the link between the source of atmospheric emissions and the user of that air at the downstream receptor site. The ambient air quality guideline values indicate safe daily exposure levels for the majority of the population, including the very young and the elderly, throughout an individual's lifetime. Air quality guidelines and standards are normally given for specific averaging periods. These averaging periods refer to the time-span over which the air concentration of the pollutant was monitored at a location. Generally, five averaging periods are applicable, namely an instantaneous peak, 1-hour average, 24-hour average, 1-month average, and annual average.

The Department of Environmental Affairs and Tourism (DEAT) have issued ambient air quality guidelines to support receiving environment management practices. Ambient air quality guidelines are only available for such criteria pollutants which are commonly emitted, such as Particulates, SO_2, Pb, NO_x, benzene and CO. The guidelines specific to the relevant pollutants during this assessment are detailed in the sections below.

3.2.1 Particulate matter

Particulate matter is the collective name for fine solid or liquid particles added to the atmosphere by processes at the earth's surface. Particulate matter includes dust, smoke, soot, pollen and soil particles (Kemp, 1998). Particulate matter has been linked to a range of serious respiratory and cardiovascular health problems. The key effects associated with exposure to ambient particulate matter include: premature mortality, aggravation of respiratory and cardiovascular disease, aggravated asthma, acute respiratory symptoms, chronic bronchitis, decreased lung function, and an increased risk of myocardial infarction (USEPA, 1996).

Particulate matter represents a broad class of chemically and physically diverse substances. Particles can be described by size, formation mechanism, origin, chemical composition, atmospheric behaviour and method of measurement. The concentration of particles in the air varies across space and time, and is related to the source of the particles and the transformations that occur in the atmosphere (USEPA, 1996).

Particulate Matter can be principally characterised as discrete particles spanning several orders of magnitude in size, with inhalable particles falling into the following general size fractions (USEPA, 1996):

- PM10 (generally defined as all particles equal to and less than 10 microns in aerodynamic diameter; particles larger than this are not generally deposited in the lung);
- PM2.5, also known as fine fraction particles (generally defined as those particles with an aerodynamic diameter of 2.5 microns or less)
- PM10-2.5, also known as coarse fraction particles (generally defined as those particles with an aerodynamic diameter greater than 2.5 microns, but equal to or less than a nominal 10 microns); and
- Ultra fine particles generally defined as those less than 0.1 microns.

Fine and coarse particles are distinct in terms of the emission sources, formation processes, chemical composition, atmospheric residence times, transport distances and other parameters. Fine particles are directly emitted from combustion sources and are also formed secondarily from gaseous precursors such as sulphur dioxide, nitrogen oxides, or organic compounds. Fine particles are generally composed of sulphate, nitrate, chloride and ammonium compounds, organic and elemental carbon, and metals.

Table 3-1: Ambient air quality standards and guidelines for particulate matter.

Pollutant	Averaging period (µg/m^3)	Guideline (µg/m^3)	Number of Exceedance Allowed Per Year
PM10	Daily average	75	4 4
	Annual average	40	0 0
PM2.5	Daily average	65 (1) 40 (2) 25 (3)	4 4 4
	Annual average	25 (1) 20 (2) 15 (3)	0 0 0

Notes: 1- Come into effect immediately until December 2015
2- Come into effect 1 January until 31 December 2029
3 – Come into effect 1 January 2030

3.2.2 Nuisance Dust

On the 7th of December 2012 the Minister of Water and Environmental Affairs published the new National Dust Control Regulations. This document now enforces the monitoring of dust fallout from activities that is suspected of contributing significantly to dust fallout in its region. The regulation provides a set standard for dust fallout to comply to, enforces that a baseline should be established to projects that would give rise to increased dust fallout, specifications for dust fallout monitoring and the format of reports if the activity should exceed the thresholds.

If an activity exceeds the standard the entity must submit a dust monitoring report to the air quality officer (local authority), before December 2013 (Section 4, GN1007 of 2012). The entity must develop a dust management plan, within three months after the submission of a dust monitoring report (Section 5, GN1007 of 2012). If the dust fallout is continued to be exceeded, the authority may request that continuous PM_{10} monitoring be conducted at the site.

Table 3-2: Acceptable Dust fallout rates as measured (using ASTM d1739:1970 or equivalent) at and beyond the boundary of the premises where dust originates.

Restriction area	Dustfall rate, D ($mg/m^2/day$, 30-day average)	Comment
Residential	D < 600	Two within a year, not sequential months.
Non residential	600 < D < 1200	Two within a year, not sequential months.

3.2.3 Methane

Methane is not toxic to humans but is of concern in terms of its explosion potential and its impact on the global climate. The most commonly accepted flammability ranges for methane in air mixtures are given as 5.3% to 14%. The flammability range becomes slightly extended to 5.0% to 15% when mixtures of methane in air are retained with a small void such as might occur should the gas collect within an enclosed void within buildings (Campbell, 1996). Methane is one of the most significant greenhouse gases known (21 times stronger than carbon dioxide). Over the last two centuries, methane concentrations in the atmosphere have more than doubled, largely due to human-related activities.

The potential exists for pockets of methane to be present in the coal seams which are mined. The methane present in the coal seams enters the atmosphere when it is disturbed or exposed to the atmosphere. Due to studies undertaken using the IPCC it was identified that methane emissions from coal are extremely erratic and will vary depending on mining rates, rainfall, atmospheric pressure and temperature and therefore are not possible to determine amount or concentrations of the methane which will be released, especially with reference to surface and open cast mining operations. As the potential for explosion does exist it is recommended that regular monitoring of the methane be carried out to ensure the levels as well below explosive limits, especially in the underground mining sectors where ventilation should be well maintained.

3.2.4 Licensing requirements

The National Environmental Management: Air Quality Act (39 of 2004) includes the following regarding Atmospheric Emission Licenses.

22. No person may without a provisional atmospheric emission license or an atmospheric license conduct an activity:

(a) Listed in the National List anywhere in the Republic; or

(b) Listed on the list applicable in a province anywhere in that province;

AQA Implementation

Listed Activities and Minimum Emission Standards

Listed Activities and associated minimum emission standards identified in terms of section 21 of the National Environmental Management: Air Quality Act, 39 of 2004 (31 March 2010 GG Vol. 537 No. 33064)

Category 5. Mineral Processing Industry

Number 5.1: Storage and handling of ore and coal not situated on the premises of a mine or works as defined in the Mines Health and Safety Act 29/1996.

Locations designed to hold more than 100 000 tons.

Notes: Should this be triggered an Atmospheric Emissions licence would be required

3.3 Sensitive receptors

A sensitive receptor for the purpose of this report is identified as a place or activity which could involuntarily be exposed to air emissions generated from the proposed operations. Based on this definition the residential, educational and recreational land uses in the area are considered to be sensitive receptors. For this study, the position of houses/dwellings on the farms was identified through use of Google Earth.

The area surrounding the proposed project is bordered by neighbouring farms. Sensitive receptors identified through Google Earth are presented in the Table 3-3 and Figure 3-1 below. The closest village in relation to the The Duel Coal Project is the Makushu village which is has a local primary school and community centre south of the proposed site. Other sensitive receptors within the area would be local fauna and flora. It has also been identified that dust settling on leaves on plants can result in damage to plants and inhalation of dust may result in sickness and associated lung disease for wildlife and humans which will be present in the vicinity of the site, especially during construction.

Table 3-3: Sensitive receptors in relation to the proposed Duel Project.

Settlement	Direction	Distance
Makushu	South – east	50 m
Mosholombe	South – east	950 m
Pfumembe	South – east	3 km
Musekwa (Ngundu)	South – east	6 km
Maranikhwe	East	8 km
Mudimeli/Fripp	West	8.5 km
Maangaani	South	9 km

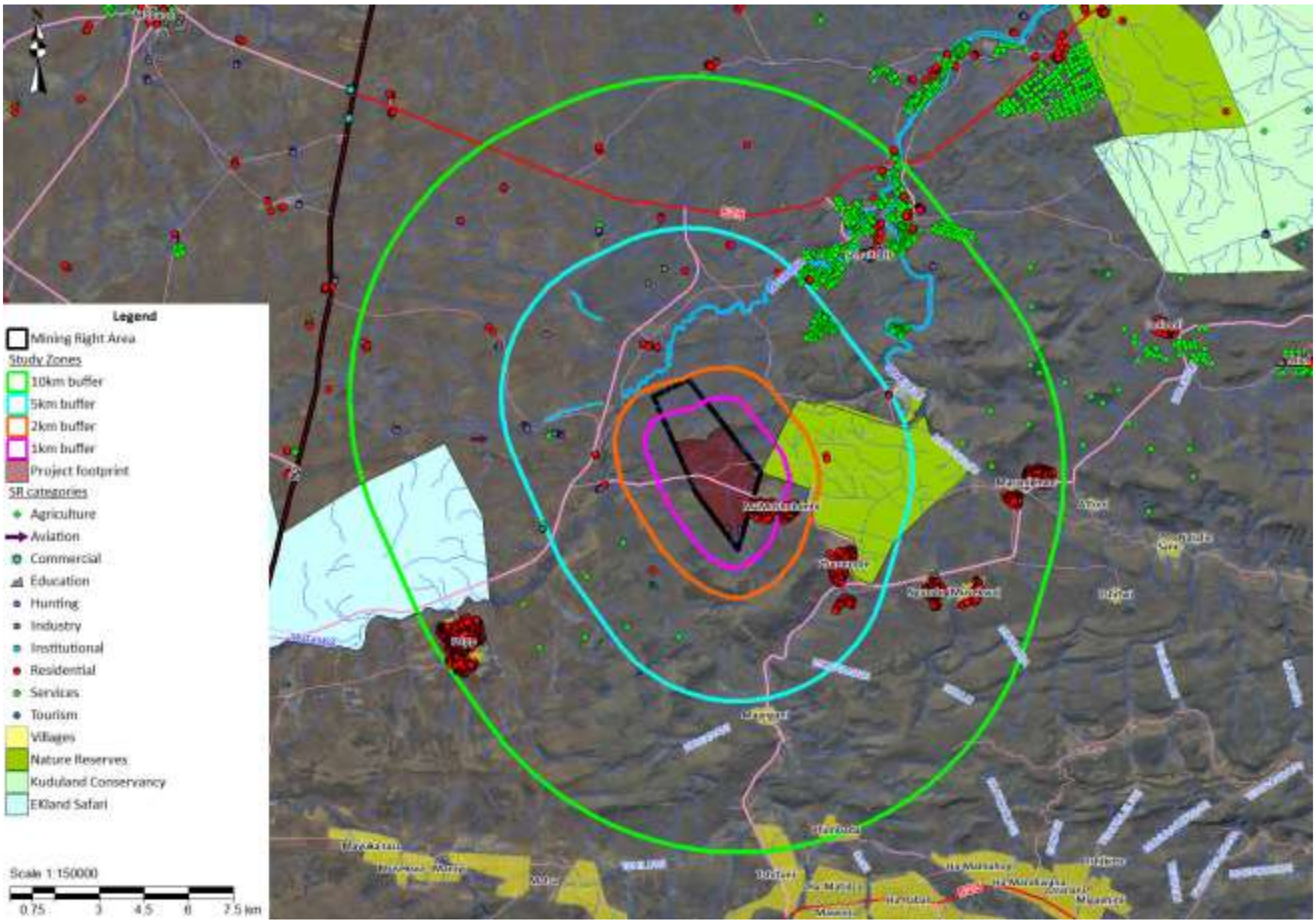


Figure 3-1: Sensitive receptor map

3.4 Existing sources of pollution

Based on satellite imagery the following surrounding sources of air pollution have been identified in the area:

- Domestic fuel burning
- Unpaved roads
- Agricultural
- Future mining activities

A qualitative discussion of each identified source is provided in the subsection below. The aim of this section is to highlight the potential contribution of surrounding sources to the overall ambient air quality within the area.

3.4.1 Domestic fuel burning

It is anticipated that low income households and communities within the area are likely to combust domestic fuels for space heating and/or cooking purposes. Typical domestic fuels used are wood, paraffin and coal as the economic benefits are advantageous, however the environmental and health effects can be detrimental. Emissions released from biomass and coal combustion emit a large number of pollutants and known health hazards including criteria pollutants such as Particulate matter (PM), Carbon monoxide (CO), Nitrogen dioxide

(NO_2), Sulphur dioxide (SO_2) as well as formaldehyde, Polycyclic organic matter and carcinogenic compounds such as benzo (a) pyrene.

The combustion of coal in particular results in an incomplete process that releases CO, methane (CH_4) and NO_2. The implications for indoor pollution as a result is a growing concern and has been indicated in varying degrees of evidence as a causal agent of acute respiratory infections, chronic pulmonary diseases and lung cancer in developing countries (Barnes et al, 2009).

3.4.2 Unpaved roads

When vehicles travel on unpaved roads, the force of the wheels on the road surface causes the pulverisation of surface material. Particles are lifted and dropped from the rolling wheels, and the road surface is exposed to stronger air currents in turbulent shear with the surface. The turbulent wake behind the vehicle continues to act on the road surface after the vehicle has passed.

The quantity of dust emissions from a given segment of unpaved road varies linearly with the volume of traffic. Emissions are also dependant on certain source parameters such as the condition of the road and the associated vehicle traffic. Dust emissions from unpaved roads have been found to vary directly with the fraction of silt in the road surface material. Other variables are important in addition to the silt content of the road surface material. For example, at industrial sites, where haul trucks and other heavy equipment are common, emissions are highly correlated with vehicle weight.

Exhaust tailpipe emission from vehicles is a significant source of particulate emissions and can be grouped into primary and secondary pollutants. Primary pollutants which are CO_2, CO, hydrocarbons, SO_2, NOX, particulates and lead are those emitted directly into the atmosphere and secondary pollutants which are nitrogen dioxide, ozone which is a photochemical oxidant, hydrocarbons, sulphuric acid, sulphates, nitric acid and nitrate aerosols are those formed in the atmosphere as a result of chemical reactions. Toxic hydrocarbons include acetylaldehyde, benzene and formaldehyde, carbon particles, sulphates, aldehydes, alkanes, and alkenes.

3.4.3 Agricultural

Agricultural activity can be considered a significant contributor to particulate emissions, although tilling, harvesting and other activities associated with field preparation are seasonally based. The main focus internationally with respect to emissions generated due to agricultural activity is related to animal husbandry, with special reference to malodours generated as a result of the feeding and cleaning of animals. The types of livestock assessed included pigs, sheep, chicken, goats and cattle, with game farming being the largest commercial enterprise. Odorous pollutants associated with animal husbandry are ammonia and hydrogen sulphide

The activity associated with farming particularly irrigation farming includes the application of pesticides, herbicides, weed control, fertilizers, harvesting activities, phosphate and nitrogen addition. Little information is available with respect to the emissions generated due to the growing of crops. The activities responsible for the release of particulates and gases to atmosphere would however include:

- Particulate emissions generated due to wind erosion from exposed areas;
- Particulate emissions generated due to the mechanical action of equipment used for tilling and harvesting operations;
- Vehicle entrained dust on paved and unpaved road surfaces;
- Gaseous and particulate emissions due to fertilizer treatment; and

- Gaseous emissions due to the application of herbicides and pesticides.

3.4.4 Mining Activities

There are numerous planned coal mines located within the vicinity of the proposed The Duel Coal Project. There exists a potential that air quality impacts from other mines could influence the cumulative air quality impacts at and near the site.

The main emission to air from mining operations consists of wind borne dust, and the products of combustion from blasting, vehicle usage, materials handling and mine power generation (if any). Mining operation involves the mobilization of large amounts of material and waste piles containing small size particles that are easily dispersed into the atmosphere. The largest sources of air pollution in mining operations are:

- Particulate matter transported by Aeolian action as a result of excavation, blasting, transportation of materials, wind erosion of exposed surfaces, fugitive dust from tailings dumps and haul roads and exhaust emissions from mobile sources also raises these levels;
- Gaseous emission from combustion of fuels in stationary and mobile sources, explosions, and mineral processing.

Once a pollutant enters the atmosphere, they undergo physical and chemical changes before reaching a receptor. These pollutants can cause serious effects to human health and to the environment. Large scale mining has the potential to contribute significantly to air pollution, especially during the operation phase. All activities during ore extraction, processing, handling and transportation depend upon the equipment, generators, processors and materials that generate hazardous air pollutants such as particulate matter, heavy metals, carbon monoxide, sulphur dioxide and nitrogen oxides.

4 IMPACT ASSESSMENT

This section of the report outlines the potential impacts associated with the construction, operation and decommissioning phase of the proposed The Duel Coal Project on the surrounding environment. To clearly detail the potential impacts on ambient ground level concentrations, only construction and operational emissions were evaluated during the impact assessment phase of the EIA. The decommissioning phase of the project was only qualitatively addressed due to its variability and unpredictable nature.

4.1 Methodology

Dispersion modelling was undertaken using the US-EPA approved Aermod Dispersion Model. This model is based on the Gaussian plume equation and 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). The AERMOD View model is used extensively to assess concentrations and deposition from a wide variety of sources.

The assessment which was carried out is the level 2 assessment which is in line with the objective of the study. Level 2 assessments are used for air quality impact assessments where:

- The distribution of pollutant concentration and deposition are required in time and space;
- The respective dispersion modelling can be treated by a steady state Gaussian plume model with first order chemical transformation;
- Emissions assessed are from sources where the greatest impacts are in the order of a few kilometres (less than 50km downwind).

4.1.1 Model overview

AERMOD, a state-of-the-art Planetary Boundary Layer (PBL) air dispersion model, was developed by the American Meteorological Society and USEPA Regulatory Model Improvement Committee (AERMIC). AERMOD is a steady-state plume dispersion model for stimulating transport and dispersion from point, area or volume sources based on an up to date characterization of the atmospheric boundary layer. AERMOD utilizes a similar input and output structure to ISCST3 and shares many of the same features, as well as offering additional features. AERMOD fully incorporates the PRIME building downwash algorithms, advanced depositional parameters, local terrain effects, and advanced meteorological turbulence calculations.

The AERMOD atmospheric dispersion modelling system is an integrated system that includes three modules:

- A steady-state dispersion model designed for short-range (up to 50 km) dispersion of air pollutant emissions from stationary industrial sources.
- A meteorological data pre-processor (AERMET) for surface meteorological data, upper air soundings, and optionally, data from on-site instrument towers. It then calculates atmospheric parameters needed by the dispersion model, such as atmospheric turbulence characteristics, mixing heights, friction velocity, Monin-Obukov length and surface heat flux.
- A terrain pre-processor (AERMAP) which provides a physical relationship between terrain features and the behaviour of air pollution plumes. It generates location and height data for each receptor location. It also provides information that allows the dispersion model to simulate the effects of air flowing over hills or splitting to flow around hills.

4.1.2 Model requirements

Input data requirements for Aermod include meteorological and emissions source data. MM5 Model data which includes wind speed, wind direction, relative humidity, pressure, temperature, precipitation, cloud cover and ceiling height was obtained for The Duel Coal Project Area (-22.6179 S; 29.8500 E). AERMOD incorporates AERMET which uses a standard meteorological measurements and surface parameters representative of the modelling domain to compute boundary layer parameters used to estimate profiles of wind, turbulence and temperature used by AERMOD (DEA, 2014). The emissions inventory was developed to determine the potential emissions generated from each source. Accurate emissions factors are required for the proper implementation of applicable air quality regulations and also for the evaluation of appropriate technologies and practices to reduce emissions. The emission factors are expressed as the weight of pollutant divided by the unit weight, volume, distance and duration of the activity emitting the pollutant. As such we deduced the emission rate of a particular pollutant at a specific stage using the respective volumes, weights and duration.

4.2 Emissions Inventory

The emissions inventory was developed to determine the emissions generated from each source activity in the project area. Emissions for The Duel Coal Project were based on the US-EPA AP42 sections: 11.9 Western surface coal mining; 12.2.3 Heavy construction operations, 13.2.4 Aggregate handling and storage piles and the Australian National Pollutant Inventory (NPI). Calculations were applied to individual processes in order to obtain an emission to air estimate, based on mass balance information sought from literature review and the client (Ref).

The anticipated key pollutant to be released from the proposed activities at The Duel Coal Project is mainly Particulate Matter (PM_{10}) and nuisance dust emissions. Particulate matter is a criteria pollutant which represents a broad and diverse class of chemically and physically diverse substances. Particulates can be described by size formation mechanism, origin, chemical composition, atmospheric behaviour and method of measurement. The concentration of particles in the air varies across space and time, and is related to the source of the particles and the transformations that occur in the atmosphere (USEPA, 1996). Particulate matter includes dust, smoke, soot, pollen and soil particles (Kemp, 1998). Particulate matter has been linked to a range of serious respiratory and cardiovascular health problems. The key effects associated with exposure to ambient particulate matter include: premature mortality, aggravation of respiratory and cardiovascular disease, aggravated asthma, acute respiratory symptoms, chronic bronchitis, decreased lung function, and an increased risk of myocardial infarction (USEPA, 1996).

4.2.1 Heavy construction

Particulate emission estimates from construction activity at The Duel Coal Project area are presented in the table below.

$$E_{TSP} = 1.2 \text{ (ton/ha/month of activity)}$$

The quantity of emissions arising from construction activities is proportional to the area of land being worked and to the level of construction. There is currently no emission factor for PM 10 for construction activities, therefore a factor of 50% was applied to the calculated TSP emission rates according to best international practice, unless specified elsewhere in the Emissions Inventory.

Table 4-1: Heavy construction emission rates

Project area	Area (ha)	Emission rate of TSP ($g/m^2/s$)	Emission rate for PM_{10} ($g/m^2/s$)
Unmitigated			
The Duel	588	9.17E-09	4.58E-09
Mitigated (control efficiency of 85%)			
The Duel	588	1.38E-09	6.88E-10

4.2.2 Bulldozing

The USEPA provides an emissions equation specifically for activities from bulldozers since this equation takes silt content and moisture into account. This was taken from the AP42 Western Surface Coal Mining specifications for opencast mining activities. Emissions from dozing of topsoil, overburden and ore were calculated using the following equations:

$$E_{TSP} = 2.6 \times \frac{(s)^{1.2}}{(M)^{1.3}}$$

$$E_{PM10} = 0.34 \times \frac{(s)^{1.5}}{(M)^{1.4}}$$

Where:

E_{TSP} = Total Suspended Particulates emission factor (kg dust/hr)

E_{PM10} = Particulate emission factor (kg dust/hr) for particulates less than 10 µm

M = material moisture content (%)

s = material silt content (%)

Table 4-2: Emission rate for bulldozing activities at The Duel Coal Project

Project area	Emission rate (g/s)
Overburden	0.12
Coal seam	0.1
Total	**0.22**

4.2.3 Blasting

The US EPA provides an emission equation for blasting activities. This was taken from the AP42 western coal mining specifications for open cast coal mining

$$EF_{TSP(kg/blast)} = 0.00022 \times A_{(m^2)}^{1.5}$$

Where:

A (m^2) = the area blasted (m^2)

M (%) = the moisture content of the blasted material (% by weight)

D (m) = the depth of the blast hole (m)

Table 4-3: Emission rates for blasting and drilling activities

Project area	Emission rate (g/s)
Blasting activities	
Blasting activities (3x per week)	0.43
Drilling activities	
Drilling activities	0.21

4.2.4 Material handling operations (Tipping)

Materials handling operations associated with the proposed mine that are predicted to result in significant fugitive dust emissions include the transfer of material by means of tipping onto stockpiles and dumps. 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. 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 (USEPA, 1995).

The USEPA does not have an emission factor or equation specific for calculating emissions from excavators or shovels. The Australian NPI, however, provides the same equation as for tipping to be applied to excavators and shovels. The following equations were used to calculate TSP and PM10 emissions respectively:

$$E_{(kg/Mg)} = k \times 0.0016 \times \left[\frac{\left(U/_{2.2}\right)^{1.3}}{\left(M/_{2}\right)^{1.4}}\right]$$

Where:

U = mean wind speed

M = the moisture content of material (%)

k = the empirical constant per size fraction

Table 4-4: Empirical constant

Constant	TSP	PM10
k	0.74	0.35

Table 4-5: Emission rate

Area	TSP (g/s)	PM10 (g/s)
Stockpiles	0.43	0.15

4.2.5 Wind erosion from exposed area

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; 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).

Significant amounts of dust will be eroded from open, exposed areas at the proposed mine 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.

The particulate matter equation from the wind erosion of exposed ground was calculated using the following equation (NPI Mining):

$$E_{TSP} = 1.9 \times \left(\frac{s}{1.5}\right) \times \left(\frac{365 - p}{235}\right) \times \left(\frac{f}{15}\right)$$

$$E_{PM10} = 1.9 \times \left(\frac{s}{1.5}\right) \times \left(\frac{365 - p}{235}\right) \times \left(\frac{f}{15}\right) \times 0.5$$

Where:

E_{TSS} = total suspended particles emission factor, kg/day/ha

S = silt content of aggregate (%)

p = number of days with .0.25mm of precipitation per year

f = percentage of time that the unobstructed wind speed exceeds 5.4m/s.

Table 4-6: Emission rate for wind erosion from stockpiles

Source	PM10 (g/s)
Stockpiles	3.03E-04

4.2.6 Methane Emissions

The first emissions released from coal production are methane. Methane is a powerful heat trapping gas and is the second contributor to global warming after Carbon dioxide. Methane is non toxic to humans but is of concern in terms of its explosive potential and its impact on the global climate. Methane is one of the most significant greenhouse gases and is 21 times stronger than carbon dioxide (Campbell, 1996).

Methane is produced during coalification (process of coal formation). Only a fraction remains trapped under pressure within the coal seams and surrounding strata. The trapped methane is released during mining when the coal seams are fractured. Methane released in this fashion will escape into the mine works and eventually diffuse into the atmosphere (Irving and Tailakov, 2000).

The amount of coal released during mining depends on a number of factors, the most important of which is the coal rank, seam depth and method of mining. As coal rank increases so does the amount of methane produced. At surface mines, methane escapes from newly exposed coal faces /surfaces as well as from areas of coal rubble created by blasting operations. Methane is also present in the overburden which breaks down during the mining process and the underlying strata can be fractured due to the removal of overburden. Methane emission per ton of coal is much lower from surface than underground mining as the gas content is lower with shallow seams (Irving and Tailakov, 2000).

4.3 Impact assessment

Dispersion modelling simulations were undertaken to determine the potential air quality impacts associated with the proposed activities. These impacts are reflected as isopleths plots. The isopleths plots reflect the gridded contours (lines of equal concentration) of zones of impact at various distances from the contributing sources. The patterns generated by the contours are representative of the maximum predicted ground level concentrations for the averaging period being represented. The impact assessment for The Duel Coal Project is based on two scenarios namely; scenario 1 which assessed the impacts arising from the construction activities on site and scenario 2 which assesses the Life of mine (LOM) activities.

4.3.1 Construction impacts

Construction is a source of dust emission which has a temporary impact on the local air quality. Infrastructure and road construction are the two types of construction activity with high emission potentials. The emissions associated with mining and road construction can be associated with land clearing, drilling, blasting, ground excavation and construction of the mining facilities. The dust emissions vary from day to day and depend on the level of activity, specific operation and the prevailing meteorological conditions (USEPA, 1996).

The temporary nature of construction activities is what distinguishes it from other fugitive sources present within the locality. Emissions from construction activities are expected to have a definitive start and end period and will vary depending on the various construction phases. In contrast to other fugitive sources, here the emissions occur in a steady state or follow a discernible pattern. The quantity of dust emissions from construction activities is proportional to the area of land under construction (USEPA, 1996).

The impact on air quality and air pollution of fugitive dust is dependent on the quantity and drift potential of the dust particles (USEPA, 1996). Large particles settle out near the source causing a local nuisance problem. Fine particles can be dispersed over much greater distances. Fugitive dust may have significant adverse impacts such as reduced visibility, soiling of buildings and materials, reduced growth and production in vegetation and may affect sensitive areas and aesthetics. Fugitive dust can also adversely affect human health.

The following are components of the environment which may be impacted upon during the project construction phase:

- The ambient air quality;
- Local residents, farms and neighbouring communities;
- Mine employees; and
- The surrounding environment and possible the fauna and flora.

A quantitative assessment of the construction impacts was based on the activities carried out in the respective mining pit. Emission rates were calculated based on the USEPA heavy construction emission factors.

Table 4-7 below represents the daily and annual concentration (µg/m^3) of PM_{10} anticipated to be released during construction activities. Based on Figure 4-1 and Figure 4-2 illustrated below, the maximum predicted annual and daily ground level concentrations of PM_{10} fall below the annual and daily South African standard of **75 µg/m^3** and **40 µg/m^3** respectively.

Table 4-7: Maximum predicted ambient ground level concentration (µg/m^3) of Particulate Matter during the construction phase of The Duel Coal Project.

Source	Maximum predicted ground level Concentration of PM_{10} (µg/m^3)	Ambient air quality standard (µg/m^3)	Fraction of the standard (%)
Daily			
Construction impacts	10.9	75	0.14
Annual			
Construction impacts	2.11	40	<0.1

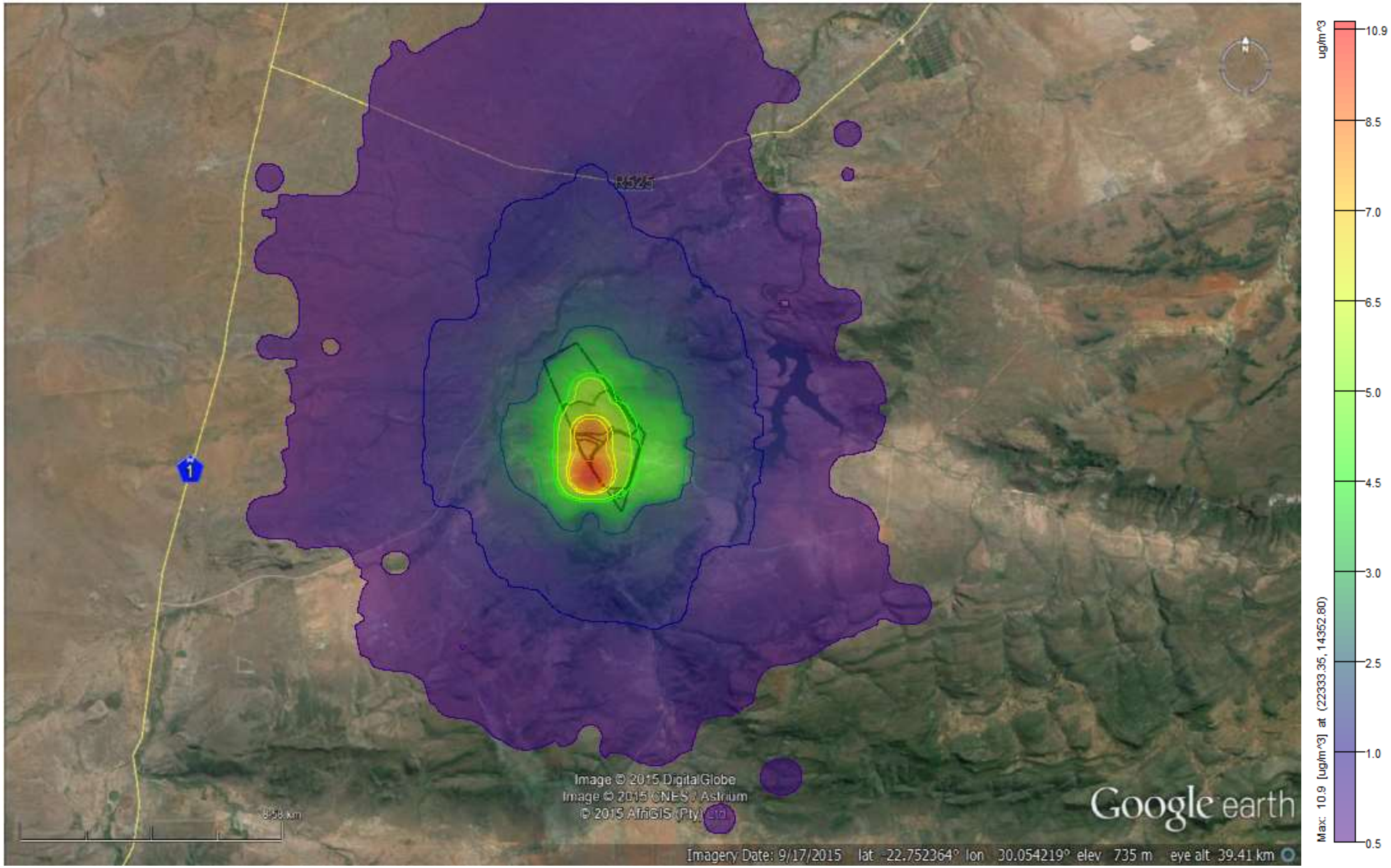


Figure 4-1: Maximum predicted daily concentration (μg/m³) of Particulate matter during construction activities

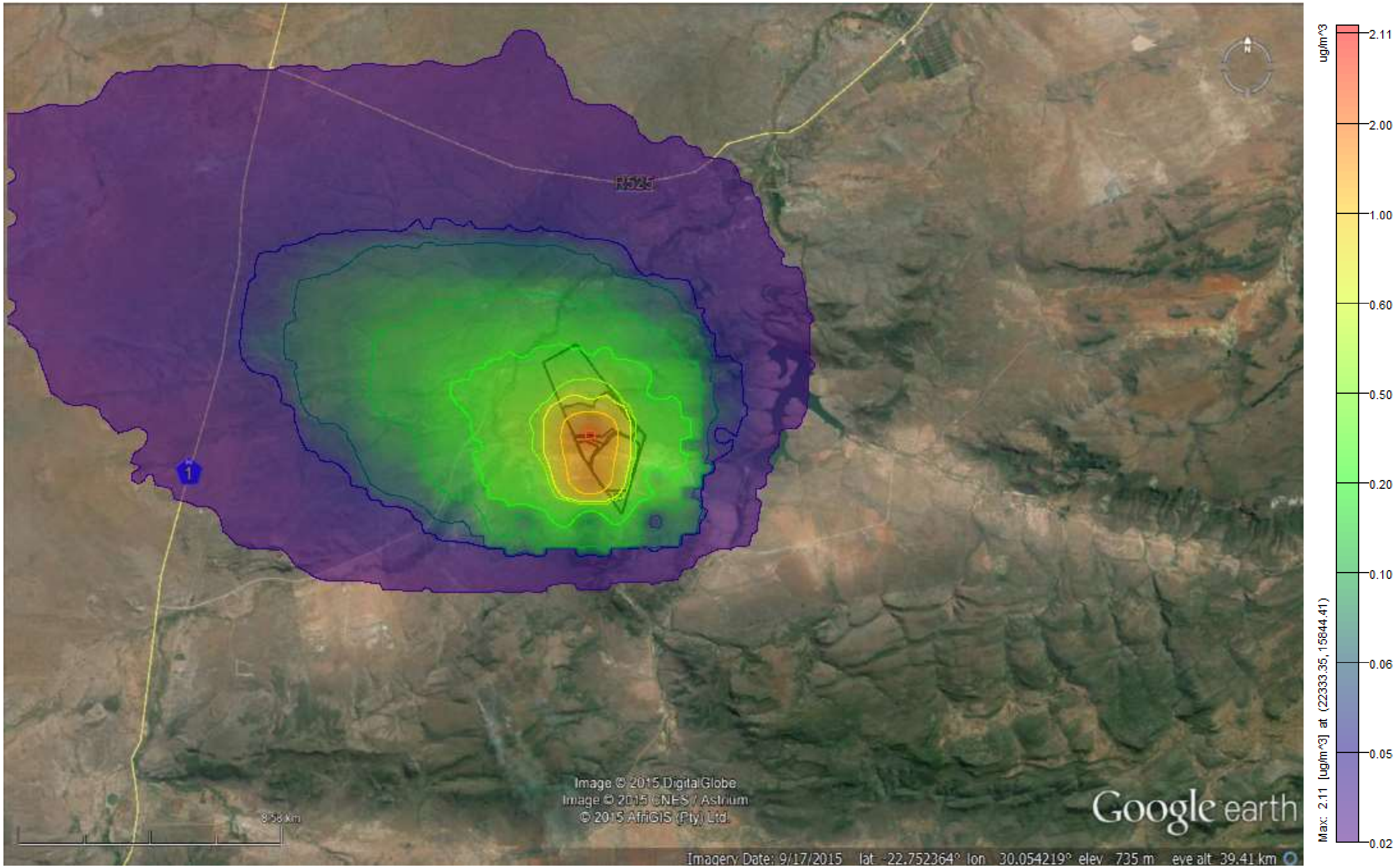


Figure 4-2:Maximum predicted annual concentration (µg/m^3) of Particulate matter during construction activities

4.4 Operational Impacts

In open cast mining, a massive overburden will have to be removed to reach the mineral deposits below. This may require excavators, transporters, loaders and conveyors belts which will result in a massive discharge of fine particulates from the overburden material. Similarly normal operations will also require excavation, transportation, loading, unloading, size reduction, stock piling, etc. All of these activities will generate particulate matter. Drilling and wind erosion over open and exposed surfaces are major sources of fugitive dust emissions. The source and characteristic of fugitive emissions from dust mining operations vary in each case, as do their impacts. Diesel trucks and equipment used in mining activities are also a source of PM.

Exposures to PM emissions are associated with a range of serious respiratory and cardio vascular health problems. The key effects associated with exposure to above standard concentration of ambient particulate matter includes: premature mortality, aggravation of respiratory disease, aggravated asthma, acute respiratory symptoms, chronic bronchitis and decreased lung function.

Methane (CH_4) is produced during coal formation. Trapped methane is released when the coal seams are fractured. Methane released in this fashion will escape into the mine and will eventually escape into the atmosphere. The amount of coal released during coal mining is dependant on a number of factors, the most important being the coal rank, seam depth and method of mining. The higher the coal rank, the higher the methane production will be (Irving and Tailakov, 2000). Underground coal mining releases more methane than surface or open pit mining. It is because the gas content is higher in deeper seams. As a safe measure and because of methane’s high explosive property, underground shafts usually have proper ventilation and gasification systems in order to remove methane (Irving and Tailakov, 2000).

At surface mines, methane escapes from coal faces as well as coal rubble from blasting activities. CH_4 may be present in the overburden, which breaks down during the mining process. Emissions per ton of coal in underground mines are higher than that of surface mining.

This section of the report aims to deal with the air quality impacts associated with the proposed mining activities scheduled to commence at the The Duel Coal Project which will be mined at a ROM production rate of 2.4 Mtpa for the first 14 years after which will be increased to a ROM production rate of 3.6 Mtpa.

The details regarding source characteristic were extrapolated from site layout plans. Sources which were evaluated in this assessment are:

- Coal processing (storage piles, crushing and screening activities).
- Open cast mining activities (drilling, blasting, bulldozing, tipping and materials handling activities).
- Wind erosion from exposed surfaces.

Table 4-8 below indicated the maximum predicted daily ground level concentration of PM_{10} at The Duel Coal Project. The maximum concentrations for the area under review are 46.65 µg/m^3. The highest contributor to particulate emissions is from the plant operations areas. Figure 4-3 below represents the dispersion potential of particulate matter during the operational phase at The Duel Coal Pine.

Table 4-8: Maximum predicted daily ground level concentration for PM_{10} during the operation conditions at The Duel Coal Project.

Source	Maximum predicted ground level Concentration of PM_{10} (µg/m^3)	Ambient air quality standard (µg/m^3)	Fraction of the standard (%)
Duel coal mine – all operations	46.65	75	0.62
Pit area	46.65	75	0.62
Plant operations	0.2	75	<0.1
Stockpiles	15.6	75	0.2

Table 4-9 below lists the maximum predicted daily ground level concentration of particulate matter located at each respective sensitive receptor. All concentrations were below the respective South African standard for daily concentrations.

Table 4-9: Maximum predicted daily ground level concentration of particulate matter at sensitive receptors.

Sensitive receptors	Maximum predicted ground level Concentration of PM_{10} (µg/m^3)	Ambient air quality standard (µg/m^3)	Fraction of the standard (%)
Makushu	28.2	75	0.4
Mosholombe	16.2	75	0.21
Pfumembe	6.9	75	<0.1
Musekwa (Ngundu)	3.04	75	<0.1
Maangaani	3.8	75	<0.1
Mudimeli/Fripp	3.9	75	<0.1

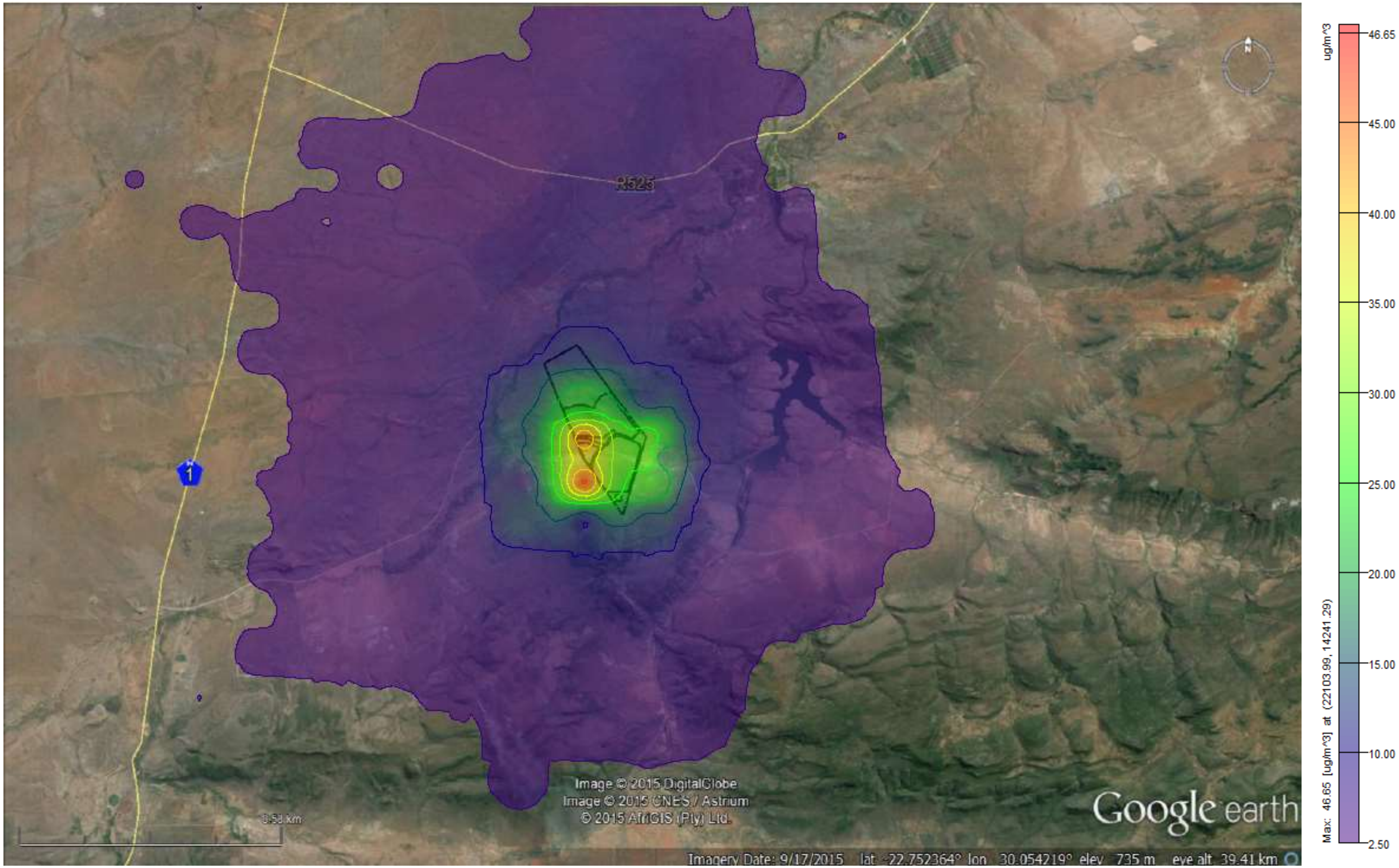


Figure 4-3: Maximum predicted daily ground level concentration (µg/m^3) of Particulate Matter during operational phase of The Duel Coal Project.

Table 4-10 below indicated the maximum predicted annual ground level concentration of PM_{10} at The Duel Coal Project. The maximum concentrations for the area under review are 7.40 µg/m^3. The highest contributor to particulate emissions is from the pit operations. Figure 4-4 below represents the dispersion potential of particulate matter during the operational phase at The Duel Coal Project.

Table 4-10: Maximum predicted annual ground level concentration for PM_{10}during the operation conditions at the Duel Coal project.

Source	Maximum predicted ground level Concentration of PM_{10} (µg/m^3)	Ambient air quality standard (µg/m^3)	Fraction of the standard (%)
Duel coal mine – all operations	7.40	40	0.2
Pit operations	6.07	40	0.15
Plant operations	1.3E-02	40	<0.1
Stockpiles	1.33	40	<0.1

The table below lists the maximum predicted annual ground level concentration of particulate matter located at each respective sensitive receptor. All concentrations were below the respective South African standard for daily concentrations.

Table 4-11: Maximum predicted annual ground level concentration of particulate matter at sensitive receptors.

Sensitive receptors	Maximum predicted ground level Concentration of PM_{10} (µg/m^3)	Ambient air quality standard (µg/m^3)	Fraction of the standard (%)
Makushu	1.25	40	<0.1
Mosholombe	0.55	40	<0.1
Pfumembe	0.10	40	<0.1
Musekwa (Ngundu)	0.03	40	<0.1
Maangaani	0.02	40	<0.1
Mudimeli/Fripp	0.06	40	<0.1

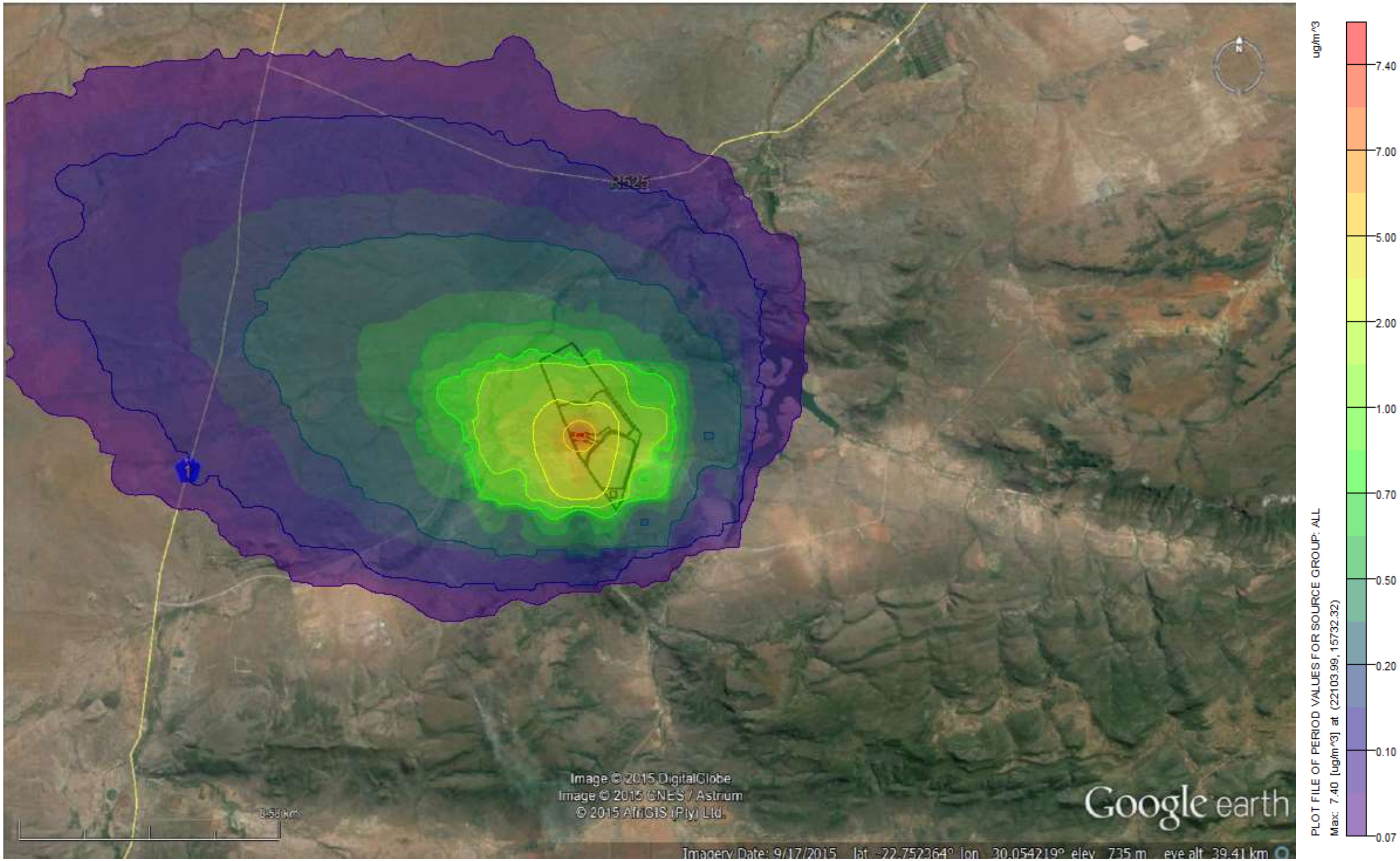


Figure 4-4: Maximum predicted annual ground level concentration (µg/m^3) of Particulate Matter during operational phase of The Duel Coal Project.

The blasting activities were modelled separate as blasting is carried out at an average of 3 times per week during intervals of approximately 10 minutes. Figure 4-5 and Figure 4-6 below illustrates the impact arising from blasting activities for The Duel Coal Project area. The daily concentration for blasting activities was modelled for a 10 minute interval. The predicted impact from blasting activity falls below above the South African Daily standard. Blasting is not a continuous activity and is limited to a maximum of three times a week, thus the initial impact from blasting is relatively high with the annual concentration being a minimum.

Measures should be taken into consideration to limit the dust impact during periods of blasting.

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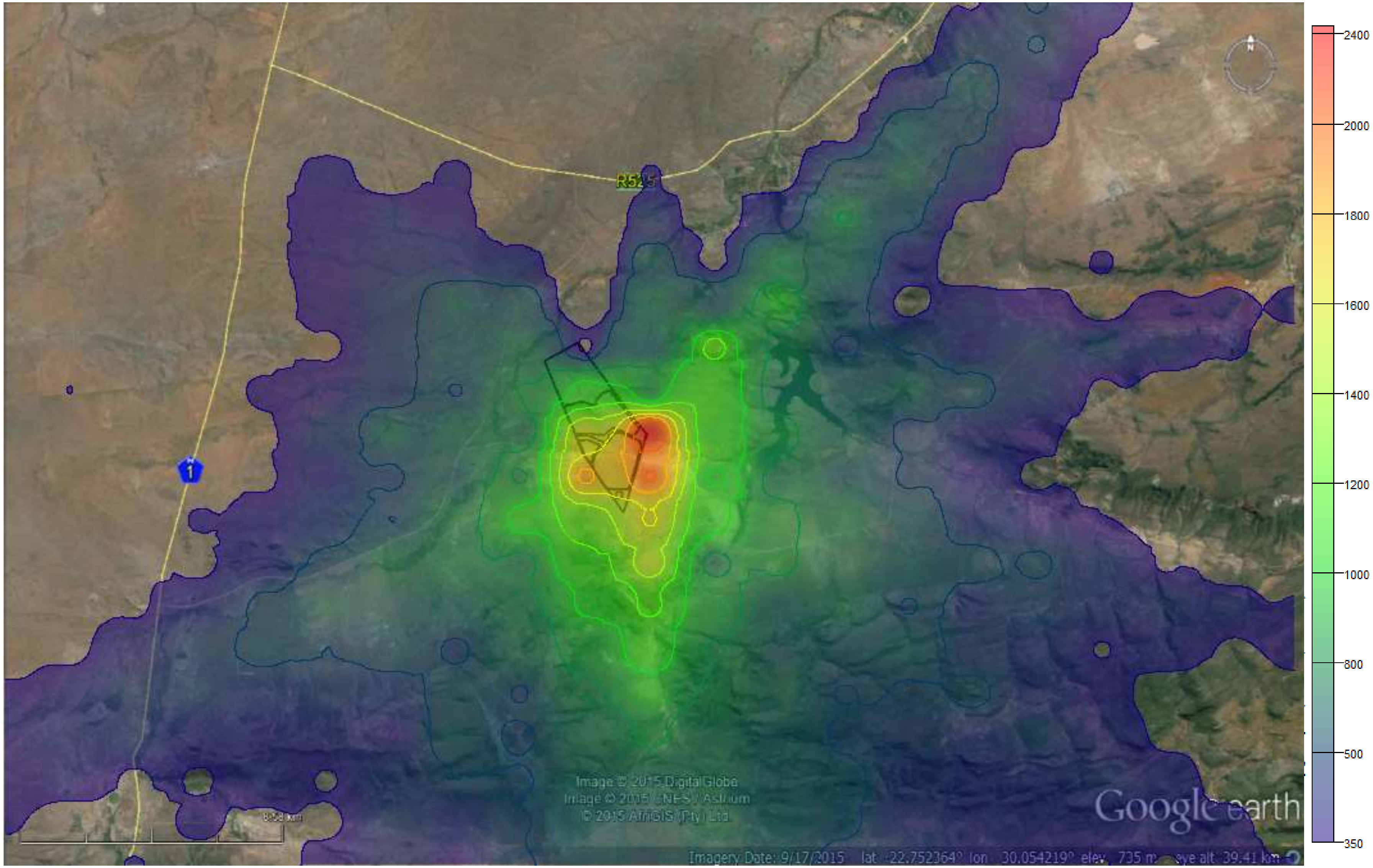

Figure 4-5: Maximum predicted hourly ground level concentration (µg/m^3) of Particulate Matter during blasting of The Duel Coal Project.

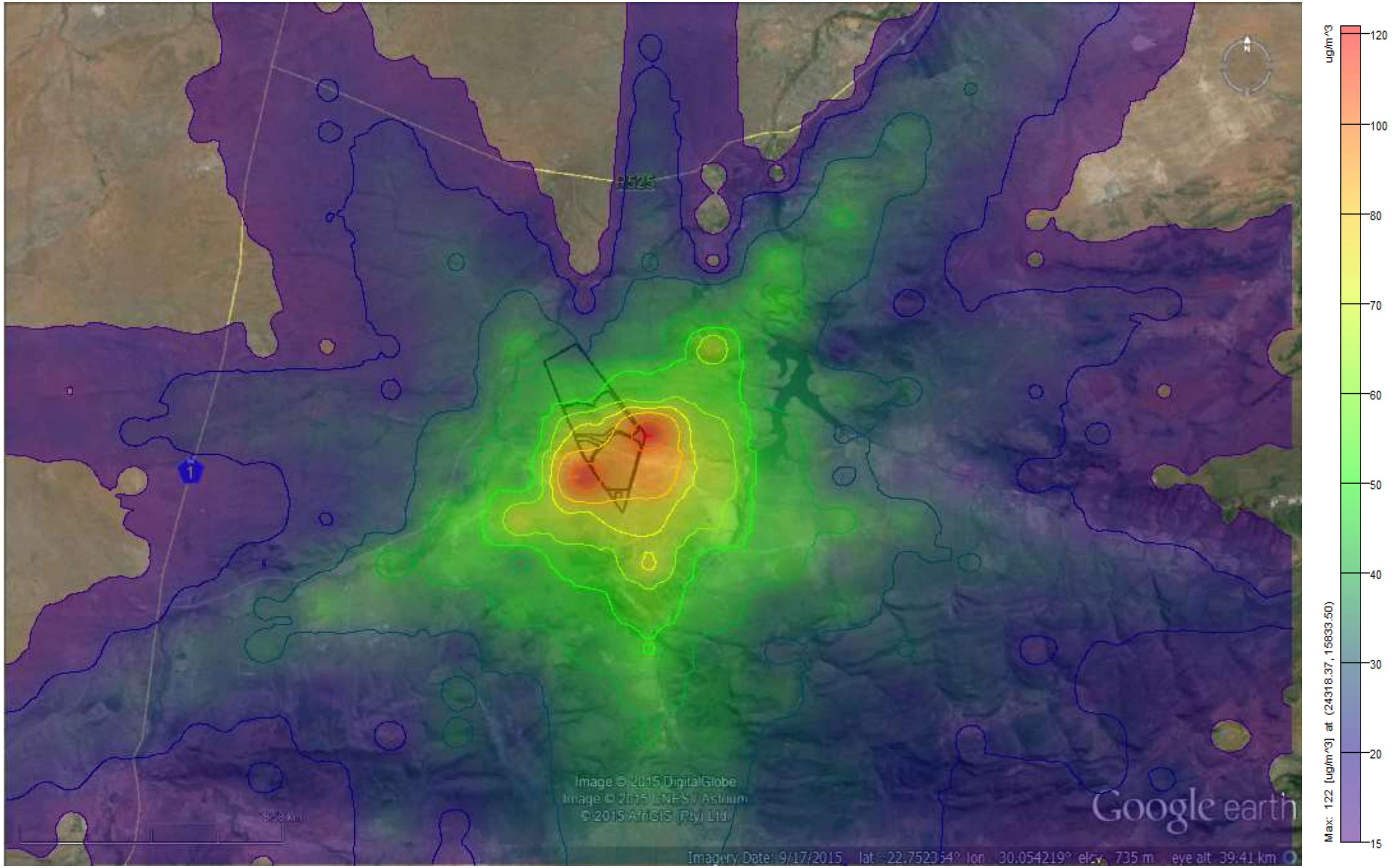

Figure 4-6: Maximum predicted daily ground level concentration (µg/m^3) of Particulate Matter during blasting of The Duel Coal Project.

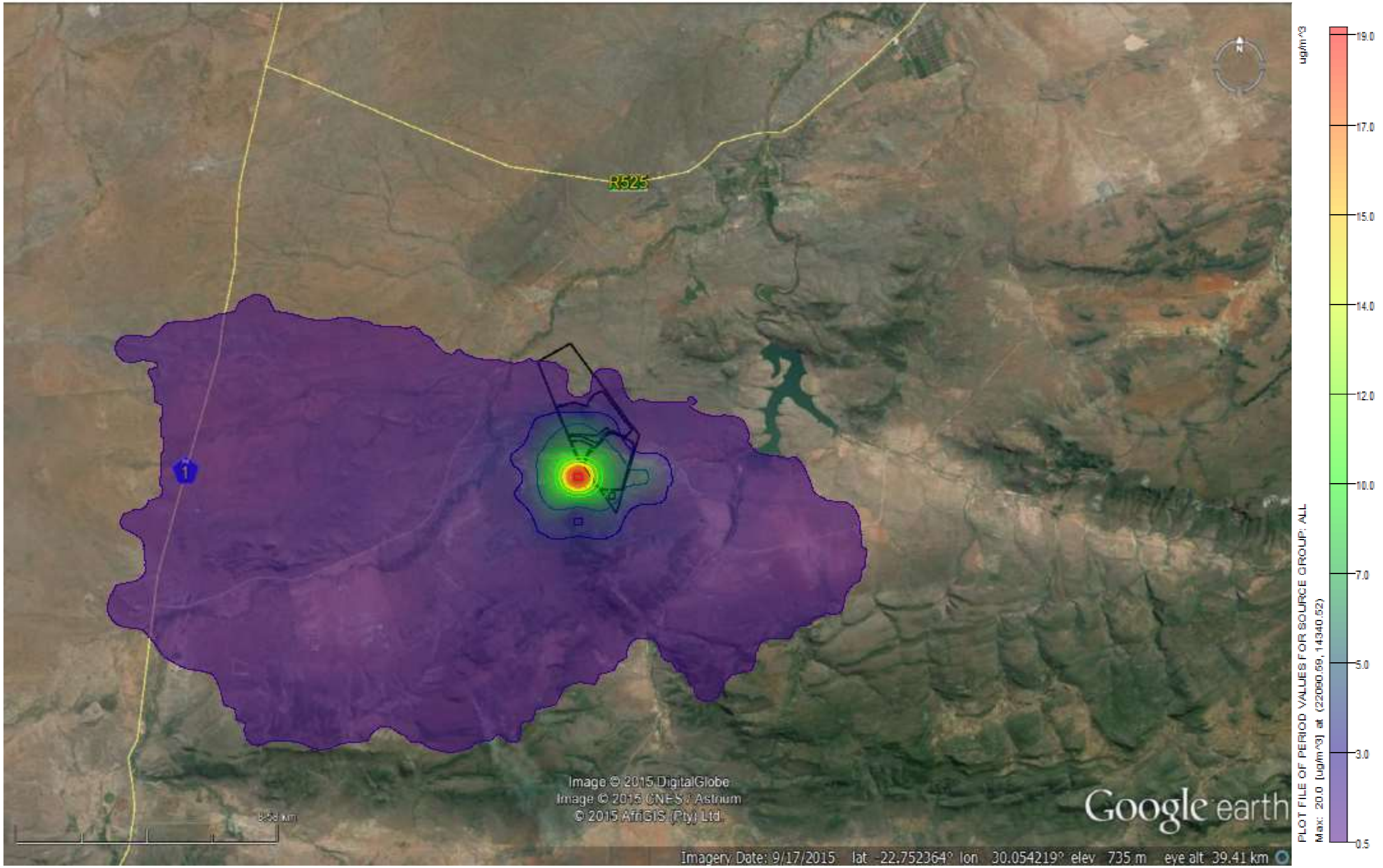

Figure 4-7: Maximum predicted annual ground level concentration (µg/m^3) of Particulate Matter during blasting of The Duel Coal Project.

4.5 Decommissioning impacts

The decommissioning phase is associated with activities related to the demolition of infrastructure and the rehabilitation of disturbed areas. The total rehabilitation will ensure that the total area will be a free draining covered with topsoil and grassed. The following activities are associated with the decommissioning phase (US-EPA, 1996):

- Existing buildings and structures demolished, rubble removed and the area levelled;
- Remaining exposed excavated areas filled and levelled using overburden recovered from stockpiles;
- Topsoil replaced using topsoil recovered from stockpiles; and
- Land and permanent waste piles prepared for re-vegetation.

Possible sources of fugitive dust emission during the closure and post-closure phase include:

- Smoothing of stockpiles by bulldozer;
- Grading of sites;
- Transport and dumping of overburden for filling;
- Infrastructure demolition;
- Infrastructure rubble piles;
- Transport and dumping of building rubble;
- Transport and dumping of topsoil; and
- Preparation of soil for re-vegetation – ploughing and addition of fertiliser, compost etc.

Exposed soil is often prone to erosion by water. The erodability of soil depends on the amount of rainfall and its intensity, soil type and structure, slope of the terrain and the amount of vegetation cover (Brady, 1974). Re-vegetation of exposed areas for long-term dust and water erosion control is commonly used and is the most cost-effective option. Plant roots bind the soil, and vegetation cover breaks the impact of falling raindrops, thus preventing wind and water erosion. Plants used for revegetation should be indigenous to the area, hardy, fast-growing, nitrogen-fixing, provide high plant cover, be adapted to growing on exposed and disturbed soil (pioneer plants) and should easily be propagated by seed or cuttings.

4.6 Assumptions and limitations

The following assumptions were made as part of this assessment:

- The moisture content for the different type of materials was not available therefore use was made of the moisture content values given in the USEPA for quarrying and processing.

- Use was made of the US-EPA AP42 for all calculations as no detailed source specific information is available at the commencement of this project.

- No vent source characteristics for underground mining were provided during the impact assessment and thus was not included in this assessment.

4.7 Proposed Mitigation

4.7.1 Construction impacts

Due to the relatively short nature of construction activities, some control measures are more effective than others. Wet suppression and wind speed reduction are two common methods used to control open dust sources at construction sites. Table 4-12 below shows the different type of mitigation measures used for dust control and particulate matter emissions.

Table 4-12: Recommended mitigation measures during construction activities (US EPA, 1996)

Emission source	Recommended control method
Debris handling	Wind speed reduction
	Wet suppression
Truck Transport [2]	Wet suppression
	Paving
	Chemical stabilization [1]
Bulldozing	Wet suppression [2]
Material handling	Wind speed reduction
	Wet suppression
General construction	Wet suppression
	Wind speed reduction
	Early paving of permanent roads

1- Chemical stabilization usually cost effective for relatively long term or semi-permanent unpaved roads.

2- Excavated material may already be moist and not require additional wetting.

Water may be combined with a surfactant as a wetting agent. Surfactants increase the surface tension of water, reducing the quantity of water required. Chemical stabilisation is of longer duration but is not cost effective for small-scale operations. Dust-A-Side (DAS) represents an example of a chemical product, which is commercially available and widely used by mines and quarries. The DAS product binds with the aggregate used to build on-site roads. It should be noted however, that the treatment with chemical stabilisers can have adverse effects on plant and animal life and can contaminate the treated material (USEPA, 1996). Environmentally friendly chemical stabilisers such as Dust- A-Side are available on the market and should be utilised to prevent an impact on the biodiversity of the area.

Revegetation of disturbed areas must be carried out as soon as possible after disturbance. This should include interim re-vegetation along road beds once heavy construction is completed and heavy mining equipment has been moved in. In open areas that are severely exposed to winds, screens may be used to reduce wind speed and dispersion of dust from site.

Dust and mud should be controlled at vehicle exit and entry points to prevent the dispersion of dust and mud beyond the site boundary. Facilities for the washing of vehicles could be provided at the entry and exit points. A speed limit of 40 km/hr should be set for all vehicles travelling over exposed areas or near stockpiles. Traffic over exposed areas should be kept to a minimum (USEPA, 1996). Additional preventative techniques include the reduction of the dust source extent and adjusting work processes to reduce the amount of dust generation (USEPA, 1996).

4.7.2 Operational impacts

Based on studies undertaken by C.B. Arpacioglu and C.Er, they indicate that most of the dust impacts associated with mining will occur within the mine site area, and will not be very significant and unlikely to exceed World Bank ambient air quality standards.

Table 4-13: Recommended Mitigation measures during operational phase

Emission source	Recommended control method
Materials handling	Wet suppression [1]
Truck transport[2]	Wet suppression
	Chemical stabilisation[3]
	Paving
Blasting	Wet suppression [4]
Bulldozers	Wet suppression

1- Dust control plans should contain precautions against watering programs that cofound track out problems.

2- Loads should be covered to avoid loss of material in transport, especially if material is transported offsite.

3- Chemical stabilization usually cost effective for relatively long term or semi-permanent unpaved roads.

4- Watering the blast area, following the charging of blast holes with explosives. Blasting should be delayed in unfavourable wind and atmospheric conditions.

Watering and the use of chemical wetting agents are the principle means for control of aggregate and storage pile emissions. The covering and enclosure of inactive piles can reduce wind blown emissions. The use of water is particularly useful in the reduction of emissions due to vehicle traffic in and around storage pile areas. Watering storage piles has a very temporary effect on total emission. A much more effective technique is the use of chemical agents such as a surfactant that permits extensive wetting. The continuous chemical treating of material loaded onto piles, couples with watering or treatment of roadways can reduce total particulate emissions from aggregate storage operations by up to 90% (US EPA, 1996).

The watering of unpaved surfaces by use of wet suppression prevents fine particulates from leaving the surface and becoming airborne through the action of mechanical turbulence and wind. Water binds smaller particles to larger ones thus reducing the emission potential.

Re-vegetate disturbed areas as soon as possible to prevent further dispersion of wind blown dust emissions. The drop heights when loaders dump soil and coal should be kept at a minimum. A speed limit should be enforced on site to reduce airborne vehicular fugitive emissions.

4.7.3 Decommissioning impacts

Revegetation of exposed areas for long-term dust and water erosion control is commonly used and is the most cost-effective option. The area should be re-vegetated as soon as the mining within the open pit stops. Plant roots bind the soil, and vegetation cover breaks the impact of falling raindrops, thus preventing wind and water erosion. Plants used for re-vegetation should be indigenous to the area, hardy, fast-growing, nitrogen-fixing, provide high plant cover, be adapted to growing on exposed and disturbed soil (pioneer plants) and should easily be propagated by seed or cuttings.

4.8 Conclusion

The air quality impact assessment undertaken for The Duel Coal Project includes a meteorological overview of the area. MM5 meteorological data was obtained from the South African weather services for The Duel Coal Project. An emissions inventory was undertaken with the aim of quantifying emissions associated with the activities involved in the mining and processing of coal. The emissions for specific activities such as bulldozing, blasting, tipping, wind erosion and materials handling activities were calculated and the cumulative impacts were compared to the relevant ambient air quality standards to determine legal compliance.

The construction and operational phases were assessed as separate scenarios. Based on the dispersion modelling simulations, the following conclusions can be summarised as follows:

- Construction impacts

The maximum predicted annual ground level concentration of PM_{10} from all construction related activities complied with both the annual and daily South African Standards for Particulate matter.

- Operational Impacts

The maximum predicted annual ground level concentration PM_{10} for all activities taking place during the Life of Mine at The Duel Coal Project was estimated at 7.40 µg/m^3. This falls below the annual standard of **40 µg/m^3**. The maximum predicted daily concentration of PM10 was estimated at 46.65 µg/m^3, this also falls below the daily South African standard of **75 µg/m^3**. The highest contributors to the particulate matter emissions were activities taking place within the mining pit such as bulldozing, tipping and materials handling as well those mineral processing activities at the plant area. The annual blasting emissions were below the annual South African Standard, however the daily average was exceeded with 120 µg/m^3.

The impacts from dust fallout and Particulate matter can be reduced by implementing dust control measures. The highest intensity of the construction work should be carried out during the summer months and not over the harsh winter months as this can result in increased dispersion of fugitive dust. The Duel project should ensure that unpaved roads are continuously watered and treated with chemical stabilisers to reduce the volume of fugitive dust emitted from unpaved roads. The use of wind screens on open ground surfaces during periods of extreme windy conditions.

Overall the impacts arising from the mining activities on the surrounding environment are within the ambient air quality standards.

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External Specialist Declaration of Independence

I, Nicole Singh, declare that I –

- Act as a specialist consultant in the field of Air Quality assessment
- 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, 2010;
- Have and will not have any vested interest in the proposed activity proceeding;
- Have no, and will not engage in, conflicting interests in the undertaking of the activity;
- Undertake to disclose, to the competent authority, any material 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, 2010;
- Will provide the competent authority with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not;
- Declare that I have reviewed the attached report, of which the final version is herewith provided, and confirm that any requested changes have been affected;
- Hereby endorse the Air Quality Assessment attached

Nicole Singh
Air Quality Specialist

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