Margot Saner & Associates

a Department of Labour Approved Inspection Authority (Cert no. C I036 OH)

REPORT

Air Quality Impact Assessment

Proposed Kangala Coal Mine

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DECLARATION OF INDEPENDENCE

Margot Saner & Associates (Pty) Ltd submits that it has:

- *The necessary expertise to conduct air quality impact assessments, including the required knowledge and understanding of any guidelines or policies that are relevant to the proposed activity;*
- *Undertaken all the work and associated studies in an objective manner, even if the findings of these studies are not favourable to the project proponent;*
- *No vested financial interest in the proposed project or the outcome thereof, apart from remuneration for the work undertaken under the auspices of the above-mentioned regulations;*
- *No vested interest, including any conflicts of interest, in either the proposed project or the studies conducted in respect of the proposed project, other than complying with the required regulations.*

DOCUMENT CONTROL SHEET

DOCUMENT: **Margot Saner & Associates (Pty) Ltd Project No MS&A01844: Air Quality Impact Assessment – Proposed Kangala Coal Mine**

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EXECUTIVE SUMMARY

Margot Saner and Associates (MS&A) were commissioned by Digby Wells & Associates to conduct an Air Quality Impact Assessment for the proposed Kangala Coal Mine near Delmas, Mpumalanga. The purpose of this study was to assess the potential impacts on local air quality associated with the proposed coal mining activities. In order to assess these potential impacts, computational air dispersion modelling was performed, with the outcome being used to inform the Environmental Impact Assessment (EIA) for the project.

The development property is known as Portion 1 and the remaining extent of Portion 2 of the farm Wolvenfontein 244. The proposed mine is located between the N17 and N12 highways just west of the R42 road, 65km east of Johannesburg, in the Delmas District in the Mpumalanga province. The nearest town is Delmas.

The proposed site falls within the Highveld Priority Area as declared by the Minister of Environmental Affairs and Tourism in terms of section 18(1) of the National Environment Management: Air Quality Act, 2004 (Act No.39 of 2004).

For the purposes of this assessment reference was made to the following ambient air standards and/or ambient air guidelines for the priority pollutants, ambient particulates < 10 µm (PM10) and fallout dust.

- National Environment Management, Air Quality Act (Act 39 of 2004)
- South African National Standard – Ambient Air Quality SANS 1929:2005

To account for current baseline (existing) conditions relating to dust fallout, reference was made to a dust deposition study performed by Digby Wells and Associates in October 2009, reference no. DIG/299-307/I/10/09. The study revealed that the area is currently characterised by fallout dust in the MODERATE to HEAVY range. Similarly, the averaged results of the study fall into Band 2 of the SANS 1929:2005 Four-Band Scale Evaluation Criteria for Dust Deposition (Table 5) and are therefore considered '*Permissible for Industrial* land use. None of the off-site results obtained during the dust fall-out study exceeded the Industrial Action level of 1200 mg/m^2/day as per SANS 1929:2005 Target, Action and Alert Thresholds for Dust Deposition.

For the purposes of this assessment, the process contribution of the proposed mine (as predicted by the atmospheric dispersion model) was added to the results obtained by the baseline study. This permitted the assessment of the combined or cumulative impacts associated with the proposed mining activities.

The following deductions/interpretations were made based on the predicted *cumulative* impacts:

- The cumulative dust deposition impacts (unmitigated) at UN 9 (centre of the proposed mine site) will increase from a baseline averaged value of 470 $mg/m^2/day$ to 2362 $mg/m^2/day$ – i.e. in excess of the Industrial action level of 1200 $mg/m^2/day$ as per SANS 1929:2005. Cumulative dust deposition impacts (unmitigated) will not however exceed the Industrial action level at any of the off-site receptors.

- If dust mitigation efficiencies of 50% and 90% are considered, the nett cumulative dust deposition impacts at UN 9 (centre of the proposed mine site) are predicted to be 1867 $mg/m^2/day$ and 1472 $mg/m^2/day$ respectively – i.e. both above the Industrial action level of 1200 $mg/m^2/day$. It is noted however that, irrespective of whether 0%, 50% or 90% dust mitigation efficiencies are implemented, cumulative dust deposition impacts *will not exceed the Industrial action level at any of the off-site receptor locations*.

- The majority of the off-site receptor locations are predicted to experience cumulative dust deposition impacts in the HEAVY range of 600 to 1200 $mg/m^2/day$ (as per SABS 1929:2005) irrespective of whether dust emissions are unmitigated (0%) or subject to 50% and 90% mitigation efficiences.

- Predicted short term PM_{10} impacts do not exceed the SANS standards of 50 $\mu g/m^3$ (target) and 75 $\mu g/m^3$ (limit) or the DWEA standard of 180 $\mu g/m^3$ beyond the site boundaries, for unmitigated (0%), 50% and 90% dust mitigation efficiences.

- Similarly, predicted long term PM_{10} impacts do not exceed the SANS standards of 30 $\mu g/m^3$ (target) and 40 $\mu g/m^3$ (limit) or the DWEA standard of 60 $\mu g/m^3$ beyond the site boundaries, for unmitigated (0%), 50% and 90% dust mitigation efficiences

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GLOSSARY

Airborne contaminant:	An airborne contaminant is a potentially harmful substance that is either naturally absent from air or is present in an unnaturally high concentration, and to which workers may be exposed in their working environment.
Emission:	The direct or indirect release of substances, vibrations, heat or noise from individual or diffuse sources in an installation into the air, water or land.
Environmental benchmark:	A standard or criterion against which the level of an emitted substance can be compared to. For a quantified risk assessment the potential impact of an emission is evaluated through comparison against these appropriate standards in order to assess the significance of the impact and allow a decision to be made on whether the impact of the site on air or water quality may be acceptable.
Hazard:	A property of a substance or a situation in which particular circumstances could lead to harm.
PM10 dust:	Particulates (dust) with an aerodynamic diameter of 10 µm or less.
Pathways:	The mechanism by which the receptor and source can come into contact (e.g. by a hazardous event or action on site giving rise to a release of the hazardous substance or material to atmosphere or to ground).
Receptors:	The entity (e.g. human, water body, ecosystem, building, etc.) that is sensitive or vulnerable to the adverse effects of the hazardous substance or material.
Risk:	A combination of the probability, or frequency, of occurrence of a defined hazard and the magnitude of the consequences of the occurrence.
Risk assessment:	The qualitative/quantitative estimation and characterisation of risks.
Risk management:	The process of making and implementing decisions about accepting or altering risks.
Source:	The hazardous substance or material.

ABBREVIATIONS / ACRONYMS

µg/m^3:	Micrograms of gaseous substance in one cubic metre of total gas
AQMP:	Air Quality Management Plan
BAT	Best Available Techniques
CNS:	Central Nervous System
CVS:	Cardiovascular System
DWEA:	Department of Water and Environmental Affairs
DEM:	Digital Elevation Model
EIA:	Environmental Impact Assessment
EPA:	Environmental Protection Agency
HI:	Hazard Index
IPPC:	Integrated Pollution Prevention and Control
Ml:	Megalitres
MS&A:	Margot Saner and Associates
NEMAQA:	National Environment Management Air Quality Act
NERDDC:	National Energy Research, Development and Demonstration Council
NOEL:	No-Observed-Effect-Level
$PC_{air:}$	Process Contribution
$PEC_{air:}$	Predicted Environmental Concentration
PPM:	Parts per Million
RBDM:	Risk-Based Decision Making
TPA:	Tonnes per annum
TSP:	Total Suspended Particulates
WHO:	World Health Organization

1. INTRODUCTION, PURPOSE AND SCOPE

Digby Wells & Associates, commissioned Margot Saner and Associates (MS&A) to conduct an Air Quality Impact Assessment for the proposed Kangala Coal Mine near Delmas, Mpumalanga. The purpose of this study was to assess the potential impacts on local air quality associated with the proposed coal mining activities. In order to assess these potential impacts, computational air dispersion modelling was performed, with the outcome being used to inform the Environmental Impact Assessment (EIA) for the project.

The proposed Kangala Coal Mine project is to be an opencast mining operation of the No. 2 and No. 4 Coal Seams of the Witbank Coal field. The seam thickness is 19 metres (Seam No. 2) and 2.2 metres (Seam No.4). The opencast mine will produce 1.5 Mtpa ROM using the truck and shovel method at a strip ratio of 2:1.The mine will have a life expectancy of approximately 10 years. Two coal products will be produced namely, B grade coal for export, and coal suitable for sale to ESKOM for power generation.

1.1 Site Location

The development property is known as Portion 1 and the remaining extent of Portion 2 of the farm Wolvenfontein 244. The proposed mine is located between the N17 and N12 highways just West of the R42, approximately 65km East of Johannesburg, in the Delmas District of the Mpumalanga province. The nearest town is Delmas.

The proposed site falls within the *Highveld Priority Area* as declared by the Minister of Environmental Affairs and Tourism in terms of section 18(1) of the National Environment Management: Air Quality Act, 2004 (Act No.39 of 2004).

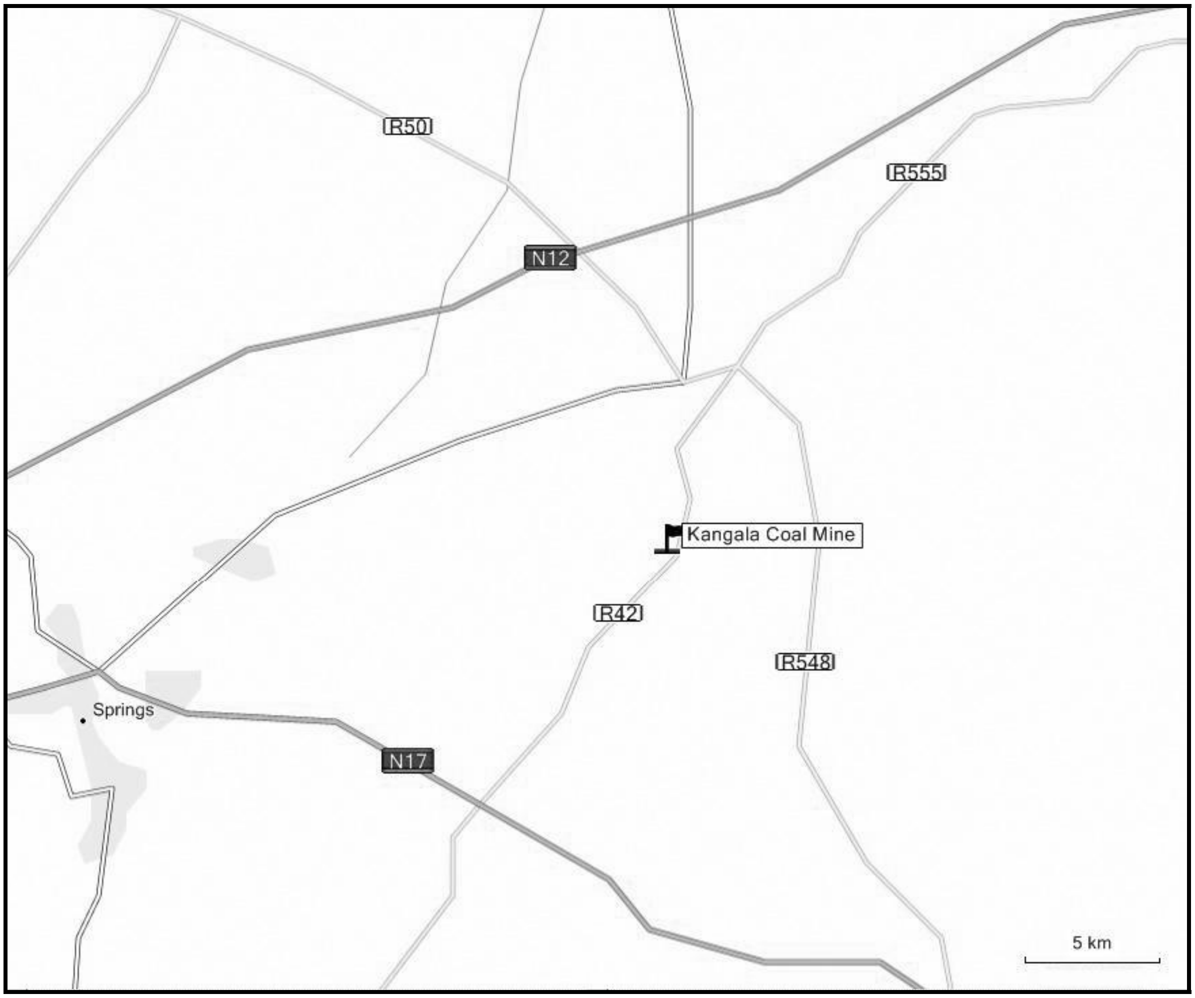


Figure 1: Location of the proposed Kangala Coal Mine

The Highveld Priority Area includes the following districts: (i) the Ekurhuleni Metropolitan Municipality in Gauteng Province; (ii) Lesedi Local Municipality (Sedibeng) in Gauteng Province; (iii) Govan Mbeki Local Municipality (Gert Sibande) in Mpumalanga Province; (iv) Dipaleseng Local Municipality (Gert Sibande) in Mpumalanga Province; (v) Lekwa Local Municipality (Gert Sibande) in Mpumalanga Province; (vi) Msukaligwa Local Municipality (Gert Sibande) in Mpumalanga Province; (vii) Pixley ka Seme Local Municipality (Gert Sibande) in Mpumalanga Province; (viii) Delmas Local Municipality (Nkangala) in Mpumalanga Province; (ix) Emalahleni Local Municipality (Nkangala) in Mpumalanga Province; and (x) Steve Tshwete Local Municipality (Nkangala) in the Mpumalanga Province.

Based on the above, the proposed Kangala Coal Mine near Delmas falls within the Highveld Priority Area.

1.2 Objective of Study

The goals of this Air Quality Impact Assessment are to:

- Determine the baseline conditions at the proposed site in order to develop an understanding of the existing site in its environmental setting, including the identification of possible sources of emission, emission pathways and potential receptors.
- Select the appropriate environmental benchmarks. These include:
    - Department of Water and Environmental Affairs Ambient Air Quality Guidelines
    - South African National Standard – Ambient Air Quality SANS 1929:2005
- Consider receptor sensitivity, and potential impact at each receptor

1.3 Scope of Work

The following scope of work was used for the purposes of this investigation:

- Illustration of the baseline conditions of the site with particular reference to particulate matter and gaseous pollutants;
- Determination of on-site source emissions;
- Calculation of off-site impacts / consequences on air quality by using mathematical atmospheric dispersion modeling;
- Description of the environmental setting in which the site is located;
- Description of environmental benchmarks initially selected for the site with particular reference to air quality;
- Assessment of impacts on ambient air quality which may occur as a result of the proposed activity.

2. METHODOLOGY

2.1 Risk-Based Decision Making

A risk-based approach is adopted in this study. Risk based decision making (RBDM) is a process that organizes information about the possibility for one or more unwanted outcomes to occur into a broad, orderly structure that helps decision makers make more informed management choices. More simply stated, RBDM asks the following questions and uses the answers in the decision-making process:

- What can go wrong?
- How likely are the potential problems to occur?
- How severe might the potential problems be?
- Is the risk of potential problems tolerable?
- What can/should be done to lessen the risk?

A tiered approach is used in this strategy, where the level of detail in the risk assessment will be proportionate to the nature and complexity of the risk to be addressed.

The three tiers are:

- Risk Screening;
- Simple Risk Assessment;
- Complex Risk Assessment.

The level of detail required increases at each tier with the risk assessment focusing more closely on high priority risks identified in the previous stage. Therefore the high priority risks would require further attention.

The ‘Source-Pathway-Receptor’ concept is the basis of this Risk Assessment. The Source-Pathway-Receptor approach is fundamental to the good practice framework for risk assessment.

For a risk to exist there must be an identified or plausible relationship between the three individual components of:

- **Source** – i.e. the hazardous substance or material;
- **Pathway** – i.e. the mechanism by which the receptor and source can come into contact;
- **Receptor** – i.e. the entity (e.g. human, water body, ecosystem, building, etc. that is vulnerable to the adverse effects of the hazardous substance or material.

The **'Source'** in this case is the dust / particulate matter generated by the mining activities as well as smelting operations.

'Pathways' are the means by which the identified pollutants are transferred from the source into the environment and from there to any defined 'receptors'. Humans (or animals) may be exposed to pollutant emissions by inhalation.

'Receptors' are those entities that are liable to be adversely affected by the identified hazards. These include, but are not necessarily restricted to:

- People working on the site;
- People outside the site boundary;
- Properties outside the site boundary.

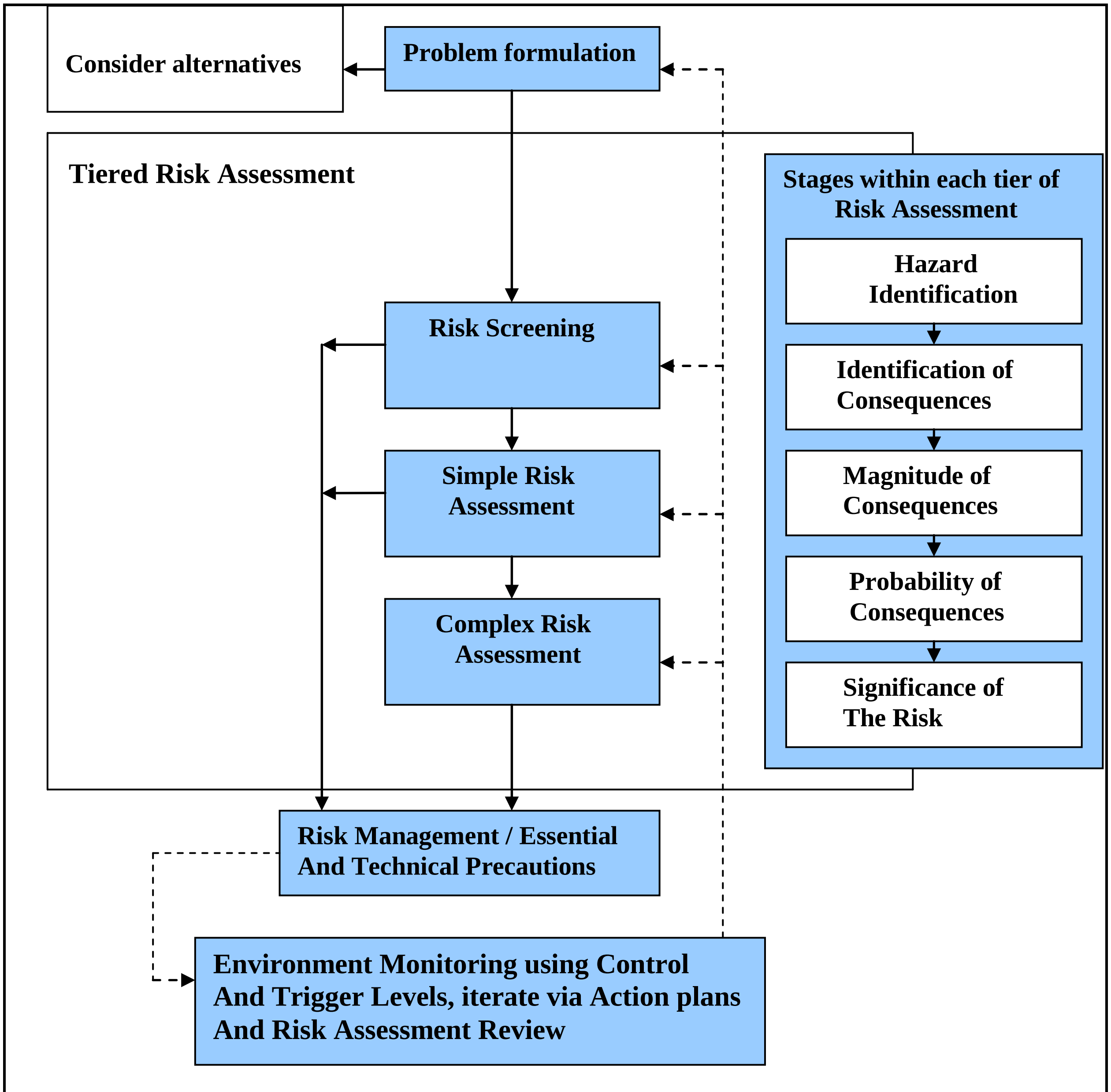


Figure 2: Conceptual approach-risk screening (DETR *et al., 2000)*

2. METHODOLOGY

2.2 Meteorology

Meteorological data for the region was obtained from the South African Weather Service station located in Springs. Data was obtained for the entire calendar year of 2008. No meteorological anomalies have occurred in this region in the recent past, therefore a single year's meteorological data is deemed sufficient for the purposes of this assessment – i.e. data covers four full seasons, i.e. Summer, Autumn, Winter and Spring. The SAWS station in Springs is the closest automated weather station to the proposed site (~21 km away) and the supplied data was deemed suitably representative of meteorological conditions for the region.

The hourly meteorological values, once processed, allow for a comprehensive analysis of local meteorological conditions and the effect they would have on dispersion of airborne pollutants and dust particulates.

The collected meteorological data was imported into AerMet View (meteorological pre-processor software) in order to create a suitable MET file for use in the AERMOD Dispersion Model.

The area is characterised by predominantly North-westerly winds. Calms occur for approximately 35% of the time, with gentle winds (0.5 – 2.1 m/s, or 1 - 4 knots) being experienced for approximately 30% of the time. Stronger winds (2.1 – 3.5 m/s, or 4 - 7 knots) are experienced for approximately 26% of the time.

Seasonally the winds have less of an Easterly component in spring and winter, with North-westerly components being dominant. Easterly components are more evident in summer and autumn. The nett result, on yearly average is that North-easterly winds dominate.

A seasonal breakdown of meteorological trends is included on Pages 19-24:

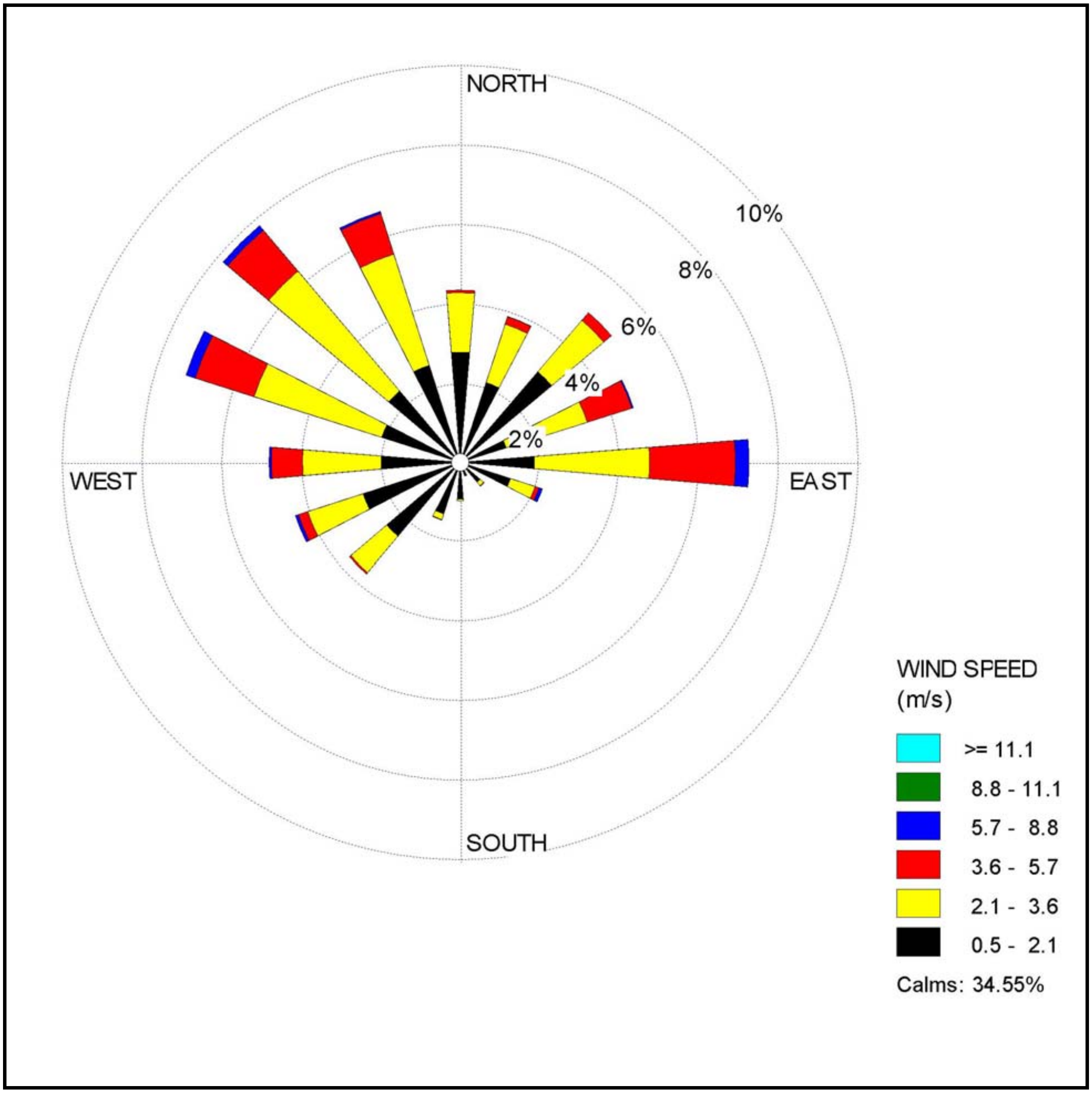


Figure 3: Wind Rose for Springs (2008)

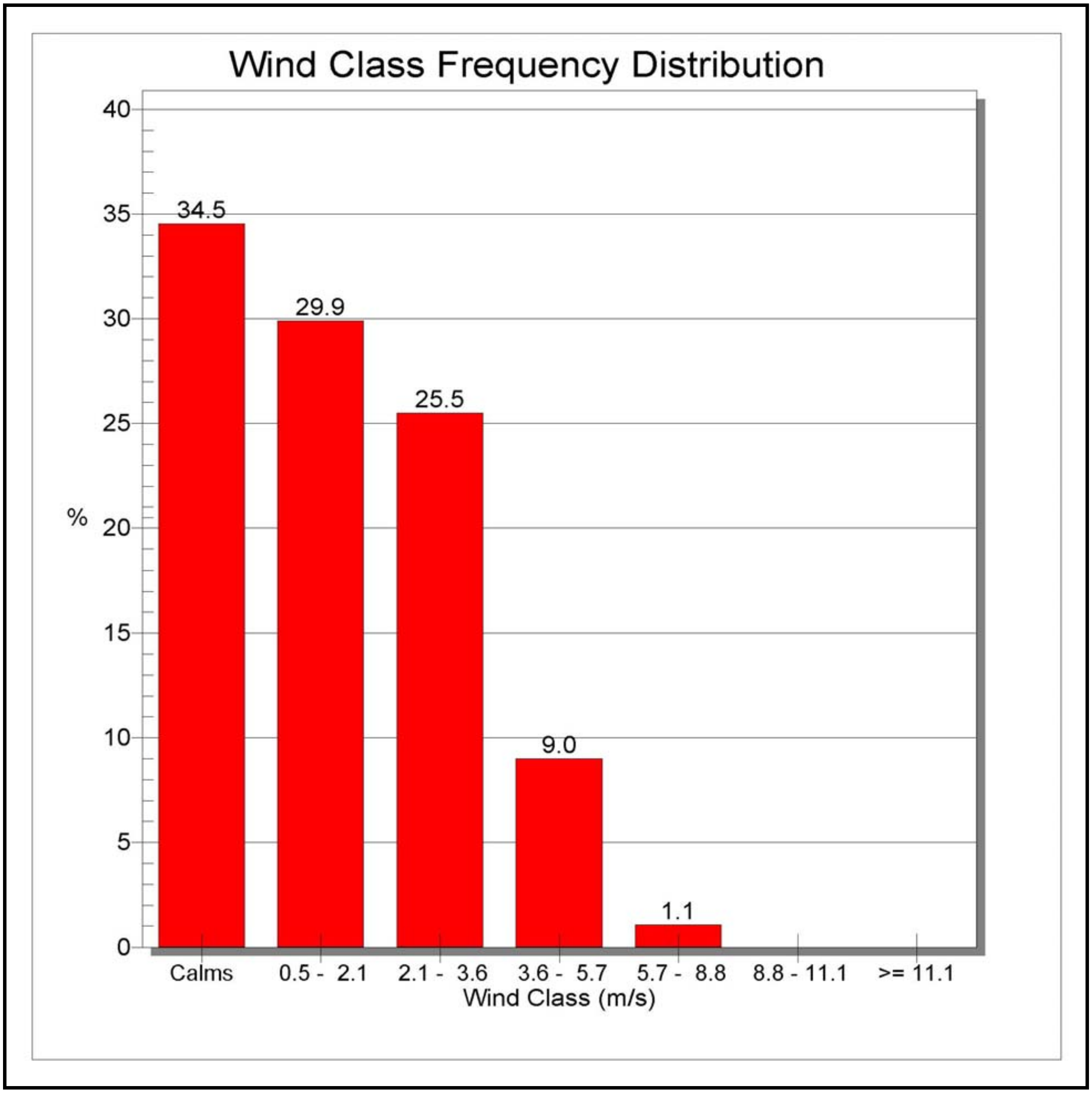


Figure 4: Wind Class Frequency Distribution for Springs (2008)

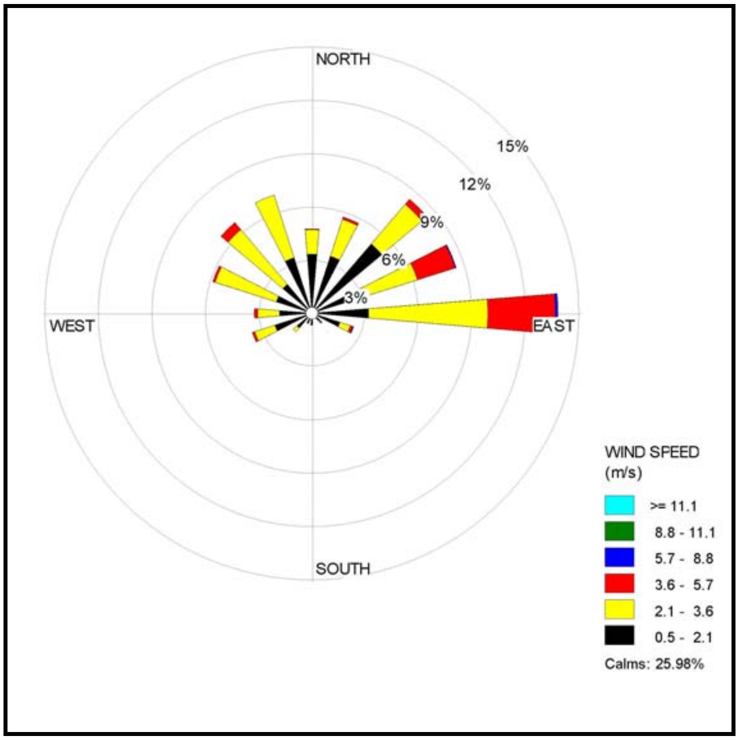


Figure 5: Wind Rose for Springs (Summer)

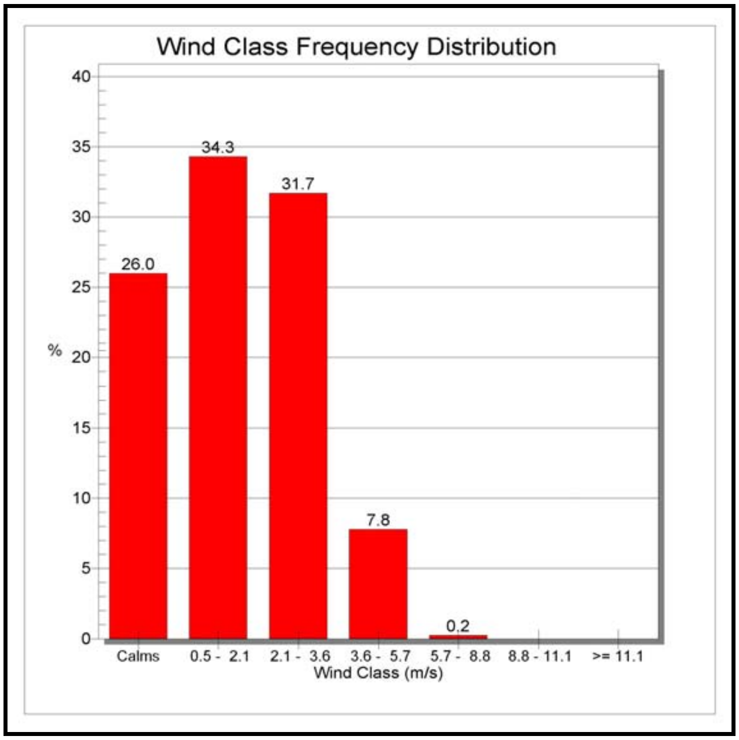


Figure 6: Wind Class Frequency Distribution for Springs (Summer)

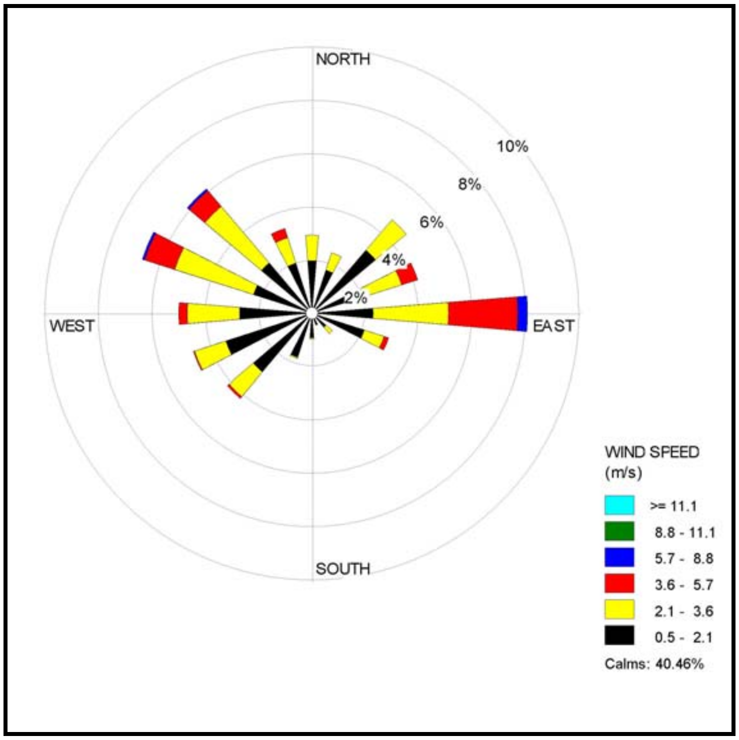


Figure 7: Wind Rose for Springs (Autumn)

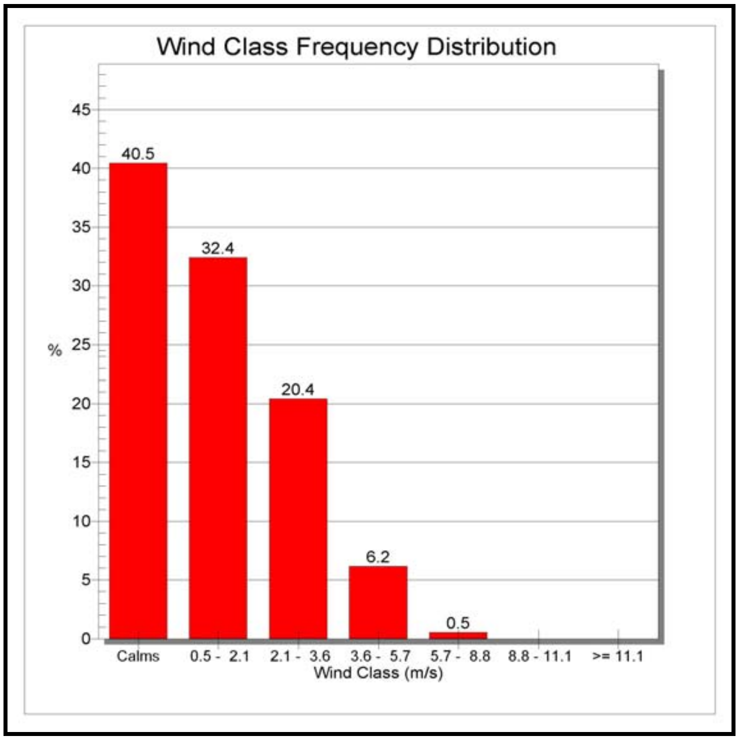


Figure 8: Wind Class Frequency Distribution for Springs (Autumn)

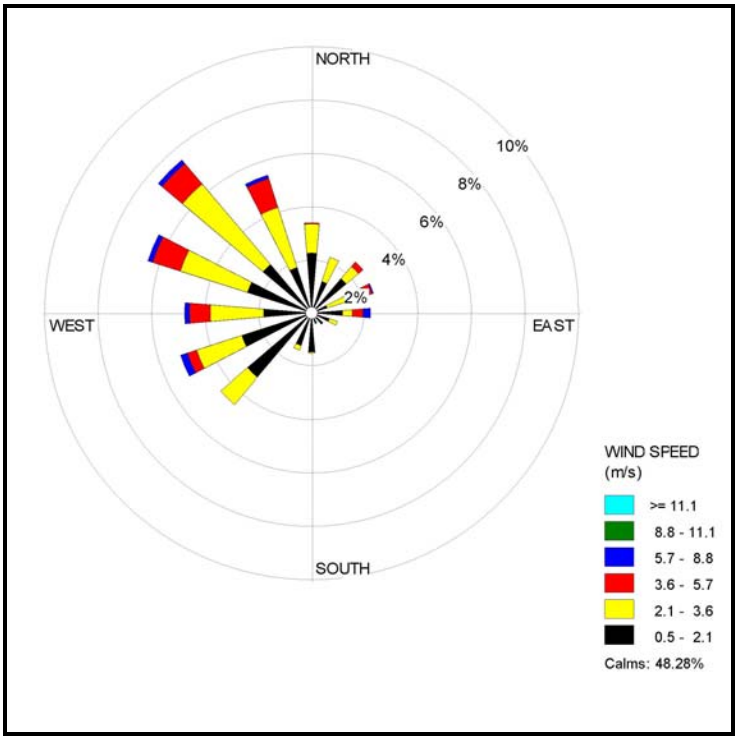


Figure 9: Wind Rose for Springs (Winter)

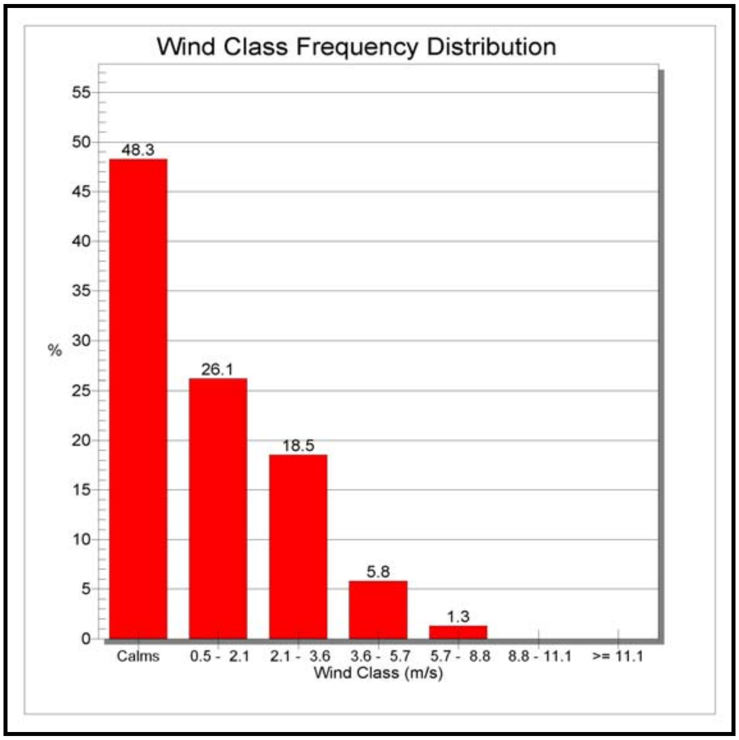


Figure 10: Wind Class Frequency Distribution for Springs (Winter)

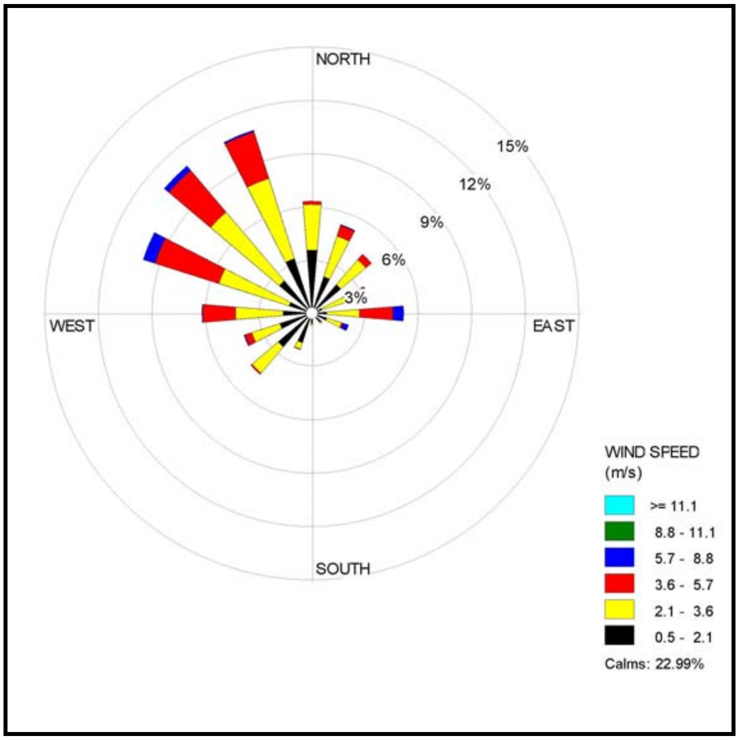


Figure 11: Wind Rose for Springs (Spring)

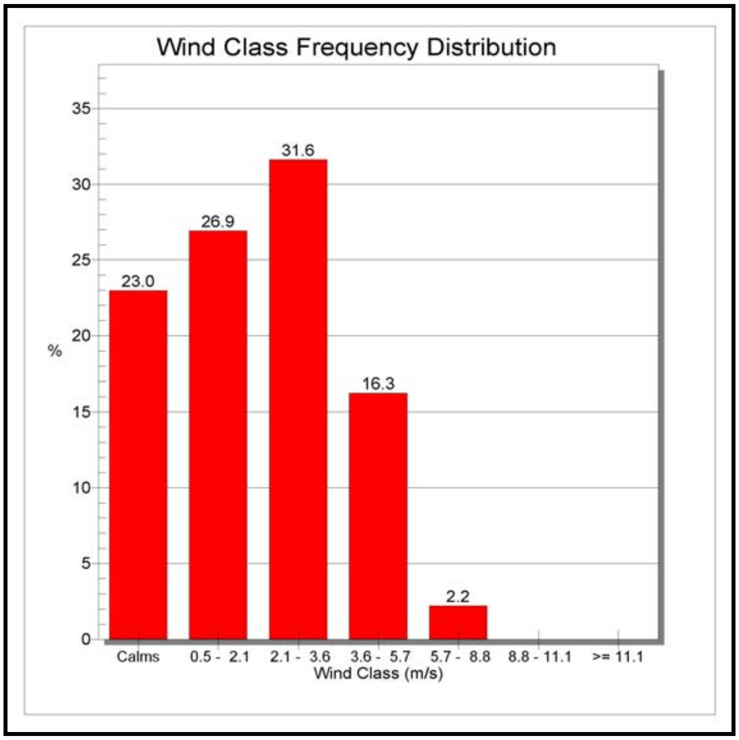


Figure 12: Wind Class Frequency Distribution for Springs (Spring)

2. METHODOLOGY

2.3 Topography

The atmospheric dispersion model (AERMOD) was simulated over a 10 km x 10 km area over DEM topography of the local terrain - as illustrated in Figure 13 below. The proposed mine is located in the centre of the modelling domain which stretches 10 000m horizontally and 10 000m vertically. These extents form the boundaries of the modelling domain into which all emission outputs will be stacked and plotted.

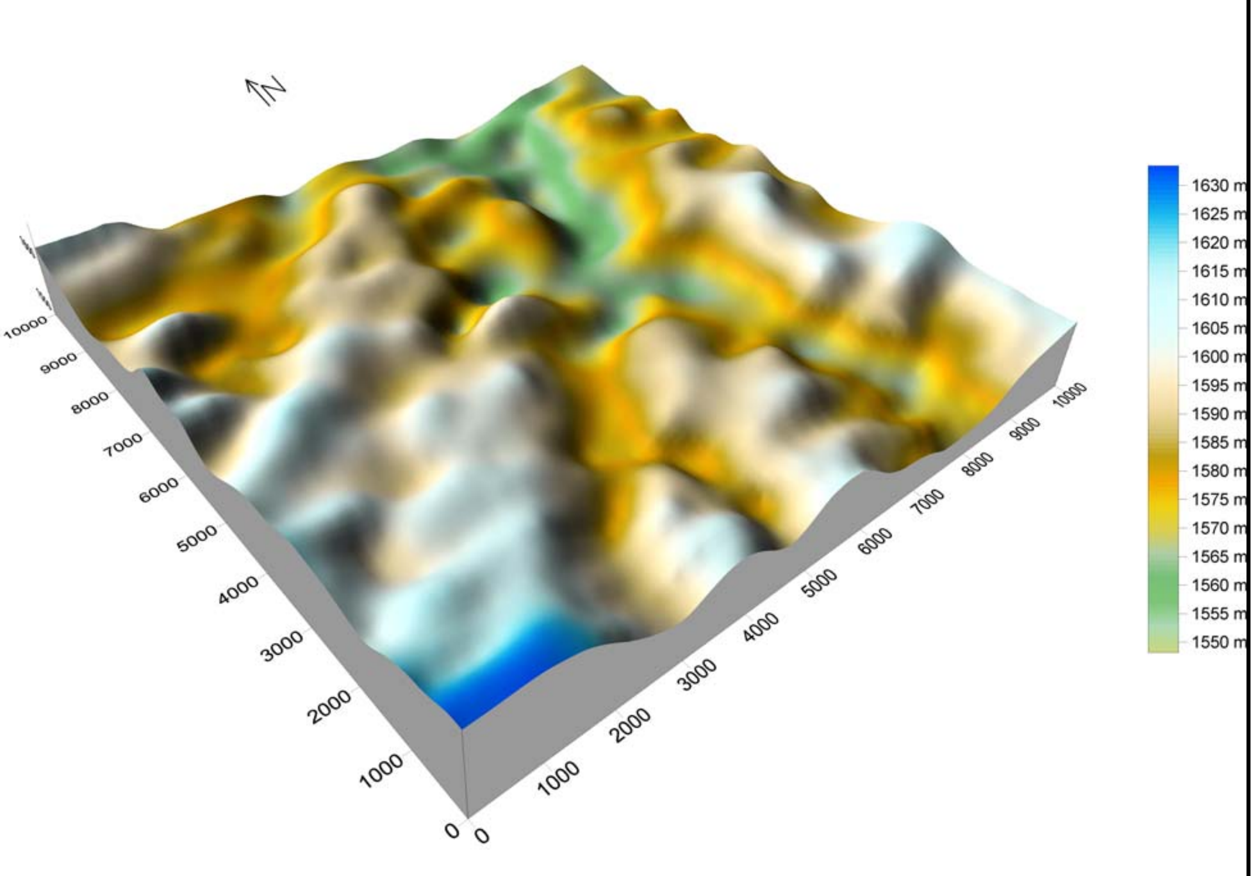


Figure 13: Topography of the proposed Kangala Coal Mine and surrounds

2. METHODOLOGY

2.4 Source Emission Quantification

In order to establish an emissions inventory for modeling of the expected process contribution to baseline conditions at the proposed site, fugitive sources of particulate emissions from the proposed Kangala Coal Mine were quantified. These are summarized in Table 1 and account for each of the individual mining operations. Emissions from the proposed Kangala Coal Mine were quantified using the National Pollution Inventory of Australia and the US-EPA emission factors as no such South African emission factor database currently exists.

The emission factor equations and emission factors discussed in this section relate specifically to coal mining activities.

Loading Truck with Overburden

The USEPA (USEPA, 1998: Section 13.2.4-3) provides an equation for batch loading. This equation (Equation A-3 below) seems to give estimates that are unrealistically low for Australian conditions. The USEPA (USEPA: 1988: Section 11.9-9, Table 11.9-4) provides a further emission factor for “Truck loading by power shovel (batch drop)”. The TSP factor is 0.018 kg/t. The note provided with this figure however, encourages the user to make use of the equation rather than the 0.018 kg/t factor. The equation is:

$$E = k \times 0.0016 \times (U / 2.2)^{1.3} / (M / 2)^{1.4} \text{ kg/t}$$

where ,
k = 0.74 for particules less than 30 micrometers aerodynamic diameter
k = 0.35 for particules less than 10 micrometers aerodynamic diameter
U = mean wind speed (m/s)
M = moisture content (%)

The NERDDC (NERDDC, 1988) work provides an estimate of TSP emissions from truck loading operations of 0.025 kg/t. If U is 3.6 m/s (fairly typical of the Hunter Valley and much of inland NSW) and M is taken to be 1%, the emission factor for TSP would be 0.0059 kg/t, using the equation above. If the moisture content is 2% then the emission factor is 0.0022 kg/t and if the moisture content is 0.5% the emission factor is 0.0156 kg/t. Thus, with a moisture content of 0.5%, the equation gives values for TSP emissions that approach the values measured in the NERDDC study. However, a moisture content of 0.5% is extremely low. Furthermore, the NERDDC emission factor for TSP is consistent with the USEPA’s emission factor for truck loading by power shovel (batch drop) quoted above. It is therefore recommended that the NERDDC (1988) TSP emission factor of 0.025 kg/t be used for coal mines until a better factor is developed.

SPCC (1986) measurements in the Hunter Valley indicate that approximately 47% of TSP particles will be in the PM10 range – i.e. dust with an aerodynamic diameter of 10 µm or less. The recommended PM10 emissions factor is therefore 0.025 x 0.47 = 0.012 kg/t.

Loading to Trucks by Shovel or FEL

As for overburden, the USEPA’s equation for batch loading seems to give estimates that are unrealistically low when applied to loading coal to trucks. The US EPA (1998) equation is:

$$E = k \times 0.0016 \times (U / 2.2)^{1.3} / (M / 2)^{1.4} \text{ kg/t}$$

where ,
k = 0.74 for particulates less than 30 micrometers aerodynamic diameter
k = 0.35 for particulates less than 10 micrometers aerodynamic diameter
U = mean wind speed (m/s)
M = moisture content (%)

If M is taken to be 8% (typical for ROM coal in the Hunter Valley) and U=3.6 m/s, the TSP emission factor is 0.00032 kg/t. The NERDDC (1988) Hunter Valley work provides an emission factor for TSP of 0.029 kg/t. Clearly, the US data provides a very different result to that quoted in the NERDDC study. Based on current information, it would seem better to use the default emission factor of 0.029 kg/t for TSP emissions from Australian mines. If this TSP emission factor is adjusted using the particle size measurements obtained in the SPCC (1986) study, then 48% of the TSP fraction (0 to 30 mm) can be taken to be PM10 particles. Thus, the default PM10 emission factor becomes 0.014 kg/t.

The USEPA provides an alternative equation specifically for the loading of coal (USEPA, 1998: Table 11.9-1):

$$E = k \times 0.0596/(M)^{0.9} \text{ kg/t}$$

where

k = 0.74 for particles less than 10 micrometers aerodynamic diameter

M = moisture content (%)

When this equation is applied with 8% moisture, the PM10 emission factor is 0.00688 kg/t. With 4% moisture the PM10 emission factor is 0.013 kg/t. This is very close to the Hunter Valley factor from the NERDDC (1988) study, adjusted to obtain the PM10 fraction (using the SPCC (1986) study), 0.014kg/t. Therefore, it is suggested that the USEPA (1998: Table 11.9- 1) equation should be used with the actual moisture levels that apply for ROM coal.

Bulldozing Coal

The TSP emission factor equation for bulldozers on coal is as follows (USEPA, 1988):

$$E = 35.6 \times \frac{s^{1.2}}{M^{1.4}} \text{ kg / h}$$

where

s = silt content (%)

M = moisture content in %

Default values of 7% for silt content and 2.5% for moisture content gives an emission rate of 102 kg/h.

The PM10 emission factor equation is:

$$E = 6.33 \times \frac{s^{1.5}}{M^{1.4}} kg/h$$

Using the same default values for silt and moisture content as provided for the TSP emission estimation gives an emission rate of 32.5 kg/h for PM10.

Bulldozer on Overburden

The emission factor equation for TSP is (USEPA, 1998):

$$E = 2.6 \times \frac{s^{1.2}}{M^{1.3}} \text{ kg/h}$$

Using default values of 10% for silt content and 2% for moisture content gives a TSP emission rate of 17 kg/h.

The emission factor rate for PM10 is (USEPA, 1998):

$$E = 0.34 \times \frac{s^{1.5}}{M^{1.4}} \ kg/h$$

Using the same default values for silt and moisture content as provided for the TSP estimation gives an emission rate of 4 kg/h.

Truck Unloading Overburden

The USEPA (1998) uses the same equation for unloading overburden as it does for loading overburden (see Section A.1.1.3 above). Again this gives an emission factor that appears to be too low for Australian mining operations. The NERDDC (1988) TSP emission factor for dumping overburden is 0.012 kg/t. It is recommended that this factor be used in preference to the USEPA emission equation. SPCC (1986) measurements in the Hunter Valley indicate that approximately 35.5% of TSP particles from trucks unloading overburden will be in the PM10 range. The recommended PM10 emission factor is therefore 0.012 x 0.355 = 0.0043 kg/t.

Truck Unloading Coal

The same equation applies as for the loading of coal (see Section A.1.1.3 above). Again, this gives an emission factor that appears to be too low for Australian mining conditions. The NERDDC TSP emission factor for dumping coal is 0.01 kg/t. It is recommended that this factor be used in preference to the USEPA emission equation. SPCC (1986) measurements in the Hunter Valley indicate that approximately 42% of TSP particles from truck unloading operations will be in the PM10 range. The recommended PM10 emissions factor is therefore 0.01 x 0.42 = 0.0042 kg/t.

Drilling

Emissions from drilling are a relatively minor component of the overall emission from an open cut mine. The only available emission equation for drilling is a simple uncontrolled TSP emission factor of 0.59 kg/hole (USEPA, 1998: Table 11.9-4). Clearly, other variables such as the depth of the hole, diameter of the hole, and moisture content of the material being drilled would also be relevant and 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.

USEPA (1998) does not provide an emission factor for the PM10 component. However, some measurements were obtained during the Hunter Valley studies (SPCC, 1988). The mean fraction of PM10/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 coal. However, in the absence of other information, the best estimate of the emission factor for drilling for PM10 is 0.31 kg/hole.

Blasting

Estimating the TSP emission from blasting is difficult, given the complex and variable nature of each blast.
The equation is:

$$E = 0.00022 \times A^{1.5} \text{ (kg/blast)}$$

where
A = area blasted in square metres

It should be noted that this equation does not provide any allowance for the moisture content in the material blasted, the depth of the holes or whether the blast is a throw blast or simply a shattering blast. Therefore, it must be considered a very rough estimate of the quantity of TSP that will be generated.

There is another equation provided by the US EPA for blasting emissions. This is:

$$E = 344 \times A^{0.8} / (M^{1.9} \times D^{1.8}) \text{ kg/blast}$$

where
A = the area blasted (square metres)
M = moisture content of the blasted material (%)
D = the depth of the blast holes (m)

This equation takes account of other variables that are likely to be important in the generation of dust (although, 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"). It is recommended that this equation be used for calculating TSP. For blasting, the USEPA estimates that the PM10 fraction constitutes 52% of the TSP (USEPA, 1998).

Topsoil Removal by Scraper

The TSP emission factor equation published in AP-42 is as follows (USEPA, 1998):

$$E = 7.6 \times 10^{-6} s^{1.3} W^{2.4} \quad \text{kg/VKT}$$

where

s = silt content (%)

W = vehicle gross mass (t)

VKT = Vehicle Kilometres Traveled

This equation appears to be the latest version. If a silt content of 10% and a gross mass of 48 t (fairly typical of conditions on Australian mines) are assumed, a TSP emission factor of 1.64 kg/VKT is obtained. This figure is consistent with the emission factor that has been developed on Hunter Valley mines for vehicle movements. (NB. to our knowledge there is no Australian field data for scrapers in travel mode).

The PM10 emission factor equation published in AP-42 is as follows:

$$EF = 1.32 \times 10^{-6} s^{1.4} W^{2.5} \quad \text{kg/VKT}$$

s = silt content (%)

W = vehicle gross mass (t)

VKT = Vehicle Kilometres Traveled

With the same assumptions about silt content and weight of scraper as provided for TSP, the PM10 default emission factor is 0.53 kg/VKT.

Wheel Generated Dust from Unpaved Roads

The equation provided in AP-42 (USEPA, 1998) for wheel generated dust is:

$$\mathrm{EF_i} \quad = \quad \mathrm{k_i} * (\mathrm{s}/12)^{\mathrm{A}} * (\mathrm{W}/3)^{\mathrm{B}} / (\mathrm{M}/0.2)^{\mathrm{C}} \ \text{kg/VKT}$$

where

k_i = 2.82 for particles less than 30 micrometres aerodynamic diameter

k_i = 0.733 for particles less than 10 micrometres aerodynamic diameter
s = surface material silt content, %
W = vehicle gross mass, t
M = surface material moisture content, %
A = empirical constant: 0.8 (for PM10) & 0.8 (for TSP)
A = empirical constant: 0.4 (for PM10) & 0.5 (for TSP)
A = empirical constant: 0.3 (for PM10) & 0.4 (for TSP)
(i) = particle size category

Using default values for surface material silt content of 10%, vehicle gross mass of 48 t and moisture content of 2% gives default TSP emission factor of 3.88 kg/VKT and default PM10 emission factor of 0.96 kg/VKT.

Use of Grader

The equation for estimating TSP from grading is (USEPA, 1998):

$$E = 0.0034 \times S^{2.5} \quad kg/VKT$$

where
S = mean vehicle speed in km/h

This equation is very sensitive to the speed assumed. There is no Australian data to verify this equation.
The proposed equation for PM10 emissions from grading is (USEPA, 1988):

$$E = 0.0034 \times S^{2.5} \quad kg/VKT$$

where
S = mean vehicle speed in km/h

Primary and Secondary Crushing and Loading Coal to Stockpiles

These activities include primary crushing of coal, secondary crushing of coal, loading of coal to stockpiles, or vehicles. In practice, these are very small contributors to the overall particulate emissions from typical coal mines.

Miscellaneous Transfer and Conveying

A common approach to estimating emissions from conveyor transfer points is to follow the approach in AP-42 (USEPA, 1998), that provides an emission factor equation for a continuous loading operation as follows:
If typical values for coal are inserted in to the equation (eg. U=3.6 m/s and M=8%) then E is 0.00032 kg/t for TSP.

Wind Erosion from Active Coal Stockpiles

The AP 42 emission factor equation for wind erosion is:

$$E = 1.9\left(\frac{s}{1.5}\right)365\left(\frac{365-p}{235}\right)\left(\frac{f}{15}\right)\text{kg/ha/year}$$

where
s = silt content(%)
p = number of days when rainfall is greater than (0.25mm)
f = percentage of time that wind speed is greater than 5.4 m/s at the mean height of the stockpile.

Taking s = 15%, p = 80 days/year and f = 30%, E is 16,821 kg/ha/year (1.92 kg/ha/h). The SPCC (1986) average value for wind erosion is 0.4 kg/ha/h (3,504 kg/ha/year). It is suggested that this value be adopted as a default in the absence of other information. AP-42 (USEPA, 1998) states that 50% of the TSP is emitted as PM10. Therefore, the default emission factor for PM10 is 0.2 kg/ha/h.

Wind Erosion from Other Exposed Areas (chitter/waste emplacement dams and wind erosion from exposed areas)

While the emission estimation equation for stockpiles presented in A.1.1.15 above, can be used for characterising emissions from other exposed areas, dams are frequently located in sheltered, or low lying areas where wind speeds may be lower than typically measured. However, in the absence of other information, it is recommended that the SPCC (1986) factor of 0.4 kg/ha/h be adopted for TSP. In a similar manner to active stockpiles, it can be assumed that 50% of TSP is in the PM10 fraction.

Table 1: Kangala Coal Mine Emissions Inventory (Tonnes per annum)

Source	**PM_{10}**	**TSP**
Loading Truck with Overburden	21.25	45.00
Loading Truck by shovel or FEL	21.00	43.50
Bulldozing Coal	284.70	893.52
Bulldozer on Overburden	35.04	148.92
Truck Unloading Overburden	6.45	18.00
Truck Unloading Coal	6.30	15.00
Drilling	6.19	11.78
Blasting	12.86	24.73
Dust generated from Unpaved Roads	120.00	310.40
Crushing	0.50	1.11
Screening	2.04	3.34
Miscellaneous Transfer and Conveying	0.30	0.59
Wind erosion from Active Stockpiles	54.75	109.50
Total:	**571.38**	**1625.40**

2. METHODOLOGY

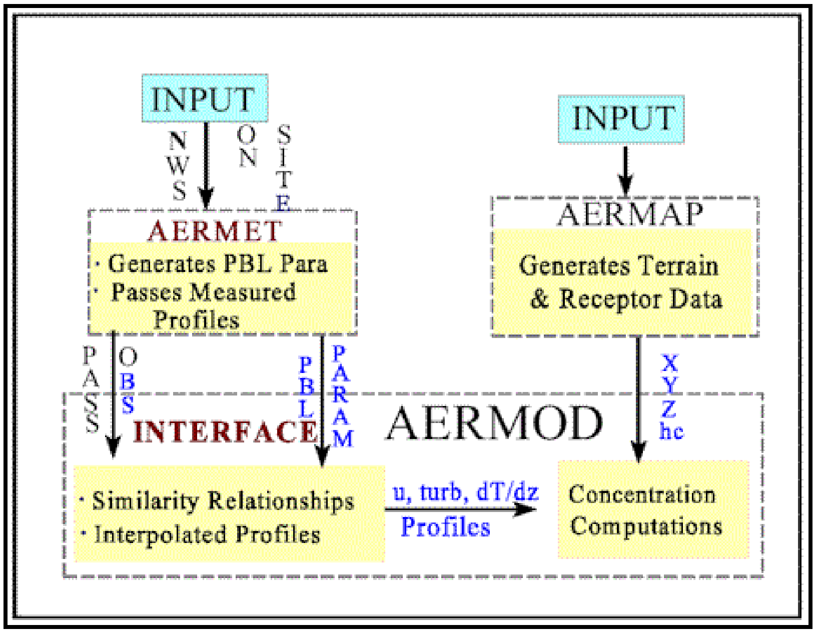
2.5 Use of AERMOD Dispersion Model

AERMOD Dispersion Model

For the purposes of this study, use as made of the AERMOD dispersion modelling system – a complete and powerful Windows air dispersion modeling system developed by Lakes Environmental software which is fully approved by the United States Environmental Protection Agency (US EPA). The diagram below shows how all the input parameters are entered into the model in order to generate the concentration outputs. Following manipulation these concentration outputs (isopleths) are plotted on relevant basemaps.

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

- A steady-state dispersion model designed for short-range (up to 50 kilometers) dispersion of air pollutant emissions from stationary industrial sources.
- A meteorological data preprocessor (**AERMET**) that accepts 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 preprocessor (**AERMAP**) whose main purpose is to provide a physical relationship between terrain features and the behavior 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.



The visual representation of the results then allows for interpretation and assessment of the potential environmental and health risks associated with predicted ambient concentrations of pollutants.

3. ASSUMPTIONS AND LIMITATIONS

- Meteorological data was obtained from the closest SA Weather Service station located in Springs ~21 kilometers West of the proposed mine. In the absence of reliable on-site meteorological data this station is deemed sufficiently close to be representative for the proposed site.

- Baseline data in the form of dust deposition (dust fall-out) was supplied by Digby Wells and Associates. Dust fall-out buckets were located at nine discrete positions and sampled over a one month period in August 2009. A summary of the results is provided in Table 7. In the absence of additional data it was, for the purposes of this study, assumed that the one month sampling period was representative of the baseline throughout the lifetime of the proposed mine.

- No baseline ambient PM_{10} monitoring data was available at the time of this assessment. Therefore the Air Quality standards used in the assessment were applied only to the modelled process contribution from the proposed Kangala Coal Mine.

- Emissions from the proposed Kangala Coal Mine were quantified using the National Pollution Inventory – Emission Estimation Technique Manual for Mining ver 2.3, Commonwealth of Australia. US-EPA emission factors are also referred to. No such South African emission factor database currently exists. A synopsis of the calculated emissions for each of the individual on-site processes is presented in Table 1.

- In order to illustrate the effectiveness of dust mitigation measures applied to haul roads (a major on-site source of both TSP and PM_{10}), efficiency factors of 50% and 90% were assumed and input into the dispersion model. In addition, an unmitigated (0%) scenario was used as a baseline. The effect of mitigation is then visually discernable.

4. AIR QUALITY LEGISLATION AND STANDARDS

The NEMAQA (Act 39 of 2004) was promulgated in February 2005. This Act repealed the Atmospheric Pollution Prevention (Act 45 of 1965), which focused primarily on the control of industrial air emissions. The new Air Quality Act covers a broad range of air quality management programs, from ambient air standards to climate change and enforcement issues. The Air Quality Act (Act 39 of 2004) describes various regulatory tools or measures which will be made available to government to implement and enforce air quality management plans and to achieve acceptable ambient air quality. These include:

- Priority areas - air pollution "hot spots" may be identified for focused attention including specific air quality management actions and the provision of specific regulations relating to the area;
- Listed activities - the identification of "problem" processes, means that they will require an atmospheric emission license before they can operate. Provision has been made in the act for the setting of minimum standards for emissions from listed activities;
- Controlled emitters - the setting of emission standards for identified "classes" of emitters (for example, motor vehicles and hazardous waste incinerators);
- Control of noise - measures may be prescribed for the control of noise;
- Control of odours and dust - measures may be prescribed for the control thereof.

The proposed site falls within the Highveld Priority Area as declared by the Minister of Environmental Affairs and Tourism in terms of section 18(1) of the NEMAQA (Act No.39 of 2004). The Highveld Priority Area includes the following districts: (i) the Ekurhuleni Metropolitan Municipality in Gauteng Province; (ii) Lesedi Local Municipality (Sedibeng) in Gauteng Province; (iii) Govan Mbeki Local Municipality (Gert Sibande) in Mpumalanga Province; (iv) Dipaleseng Local Municipality (Gert Sibande) in Mpumalanga Province; (v) Lekwa Local Municipality (Gert Sibande) in Mpumalanga Province; (vi) Msukaligwa Local Municipality (Gert Sibande) in Mpumalanga Province; (vii) Pixley ka Seme Local Municipality (Gert Sibande) in Mpumalanga Province; (viii) Delmas Local Municipality (Nkangala) in Mpumalanga Province; (ix) Emalahleni Local Municipality (Nkangala) in Mpumalanga Province; and (x) Steve Tshwete Local Municipality (Nkangala) in the Mpumalanga Province.

For the purposes of this assessment reference was made to the following ambient air standards and/or ambient air guidelines for priority pollutants:

- National Environment Management, Air Quality Act (Act 39 of 2004)
- South African National Standard – Ambient Air Quality SANS 1929:2005

The tables listed below list the relevant standards / guidelines for the priority pollutants

Table 2: SANS 1929:2005 PM10 limit values

Substituent	**Exposure periods**	
	Daily limit (Short Term) (μg/m^3)	**Annual limit (Long Term) (μg/m^3)**
PM10	75	40

Table 3: SANS 1929:2005 PM10 target values

Substituent	**Exposure periods**	
	Daily limit (Short Term) (μg/m^3)	**Annual limit (Long Term) (μg/m^3)**
PM10	50	30

Table 4: NEMAQA PM10 values

Substituent	**Exposure periods**	
	Daily limit (Short Term) (μg/m^3)	**Annual limit (Long Term) (μg/m^3)**
PM10	180	60

Table 5: SANS 1929:2005 Four-Band Scale Evaluation Criteria for Dust Deposition

Band Number	Band Description level	Dustfall Rate, D (mg/m^2/day, 30 day average)	Comment
1	Residential	D < 600	Permissible for residential and light commercial
2	Industrial	600 < D < 1200	Permissible for heavy commercial and industrial
3	Action	1200 < D < 2400	Requires investigation and remediation if two sequential months lie in this band more than three occur in a year.
4	Alert	D > 2400	Immediate action and remediation required following the first incidence of the dustfall rate being exceeded. Incident report to be submitted to the relevant authority.

Table 6: SANS 1929:2005 Target, Action and Alert thresholds for Dust Deposition

Level	Dustfall Rate, D (mg/m^2/day, 30 day average)	Averaging Period	Permitted frequency of exceeding dustfall rate
Target	300	Annual	
Action (residential)	600	30 days	Three within any year, no two sequential months.
Action (industrial)	1200	30 days	Three within any year, not sequential months.
Alert threshold	2400	30 days	None. First incidence of dustfall rate being exceeded requires remediation and compulsory report to the relevant authorities.

5. EXISTING BASELINE CONDITIONS

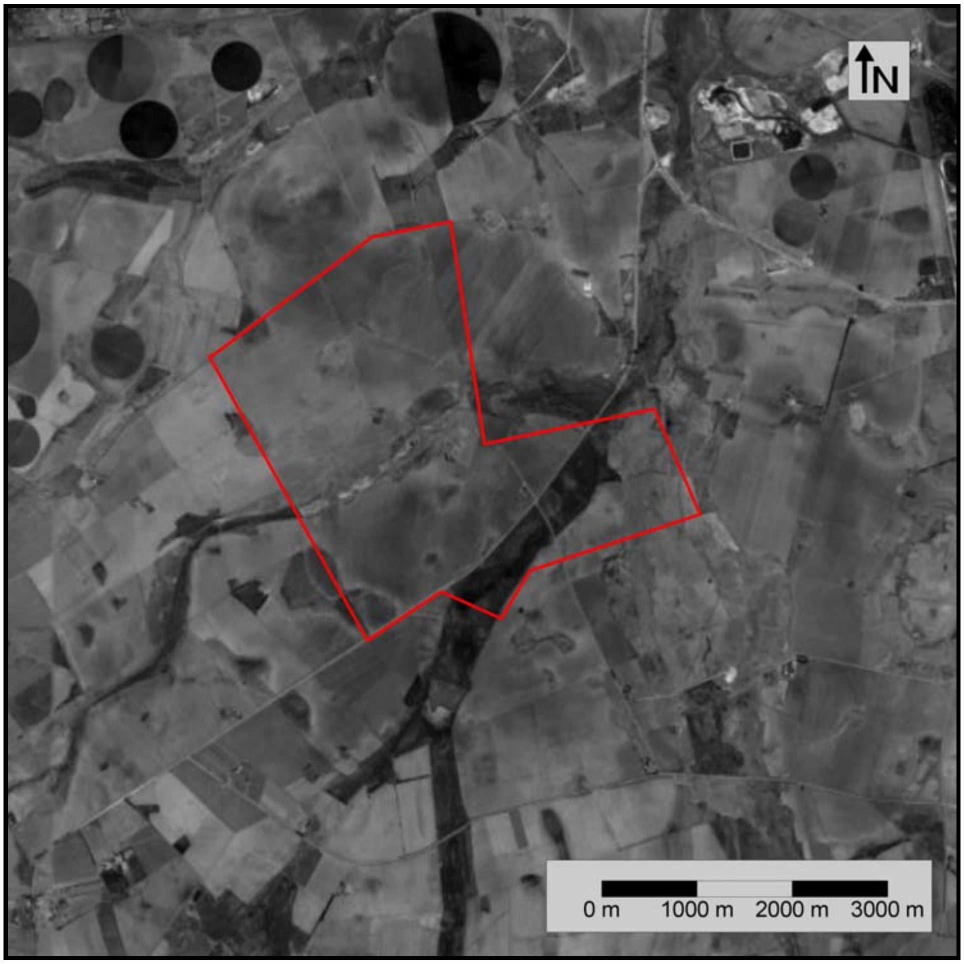


Figure 14: Kangala Coal Mine site boundary (marked in red)

Digby Wells and Associates provided baseline dust deposition (dust fall-out) data for use in this assessment. Nine predetermined bucket locations were sampled over a one month period in August 2009. A summary of the results of this study is provided in Table 7. The bucket locations (GPS coordinates) are listed below and illustrated on Figure 15:

UN 1 - (S26.16682° E28.65898°)
UN 2 - (S26.20428° E28.64007°)
UN 3 - (S26.22448° E28.69483°)
UN 4 - (S26.22196° E28.71162°)
UN 5 - (S26.19533° E28.71213°)

UN 6 - (S26.18648° E28.69038°)
UN 7 - (S26.17139° E28.67902°)
UN 8 - (S26.22637° E28.65454°)
UN 9 - (S26.20264° E28.67663°)

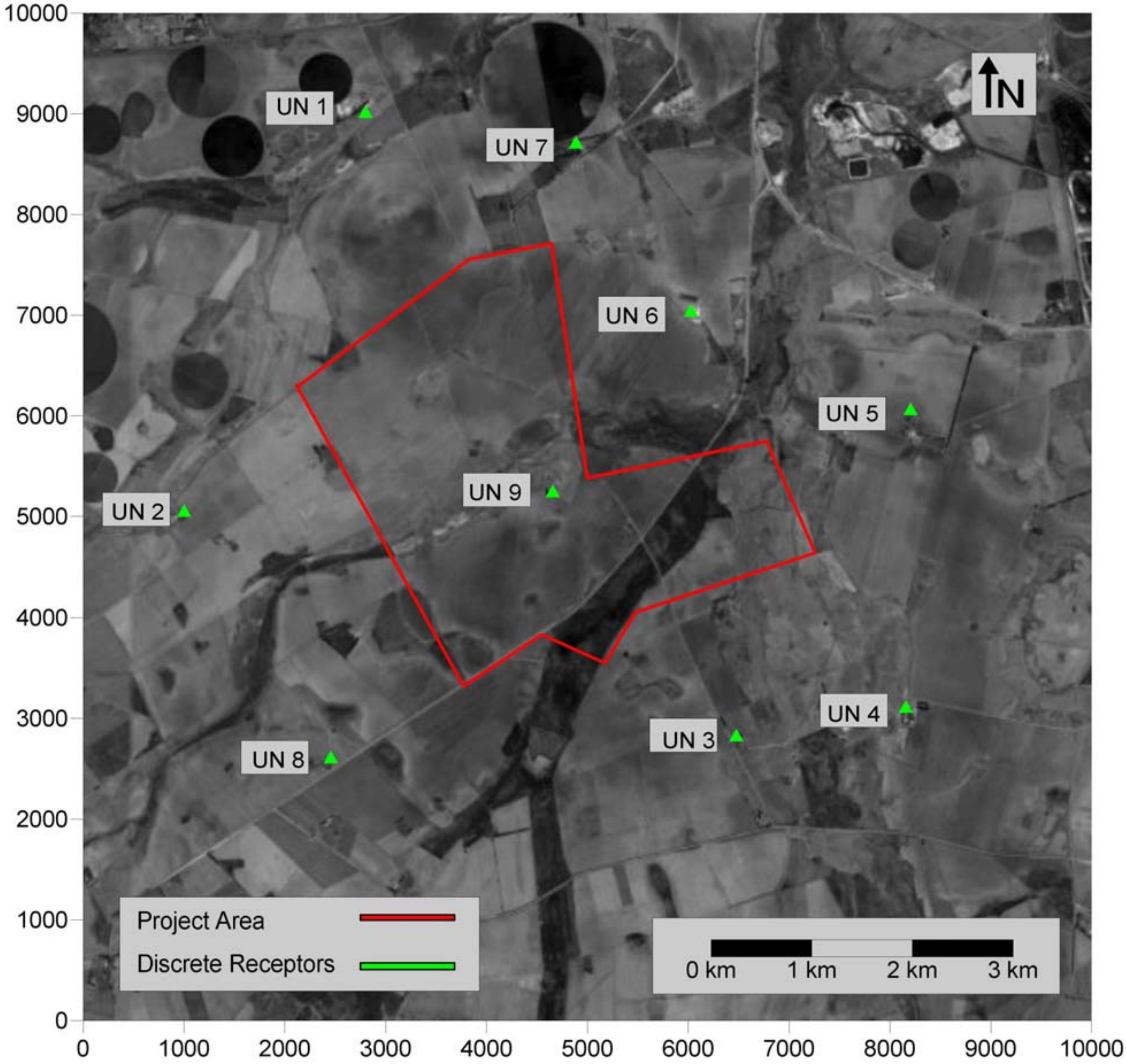


Figure 15: Location of dust buckets relative to proposed site boundary

For the purposes of this study it was assumed that the one month sampling period was representative of baseline conditions throughout the lifetime of the proposed mine.

No baseline ambient PM_{10} monitoring data was available at the time of this assessment. The Air Quality standards for PM_{10} used in the assessment were therefore applied solely to the modelled process contribution from the proposed Kangala Coal Mine.

Table 7: Baseline Dust deposition mg/m^2/day at Receptor Level

Discrete Receptor	Average Dust deposition*
UN 1	287
UN 2	596
UN 3	697
UN 4	622
UN 5	765
UN 6	404
UN 7	503
UN 8	628
UN 9	470

* One month sampling average, August 2009

6. ASSESSMENT OF CUMULATIVE IMPACTS

The National Environmental Management Act, Act 107 of 1998 sections 28(1) and 28(2) require that *cumulative impacts* be assessed, and to comply with this requirement the *cumulative impacts* were calculated by summation of the baseline conditions provided for the existing environment and the modelled process contribution of the proposed mine. The resultant *cumulative impacts* for TSP (Total Suspended Particulates) are represented in Tables 8, 9 and 10.

As no baseline data exists for PM_{10}*, cumulative impacts for* PM_{10} *could not be assessed and only the process contribution (the mine's contribution) was considered - as predicted by the dispersion model*.

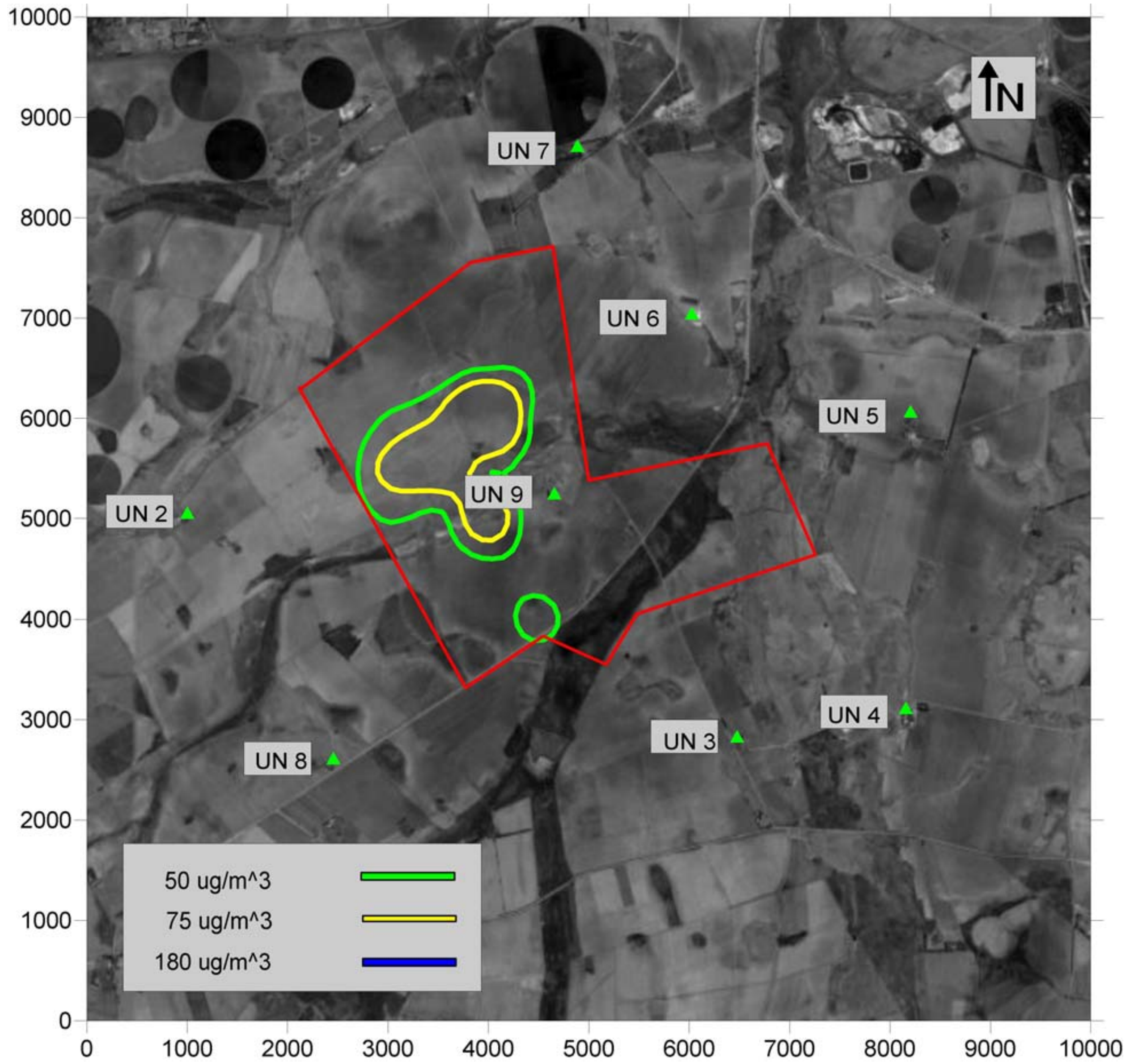


Figure 16
Predicted Process Contribution PM_{10}
24 Hour Exposure (0% mitigation)

Isopleths shown are the relevant PM_{10} reference standard concentrations, as predicted by the atmospheric dispersion model. The illustrated values are: 50 µg/m^3, 75 µg/m^3 and 180 µg/m^3 – i.e. the SANS 1929:2005 Target, SANS 1929:2005 Limit and NEMAQA reference standards for short term, 24 Hour (Daily exposure) for PM_{10} respectively – refer Tables 2-4.

No mitigative measures are assumed in the above modelled scenario.

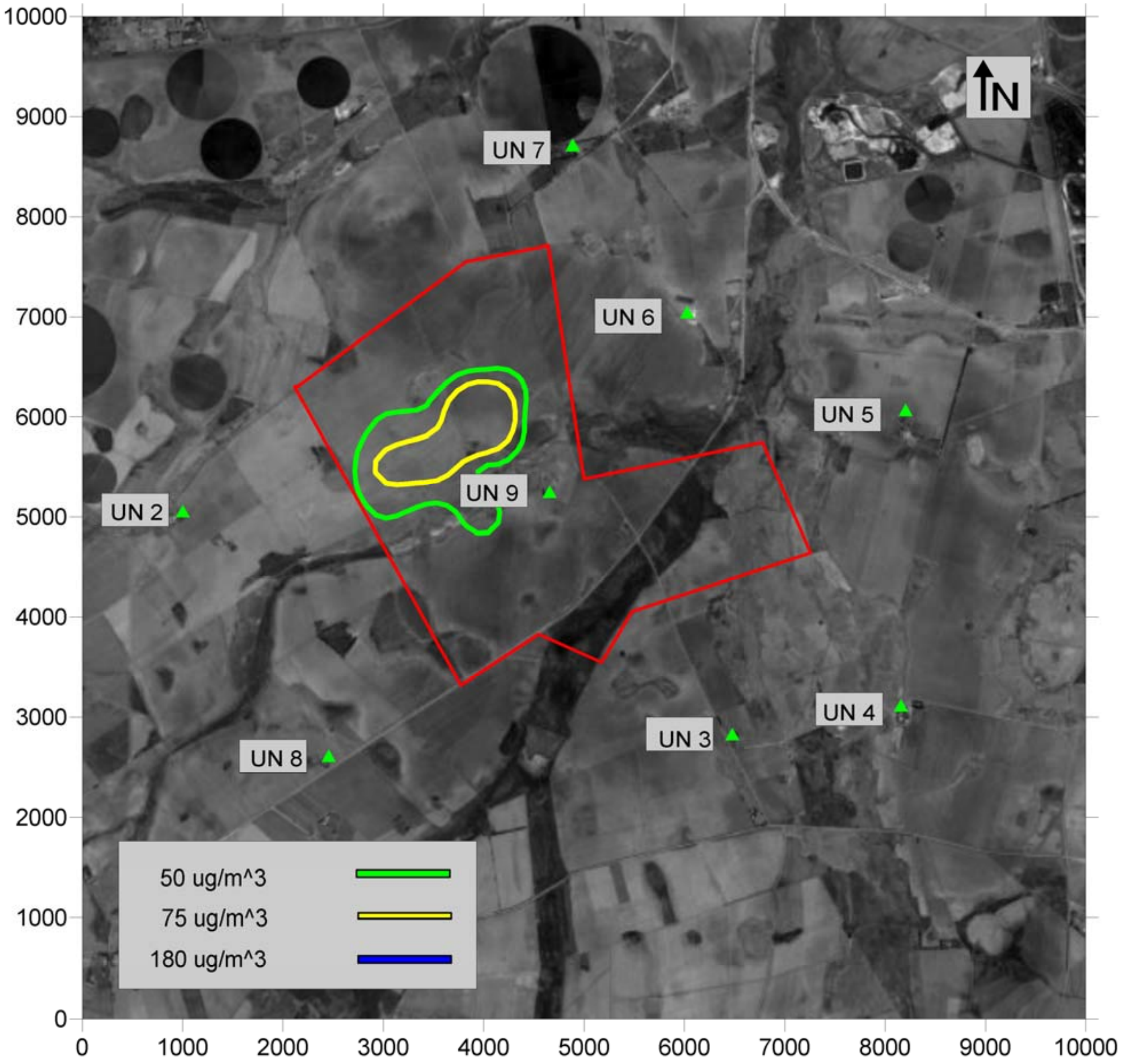


Figure 17
Predicted Process Contribution PM_{10}
24 Hour Exposure (50% mitigation)

Isopleths shown are the relevant PM_{10} reference standard concentrations, as predicted by the atmospheric dispersion model. The illustrated values are 50 µg/m^3, 75 µg/m^3 and 180 µg/m^3 – i.e. the SANS 1929:2005 Target, SANS 1929:2005 Limit and NEMAQA reference standards for short term, 24 Hour (Daily exposure) for PM_{10} respectively – refer Tables 2-4.

A 50% mitigation effectiveness is assumed in the above scenario.

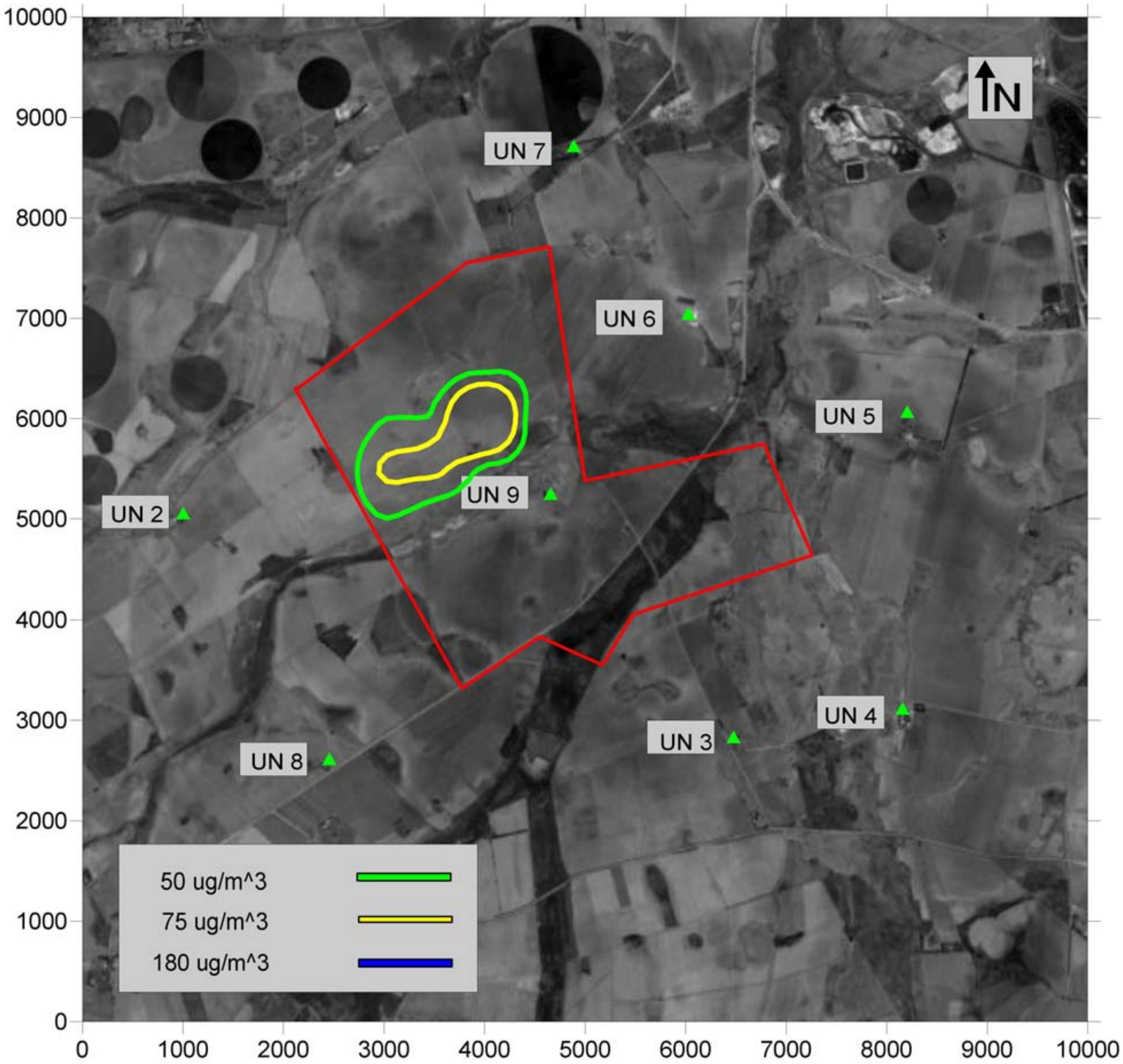


Figure 18
Predicted Process Contribution PM_{10}
24 Hour Exposure (90% mitigation)

Isopleths shown are the relevant PM_{10} reference standard concentrations, as predicted by the atmospheric dispersion model. The illustrated values are 50 μg/m^3, 75 μg/m^3 and 180 μg/m^3 – i.e. the SANS 1929:2005 Target, SANS 1929:2005 Limit and NEMAQA reference standards for short term, 24 Hour (Daily exposure) for PM_{10} respectively – refer Tables 2-4.

A 90% mitigation effectiveness is assumed in the above scenario.

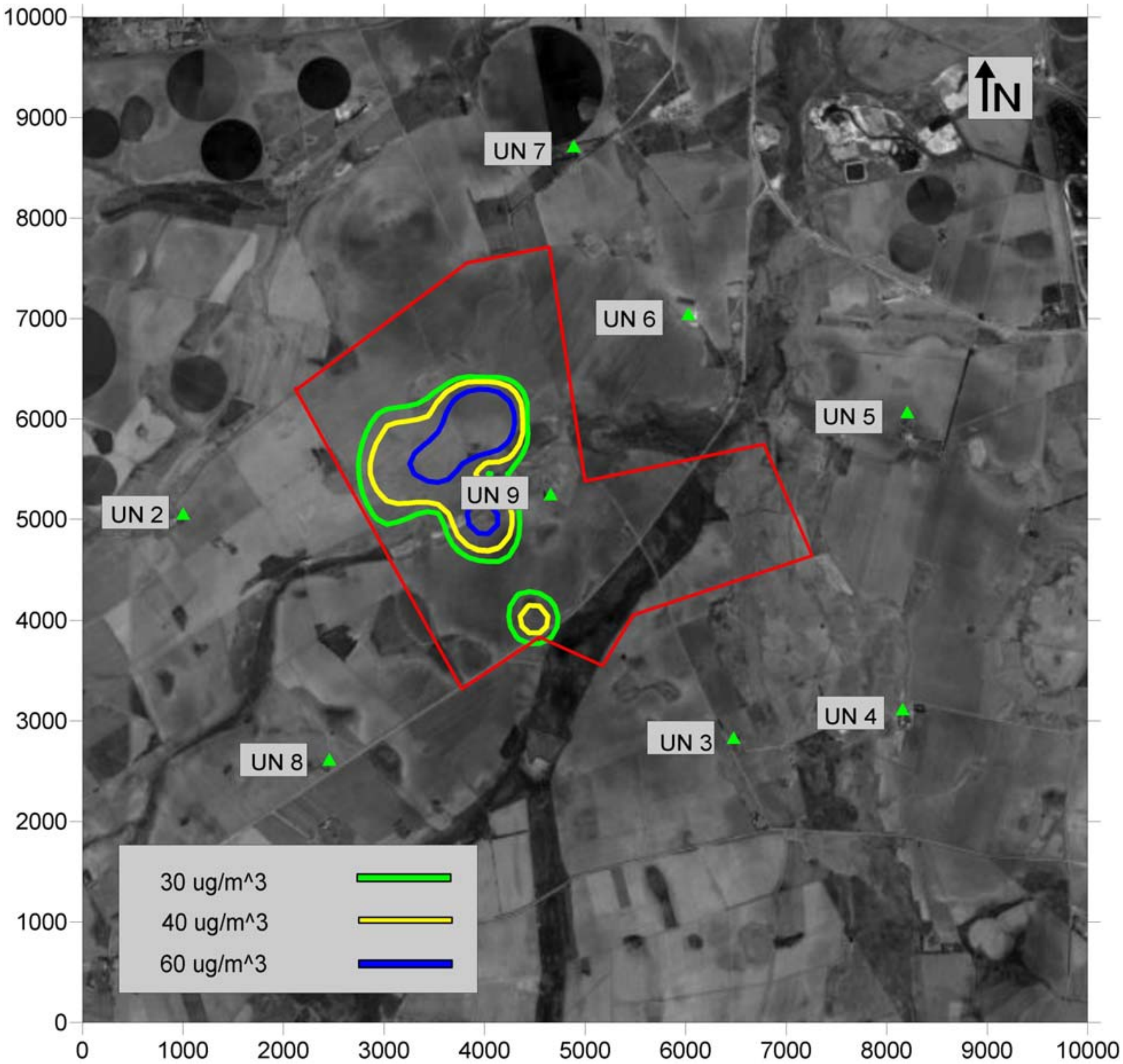


Figure 19
Predicted Process Contribution PM_{10}
Annual Exposure (0% mitigation)

Isopleths shown are the relevant PM_{10} reference standard concentrations, as predicted by the atmospheric dispersion model. The illustrated values are 30 μg/m^3, 40 μg/m^3 and 60 μg/m^3 – i.e. the SANS 1929:2005 Target, SANS 1929:2005 Limit and NEMAQA reference standards for long term, Annual (yearly average exposure) for PM_{10} respectively – refer Tables 2-4.

No mitigative measures are assumed in the above scenario.

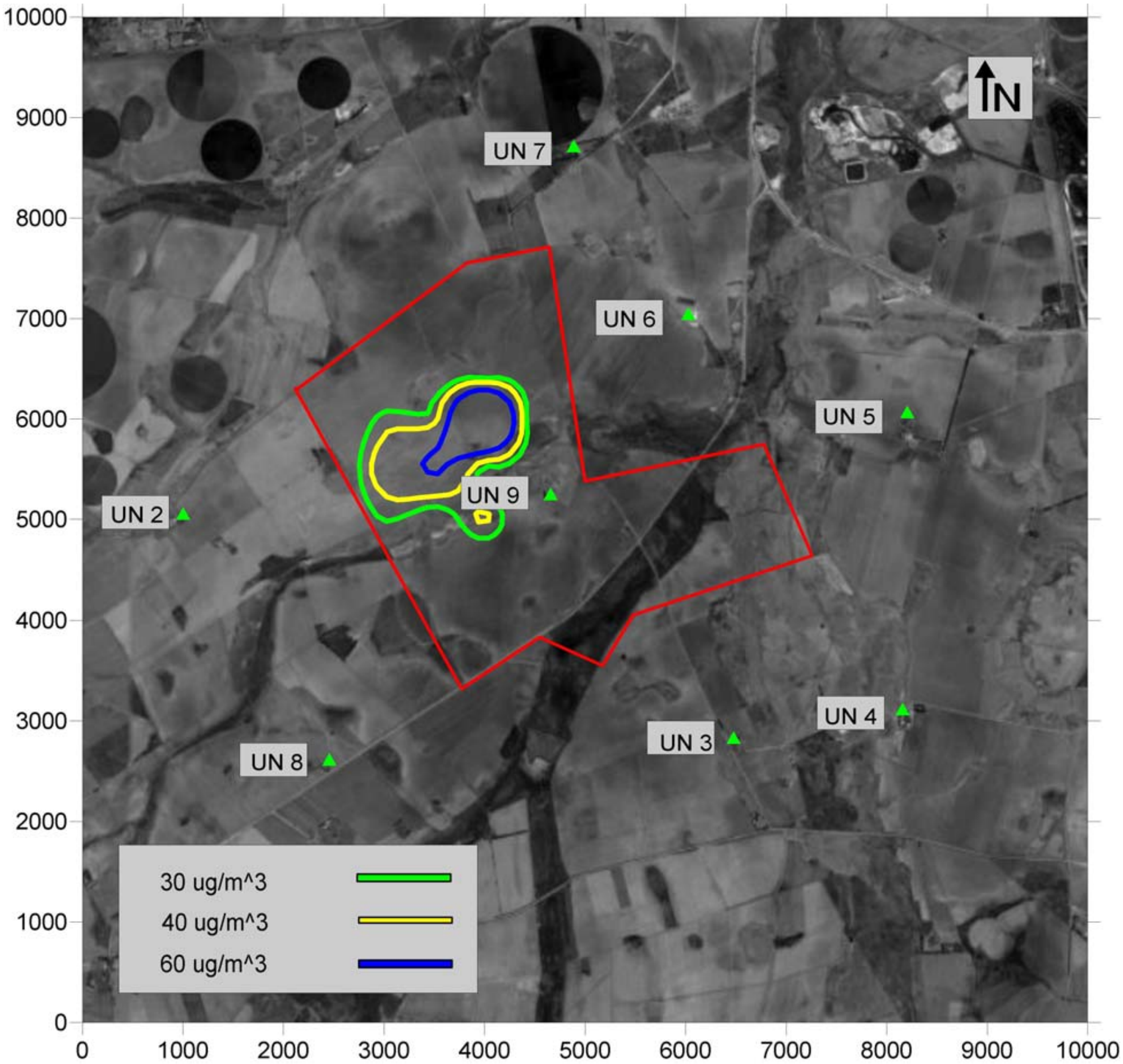


Figure 20
Predicted Process Contribution PM_{10}
Annual Exposure (50% mitigation)

Isopleths shown are the relevant PM_{10} reference standard concentrations, as predicted by the atmospheric dispersion model. The illustrated values are 30 μg/m^3, 40 μg/m^3 and 60 μg/m^3 – i.e. the SANS 1929:2005 Target, SANS 1929:2005 Limit and NEMAQA reference standards for long term, Annual (yearly average exposure) for PM_{10} respectively – refer Tables 2-4.

A 50% mitigation effectiveness is assumed for the above scenario.

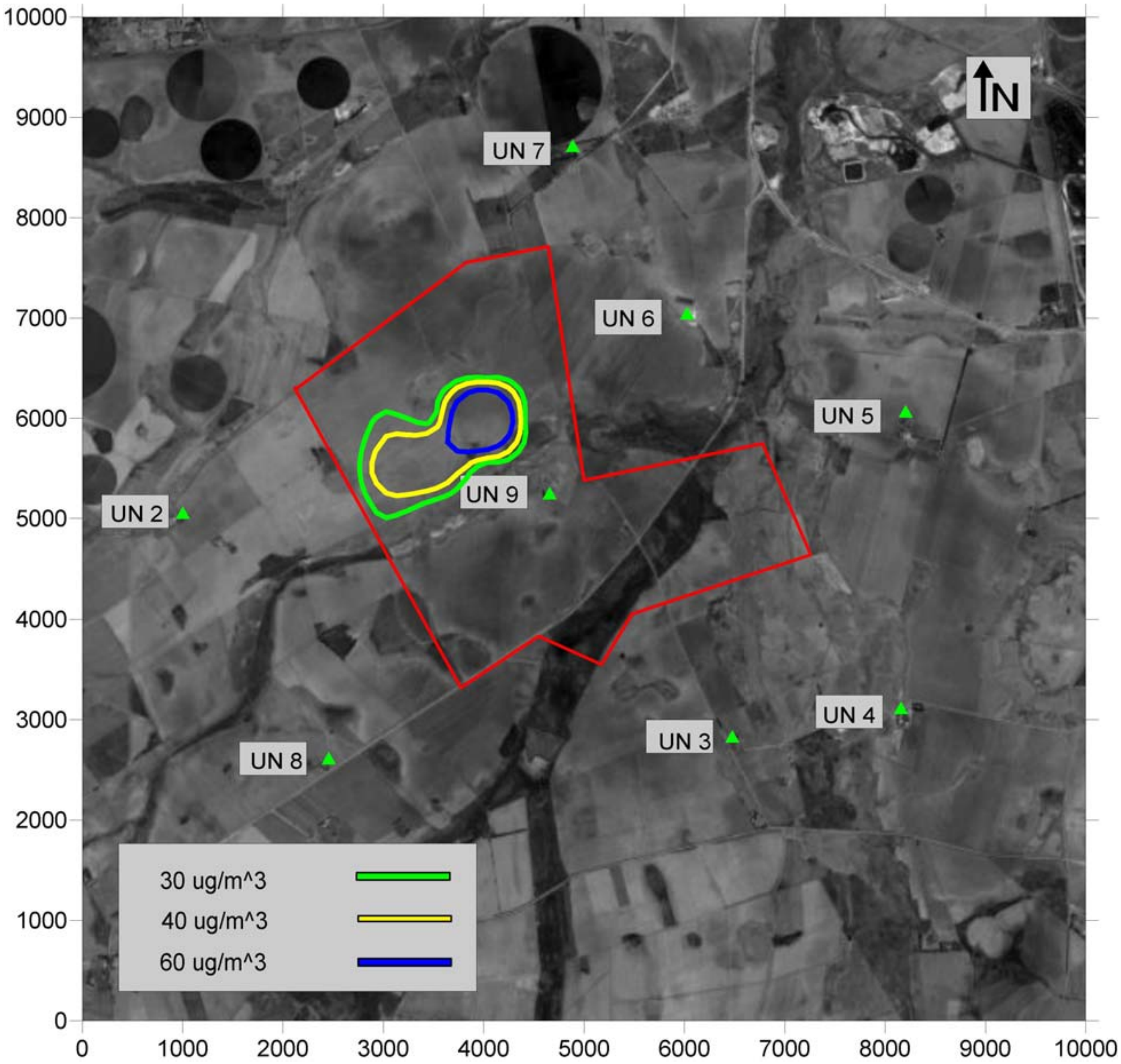


Figure 21
Predicted Process Contribution PM_{10}
Annual Exposure (90% mitigation)

Isopleths shown are the relevant PM_{10} reference standard concentrations, as predicted by the atmospheric dispersion model. The values shown are 30 µg/m^3, 40 µg/m^3 and 60 µg/m^3 – i.e. the SANS 1929:2005 Target, SANS 1929:2005 Limit and NEMAQA reference standards for long term, Annual (yearly average exposure) for PM_{10} respectively – refer Tables 2-4.

A 90% mitigation effectiveness is assumed for the above scenario.

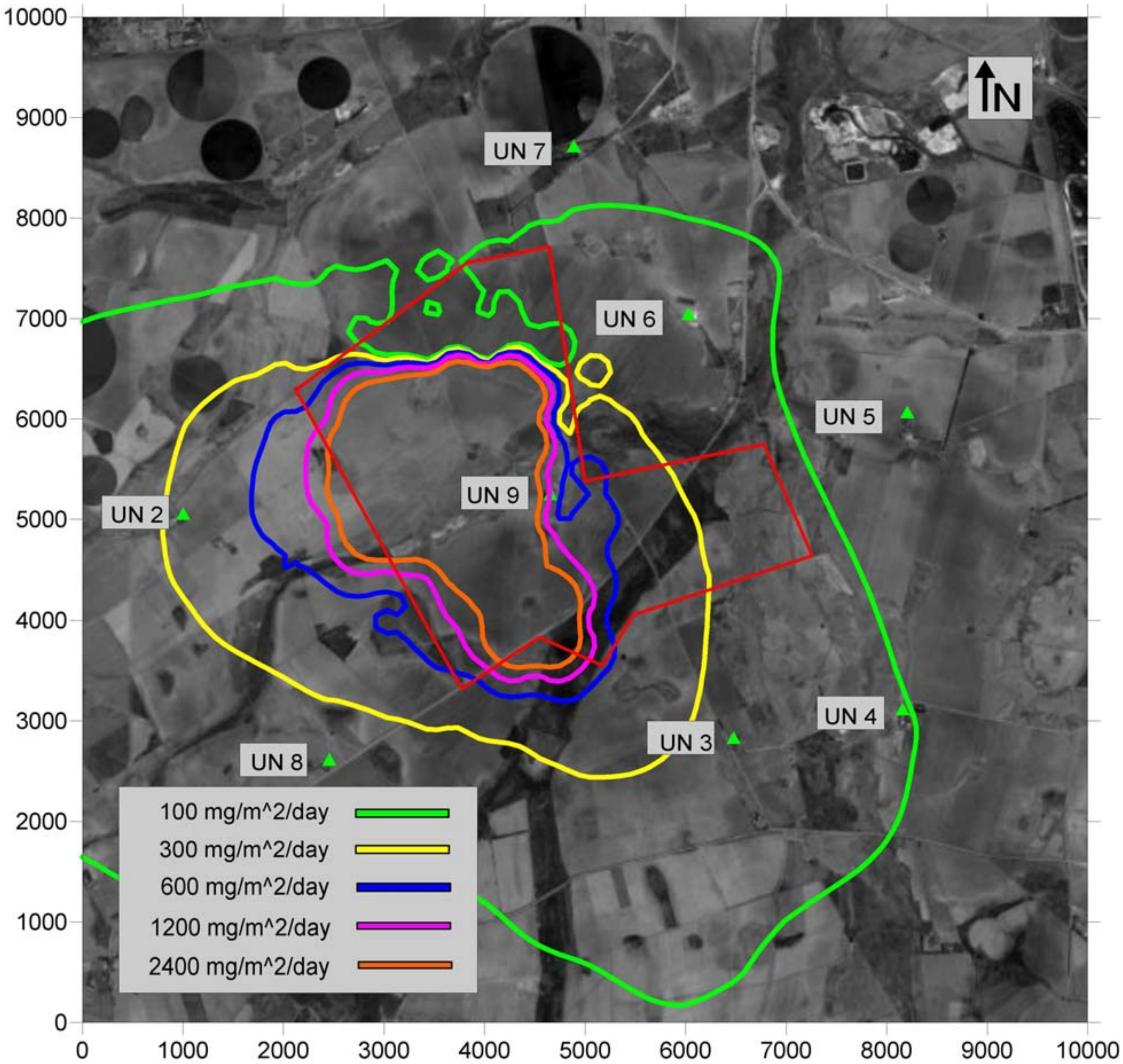


Figure 22
Predicted Process Contribution fallout dust
Annual Exposure (0% mitigation)

Depicted isopleths illustrate the relevant fallout dust reference standard concentrations, as predicted by the atmospheric dispersion model. The illustrated values are 100 µg/m^3, 300 µg/m^3 600 µg/m^3, 1200 µg/m^3 and 2400 mg/m^2/day – i.e. the SANS 1929:2005 Target, Action and Alert thresholds for dust deposition respectovely – refer Tables 5 and 6.

No mitigative measures are assumed for the above scenario.

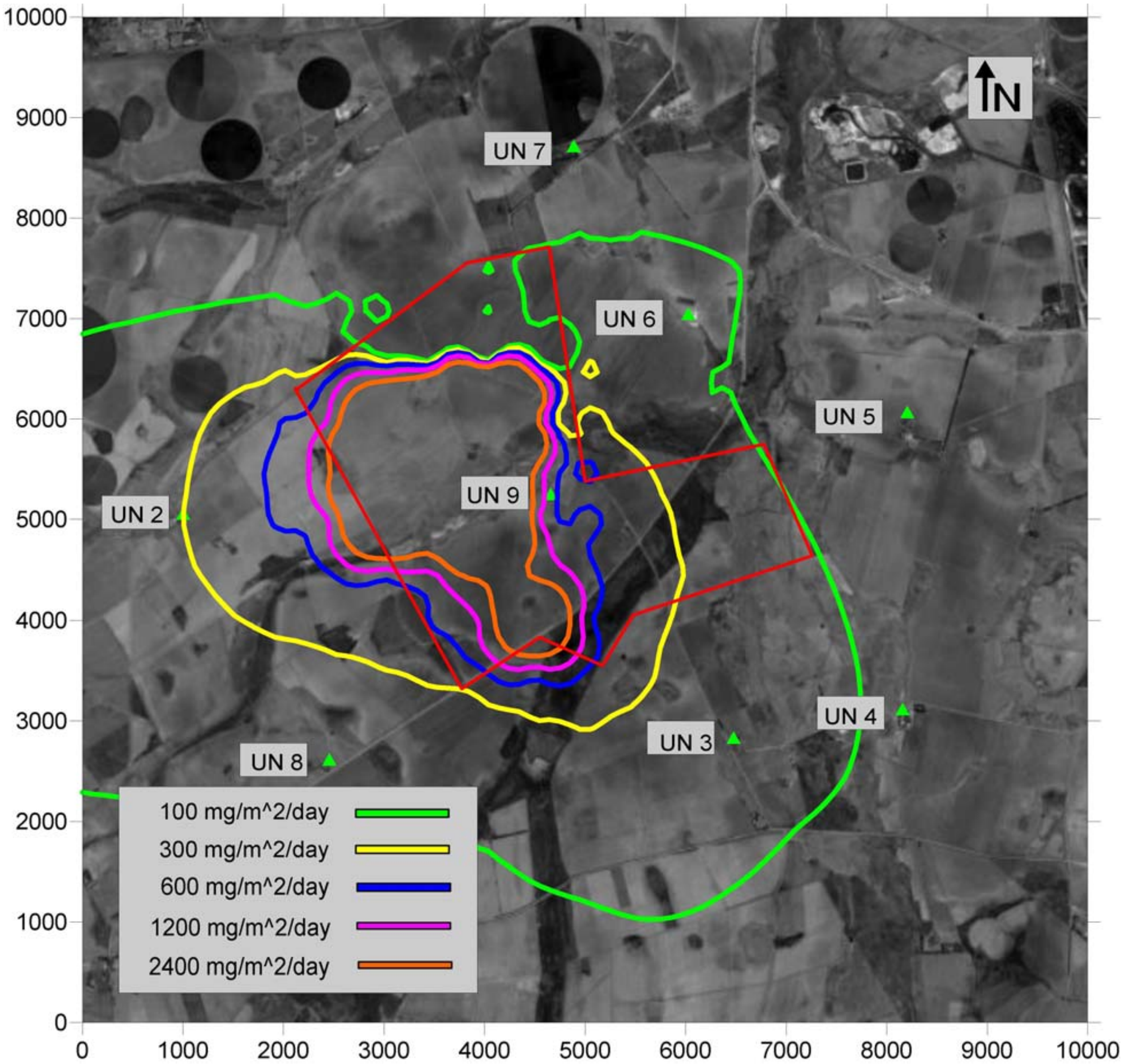


Figure 23
Predicted Process Contribution fallout dust
Annual Exposure (50% mitigation)

Depicted isopleths illustrate the relevant fallout dust reference standard concentrations, as predicticted by the atmospheric dispersion model. The illustrated values are 100 µg/m^3, 300 µg/m^3 600 µg/m^3, 1200 µg/m^3 and 2400 mg/m^2/day – i.e. the SANS 1929:2005 Target, Action and Alert thresholds for dust deposition respectovely – refer Tables 5 and 6.

A 50% mitigation effectiveness is assumed for the above scenario.

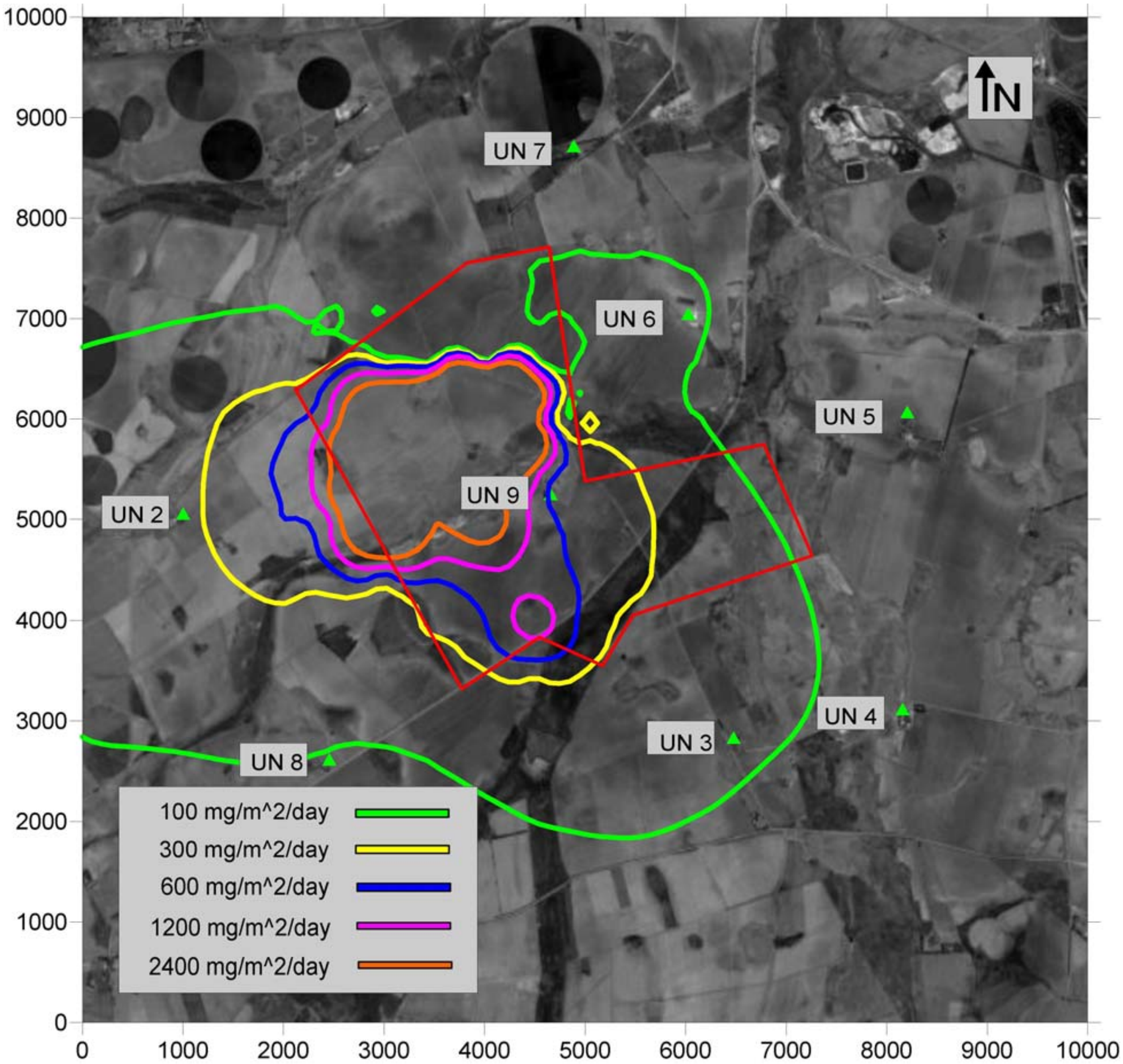


Figure 24
Predicted Process Contribution fallout dust
Annual Exposure (90% mitigation)

Depicted isopleths illustrate the relevant fallout dust reference standard concentrations, as predicticted by the atmospheric dispersion model. The illustrated values are 100 µg/m^3, 300 µg/m^3 600 µg/m^3, 1200 µg/m^3 and 2400 mg/m^2/day – i.e. the SANS 1929:2005 Target, Action and Alert thresholds for dust deposition respectively – refer Tables 5 and 6.

A 90% mitigation effectiveness is assumed for the above scenario.

Table 8: Cumulative Dust Deposition (mg/m^2/day) at Receptor Level (0% mitigation)

Discrete Receptor	Average*	PC**	Cumulative	SANS1929:2005 Permissible dust fall out rate (Industrial areas)
UN1	287	40	327	600 < D < 1200
UN2	596	356	952	600 < D < 1200
UN3	697	223	920	600 < D < 1200
UN4	622	110	732	600 < D < 1200
UN5	765	61	826	600 < D < 1200
UN6	404	174	578	600 < D < 1200
UN7	503	75	578	600 < D < 1200
UN8	628	190	818	600 < D < 1200
UN9	470	1892	2362	600 < D < 1200

* One month sampling average, August 2009
** Process contribution

Table 9: Cumulative Dust Deposition (mg/m^2/day) at Receptor Level (50% mitigation)

Discrete Receptor	Average*	PC**	Cumulative	SANS1929:2005 Permissible dust fall out rate (Industrial areas)
UN1	287	30	317	600 < D < 1200
UN2	596	300	896	600 < D < 1200
UN3	697	168	865	600 < D < 1200
UN4	622	89	711	600 < D < 1200
UN5	765	46	811	600 < D < 1200
UN6	404	145	549	600 < D < 1200
UN7	503	60	563	600 < D < 1200
UN8	628	195	823	600 < D < 1200
UN9	470	1397	1867	600 < D < 1200

* One month sampling average, August 2009
** Process contribution

Table 10: Cumulative Dust Deposition (mg/m^2/day) at Receptor Level (90% mitigation)

Discrete Receptor	Average*	PC**	Cumulative	SANS1929:2005 Permissible dust fall out rate (Industrial areas)
UN1	287	23	310	600 < D < 1200
UN2	596	256	852	600 < D < 1200
UN3	697	125	822	600 < D < 1200
UN4	622	72	694	600 < D < 1200
UN5	765	33	798	600 < D < 1200
UN6	404	122	526	600 < D < 1200
UN7	503	49	552	600 < D < 1200
UN8	628	84	712	600 < D < 1200
UN9	470	1001	1472	600 < D < 1200

* One month sampling average, August 2009
** Process contribution

7. DISCUSSION

The aim of this Air Quality Impact Assessment was to determine, through computational techniques, the potential impacts to the environment (in the form of dust deposition and ambient PM$_{10}$ concentrations) that would result from activities performed on proposed Kangala Coal Mine, near Delmas, Mpumalanga.

Baseline dust fall-out conditions were assessed using data acquired during a one month dust deposition study conducted by Digby Wells and Associates in August 2009. The results of this study are detailed in Table 7. No baseline data exists for ambient PM$_{10}$ conditions.

The predicted cumulative impacts for dust fallout are summarized in Table 8, Table 9 and Table 10, illustrating various scenarios of mitigation effectiveness (0%, 50% and 90% respectively) on haul roads (wetting).

According to the Department of Water and Environmental Affairs (DWEA), dust deposition can be classified as follows:

SLIGHT : less than 250 mg/m^2/day
MODERATE : 250 to 500 mg/m^2/day
HEAVY : 500 to 1200 mg/m^2/day
VERY HEAVY: more than 1200 mg/m^2/day

Investigation of the *current baseline conditions* revealed that the area is characterised by fallout dust in the MODERATE to HEAVY range. It is further noted that the averaged results obtained by the Digby Wells and Associates study fall into Band 2 of the SANS 1929:2005 Four-Band Scale Evaluation Criteria for Dust Deposition (Table 5) – i.e. considered '*Permissible for Industrial'* land use.

When the cumulative impacts are assessed by summation of the current baseline conditions and the predicted process contribution of the proposed Kangala Coal Mine, the following deductions and interpretations can be made:

- The cumulative dust deposition impacts (unmitigated) at UN 9 (centre of the proposed mine site) will increase from a baseline averaged value of 470 mg/m^2/day to 2362 mg/m^2/day – i.e. in excess of the Industrial action level of 1200 mg/m^2/day as per SANS 1929:2005. Cumulative dust deposition impacts (unmitigated) will not however exceed the Industrial action level at any of the off-site receptors.

- If dust mitigation efficiencies of 50% and 90% are considered, the nett cumulative dust deposition impacts at UN 9 (centre of the proposed mine site) are predicted to be 1867 mg/m^2/day and 1472 mg/m^2/day respectively – i.e. both above the Industrial action level of 1200 mg/m^2/day. It is noted however that, irrespective of whether 0%, 50% or 90% dust mitigation efficiencies are implemented, cumulative dust deposition impacts *will not exceed the Industrial action level at any of the off-site receptor locations*.

- The majority of the off-site receptor locations are predicted to experience cumulative dust deposition impacts in the HEAVY range of 600 to 1200 mg/m^2/day (as per SABS 1929:2005) irrespective of whether dust emissions are unmitigated (0%) or subject to 50% and 90% mitigation efficiences.

- Predicted short term PM_{10} impacts do not exceed the SANS standards of 50 µg/m^3 (target) and 75 µg/m^3 (limit) or the DWEA standard of 180 µg/m^3 beyond the site boundaries, for unmitigated (0%), 50% and 90% dust mitigation efficiences.

- Similarly, predicted long term PM_{10} impacts do not exceed the SANS standards of 30 µg/m^3 (target) and 40 µg/m^3 (limit) or the DWEA standard of 60 µg/m^3 beyond the site boundaries, for unmitigated (0%), 50% and 90% dust mitigation efficiences

Recommendations for the mitigation of dust emissions were derived from Control Alternatives: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions, Centre for Environmental Research Information Office of Research and Development, U.S. Environmental Protection Agency.

Recommended dust mitigation measures include:

- Wet suppression

  Water or a water-based solution of a chemical agent is applied to the surface of the road. Wet suppression prevents or suppresses the fine particles contained in that material from leaving the surface and becoming airborne. The suppressant agglomerates and binds the fines to the aggregate surface, thus eliminating or reducing the emissions potential. Water is generally applied to the surface of unpaved roads by a truck or some or other vehicle using either a pressurized or a gravity flow system. Watering unpaved roads is only a temporary measure and must be repeated at regular intervals. To improve the overall efficiency of wet suppression systems, wetting agents can be added to reduce the surface tension. The additives allow particles to more easily penetrate the water droplet and increase the number of droplets thus increasing the surface area and contact potential.

- Chemical stabilization

  Particulate release from unpaved surfaces can be reduced or prevented by stabilizing those surfaces. Chemical suppressants can be classified into six generic categories: salts (i.e. $CaCl_2$ and $MgCl_2$), lignin sulphate, wetting agents, latexes, plastics, and petroleum derivatives. Salts, which are usually obtained from natural brine deposits, control dust by absorbing and retaining moisture in the surface material. Wetting agents lower the surface tension of the water, thereby causing more rapid penetration into the surface material. The remaining dust suppressants, both natural and synthetic, bind the fines to larger aggregates in the surface material. Chemical dust suppressants are generally applied to the road surface as a water solution of the agent. The degree of control achieved is a direct function of the application intensity, dilution ratio, and the frequency number (number of applications/unit time) of the chemical applied to the surface. Control depends on the type and number of vehicles using the road.

- Physical stabilization

  Physical stabilization techniques can also be used for the control of fugitive emissions from unpaved road surfaces. Physical stabilization includes any measure, such as compaction of fill material at construction times, which physically reduces the emissions potential of a source from either mechanical disturbance or wind erosion.

- Other unpaved road control techniques

  Other practices may be used to reduce fugitive particulate emission from an open dust source. Work practices focus on transport equipment operation. For an unpaved travel surface, emissions can be markedly reduced by decreasing vehicle speed and weight. A recent study indicates that paved road cleaning techniques (such as flushing or vacuuming) may be used to increase the control efficiency of chemically treated unpaved roads.

8. REFERENCES

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