Appendix I

Air Quality

Project done on Behalf of

Groundwater Consulting Services (Pty) Ltd

Consolidated Environmental Management Programme Report for Leeuwpan Coal Mine – Air Quality Baseline Assessment

Report No.: APP/11/GCS-10 Revision 0

Date: 31 July 2012

Prepared by:

R. Bornman

G. Kornelius

Airshed Planning Professionals (Pty) Ltd

P O Box 5260
Halfway House
1685

Tel : +27 (0)11 805 1940
Fax : +27 (0)11 805 7010
e-mail : mail@airshed.co.za

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Prepared by	Rochelle Bornman, MPhil GIS & Remote Sensing (University of Cambridge) Gerrit Kornelius Pr Eng BEng (Hons) MBA PhD (Chemical Engineering) (University of Pretoria)
Notice	Airshed Planning Professionals (Pty) Ltd is a consulting company located in Midrand, South Africa, specialising in all aspects of air quality, ranging from nearby neighbourhood concerns to regional air pollution impacts as well as noise impact assessments. The company originated in 1990 as Environmental Management Services, which amalgamated with its sister company, Matrix Environmental Consultants, in 2003.
Declaration	I, Gerrit Kornelius as authorised representative of Airshed Planning Professionals (Pty) Ltd hereby confirm my independence as a specialist and declare that neither I nor Airshed Planning Professionals (Pty) Ltd have any interest, be it business, financial, personal or other, in any proposed activity, application or appeal in respect of which Airshed Planning Professionals (Pty) Ltd was appointed as air quality specialists in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998), other than fair remuneration for worked performed, specifically in connection with the assessment summarised in this report. I further declare that I am confident in the results of the studies undertaken and conclusions drawn as a result of it – as is described in this report. Signed………………….. Date………………….
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Executive Summary

Leeuwpan Coal Mine is situated 10 km southeast of the town Delmas, in the Delmas Local Municipality, Mpumalanga province. Leeuwpan is one of 8 coal mines in the Exxaro Resources group. It uses a modified terrace mining method due to the quality differences between the coal zones, whereby the top bench exploits the top coal zone (seam 4 and 5 along with their shale partings) and the bottom bench exploits the bottom coal zone (seam 2). The ROM coal production is approximately 2.7 million tons per annum, and the overburden removed is approximately 13 million tons per annum. The main activities that may give rise to air pollution are the removal of vegetation and topsoil; drilling and blasting of overburden and ore; removal of overburden and ore; transporting and stockpiling of overburden and ore; crushing and beneficiation of ore; vehicle entrainment of dust on unpaved roads; and rehabilitation operations.

Airshed Planning Professionals (Pty) Ltd were appointed by Groundwater Consulting Services (Pty) Ltd to provide an air quality impact assessment for the current and future mining operations at Leeuwpan Coal Mine towards the compilation of a consolidated Environmental Management Programme Report. This study comprises the baseline air quality characterization component of the assessment. The baseline assessment includes a study of the legal requirements pertaining to air quality, identification of sensitive receptors in the area surrounding the project site and the analysis of available ambient air quality and meteorological data.

To describe background air quality an overview of the entire study area was provided, including a description of the atmospheric dispersion potential of the site to assess the potential for air quality impacts on the surrounding environment and human health. Due to a lack of onsite meteorological data, use was made of hourly MM5[1] data for the period 2010 – 2011. This data would also be used for the dispersion simulations for the project. The ambient air quality within the study region was described by (i) identifying existing sources of air pollution; (ii) discussing the ambient PM_{10}[2] concentrations for the area as predicted by the Highveld Priority Area Baseline Assessment; (iii) and analysing dust deposition (TSP[3]) as measured in the vicinity of the site.

The main findings of the baseline assessment were as follows:

- Airborne particulates represent the main pollutant of concern, given the location and nature of the proposed operations.
- The sensitive receptors were identified as the residential areas of Botleng, Botleng Ext 2, Mandela Village, Mandela Ext 2, Delmas, Delmas West and an informal settlement, as well as farm houses surrounding the project area.
- The local wind field is characterised by:

[1] The MM5 model is an acronym for the Fifth-Generation NCAR / Penn State Mesoscale Model, which is a limited-area, nonhydrostatic, terrain-following sigma-coordinate model designed to simulate or predict mesoscale and regional-scale atmospheric circulation. Terrestrial and isobaric meteorological data are horizontally interpolated with observations from the standard network of surface and rawinsonde stations.

[2] Particles with aerodynamic diameters less than or equal to 10 micron

[3] Total Suspended Particulates

- Northerly and north-westerly winds with a strong component from the easterly sector. The north-westerly wind flow increases during day-time conditions with easterly wind flow increasing during the night.
    - Low to moderate wind speeds with an average wind speed of 3.1 m/s.
    - Calm conditions occurring approximately 13% of the time.
- The region experiences high rainfall (between 600 – 800 mm per year), mainly from October to March. Average daily maximum temperatures range from 23.7°C in December to 11.3°C in July, with daily minima ranging from 18.8°C in January to 2.8°C in July.
- The highest concentrations for ground level, or near-ground level releases from non-wind dependent sources would occur during weak wind speeds and stable (night-time) atmospheric conditions. Calculations indicate that stable, neutral and unstable conditions at the site occur 45%, 13% and 42% of the time respectively.
- Leeuwpan Coal Mine is located in the Highveld Priority Area (HPA). According to the HPA Baseline Assessment Delmas is considered a "hotspot" area for PM_{10} (where ambient air quality is poor and where ambient PM_{10} generally exceeds air quality standards). The HPA dispersion modelling results showed that the study site does not fall within an area where more than the allowable 4 exceedances of the PM_{10} air quality standard were predicted per annum. The contribution of residential fuel burning, motor vehicles and coal mining were found to be less significant than industrial sources in the total air quality loading in the Delmas local municipality.
- The findings from the HPA baseline assessment apply to the greater Delmas region. Local source contributors to ambient PM_{10} concentrations in the vicinity of the study site are:
    - domestic fuel burning and vehicle activity in residential areas (Delmas town to the northwest, Botleng and Mandela Village to the north and the informal settlement to the southwest of the mine);
    - mining activities – Stuart Coal Mine and SamQuarz Silica Mine directly adjacent to Leeuwpan; and
    - agricultural activities on the surrounding cultivated farm lands.
- However, the pollutants originating at the Leeuwpan Coal Mine may also impact the air quality of surrounding areas. It is expected that vehicle entrainment will be the largest source of dust emissions at the mine.
- Dust deposition has been measured at a number of locations around the Leeuwpan site. The gauges at the 7 monitoring stations are directional. For these stations, conclusions can only be drawn on the direction of the most prominent source of dust deposition impact, although the frequency of the wind from that direction also has to be taken into account. Dust deposition (TSP) results for Feb/Mar 2012, Apr/May 2012 and June 2012 show that the units with the highest and second highest average monthly fallout are monitoring unit 2 (East) and monitoring unit 4 (South) located next to a haul road and a farm respectively.

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Consolidated Environmental Management Programme Report for Leeuwpan Coal Mine – Air Quality Baseline Assessment

1 Introduction

Airshed Planning Professionals (Pty) Ltd were appointed by Groundwater Consulting Services (Pty) Ltd to provide an air quality impact assessment for the current and future mining operations at Leeuwpan Coal Mine towards the compilation of a consolidated Environmental Management Programme Report (EMPR). This study comprises the baseline air quality characterization component of the assessment. The baseline assessment includes a study of the legal requirements pertaining to air quality, a study of the physical environment of the area surrounding the project site and the analysis of available ambient air quality and meteorological data.

1.1 Background

Leeuwpan is situated 10km south east of the town of Delmas in Mpumalanga Province, approximately 80km east of Johannesburg and 70km southeast of Pretoria (Figure 1-1). Leeuwpan Coal Mine is a multi-product mine that uses a modified terrace mining method due to the quality differences between the coal zones, whereby the top bench exploits the top coal zone (seam 4 and 5 along with their shale partings) and the bottom bench exploits the bottom coal zone (seam 2). Coal is loaded by excavators and hauled by fully articulated 40 ton dump trucks. The ROM coal production is approximately 2.7 million tons per annum, and the overburden removed is approximately 13 million tons per annum (Botha, 2008).

The main activities that may give rise to air pollution are the removal of vegetation and topsoil; drilling and blasting of overburden and ore; removal of overburden and ore; transporting and stockpiling of overburden and ore; crushing and beneficiation of ore; vehicle entrainment of dust on unpaved roads; and rehabilitation operations.

Airborne particulates (PM_{10}, $PM_{2.5}$ and TSP) represent the main pollutant of concern, given the nature of the proposed operations.

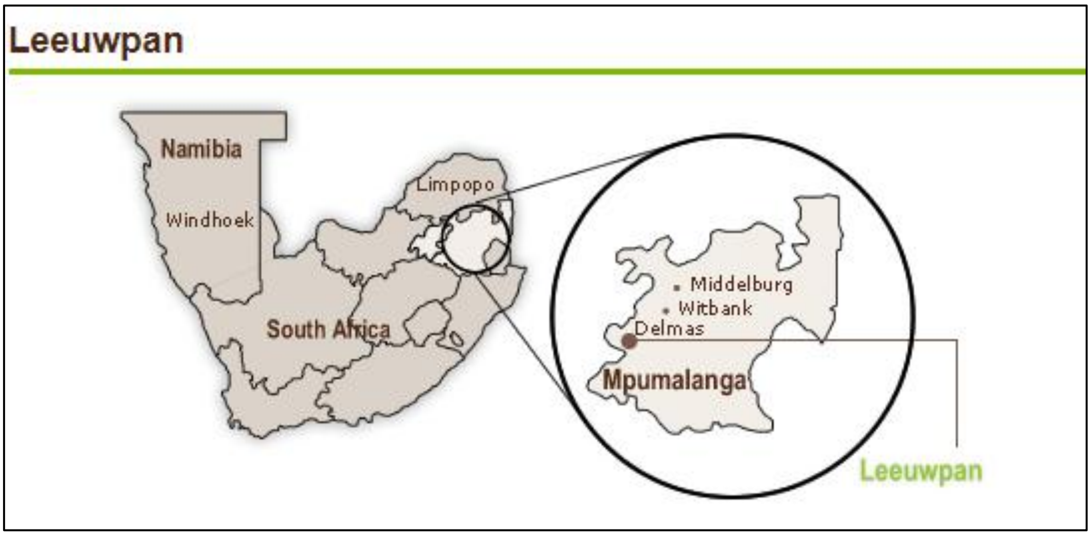


Figure 1-1: General location of study area.

1.2 Report Outline

The report is structured as follows:

Section 1	Introduction
Section 2	Legislative and Regulatory Review
Section 3	Baseline Study
Section 4	Conclusions
Section 5	References

2 Legislative and Regulatory Review

Prior to assessing the impact of coal mining operations at the Leeuwpan Coal Mine on the atmospheric environment, reference needs to be made to the environmental regulations governing the impact of such operations i.e. emission standards and ambient air quality standards.

- Emission standards: Emission standards are generally provided for point sources and specify the amount of the pollutant acceptable in an emission stream and are often based on proven efficiencies of air pollution control equipment.
- 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 standards and 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 or exposure 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 application of these standards varies, with some countries allowing a certain number of exceedances of each of the standards per year.

This section summarises national and international legislation pertaining to air quality for sources and pollutants relevant to the current study.

2.1 Legal Requirements According to the Air Quality Act No. 39 of 2004

The new National Environmental Management Air Quality Act has shifted the approach of air quality management from source-based control only to the control of the receiving environment. The Act has also placed the responsibility of air quality management on the shoulders of local authorities that will be tasked with baseline characterisation, management and operation of ambient monitoring networks, licensing of listed activities, and emissions reduction strategies. The main objective of the act is to ensure the protection of the environment and human health through reasonable measures of air pollution control within the sustainable (economic, social and ecological) development framework. The Minister was required to, within two years of the date on which this section took effect, establish a national framework for achieving the object of the Act. This needed to include mechanisms, systems and procedures to attain compliance with ambient air quality standards, to give effect to the Republic's responsibility to international agreements and to control emissions from point and non-point sources. It also provides the norms and standards to guide air quality management initiatives at national, provincial and local government levels throughout the country. The National Framework is a medium- to long term plan on how to implement the Air Quality Act to ensure the objectives of the act are met. The plan was first published in the Government Gazette on the 11th of September 2007 and the DEA has indicated that an updated version will be published during 2012.

2.2 National Ambient Air Quality Guidelines and Standards for Criteria Pollutants

The Department of Environmental Affairs and Tourism (DEAT) has issued ambient air quality guidelines to support receiving environment management practices. A detailed discussion on the establishment of guidelines and standards is provided in the subsection below.

Air quality limits proposed locally are reflected in subsequent sections of this document together with limits published by the WHO (World Health Organisation), EC (European Community) and US-EPA (United States Environmental Protection Agency). SANS (previously the SABS) was engaged to assist DEAT in the facilitation of the development of ambient air quality standards. A technical committee was established to oversee the development of standards. Three working groups were established by this committee for the drafting of ambient air quality standards for (i) sulphur dioxide, particulates, oxides of nitrogen and ozone, (ii) lead and (iii) volatile organic compounds, specifically benzene. Two documents were produced during the process, viz.:

- SANS 69 - South African National Standard - Framework for setting & implementing national ambient air quality standards
- SANS 1929 - South African National Standard - Ambient Air Quality - Limits for common pollutants

The latter document includes air quality limits for particulate matter less than 10 µm in aerodynamic diameter (PM_{10}), dustfall, sulphur dioxide, nitrogen dioxide, ozone, carbon monoxide, lead and benzene. The SANS documents were approved by the technical committee for gazetting for public comment and were finalized and published in November 2004. Government Gazette 32816 of 24 Dec 2009 (GN1210) finally published these numbers as a regulation, with interim measures for PM_{10} standards until 2014 (DEA 2009) and with the exception of dust fall standards, which will apparently be issued as regulations under section 32 of the Act. Permissible frequencies of exceedance (initially 1% of the number of averaging periods per year e.g. 88 hours of the 8760 hours per year) are included as part of this final regulation.

The proposed national ambient standard for particulate matter less than 2.5 µm in aerodynamic diameter ($PM_{2.5}$), with interim measures for $PM_{2.5}$ standards until 2016, was published for public comment in the Government Gazette 34493 of 5 August 2011 and issued as regulation in the Government Gazette of 29 June 2012.

The national ambient standards are listed in Table 2-1. Since particulate matter is the pollutant of concern at Leeuwpan Coal, it is discussed in more detail in Section 2.3. International air quality standards and guidelines for suspended particulate concentrations are provided (for comparison with local standards).

Table 2-1: National Ambient Air Quality Standards

Pollutant	Averaging Period	Limit Value (µg/m³)	Limit Value (ppb)	Frequency of Exceedance	Compliance Date
Benzene	1 year	10	3.2	0	Immediate – 31 Dec 2014
	1 year	5	1.6	0	1 Jan 2015
CO	1 hour	30000	26000	88	Immediate
	8 hour[(a)]	10000	8700	11	Immediate
Pb	1 year	0.5	-	0	Immediate
NO_2	1 hour	200	106	88	Immediate
	1 year	40	21	0	Immediate
Ozone	8 hour[(b)]	120	61	11	Immediate
PM_{10}	24 hour	120	-	4	Immediate – 31 Dec 2014
	24 hour	75	-	4	1 Jan 2015
	1 year	50	-	0	Immediate – 31 Dec 2014
	1 year	40	-	0	1 Jan 2015
$PM_{2.5}$	24 hour	65	-	4	Immediate – 31 Dec 2015
	24 hour	40	-	4	1 Jan 2016 – 31 Dec 2029
	24 hour	25	-	4	1 Jan 2030
	1 year	25	-	0	Immediate – 31 Dec 2015
	1 year	20	-	0	1 Jan 2016 – 31 Dec 2029
	1 year	15	-	0	1 Jan 2030
SO_2	10 minutes	500	191	526	Immediate
	1 hour	350	134	88	Immediate
	24 hour	125	48	4	Immediate
	1 year	50	19	0	Immediate

Notes:

(a) Calculated on 1 hour averages.

(b) Running average.

2.3 Suspended Particulate Matter

The impact of particles on human health is largely dependent on (i) particle characteristics, particularly particle size and chemical composition, and (ii) the duration, frequency and magnitude of exposure. The potential of particles to be inhaled and deposited in the lung is a function of the aerodynamic characteristics of particles in flow streams. The aerodynamic properties of particles are related to their size, shape and density. The deposition of particles in different regions of the respiratory system depends on their size.

The nasal openings permit very large dust particles to enter the nasal region, along with much finer airborne particulates. Larger particles are deposited in the nasal region by impaction on the hairs of the nose or at the bends of the nasal passages. Smaller particles (PM_{10} and $PM_{2.5}$) pass through the nasal region and are deposited in the tracheobronchial and pulmonary regions. Particles are removed by impacting with the wall of the bronchi when they are unable to follow the gaseous streamline flow through subsequent bifurcations of the bronchial tree. As the airflow decreases near the terminal bronchi, the smallest particles are removed by Brownian motion, which pushes them to the alveolar membrane (CEPA/FPAC Working Group, 1998; Dockery and Pope, 1994).

Particulate matter (PM) from natural background sources and anthropogenic sources (such as construction activities, road dust suspension and wind erosion) primarily fall within the TSP and PM_{10} size ranges. $PM_{2.5}$ is mainly a result from combustion sources and a concern in highly urbanized areas (WHO, 2005). Usually the fine mode ($PM_{2.5}$) is characterised by chemical constituents such as sulphate, nitrate, ammonium, lead, elemental carbon, metals and hundreds of different organic carbon compounds. The coarse mode (TSP and PM_{10}) is characterized by materials typical of the earth's crust (oxides of iron, calcium, silicon and aluminium), sea spray (sodium and chloride).

Air quality guidelines for particulates are given for various particle size fractions, including total suspended particulates (TSP), thoracic dust or PM_{10}, and respirable particulates or $PM_{2.5}$. Although TSP is defined as all particulates with an aerodynamic diameter of less than 100 µm, an effective upper limit of 30 µm aerodynamic diameter is frequently assigned. PM_{10} and $PM_{2.5}$ are of concern due to their health impact potentials. As indicated previously, such fine particles are able to be deposited in, and damaging to, the lower airways and gas-exchanging portions of the lung.

The limits and guidelines issued locally and internationally for inhalable particulates and dust fallout are provided in Sections 2.3.1 and 2.3.2 respectively.

2.3.1 Inhalable Particulates (PM_{10} and $PM_{2.5}$)

PM_{10} is suggested as an indicator with relevance to the majority of the epidemiological data and for which there is more extensive measurement data throughout the world. However the WHO numerical guideline value itself is based on studies using the $PM_{2.5}$ as an indicator and a $PM_{2.5}/PM_{10}$ ratio of 0.5 is used to derive an appropriate PM_{10} guideline value. This ratio of 0.5 is close to that observed typically in developing country urban areas and at the bottom of the range (0.5 – 0.8) found in developed country urban areas. If justified by local conditions, this ratio may be changed based on local data when the local PM_{10} standards are set.

During the 1990s the WHO stated that no safe thresholds could be determined for particulate exposures and responded by publishing linear dose-response relationships for PM_{10} and $PM_{2.5}$ concentrations (WHO, 2000). This approach was not well accepted by air quality managers and policy makers. As a result the WHO Working Group of Air Quality Guidelines recommended that the updated WHO air quality guideline document contain guidelines that define concentrations which, if achieved, would be expected to result in significantly reduced rates of adverse health effects. These guidelines would provide air quality managers and policy makers with an explicit objective when they were tasked with setting national air quality standards. Given that air pollution levels in developing countries frequently far exceed the recommended WHO air quality guidelines (AQGs), the Working Group also proposed interim targets (IT) levels, in excess of the WHO AQGs themselves, to promote steady progress towards meeting the WHO AQGs (WHO, 2005).

PM_{10} and $PM_{2.5}$ limits and standards issued nationally and abroad are documented in Table 2-2 and Table 2-3 below. The 24-hour average values refer to the 99th percentile of the distribution of daily values – that is the 4th next highest value of the year. The frequency distribution of daily $PM_{2.5}$ and PM_{10} values is most often roughly log-normal. Depending on the specific characteristics of their sources and location, countries may find that either the 24-hour guidelines or ITs or the annual average values are more restrictive. When evaluating the WHO AQG and IT, the annual average is suggested to take precedence over the 24-hour average since, at low levels, there is less concern about remaining episodic excursions. Meeting the guideline values for 24-hour mean should protect against peaks of pollution that would lead to substantial excess morbidity or mortality.

Table 2-2: Air quality guidelines and standards for PM_{10}

Authority	Maximum 24-hour Concentration (µg/m³)	Annual Average Concentration (µg/m³)
SA standards	75[(a)] (120 until end 2014) 50[(b)]	40[(c)] (60 until end 2014) 30[(d)]
Australian standards	50[(e)]	-
European Community (EC)	50[(f)]	30[(g)] 20[(h)]
World Bank (General Environmental Guidelines)	70[(i)]	50[(i)]
World Bank (Thermal Power Guidelines)	150[(j)]	50[(j)]

Authority	Maximum 24-hour Concentration (µg/m³)	Annual Average Concentration (µg/m³)
United Kingdom	50[k]	40[l]
United States EPA	150[m]	50[n]
World Health Organisation	150[o] 100[p] 75[q] 50[r]	70[o] 50[p] 30[q] 20[r]

Notes:

(a) Limit value. Permissible frequencies of exceedance 1%.

(b) Target value in terms of SANS 1929.

(c) Limit value. .

(d) Target value in terms of SANS 1929.

(e) Australian ambient air quality standards. (http://www.deh.gov.au/atmosphere/airquality/standards.html). Not to be exceeded more than 35 days per year. Compliance by 2008.

(f) EC First Daughter Directive, 1999/30/EC (http://europa.eu.int/comm/environment/air/ambient.htm). Compliance by 1 January 2005. Not to be exceeded more than 25 times per calendar year. (By 1 January 2010, no violations of more than 7 times per year will be permitted.)

(g) EC First Daughter Directive, 1999/30/EC (http://europa.eu.int/comm/environment/air/ambient.htm). Compliance by 1 January 2005

(h) EC First Daughter Directive, 1999/30/EC (http://europa.eu.int/comm/environment/air/ambient.htm). Compliance by 1 January 2010

(i) World Bank, 1998. Pollution Prevention and Abatement Handbook. (www.worldbank.org). Ambient air conditions at property boundary.

(j) World Bank, 1998. Pollution Prevention and Abatement Handbook. (www.worldbank.org). Ambient air quality in Thermal Power Plants.

(k) UK Air Quality Objectives. www.airquality.co.uk/archive/standards/php. Not to be exceeded more than 35 times per year. Compliance by 31 December 2004

(l) UK Air Quality Objectives. www.airquality.co.uk/archive/standards/php. Compliance by 31 December 2004

(m) US National Ambient Air Quality Standards (www.epa.gov/air/criteria.html). Not to be exceeded more than once per year.

(n) US National Ambient Air Quality Standards (www.epa.gov/air/criteria.html). To attain this standard, the 3-year average of the weighted annual mean PM10 concentration at each monitor within an area must not exceed 50 µg/m³.

(o) WHO interim target-1 (IT-1). World Health Organisation air quality guidelines global update 2005.

(p) WHO interim target-2 (IT-2). World Health Organisation air quality guidelines global update 2005.

(q) WHO interim target-3 (IT-3). World Health Organisation air quality guidelines global update 2005.

(r) WHO guideline. World Health Organisation air quality guidelines global update 2005.

Table 2-3: Air quality guidelines and standards for $PM_{2.5}$

Authority	Maximum 24-hour Concentration (µg/m³)	Annual Average Concentration (µg/m³)
SA standards	65[a] (immediate until end 2015) 40[a] (2016 until end 2029) 25[a] (from 2030)	25[b] (immediate until end 2015) 20[b] (2016 until end 2029) 15[b] (from 2030)

Authority	Maximum 24-hour Concentration (µg/m³)	Annual Average Concentration (µg/m³)
Australian standards	25(c)	8(c)
Canadian standards	30(d) 25(e)	- 8(f); 6(g)
Chinese standards	35(h) 75(i)	15(h) 35(i)
Mongolian standards	50(j)	25(j)
UK/EU standards	-	25(k) 20(l)
United States EPA	35(m)	15(n)
World Health Organisation	75(o) 50(p) 37.5(q) 25(r)	35(o) 25(p) 15(q) 10(r)

Notes:

(a) Limit value. Permissible frequencies of exceedance 4.

(b) Limit value. No exceedances will be permitted.

(c) Advisory reporting standards and goals for particles as $PM_{2.5}$. Measure schedule commenced in 2005 (http://www.deh.gov.au/atmosphere/airquality/standards.html).

(d) Canada-Wide Standards issued by the Canadian Council of Ministers of the Environment (2005). Based on annual 98th percentile value, averaged over 3 consecutive years.

(e) Ambient Air Quality Objective (established in 2009). Based on annual 98th percentile value.

(f) Ambient Air Quality Objective (established in 2009). Based on annual arithmetic mean.

(g) Planning goal (2009). Based on annual arithmetic mean.

(h) Limit value Grade I (natural protection areas and other areas which need special protection). GB 3095-2012 (http://cleanairinitiative.org/portal/node/8163).

(i) Limit value for Grade II (residential, commercial, industrial and rural areas). GB 3095-2012 (http://cleanairinitiative.org/portal/node/8163).

(j) World Bank Study. Sustainable Development Series: Discussion Paper 52970 (December 2009) (http://siteresources.worldbank.org/INTMONGOLIA/Resources/Air_pollution_final_report.pdf).

(k) Standard introduced by the new Directive, (http://ec.europa.eu/environment/air/quality/standards.htm). Compliance by 1 January 2015. Based on 3-year average. No exceedances will be permitted.

(l) Indicative value for 2020.

(m) US National Ambient Air Quality Standards (www.epa.gov/air/criteria.html). To attain this standard, the 3-year average of the 98th percentile of the 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 µg/m³.

(n) US National Ambient Air Quality Standards (www.epa.gov/air/criteria.html). To attain this standard, the 3-year average of the weighted annual mean $PM_{2.5}$ concentration at each monitor within an area must not exceed 15 µg/m³.

(o) WHO interim target-1 (IT-1). World Health Organisation air quality guidelines global update 2005.

(p) WHO interim target-2 (IT-2). World Health Organisation air quality guidelines global update 2005.

(q) WHO interim target-3 (IT-3). World Health Organisation air quality guidelines global update 2005.

(r) WHO guideline. World Health Organisation air quality guidelines global update 2005.

2.3.2 Dustfall (TSP)

Locally dustfall is evaluated according to the criteria published by DEAT. In terms of these criteria dustfall is 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 $mg/m^2/day$

"Slight" dustfall is barely visible to the naked eye. "Heavy" dustfall indicates a fine layer of dust on a surface; with "very heavy" dustfall being easily visible should a surface not be cleaned for a few days. Dustfall levels of > 2000 $mg/m^2/day$ constitute a layer of dust thick enough to allow a person to "write" words in the dust with their fingers.

A perceived weakness of the current dustfall guidelines is that they are purely descriptive, without giving any guidance for action or remediation (SLIGHT, MEDIUM, HEAVY, and VERY HEAVY). It has recently been proposed (as part of the SANS air quality standard setting processes) that dustfall rates be evaluated against a four-band scale, as presented in Table 2-4. Proposed target, action and alert thresholds for ambient dust deposition are given in Table 2-5.

It should be noted that the SANS limits provided for dust fallout are stipulated according to the American Standard for Testing and Materials (ASTM D1739, 1998) standard measurement method. This method employs a single bucket device consisting of a cylinder not less than 150 mm in diameter with height not less than twice its diameter and exposed for one calendar month (30 ±2 days).

The Department of Minerals and Energy (DME) uses the 1 200 $mg/m^2/day$ threshold level as an action level (Table 2-4). In the event that on-site dustfall exceeds this threshold, the specific causes of high dustfall should be investigated and remedial steps taken. According to the proposed SA dustfall limits an enterprise may submit a request to the authorities to operate within the Band 3 ACTION band for a limited period, providing that this is essential in terms of the practical operation of the enterprise (for example the final removal of a tailings deposit) and provided that the best available control technology is applied for the duration. No margin of tolerance will be granted for operations that result in dustfall rates in the Band 4 ALERT[4].

A draft regulation containing the above limits for residential and light commercial areas has recently been published for public comment in the Government Gazette 27 May 2011.

[4] Dust fall that exceeds the specified guidelines may be discounted by the authorities for enforcement and control purposes if they are shown to be the result of an extreme weather or geological event. Such an extreme event must be characterised by excessive dust fall over an entire metropolitan area and not be localised to a particular operation. Natural seasonal variations will not be considered as extreme events and will not be discounted.

Table 2-4: Bands of dustfall rates proposed for adoption

Band Number	Band Description Label	30 Day Average Dustfall Rate (mg/m^2-day)	Comment
1	RESIDENTIAL	D < 600	Permissible for residential and light commercial
2	INDUSTRIAL	600 < D < 1 200	Permissible for heavy commercial and industrial
3	ACTION	1 200 < D < 2 400	Requires investigation and remediation if two sequential months lie in this band, or more than three occur in a year.
4	ALERT	2 400 < D	Immediate action and remediation required following the first exceedance. Incident report to be submitted to relevant authority.

Table 2-5: Target, action and alert thresholds for ambient dustfall

Level	Dustfall Rate (mg/m^2-day)	Averaging Period	Permitted Frequency of Exceedance
TARGET	300	Annual	
ACTION RESIDENTIAL	600	30 days	Three within any year, no two sequential months.
ACTION INDUSTRIAL	1 200	30 days	Three within any year, not sequential months.
ALERT THRESHOLD	2 400	30 days	None. First exceedance requires remediation and compulsory report to authorities.

Foreign dust deposition standards issued by various countries are given in Table 2-6. It is important to note that the limits given by Argentina, Australia, Canada, Spain and the USA are based on annual average dustfall. The standards given for Germany are given for maximum monthly dustfall and therefore comparable to the dustfall categories issued locally. Based on a comparison of the annual average dustfall standards it is evident that in many cases a threshold of ~200 mg/m^2/day to ~300 mg/m^2/day is given for residential areas.

Table 2-6: Dust deposition standards issued by various countries.

Country	Annual Average Dust Deposition Standards (based on monthly monitoring) (mg/m^2/day)	Maximum Monthly Dust Deposition Standards (based on 30 day average) (mg/m^2/day)
Argentina	133	
Australia	133 (onset of loss of amenity) 333 (unacceptable in New South Wales)	
Canada Alberta: Manitoba:	179 (acceptable) 226 (maximum acceptable) 200 (maximum desirable)	
Germany		350 (maximum permissible in general areas) 650 (maximum permissible in industrial areas)
Spain	200 (acceptable)	
USA: Hawaii Kentucky New York Pennsylvania Washington Wyoming	 200 175 200 (urban, 50 percentile of monthly value) 300 (urban, 84 percentile of monthly value) 267 183 (residential areas) 366 (industrial areas) 167 (residential areas) 333 (industrial areas)	

3 Baseline Study

3.1 Study Area

The local study area for the assessment was selected based on the expected extent of air quality impacts and possible sensitive receptors such as individual homes and communities. A study area of 20 km east-west and 15 km north-south was identified. The extent of the study area, surrounding mines (SamQuarz Silica Mine and Stuart Colliery), farm houses, main roads and closest sensitive receptors relative to the opencast pit areas are shown in **Error! Reference source not found.**. Figure 3-1 also indicates the site layout as provided by the client, with the mine plan authorization area in purple, and the opencast pits (Blocks OA to OM, ODN, OWM_WTN and OWM_MN) shown as yellow hatched areas.

3.2 Sensitive Receptors

The sensitive receptors closest to the mine (numbered 1 to 7 in Figure 3-1) are the residential areas of Botleng, Mandela Village, Botleng Ext 2, Mandela Ext 2, Delmas, Delmas West and an informal settlement. The various farmsteads scattered around the project area are indicated in grey using a house symbol. The residential areas, informal settlement and individual farm houses were identified from Google Earth imagery and 1:50 000 topographic maps.

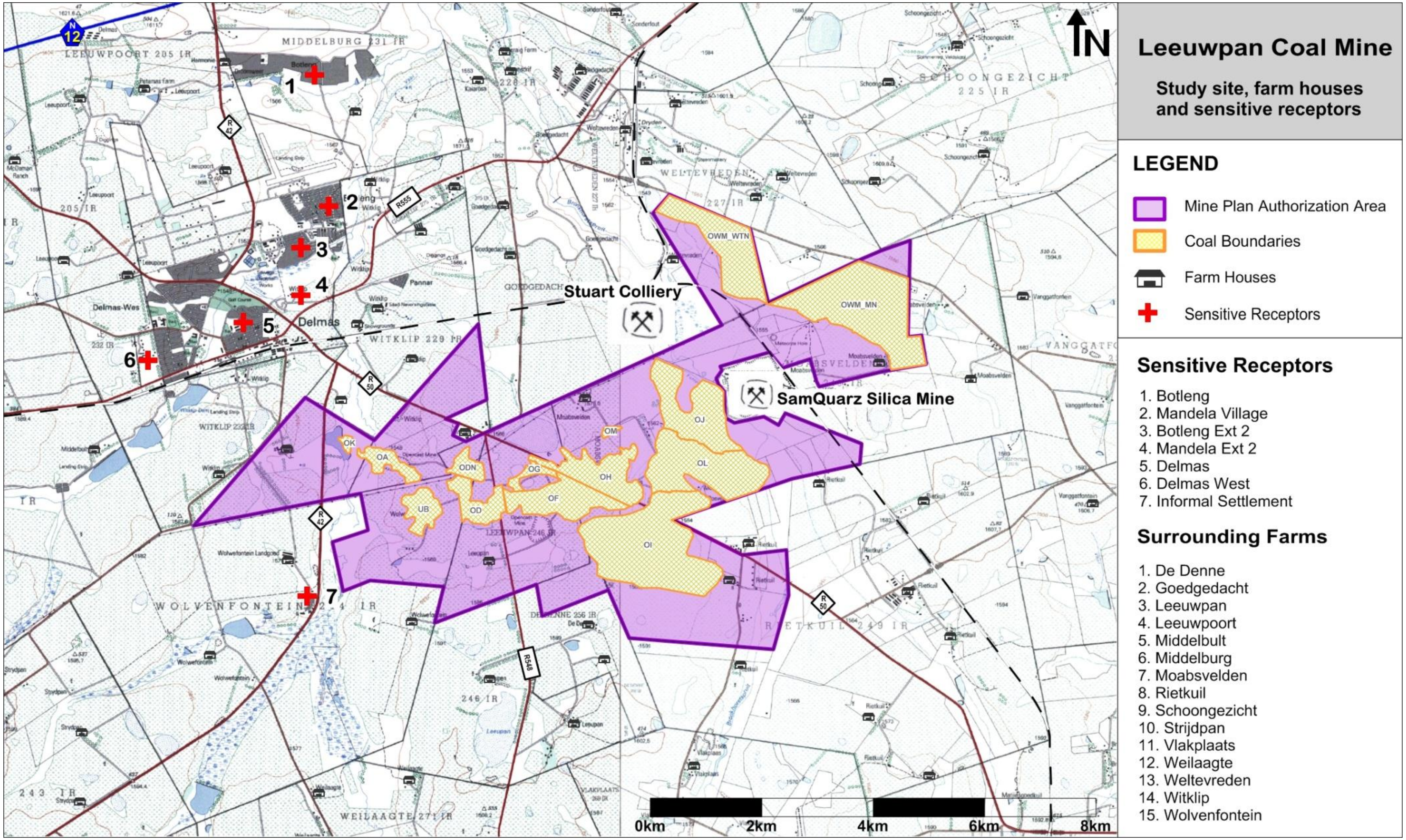


Figure 3-1: Study area, with major roads, sensitive receptors, nearby mining operations and surrounding farmhouses indicated

3.3 Atmospheric Dispersion Potential

Meteorological mechanisms govern the dispersion, transformation, and eventual removal of pollutants from the atmosphere. The analysis of hourly average meteorological data is necessary to facilitate a comprehensive understanding of the ventilation potential of the site. The vertical dispersion of pollution is largely a function of the wind field. The wind speed determines both the distance of downward transport and the rate of dilution of pollutants. The generation of mechanical turbulence is similarly a function of the wind speed, in combination with the surface roughness.

In the absence of representative measured meteorological data, reference was made to modelled MM5 data for the project area for the period January 2010 to December 2011.

3.3.1 Wind Field

Wind roses comprise 16 spokes, which represent the directions from which winds blew during a specific period. The colours used in the wind roses below, reflect the different categories of wind speeds; the red area, for example, representing winds in excess of 5 m/s. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories. The frequency with which calms occurred, i.e. periods during which the wind speed was below 1 m/s are also indicated. The period and diurnal wind flow field variability is shown in Figure 3-2. From Figure 3-2 it is apparent that the dominant wind is from the northwest to northern sector, with a strong component from the easterly sector. The wind field is characterised by dominant northerly and easterly winds. Calm conditions prevailed 13.12% during the 2010-2011 period with a period average wind speed of 3.1 m/s. Wind speeds exceeding 5 m/s occurred with a frequency of 13%. The north-westerly wind flow increases during day-time conditions with easterly wind flow increasing during the night. The seasonal wind flow field variability is shown in Figure 3-3. A distinct shift in the prevailing wind field between seasons was noted. During spring months, the strongest winds were from the northerly direction. Summer and autumn months were characterised by a higher frequency in moderate winds with a wind flow field similar to that of the period windrose. Winter months were found to be dominated by strong winds from the southeasterly and southerly sectors, with a small component from the northwest.

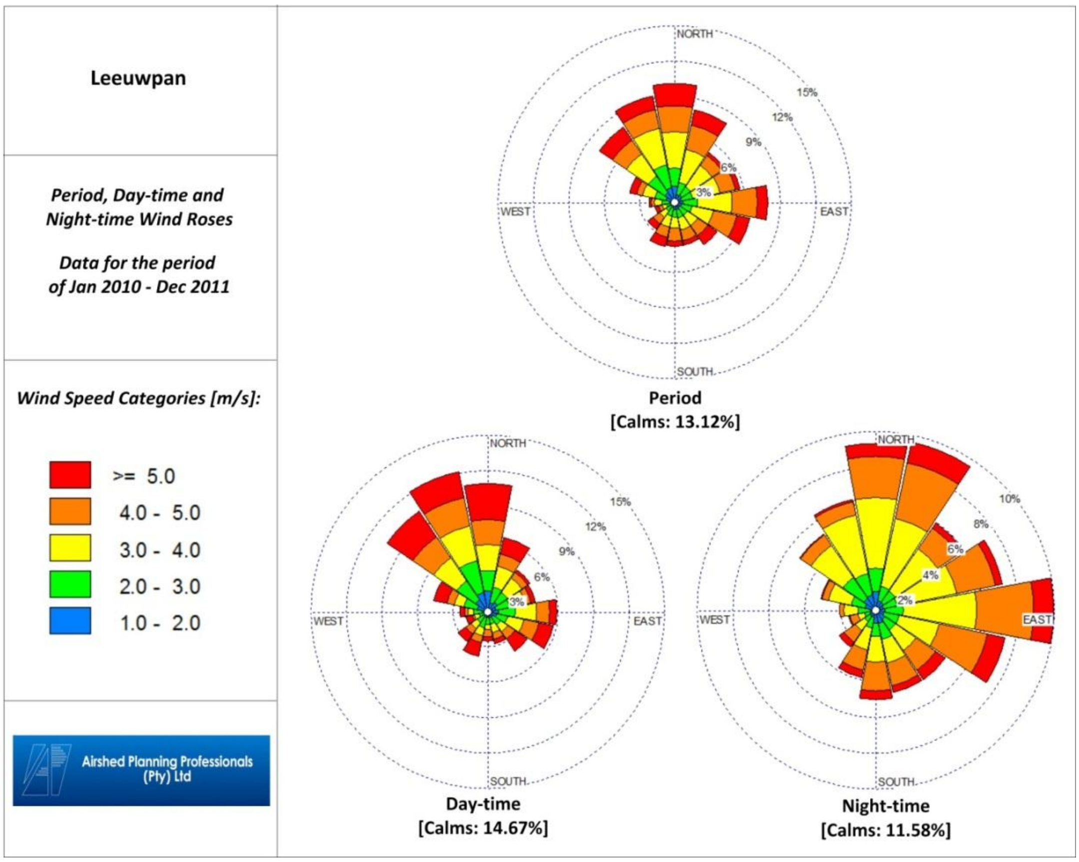


Figure 3-2: Period and diurnal wind roses (MM5 data: 2010-2011)

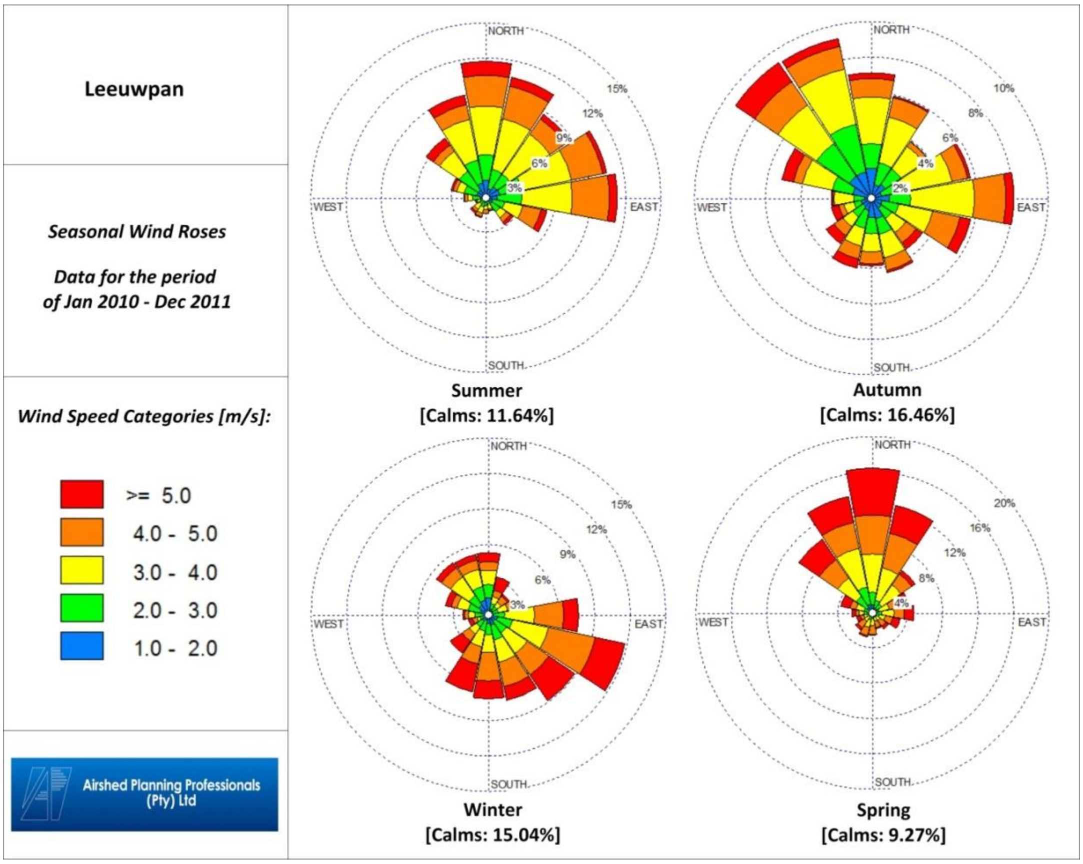


Figure 3-3: Seasonal wind roses (MM5 data: 2010-2011)

3.3.2 Temperature

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

Long-term monthly average maximum, mean and minimum temperatures for the nearest major town of Witbank are shown in Table 3-1, and long-term monthly daily maximum and minimum temperatures in Table 3-2 (Schulze, 1986). The annual maximum, minimum and mean temperatures for Witbank are given as 33°C, -0.8°C and 16°C respectively, which are in agreement with the MM5 modelled data for the study site (see Figure 3-5). Average daily maximum temperatures range from 27°C in December to 17°C in June, and daily minima from 16°C in December to 5°C in July.

Table 3-1: Long-term minimum, maximum and mean temperatures (°C) for Witbank

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Maximum	29	28	27	26	23	24	23	24	29	33	31	31
Minimum	15	13	9	5	2	-0.8	5	0.1	4	9	8	11
Mean	20	20	17	16	12	11	14	12	17	20	19	21

Table 3-2: Long-term daily minimum and maximum temperatures (°C) for Witbank

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Maximum	25	27	27	25	21	17	19	19	24	26	25	27
Minimum	15	16	14	12	8	6	5	6	10	13	15	16

The diurnal temperature profile for the site is given in Figure 3-4. The temperature profile for the site (minimum, maximum, daily minimum, daily maximum and average temperatures) is shown in Figure 3-5. From the data table in Figure 3-5 the annual mean temperature for the site may be calculated as 15.1°C. Average daily maximum temperatures range from 23.7°C in December to 11.3°C in July, with daily minima ranging from 18.8°C in January to 2.8°C in July.

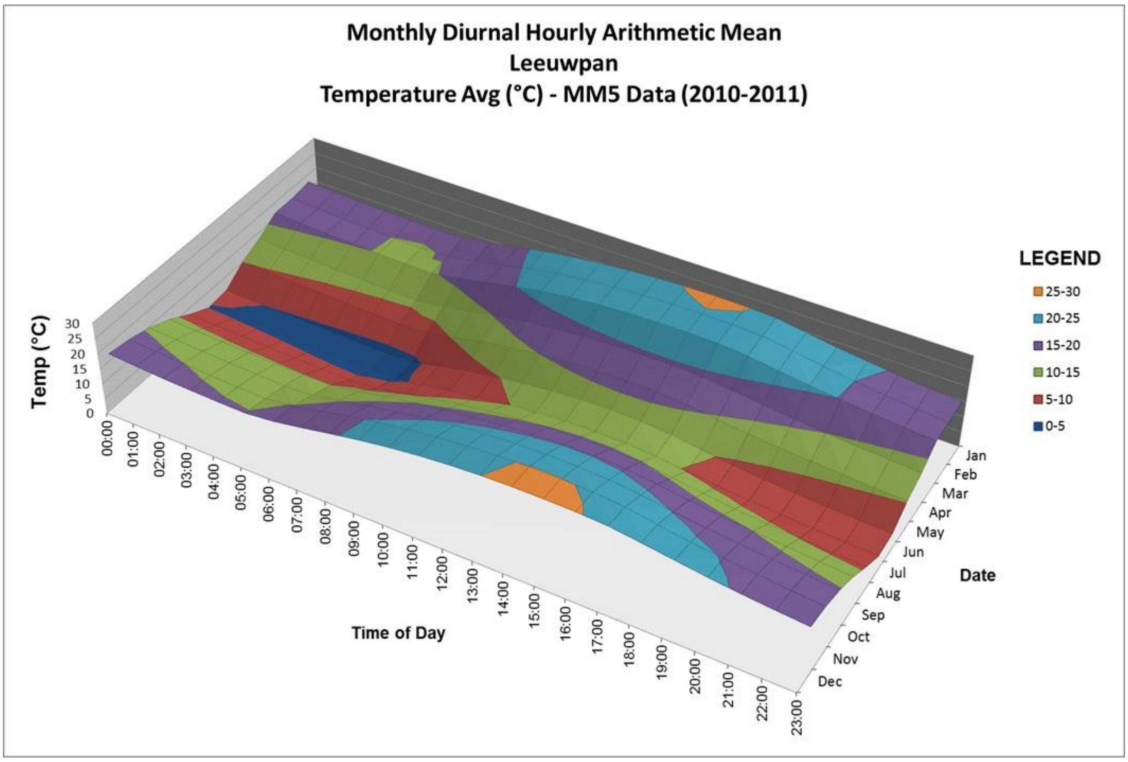
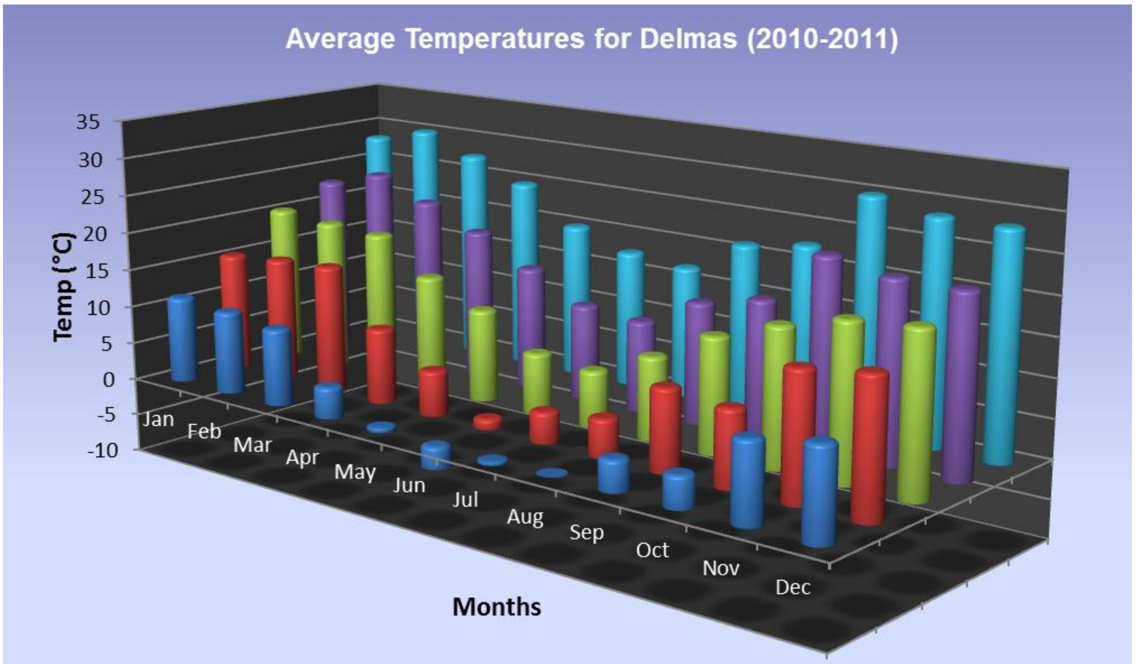


Figure 3-4: Diurnal temperature profile for the site (MM5 data: 2010-2011)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MIN	11.4	10.9	10.1	4.1	0.6	-2.9	-0.5	0	4	4.1	10.1	11.4
MIN DY	15.6	16.3	16.7	9.8	5.9	1.4	4.0	5.0	10.4	9.7	16.0	17.1
AVG	20.4	19.8	19.5	15.0	12.0	7.9	7.2	10.6	14.7	17.5	19.7	20.4
MAX DY	23.1	25.2	22.5	19.6	15.9	12.4	11.7	15.6	17.4	24.2	22.9	22.8
MAX	28.3	30.1	27.6	24.8	20.1	17.8	17.1	21.4	22.6	30.0	28.6	28.5

Figure 3-5: Average temperature profile for the site (MM5 data: 2010-2011)

3.3.3 Rainfall

Precipitation is important to air pollution studies since it represents an effective removal mechanism for atmospheric pollutants and inhibits dust generation potentials. Witbank normally receives about 625 mm of rain per year, with most rainfall occurring during summer. It receives the lowest rainfall (2 mm) in July and August, and the highest (117 mm) in January. The long-term monthly rainfall for Witbank (data sourced from worldweatheronline.com) is illustrated in Figure 3-6.

The MM5 data also includes precipitation as one of its output parameters (Figure 3-7). A comparison between the two rainfall graphs shows a similar rainfall trend; a higher average annual rainfall is evident in the Delmas graph however, and notably higher rainfall is predicted for the Delmas site during the months of January and December.

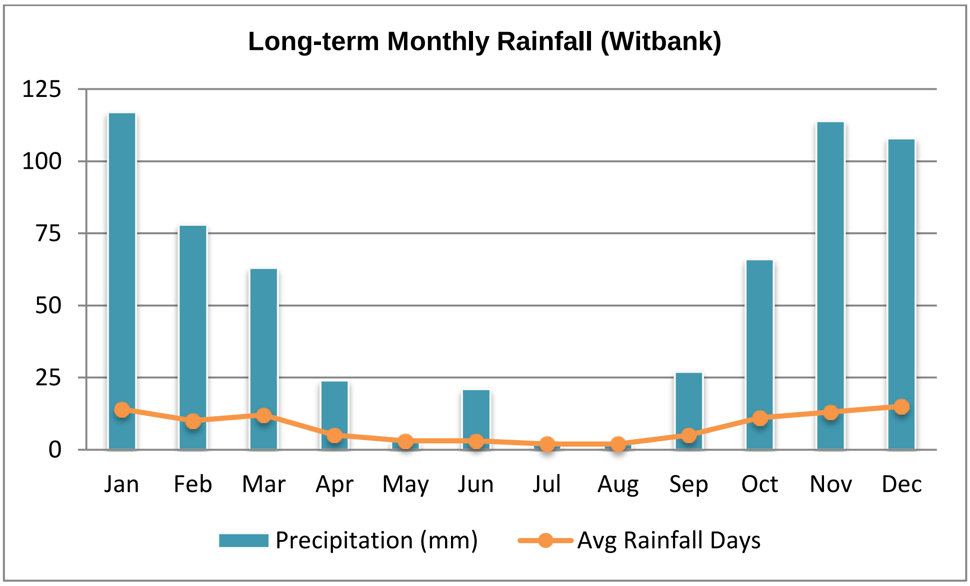


Figure 3-6: Long-term average monthly rainfall for Witbank

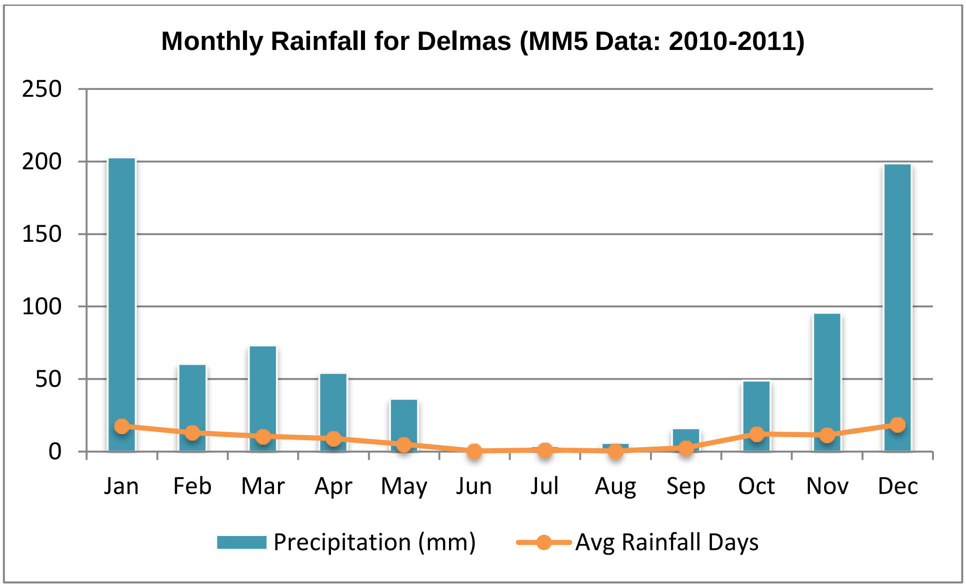


Figure 3-7: Average monthly rainfall and rainfall days for the site (2010-2011)

3.3.4 Atmospheric Stability and Mixing Depth

The atmospheric boundary layer properties are described by two parameters; the boundary layer depth and the Monin-Obukhov length.

The Monin-Obukhov length (L_{Mo}) provides a measure of the importance of buoyancy generated by the heating of the ground and mechanical mixing generated by the frictional effect of the earth's surface. Physically, it can be thought of as representing the depth of the boundary layer within which mechanical mixing is the dominant form of turbulence generation (CERC, 2004). The atmospheric boundary layer constitutes the first few hundred metres of the atmosphere. During daytime conditions, the atmospheric boundary layer is characterised by thermal turbulence due to the heating of the earth's surface. Night times are characterised by weak vertical mixing and the predominance of a stable layer. These conditions are normally associated with low wind speeds and less dilution potential.

Diurnal variation in atmospheric stability, as calculated from on-site data, and described by the inverse Monin-Obukhov length and the boundary layer depth is provided in Figure 3-8. The highest concentrations for ground level, or near-ground level releases from non-wind dependent sources would occur during weak wind speeds and stable (night-time) atmospheric conditions. For elevated releases, unstable conditions can result in intermittently very high concentrations of poorly diluted plume close to the source.

Atmospheric stability is frequently categorised into one of six stability classes. These are briefly described in Table 3-3. Calculations indicate stable, neutral and unstable conditions at the site occur 45%, 13% and 42% of the time respectively (Figure 3-9).

Table 3-3: Atmospheric stability classes

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

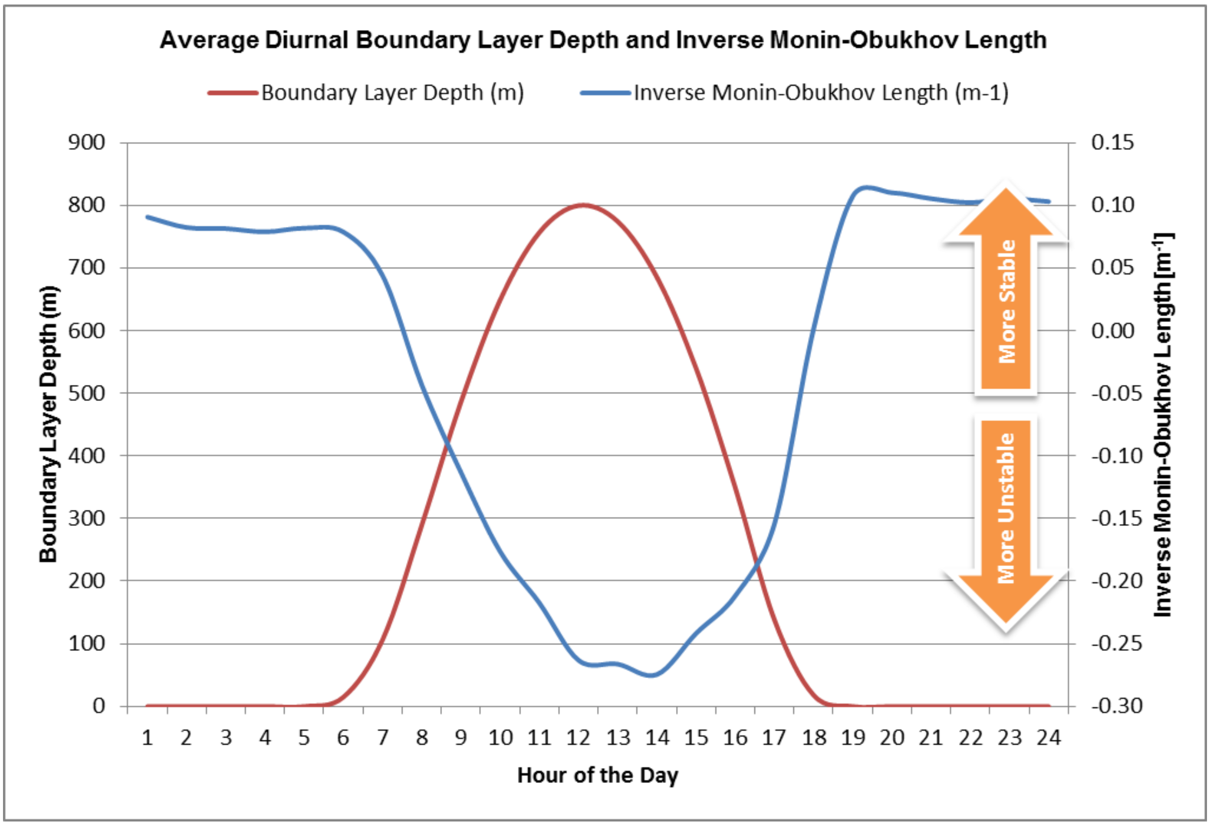


Figure 3-8: Calculated average diurnal mixing height and inverse Monin-Obukhov length

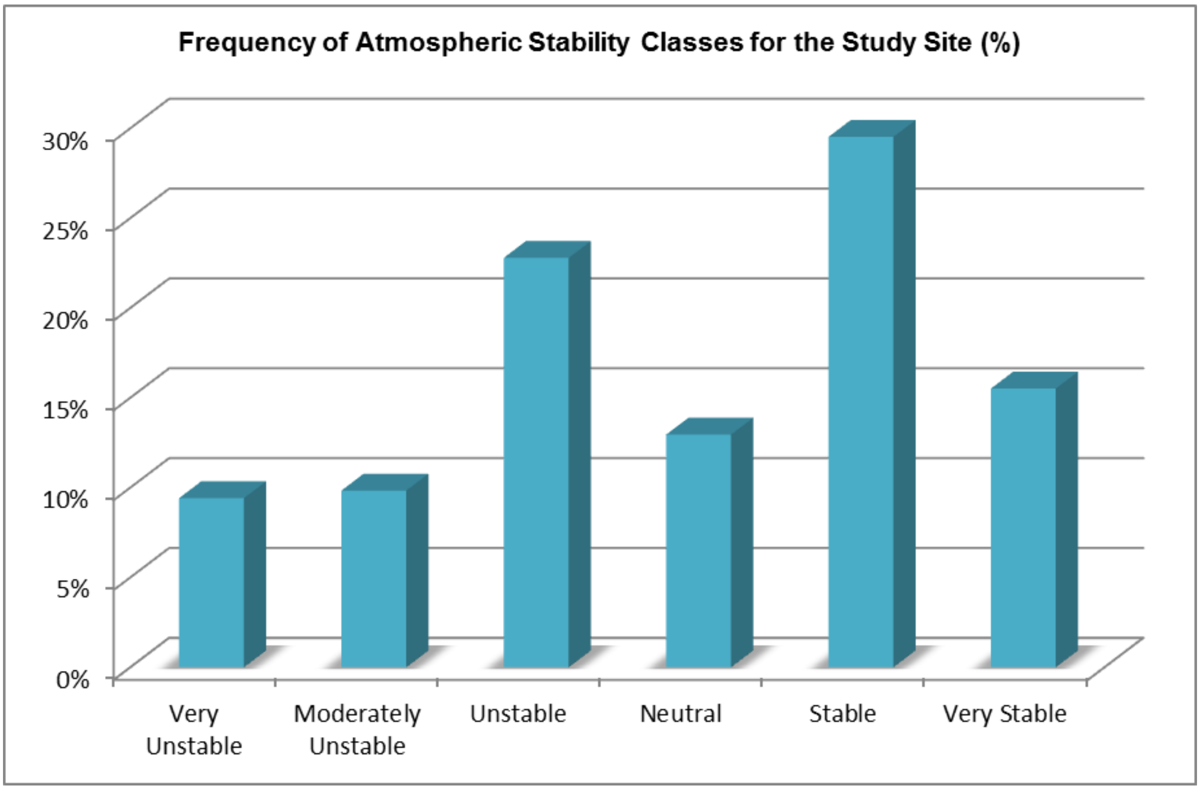


Figure 3-9: Frequency of atmospheric stability classes for the site (in %)

3.4 Existing Ambient Air Quality

The characterisation of existing air quality is crucial for assessing the potential for cumulative impacts due to the emissions from mining operations at Leeuwpan Coal Mine. The focus of this discussion is on PM_{10} as no information is yet available on ambient $PM_{2.5}$. Measured dust deposition values for monitoring stations around the Leeuwpan site are also included.

3.4.1 Inhalable particulate matter (PM_{10})

The Mpumalanga Highveld has frequently been the focus of air pollution studies for two reasons. Firstly, elevated air pollution concentrations have been noted to occur in the region itself. Secondly, various elevated sources of emissions located in this region have been associated with long-range transportation of pollutants and with the potential for impacting on the air quality of adjacent and more distant regions (Piketh, 1994). The Minister of Environmental Affairs and Tourism therefore declared the Highveld Priority Area (HPA) on 23 November 2007 (Highveld Priority Area Air Quality Baseline Assessment, 2010).

Leeuwpan Coal Mine is located in the local municipality of Delmas. According to the HPA Baseline Assessment Delmas is considered a "hotspot" area for PM_{10} (where ambient air quality is poor and where ambient PM_{10} generally exceeds air quality standards – see Figure 3-10). The air quality hotspots result mostly from a combination of emissions from industrial sectors and domestic fuel burning; other sources are motor vehicle emissions, mining and cross-boundary transport of pollutants into the HPA.

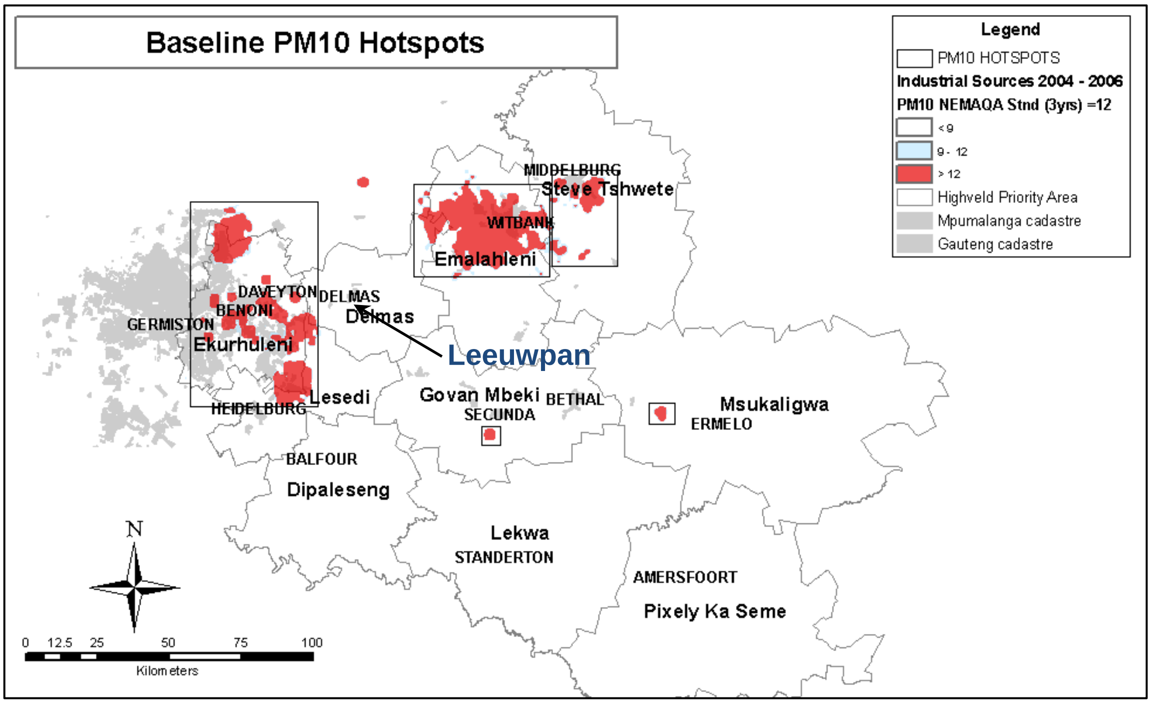


Figure 3-10: Modelled frequency of exceedance of 24-hour ambient PM_{10} standards in the HPA, indicating the air quality hot spot areas (Draft HPA AQMP, 2011)

Figure 3-10 shows that the study site does not fall within an area where more than the allowable 4 exceedances of the PM_{10} air quality standard were predicted per annum. The contribution by industries in the local municipality was found to dominate the source apportionment, showing clearly that residential fuel burning, motor vehicles and coal mining are less significant in the total air quality loading. The municipality of Delmas is still considered a hotspot area, however, because of the notable contribution of household fuel combustion to PM_{10} concentrations (Figure 3-11).

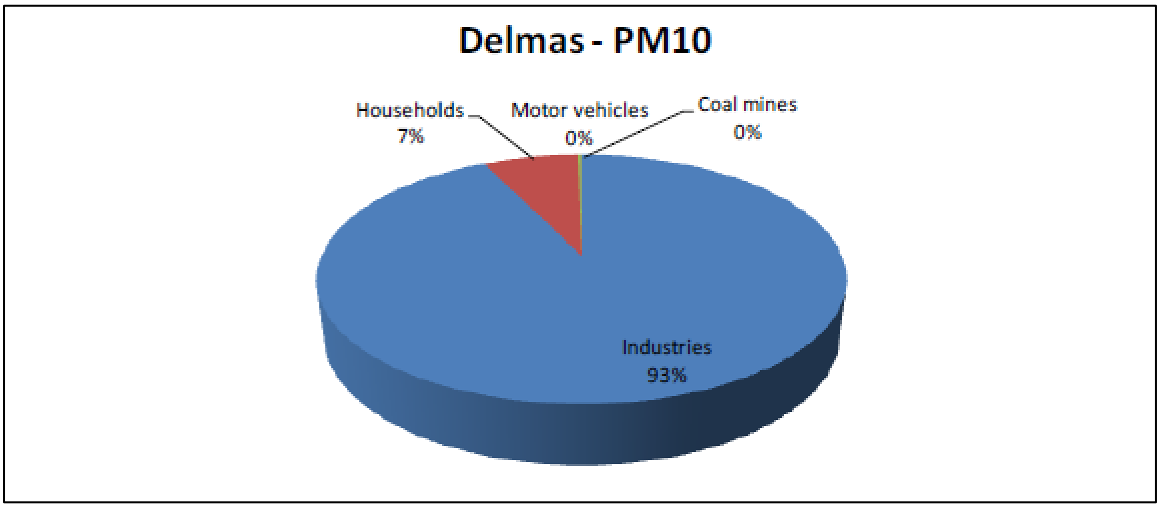


Figure 3-11: Contribution of different sources to ambient PM_{10} concentrations in the Delmas Hotspot (Draft HPA AQMP, 2011)

The above findings from the HPA baseline assessment apply to the greater Delmas region. Local source contributors to ambient PM_{10} concentrations in the vicinity of the study site are:

- domestic fuel burning and vehicle activity in residential areas (Delmas town to the northwest, Botleng and Mandela Village to the north and the informal settlement to the southwest of the mine);
- mining activities – Stuart Coal Mine and SamQuarz Silica Mine directly adjacent to Leeuwpan
- agricultural activities on the surrounding cultivated farm lands.

However, the pollutants originating at the Leeuwpan Coal Mine may also impact the air quality of surrounding areas. It is expected that vehicle entrainment will be the largest source of dust emissions at the mine (see Figure 3-12 for a breakdown of source contribution to total dust emissions from a typical South African opencast coal mine, sourced from Draft HPA AQMP Baseline Assessment, March 2010).

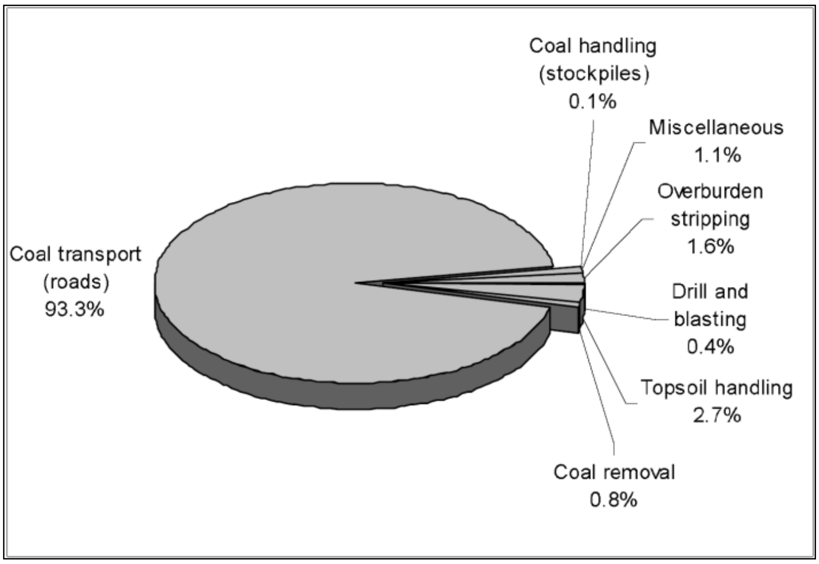


Figure 3-12: Percentage contributions to total dust emissions from a typical South African strip mine (Visser and Thompson 2001, sourced from Draft HPA AQMP Baseline Assessment, March 2010)

3.4.2 Dust deposition (fallout)

Dust deposition has been measured at a number of locations around the Leeuwpan site. The locations are indicated in Figure 3-13. The gauges at the 7 monitoring stations are directional, and because the method employed to measure dust fallout at Leeuwpan Coal Mine is not according to the ASTM 1739-98 standard measurement method, the results should be seen as an indicator rather than an actual comparison with the standards proposed in SANS 1929. For these stations, conclusions can only be drawn on the direction of the most prominent source of dust deposition impact, although the frequency of the wind from that direction also has to be taken into account.

Monthly average results for the period February/March, Apr/May and June 2012 are given in Table 3-4 and illustrated in Figure 3-14 to Figure 3-16, together with the corresponding wind roses for each period. From the wind roses it appears that the wind flow fields corresponding to each sampling period vary quite substantially from one another. For February/March the dominant wind is from the eastern sector, with wind speeds generally below 4 m/s. For April/May the wind field is characterised by winds mainly from the north-western sector, with an increase in wind speeds higher than 4 m/s. The prevailing wind field for June is from the southern sector, with a high frequency of strong winds.

The highest fallout was recorded in the February/March period for Monitoring Unit No. 2 (next to the OWM road) and the second highest for Monitoring Unit No. 4 (Becker's Farm). Fallout results for Monitoring Unit No. 7 (Moabsvelden) sharply increase in the month of June (maximum recorded at the western gauge). Soil analyses for two monthly dustwatch reports of 2011 reported that dust at Unit 2 was inundated by an immediate coal source; at Unit 4 it was composed of mainly coal fines, followed by agricultural soil dust and pulverised roadway dust; and at Unit 7 dust content comprised mainly agricultural soil dust, followed by coal fines, fine rounded quartz, topsoil and pulverized road dust.

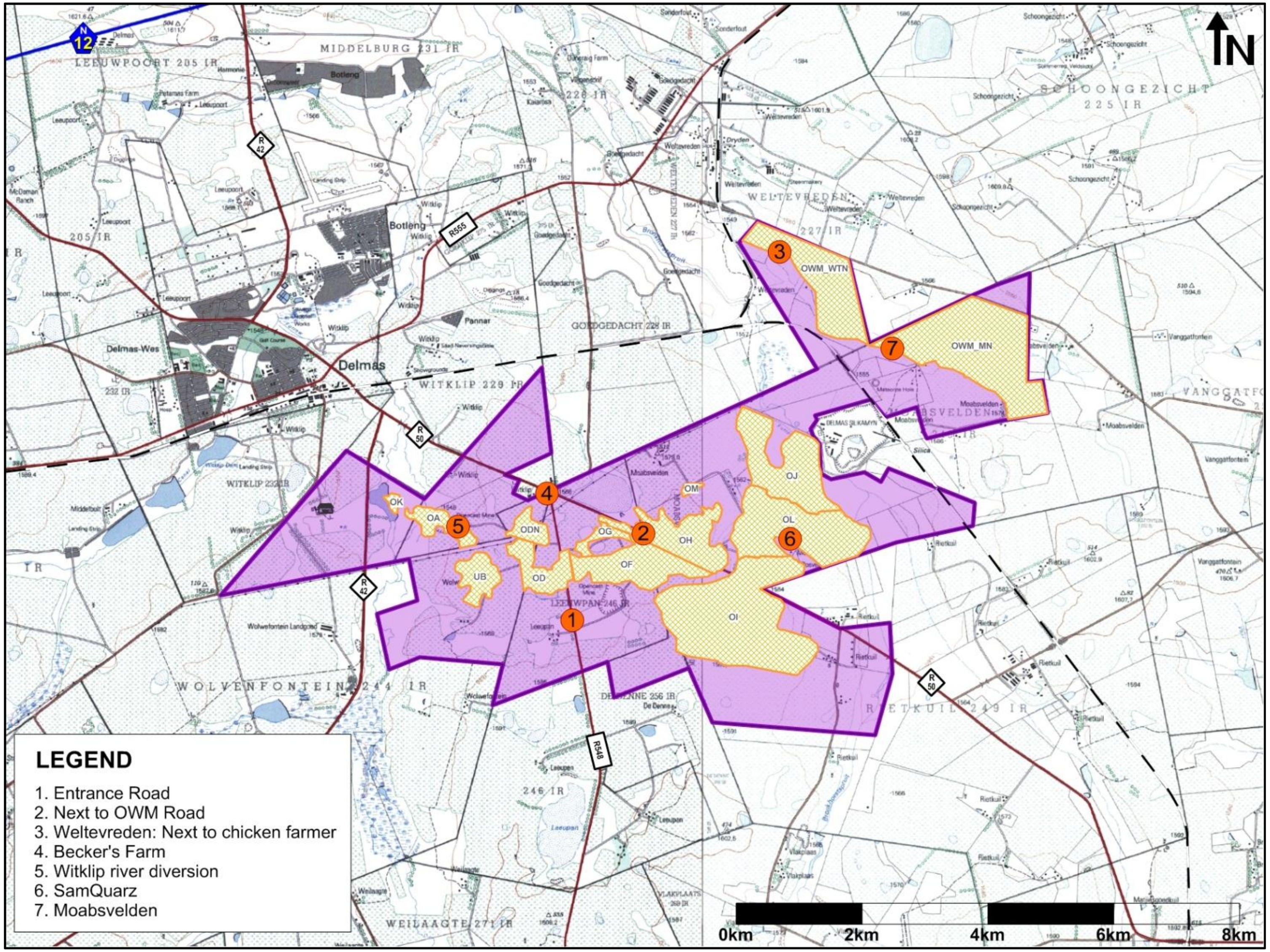


Figure 3-13: Locations of dust fallout monitoring stations

Table 3-4: Measured average deposition values (in mg/m^2/day) at Leeuwpan Coal directional monitoring stations for the periods Feb/March, Apr/May and June 2012

No	Direction	Description	Feb/Mar 2012 (mg/m²/day)	Apr/May 2012 (mg/m²/day)	June 2012 (mg/m²/day)
1	North	Entrance Road	895	846	965
1	South	Entrance Road	748	671	758
1	East	Entrance Road	730	832	869
1	West	Entrance Road	834	690	700
2	North	Next to OWM Road	3018	2941	2920
2	South	Next to OWM Road	2616	3081	2149
2	East	Next to OWM Road	3354	3222	2750
2	West	Next to OWM Road	2681	3249	1892
3	North	Weltevreden: Next to chicken farm	-	1738	-
3	South	Weltevreden: Next to chicken farm	-	1095	-
3	East	Weltevreden: Next to chicken farm	-	1353	-
3	West	Weltevreden: Next to chicken farm	-	1186	-
4	North	Becker's Farm	2259	1374	2290
4	South	Becker's Farm	2696	1123	2054
4	East	Becker's Farm	2362	1084	2512
4	West	Becker's Farm	2351	944	2200
5	North	Witklip River Diversion	924	995	1043
5	South	Witklip River Diversion	770	707	898
5	East	Witklip River Diversion	1356	558	778
5	West	Witklip River Diversion	1185	546	762
6	North	SamQuarz	825	508	675
6	South	SamQuarz	715	498	632
6	East	SamQuarz	462	518	667
6	West	SamQuarz	593	523	628
7	North	Moabsvelden	715	-	1710
7	South	Moabsvelden	383	-	1973
7	East	Moabsvelden	342	-	2124
7	West	Moabsvelden	675	-	3357

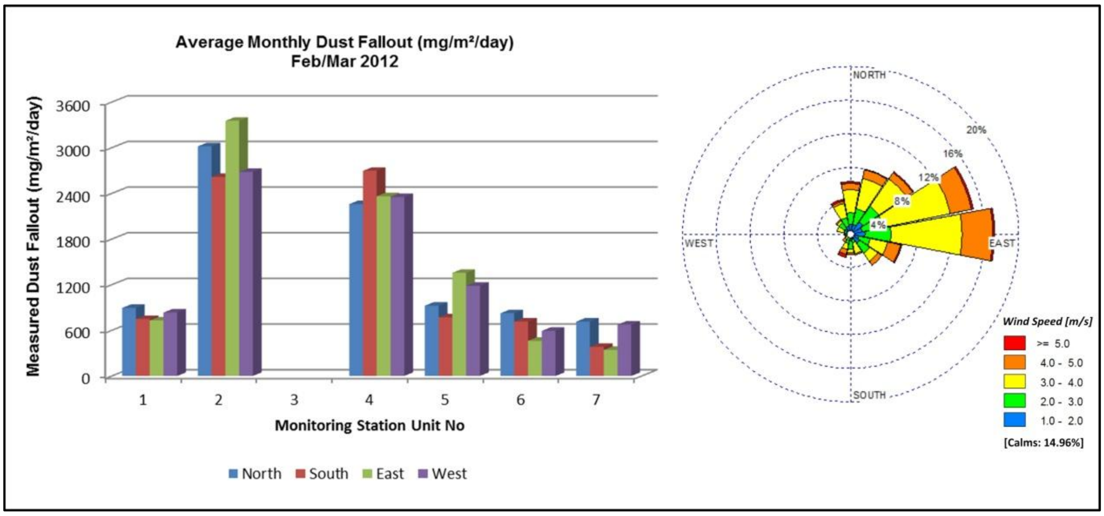


Figure 3-14: Average monthly dust fallout (mg/m²/day) and period windrose at Leeuwpan directional monitoring stations (Feb/Mar 2012)

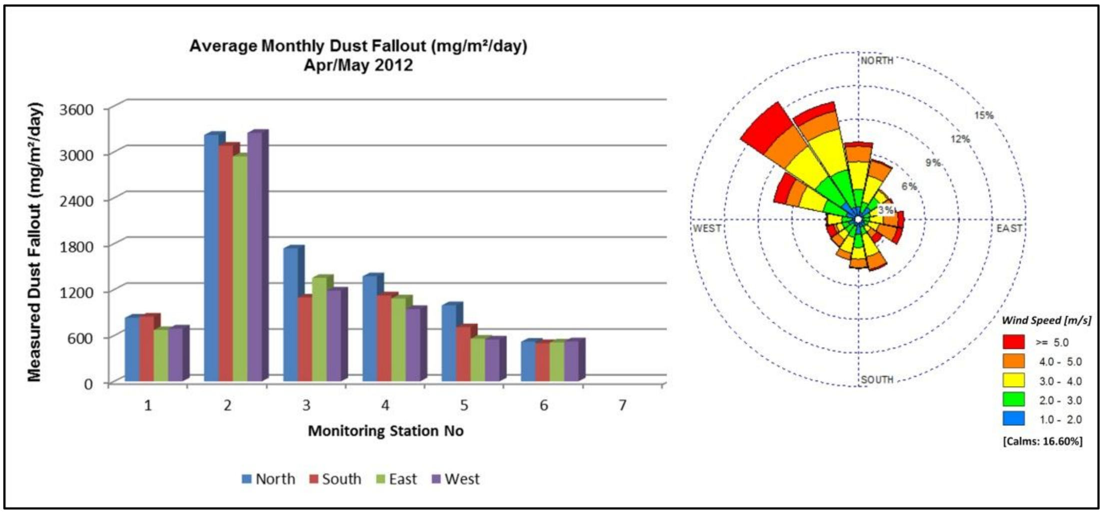


Figure 3-15: Average monthly dust fallout (mg/m²/day) and period windrose at Leeuwpan directional monitoring stations (Apr/May 2012)

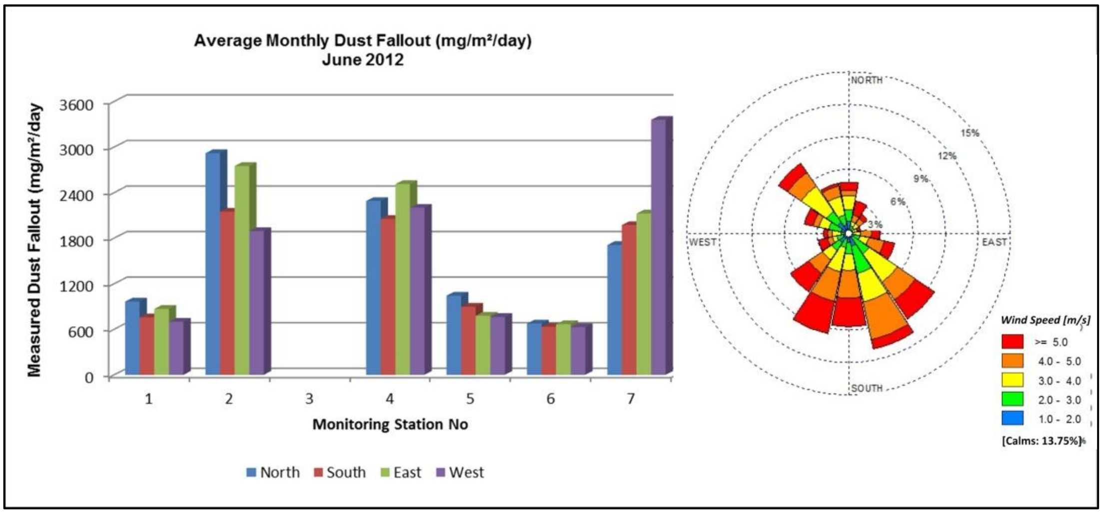


Figure 3-16: Average monthly dust fallout (mg/m²/day) and period windrose at Leeuwpan directional monitoring stations (Jun 2012)

4 Conclusions

4.1 Main Findings

The main findings of the baseline assessment were as follows:

- Airborne particulates represent the main pollutant of concern, given the nature of the proposed operations.
- The sensitive receptors were identified as the residential areas of Botleng, Botleng Ext 2, Mandela Village, Mandela Ext 2, Delmas, Delmas West and an informal settlement, as well as farm houses surrounding the project area.
- The local wind field is characterised by:
  - Northerly and north-westerly winds with a strong component from the easterly sector. The north-westerly wind flow increases during day-time conditions with easterly wind flow increasing during the night.
  - Low to moderate wind speeds with an average wind speed of 3.1 m/s.
  - Calm conditions occurring approximately 13% of the time.
- The region experiences high rainfall (between 600 – 800 mm per year), mainly from October to March. Average daily maximum temperatures range from 23.7°C in December to 11.3°C in July, with daily minima ranging from 18.8°C in January to 2.8°C in July.
- The highest concentrations for ground level, or near-ground level releases from non-wind dependent sources would occur during weak wind speeds and stable (night-time) atmospheric conditions. Calculations indicate that stable, neutral and unstable conditions at the site occur 45%, 13% and 42% of the time respectively.
- Leeuwpan Coal Mine is located in the Highveld Priority Area (HPA). According to the HPA Baseline Assessment Delmas is considered a "hotspot" area for PM_{10} (where ambient air quality is poor and where ambient PM_{10} generally exceeds air quality standards). The HPA dispersion modelling results showed that the study site does not fall within an area where more than the allowable 4 exceedances of the PM_{10} air quality standard were predicted per annum. The contribution of residential fuel burning, motor vehicles and coal mining were found to be less significant than industrial sources in the total air quality loading in the Delmas local municipality.
- The findings from the HPA baseline assessment apply to the greater Delmas region. Local source contributors to ambient PM_{10} concentrations in the vicinity of the study site are:
  - domestic fuel burning and vehicle activity in residential areas (Delmas town to the northwest, Botleng and Mandela Village to the north and the informal settlement to the southwest of the mine);
  - mining activities – Stuart Coal Mine and SamQuarz Silica Mine directly adjacent to Leeuwpan; and

    - agricultural activities on the surrounding cultivated farm lands.
- However, the pollutants originating at the Leeuwpan Coal Mine may also impact the air quality of surrounding areas. It is expected that vehicle entrainment will be the largest source of dust emissions at the mine.
- Dust deposition has been measured at a number of locations around the Leeuwpan site. The gauges at the 7 monitoring stations are directional. For these stations, conclusions can only be drawn on the direction of the most prominent source of dust deposition impact, although the frequency of the wind from that direction also has to be taken into account. Dust deposition (TSP) results for Feb/Mar 2012, Apr/May 2012 and June 2012 show that the units with the highest and second highest average monthly fallout are monitoring unit 2 (East) and monitoring unit 4 (South) located next to a haul road and a farm respectively.

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