9. AIR QUALITY

9.1. Approach

Specialist investigations conducted as part of an air quality assessment typically comprise two components, viz. a baseline study and an impact and/or compliance assessment study. The baseline study includes the review of the site-specific atmospheric dispersion potential, relevant air quality guidelines and limits and existing ambient air quality in the region. In this investigation, use was made of readily available meteorological and air quality data recorded in the study area in the characterisation of the baseline condition. The baseline study was also extended to include the consideration and qualitative evaluation of the candidate sites from an air quality impact assessment perspective.

The ambient air quality impact assessment comprises the establishment of an emissions inventory for the proposed development, the simulation of ambient air pollutant concentrations and dustfall rates occurring due to project development and operation, and the evaluation of the resultant potential for impacts and non-compliance. The comparison of predicted concentrations with ambient air quality guidelines facilitates a *preliminary* assessment of health risks.

The terms of reference of the *baseline study component* are as follows:

- Description of the synoptic climatology and meso-scale atmospheric dispersion potential based on available literature and meteorological data;
- Review of legislative and regulatory requirements pertaining to air pollution control and air quality management, specifically local and international ‘ good practice’ emission limits and air quality limits;
- Characterisation of the existing air quality including the identification of existing sources and the analysis of existing air quality monitoring data; and
- Identification of sensitive receptors in the vicinity of the proposed development sites.

9.2. Project Description

9.2.1. Proposed Technology

The proposed power station is coal-fired and will source coal from local coalfields. The planned power station is given as having a maximum installed capacity of up to 4800 MW, with the capacity being approximately half the installed capacity during the first phase. The project comprises a power plant and associated plant (terrace area) of about 700 h and associated ashing facilities (covering 500 – 1000 ha). It is estimated that approximately 7 million tpa of coal would be needed to supply the power station, and it is proposed that this coal be conveyed in from the local coalfields.

The proposed power station is a dry-cooled, pulverised fuel (PF) supercritical station with a thermal efficiency of up to 40%.

9.3. Sensitive Receptors

Given that the project will be associated with low level emissions (e.g. from mining and ashing operations) and elevated emissions (power stack stacks), the proposed project has the potential of impacting on receptors in the near and medium fields. Ward numbers 2, 3 and 4 of the Lephalale Local Municipality are the most sensitive to impacts related to atmospheric emissions. Wards 1 and 5 may also be affected depending on the spatial extent of impacts.

Residential areas in the vicinity of the proposed operations include Marapong (Ward 2) located just south of the Farm Zongezien and northeast of the existing Matimba Power Station and Onverwacht (Ward 4) and Lephalale (Ward 5) situated to the southeast and east of the existing power station respectively. Farm households are scattered through the area, with livestock farming (primarily cattle and game) representing the main agricultural landuse in the area. The closest schools and clinics include: Ellisras School, Clinic and Hospital (Ward 4), the Lekhureng Primary School (Ward 1) and Weltevrede Montoma School (Ward 5).

9.4. Atmospheric Emission Limits and Ambient Air Quality Criteria

Legislative, regulatory and 'good practice' requirements pertaining to power station and related ashing operations are outlined in this section. Such requirements include source and operational requirements including emission limits and permissible ambient air quality limits. Source and operational requirements and permissible emission concentrations for Scheduled Processes are given in the Department of Environmental Affairs and Tourism's *Guidelines for Schedule Processes*, as discussed in Section 9.4.1. Local and international 'good practice' ambient air quality guidelines and standards are presented in Section 9.4.2.

9.4.1. DEAT Permit Requirements for Scheduled Processes

Power generation processes, including the combustion of fuel for the generation of electricity for distribution to the public, are classified as Scheduled Processes (Process number 29) in the Atmospheric Pollution Prevention Act, Act 45 of 1965 (as amended)[1]. Such processes are required to obtain a registration certificate from the Chief Air Pollution Control Officer (CAPCO), who operates from the Department of Environmental Affairs and Tourism (DEAT), in order to operate.

Terms and conditions related to the operation of Scheduled Processes, the extent of emissions and the control efficiency and availability of abatement technology are typically included in the registration certificates. DEAT requirements pertaining to power generation processes, as extracted from DEAT's *Guidelines for Scheduled Processes*, are given in Appendix L. It is recognised that these requirements represent primarily an indication of the pollutants controlled and the likely extent of emissions limits, with specific registration certificate conditions having historically been the result of discussions on individual operations between the CAPCO and project proponent.

Pollutants which are controlled for include: fly-ash (particulates) with an emission concentration limit of 100 mg/Sm³ indicated, sulphur dioxide (if being required that at least 70% of the sulphur in the coal be removed or captured, and oxides of nitrogen (provision being made for the use of low-NOx burners by new plants).

The air quality impact assessment will inform the recommendation of plant-specific emission limits for the proposed power station, with the potential for impacts reflecting the prevailing meteorology, the proximity of sensitive receptors and the extent of existing air pollution.

9.4.2. Local and International Ambient Air Quality Guidelines and Standards

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

[1] The APPA is scheduled to be replaced by the National Environmental Management: Air Quality Act 39 of 2004. The new Act was signed by the President and gazetted in February 2005 but has not yet come into force. In terms of this Act power generation processes will be classified as a 'listed activity' and as such will require an 'atmospheric emissions license' in order to operate. During the transitional phase an application for a registration certificate under the APPA will be taken as an application for an atmospheric emission license under the Air Quality Act. Holders of registration certificates will be responsible for proving compliance with the requirements of such permits and for applying for atmospheric emissions licenses.

The ambient air quality guidelines and standards for pollutants relevant to the current study are presented in Tables 9.1 to 9.7. Air quality limits issued locally by South Africa and SABS (South African Bureau of Standards) are reflected in the tables together with guidelines published by the WHO (World Health Organisation), limits issued by EC (European Community) and US-EPA (United States Environmental Protection Agency) standards.

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 (PM10), 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. These draft documents were made available for public comment during the May/June 2004 period and were finalized and published during the last quarter of 2004. DEAT raised concerns regarding certain policy issues having been addressed in the documents. Although the SANS documents have been finalised, it is currently uncertain whether these standards will be adopted by DEAT. The current, primarily outdated DEAT air quality guidelines have been included in the South African Air Quality Act (National Environmental Management: Air Quality Act No.39 of 2004) (to be referred to as SA standard in the current report).

A DEAT representative recently indicated that air quality limits were being investigated as part of the DEAT's Transitional Phase project and that such limits will be published for comment in the near future. Although the threshold levels to be selected for the proposed air quality limits are not currently known it is expected that such thresholds will be more stringent than the SA standards (previously known as DEAT guidelines) and more in line with the SANS limits.

Table 9.1: South African NO_x standards.

Averaging Period	Ground Level Concentrations	
	µg/m³	**ppm**
Annual average	283	0.2
Max 24-hour average	566	0.4
Max 1-hour average	1132	0.8

Table 9.2: Air quality standards for nitrogen dioxide (NO_2).

	Annual Average		Max 24-hour Average		Max 1-hour Average	
	µg/m³	**ppm**	**µg/m³**	**ppm**	**µg/m³**	**ppm**
SA standards	96	0.05	191	0.1	382	0.2
SANS limits (5)	40	0.021	-	-	200	0.10
United States EPA	100(1)	0.053(1)	-	-	-	-
European Community	40(2)	0.021(2)	-	-	200(3)	0.10(3)
World Health Organisation	40	0.021	150	0.08	200	0.1
Canada (4)	100	0.053	-	-	400	0.20

Notes:

(1) Annual arithmetic mean.

(2) Annual limit value for the protection of human health, to be complied with by 1 January 2010.

(3) Averaging times represent the 98th percentile of averaging periods; calculated from mean values per hour or per period of less than an hour taken throughout the year; not to be exceeded more than 8 times per year. This limit is to be complied with by 1 January 2010.

(4) Acceptable Canadian air quality objectives.

(5) SABS, 2004.

Table 9.3: Ambient air quality guidelines and standards for sulphur dioxide for various countries and organisations

Averaging Period	**South Africa (SA Standard /SANS)**	**World Bank (2002)**	**World Health Organisation (1999)**	**US-EPA**	**European Community**	**United Kingdom**
	$\mu g/m^3$	**$\mu g/m^3$**	**$\mu g/m^3$**	**$\mu g/m^3$**	**$\mu g/m^3$**	**$\mu g/m^3$**
Annual Average	50(7)	50	50(3) 10-30(10)	80(1)	20(2)	
Max. 24-hour Ave	125(7)	125	125(3)	365(4)	125(5)	125(11)
Max 1-hour	-	-	350(9)	-	350(6)	350(12)
Instantaneous Peak	500(7)(8)	-	500(3)(8)	-	-	266(13)

Notes:

(1) Arithmetic mean.

(2) Limited value to protect ecosystems. Applicable two years from entry into force of the Air Quality Framework Directive 96/62/EC.

(3) Air Quality guidelines (issued by the WHO for Europe) for the protection for human health (WHO, 2000).

(4) Not to be exceeded more than 1 day per year.

(5) Limit to protect health, to be complied with by 1 January 2005 (not to be exceeded more than 3 times per calendar year).

(6) Limit to protect health, to be complied with by 1 January 2005 (not to be exceeded more than 4 times per calendar year).

(7) Recommended interim guidelines for South Africa by the DEAT (Government Gazette, 21 Dec. 2001). These thresholds are also supported by SANS (SANS, 2004).

(8) 10 minute average.

(9) WHO 1994.

(10) Represents the critical level of ecotoxic effects (issued by WHO for Europe); a range is given to account for different sensitivities of vegetation types.

(11) Not to be exceeded more than 3 times a year; to be complied with by 31 Dec 2004.

(12) Not to be exceeded more than 24 times a year, to be complied with by 31 Dec 2004.

(13) Not to be exceeded more than 35 times a year, to be complied with by 31 Dec 2005.

Table 9.4: Air quality standards for inhalable particulates (PM10)

	Maximum 24-hour Concentration (μg/m³)	Annual Average Concentration (μg/m³)
SA standards	180	60
SANS limits (9)	75	40
United States EPA	150(1)(2)	50(3)
European Union (EU)	130(4) 250(5)	80
European Community (EC)	50(6)	30(7) 20(8)
Canada	24	-

Reference: Chow and Watson, 1998; Cochran and Pielke, 1992.

Notes:

(1) Requires that the *three-year* annual average concentration be less than this limit;
(2) Not to be exceeded more than once per year;
(3) Represents the arithmetic mean;
(4) Median of daily means for the winter period (1 October to 31 March);
(5) Calculated from the 95th percentile of daily means for the year;
(6) 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.)
(7) Compliance by 1 January 2005;
(8) Compliance by 1 January 2010;
(9) SABS, 2004.

Foreign dust deposition standards issued by various countries are given in Table 9.5. 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.

Locally dust deposition is evaluated according to the criteria published by the South African Department of Environmental Affairs and Tourism (DEAT). In terms of these criteria dust deposition is classified as follows:

- SLIGHT - less than 250 mg/m2/day
- MODERATE - 250 to 500 mg/m2/day
- HEAVY - 500 to 1200 mg/m2/day
- VERY HEAVY - more than 1200 mg/m2/day

The Department of Minerals and Energy (DME) uses the uses the 1 200 mg/m^2/day threshold level as an action level. In the event that on-site dustfall exceeds this threshold, the specific causes of high dustfall should be investigated and remedial steps taken.

"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.

Table 9.5: 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)	

A perceived weakness of the current DEAT dustfall guidelines is that they are purely descriptive, without giving any guidance for action or remediation (SLIGHT, MEDIUM, HEAVY, 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 9.6. Proposed target, action and alert thresholds for ambient dust deposition are given in Table 9.7.

According to the proposed 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.

Table 9.6: Bands of dustfall rates proposed for adoption

BAND NUMBER	**BAND DESCRIPTION LABEL**	**DUST-FALL RATE (D) (mg m^{-2} day^{-1}, 30-day average)**	**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 9.7: Target, action and alert thresholds for ambient dustfall

LEVEL	**DUST-FALL RATE (D) (mg m^{-2} day^{-1}, 30-day average)**	**AVERAGING PERIOD**	**PERMITTED FREQUENCY OF EXCEEDANCES**
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.

9.5. Climatology and Atmospheric Dispersion Potential

Meteorological mechanisms govern the dispersion, transformation and eventual removal of pollutants from the atmosphere (Pasquill and Smith, 1983; Godish, 1990). The extent to which pollution will accumulate or disperse in the atmosphere is dependent on the degree of thermal and mechanical turbulence within the earth's boundary layer. Dispersion comprises vertical and horizontal components of motion. The vertical component is defined by the stability of the atmosphere and the depth of the surface mixing layer. The horizontal dispersion of pollution in the boundary layer is primarily a function of the wind field. The wind speed determines both the distance of downwind transport and the rate of dilution as a result of plume 'stretching'. The generation of mechanical turbulence is similarly a function of the wind speed, in combination with the surface roughness. The wind direction, and the variability in wind direction, determine the general path pollutants will follow, and the extent of cross-wind spreading (Shaw and Munn, 1971; Pasquill and Smith, 1983; Oke, 1990).

Pollution concentration levels therefore fluctuate in response to changes in atmospheric stability, to concurrent variations in the mixing depth, and to shifts in the wind field. Spatial variations, and diurnal and seasonal changes, in the wind field and stability regime are functions of atmospheric processes operating at various temporal and spatial scales (Goldreich and Tyson, 1988). Atmospheric processes at macro- and meso-scales need therefore be taken into account in order to accurately parameterise the atmospheric dispersion potential of a particular area.

A qualitative description of the synoptic systems determining the macro-ventilation potential of the proposed development site is provided in Section 9.5.1 based on the review of pertinent literature and on the analysis of meteorological data observed for the region. The meso-scale wind field and ventilation potential is characterised (Section 9.5.2) based on the analysis of surface meteorological data from stations located in the area including:

- South African Weather Services (SAWS) station at Ellisras
- Eskom's monitoring sites, viz. Zwartwater, Grootstryd and Waterberg

Upper air meteorological data generated by the SAWS using the ETA model were also purchased for a point in the region to provide the required input data for the atmospheric dispersion modelling to be conducted during the air quality impact assessment component of the project. The data availability for the surface and upper are data used / to be used in the current study is given in Table 9.8.

Table 9.8: Data availability for surface and upper air meteorological data for the period 2001 to 2003.

Data	Station	Period		
		2001	2002	2003
Surface data	Ellisras	100%	100 %	100 %
	Zwartwater(1)	64%	90 %	69%
	Grootstryd(2)	0 %	0 %	100 %
Upper air data	ETA	100 %	42 %	76%

Notes:
The Zwartwater monitoring station was decommissioned in October 2003.
The Grootstryd monitoring station was started in October 2003.

Windfield data were also obtained for the Waterberg station which was operated by Eskom during the 1984 to 1989 period at a site located ~18 km south of Matimba Power Station. These data were primarily used in the analysis of the air pollutant concentrations recorded at this station and will not be input into the dispersion model. Windfield data availability for this station was in the order of 70%.

9.5.1. Synoptic Climatology and Regional Atmospheric Dispersion Potential

- *Synoptic Climatology*

Situated in the subtropical high pressure belt, southern Africa is influenced by several high pressure cells, in addition to various circulation systems prevailing in the adjacent tropical and temperature latitudes. The mean circulation of the atmosphere over southern Africa is anticyclonic throughout the year (except near the surface) due to the dominance of three high pressure cells, viz. the South Atlantic HP off the west coast, the South Indian HP off the east coast, and the continental HP over the interior.

The five major synoptic circulation types affecting southern Africa are: continental anticyclone, ridging anticyclone, topical easterly disturbances, westerly waves and troughs and cut-off lows (Vowinckel, 1956; Schulze, 1965; Taljaard, 1972; Preston-Whyte and Tyson, 1988). The most important of these is the semi-permanent, subtropical continental anticyclones which are shown by both Vowinckel (1956) and Tyson (1986) to dominate 70 % of the time during winter and 20 % of the time in summer. This leads to the establishment of extremely stable atmospheric conditions which can persist at various levels in the atmosphere for long periods.

Seasonal variations in the position and intensity of the HP cells determine the extent to which the tropical easterlies and the circumpolar westerlies impact on the atmosphere over the subcontinent. The tropical easterlies, and the occurrence of easterly waves and lows, affect most of southern Africa throughout the year. In winter, the high pressure belt intensifies and moves northward, the upper level circumpolar westerlies expand and displace the upper tropical easterlies equatorward. The winter weather of South Africa is, therefore, largely dominated by perturbations in the westerly circulation. Such perturbations take the form of a succession of cyclones or anticyclones moving eastwards around the coast or across the country. During summer months, the anticyclonic belt weakens and shifts southwards, allowing the tropical easterly flow to resume its influence over South Africa. A weak heat low characterises the near surface summer circulation over the interior, replacing the strongly anticyclonic winter-time circulation (Schulze, 1986; Preston-Whyte and Tyson, 1988).

Anticyclones situated over the subcontinent are associated with convergence in the upper levels of the troposphere, strong subsidence throughout the troposphere, and divergence in the near-surface wind field. Subsidence inversions, fine conditions with little or no rainfall, and light variable winds occur as a result of such widespread anticyclonic subsidence. Anticyclones occur most frequently over the interior during winter months, with a maximum frequency of occurrence of 79 percent in June and July. During December such anticyclones only occur 11 percent of the time. Although widespread subsidence dominates the winter months, weather occurs as a result of uplift produced by localized systems.

Tropical easterly waves give rise to surface convergence and upper air (500 hPa) divergence to the east of the wave resulting in strong uplift, instability and the potential for precipitation. To the west of the wave, surface divergence and upper-level convergence produces subsidence, and consequently fine clear conditions with no precipitation. Easterly lows are usually deeper systems than are easterly waves, with upper-level divergence to the east of the low occurring at higher levels resulting in strong uplift through the 500 hPa level and the occurrence of copious rains. Easterly waves and lows occur almost exclusively during summer months, and are largely responsible for the summer rainfall pattern and the northerly wind component which occurs over the interior.

Westerly waves are characterised by concomitant surface convergence and upper-level divergence which produce sustained uplift, cloud and the potential for precipitation to the rear of the trough. Cold fronts are associated with westerly waves and occur predominantly during winter when the amplitude of such disturbances is greatest. Low-level convergence in the southerly airflow occurs to the rear of the front producing favourable conditions for convection. Airflow ahead of the front has a distinct northerly component, and stable and generally cloud-free conditions prevail as a result of subsidence and low-level divergence. The passage of a cold front is therefore characterised by distinctive cloud bands and pronounced variations in wind direction, wind speeds, temperature, humidity, and surface pressure. Following the passage of the cold front the northerly wind is replaced by winds with a distinct southerly component. Temperature decrease immediately after the passage of the front, with minimum temperatures being experienced on the first morning after the cloud associated with the front clears. Strong radiational cooling due to the absence of cloud cover, and the advection of cold southerly air combining to produce the lowest temperatures.

- *Regional Atmospheric Dispersion Potential*

The impact of various synoptic systems and weather disturbances on the dispersion potential of the atmosphere largely depends on the effect of such systems on the height and persistence of elevated inversions. Elevated inversions suppress the diffusion and vertical dispersion of pollutants by reducing the height to which such pollutants are able to mix, and consequently result in the concentration of pollutants below their bases. Such inversions therefore play an important role in controlling the long-range transport, and recirculation of pollution.

Subsidence inversions, which represent the predominant type of elevated inversion occurring over South Africa, result from the large-scale anticyclonic activity which dominates the synoptic circulation of the subcontinent. Subsiding air warms adiabatically to temperatures in excess of those in the mixed boundary layer. The interface between the subsiding air and the mixed boundary layer is thus characterised by a marked elevated inversion. Protracted periods of anticyclonic weather, such as characterize the plateau during winter, result in subsidence inversions which are persistent in time, and continuous over considerable distances. The fairly constant afternoon mixing depths, with little diurnal variation, associated with the persistence of subsidence inversions, are believed to greatly reduce the dispersion potential of the atmosphere over the plateau, resulting in the accumulation of pollutants over the region.

Multiple elevated inversions occur in the middle to upper troposphere as a result of large-scale anticyclonic subsidence. The mean annual height and depth of such absolutely stable layers are illustrated in Figure 9.1. Three distinct elevated inversions, situated at altitudes of approximately 700 hPa (~3 km), 500 hPa (~5 km) and 300 hPa (~7 km), were identified over southern Africa. The height and persistence of such elevated inversions vary with latitudinal and longitudinal position. During winter months the first elevated inversion is located at an altitude of around 3 km over the plateau.

In summer this inversion is known to increase in to 4 to 5 km over the plateau (Diab, 1975; Cosijn, 1996).

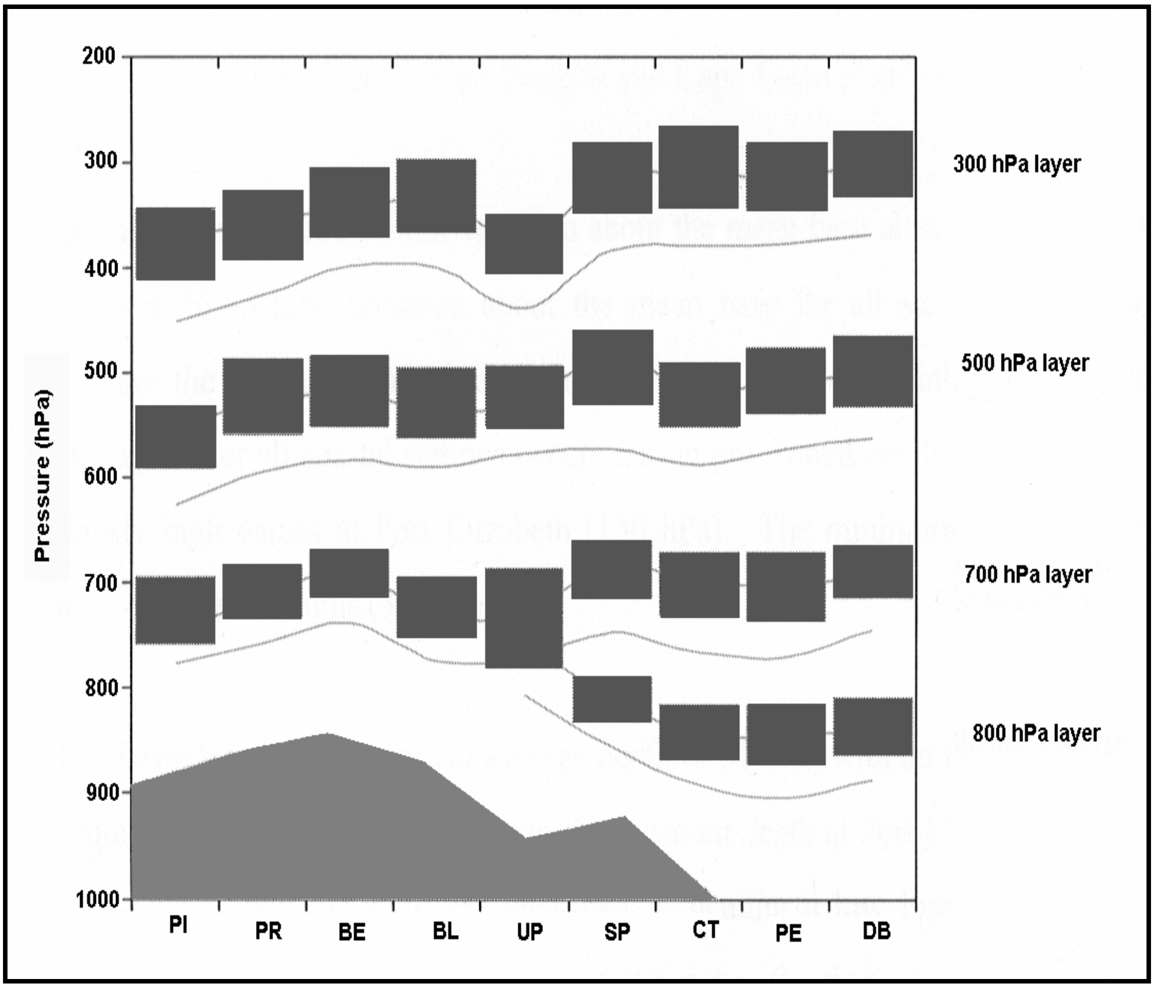

Figure 9.1: Mean annual stable layers (shaded) over Pietersburg (PI), Pretoria (PR), Bethlehem (BE), Bloemfontein (BL), Upington (UP), Springbok (SP), Cape Town (CT), Port Elizabeth (PE) and Durban DB). Upper and lower 95% confidence limits for the base heights of the layers are shown in each case (after Cosijn, 1996).

In contrast to anticyclonic circulation, convective activity associated with westerly and easterly wave disturbances hinders the formation of inversions. Cyclonic disturbances, which are associated with strong winds and upward vertical air motion, either destroy, weaken, or increase the altitude of, elevated inversions. Although cyclonic disturbances are generally associated with the dissipation of inversions, pre-frontal conditions tend to lower the base of the elevated inversion, so reducing the mixing depth. Pre-frontal conditions are also characterised by relatively calm winds. Over the interior due to the passage of a cold front, there is a tendency for the lowest mixing depths to coincide with the coldest air temperatures and rising pressure. Following the passage of the front, a gradual rise in the mixing depth occurs over the interior (Cosijn, 1996; Preston-Whyte and Tyson, 1988).

9.5.2. Meso-scale Atmospheric Dispersion Potential

- *Meso-Scale Wind Field*

Annual and seasonal wind roses generated based on measured data from the Ellisras Weather Service Station are illustrated in Figure 9.2 and Figure 9.3 respectively.

Wind roses represent wind frequencies for the 16 cardinal wind directions. Wind frequencies are indicated by the length of the shaft when compared to the circles drawn to represent a 5% frequency of occurrence. Wind speed classes are assigned to illustrate the frequencies of high and low wind for each wind vector. The frequency of calm periods, defined as periods for which wind speeds are below 1 m/s, are indicated in the centre of the wind rose.

The wind regime of the study area largely reflects the synoptic scale circulation. The flow field is dominated by northeasterly winds as may be expected due to the continental high pressure, which persists over the region, in combination with the tropical easterly systems which influence the flow field during much of the year. Winds are infrequently experienced from the westerly and southeasterly sector for all three periods analysed. The wind speeds are generally low throughout the period (1-3 m/s).

Although the northeasterly winds dominate for all four seasons the frequency of occurrence of these winds vary. During winter, the percentage of northeasterly winds decreases due to the northward shift of the high-pressure belt. East-northeasterly and northeasterly winds increase in frequency during summer months, with the continental high pressure and tropical easterlies having resumed their influence over the region.

Period average and day- and night-time wind roses for the Waterberg station are illustrated in Figure 9.4. This station is located within a WSW – ENE orientated valley. The influence of slope and valley flows are clearly evident with the easterly component being stronger than is typical of the regional windfield. The west-southwesterly airflow recorded at this site similarly represents a deviation from the regional wind regime. This flow component is predominantly associated with katabatic airflow down the valley during the night-time. A higher incidence of calm conditions was measured to occur at Waterberg when compared to Ellisras.

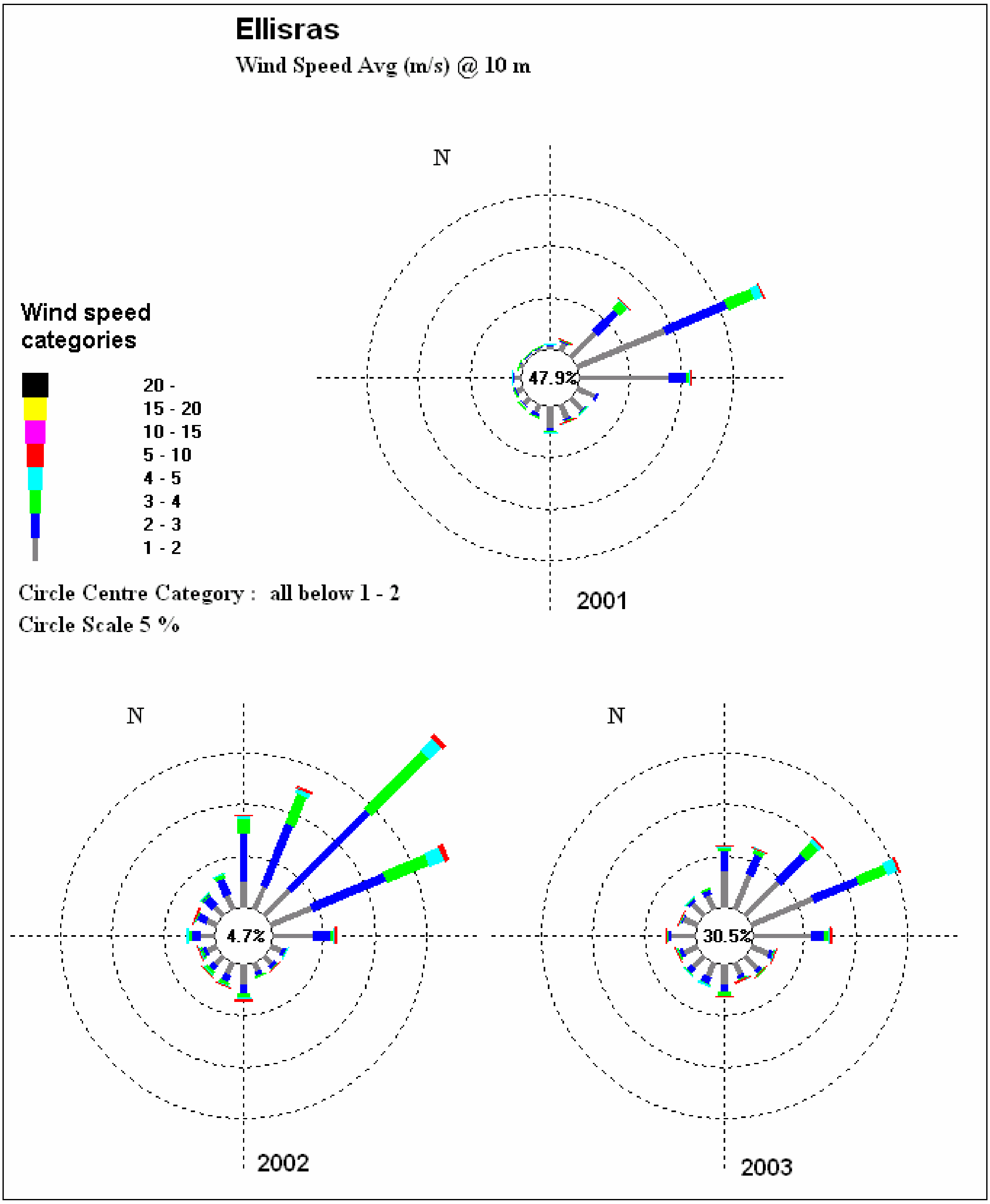

Figure 9.2: Annual average wind roses for the Ellisras Weather Service Station.

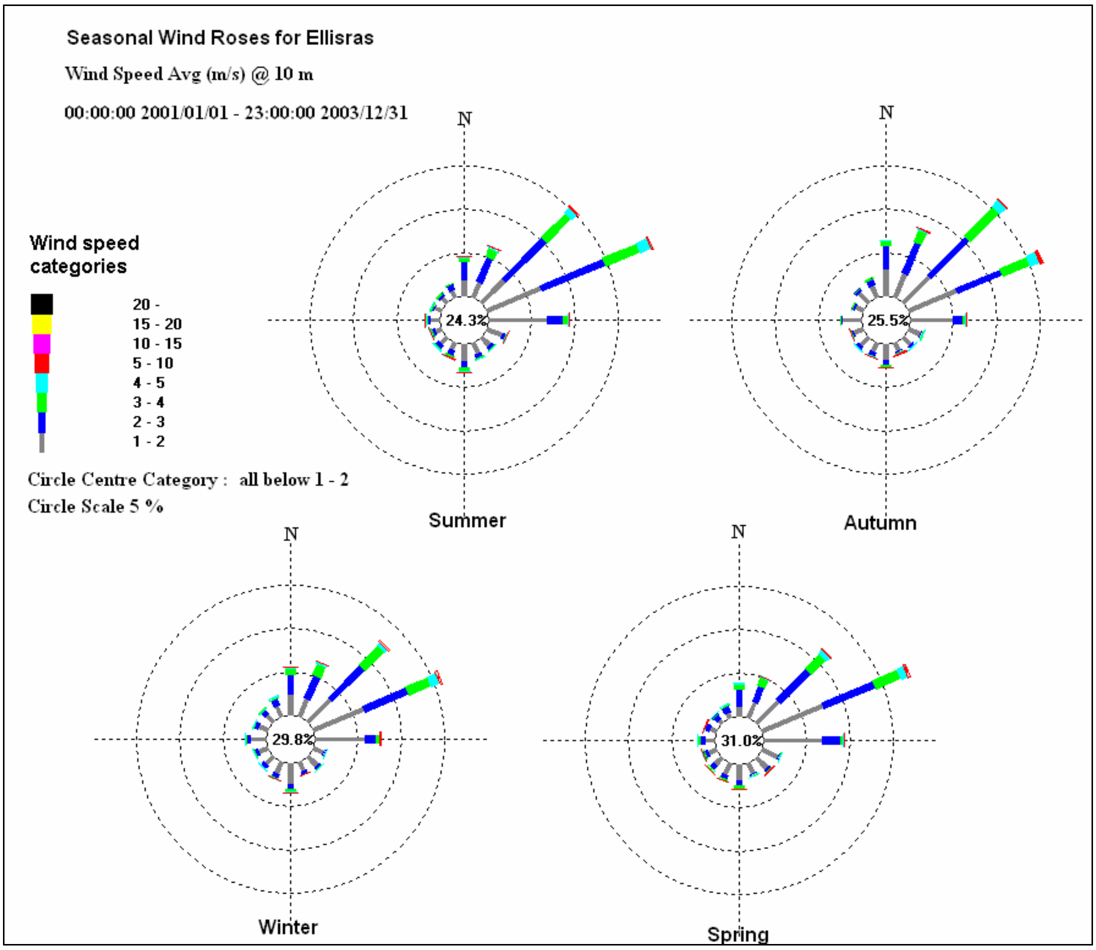

Figure 9.3: Seasonal-average wind roses for the Ellisras Weather Service Station for the period 2001 to 2003**.**

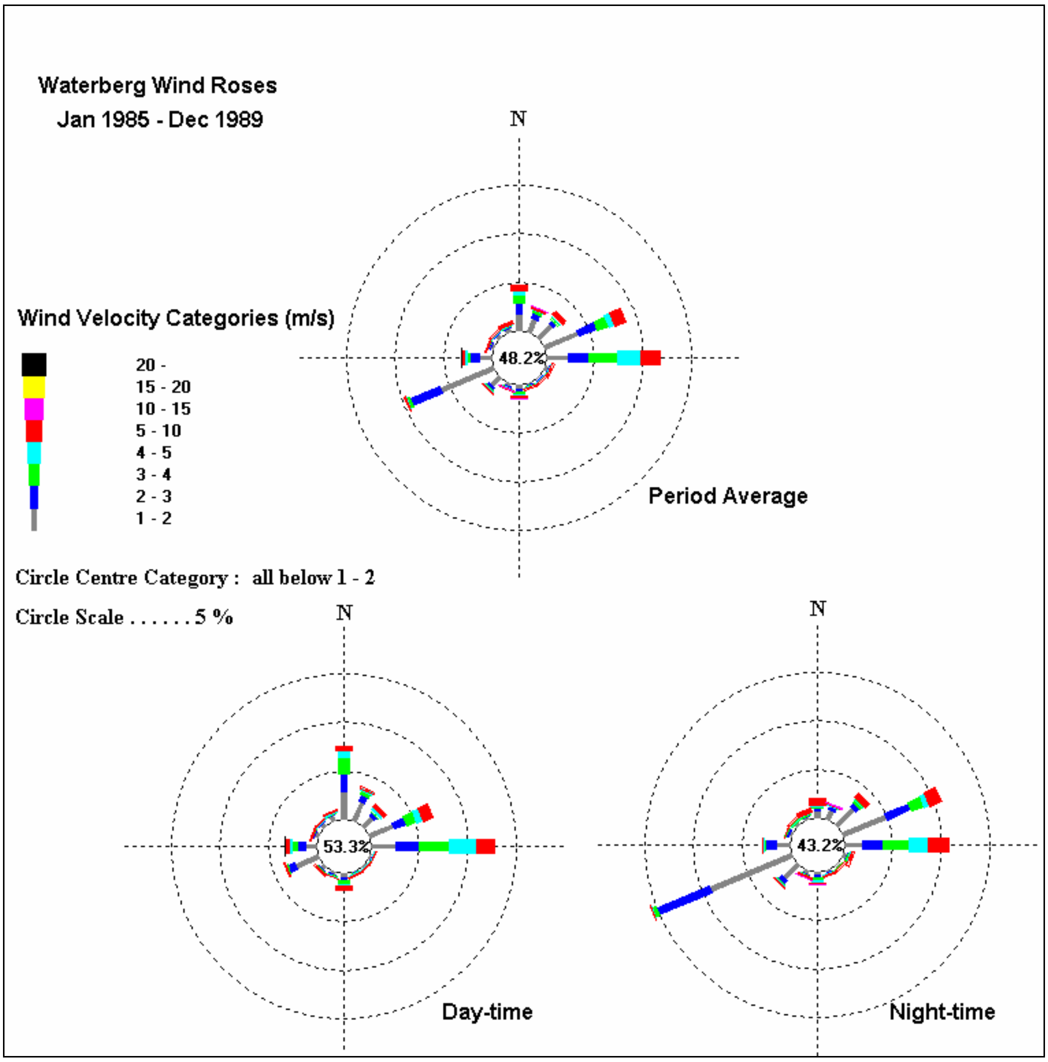

Figure 9.4: Period-average and daytime and night-time wind roses for the Waterberg Station for the period 1985 to 1989.

- *Atmospheric Stability and Mixing Depth*

The atmospheric boundary layer constitutes the first few hundred metres of the atmosphere. This layer is directly affected by the earth's surface, either through the retardation of flow due to the frictional drag of the earth's surface, or as result of the heat and moisture exchanges that take place at the surface. During the daytime, the atmospheric boundary layer is characterised by thermal turbulence due to the heating of the earth's surface and the extension of the mixing layer to the lowest elevated inversion. Radiative flux divergence during the night usually results in the establishment of ground-based inversions and the erosion of the mixing layer. Nighttimes are characterised by weak vertical mixing and the predominance of a stable layer. These conditions are normally associated with low wind speeds, hence less dilution potential.

The mixed layer ranges in depth from a few metres (i.e. a stable or neutral layers) during nighttimes to the base of the lowest-level elevated inversion during unstable, daytime conditions. Elevated inversions may occur for a variety of reasons, and on some occasions as many as five may occur in the first 1000 m above the surface. The lowest-level elevated inversion is located at a mean height above ground of 1 550 m during winter months with a 78 % frequency of occurrence. By contrast, the mean summer subsidence inversion occurs at 2 600 m with a 40% frequency.

Atmospheric stability is frequently categorised into one of six stability classes. These are briefly described in Table 9.9.

Table 9.9: Atmospheric stability classes

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

The atmospheric boundary layer is normally unstable during the day as a result of the turbulence due to the sun's heating effect on the earth's surface. The thickness of this mixing layer depends predominantly on the extent of solar radiation, growing gradually from sunrise to reach a maximum at about 5-6 hours after sunrise. This situation is more pronounced during the winter months due to strong night-time inversions and a slower developing mixing layer. During the night a stable layer, with limited vertical mixing, exists. During windy and/or cloudy conditions, the atmosphere is normally neutral.

For elevated releases, the highest ground level concentrations would occur during unstable, daytime conditions. In contrast, the highest concentrations for ground level non-wind dependent releases would occur during weak wind speeds and stable (night-time) atmospheric conditions.

9.6. Existing Sources of Emission and Baseline Air Quality

The identification of existing sources of emission in the region and the characterisation of existing ambient pollutant concentrations is fundamental to the assessment of the potential for cumulative impacts and synergistic effects. Existing sources of emissions are briefly discussed in Section 9.6.1. Air pollution monitoring measurements undertaken in the region are primarily limited to the measurement of key criteria pollutants by Eskom (Section 9.6.2).

9.6.1. Existing Sources of Atmospheric Emission

A comprehensive emissions inventory has not been completed for the region to date. The establishment of such an inventory is not within the scope of the current study. Instead source types present in the area and the pollutants associated with such source types are noted with the aim of identifying pollutants that may be of importance in terms of cumulative impact potentials.

Existing sources of atmospheric emission which occur in the vicinity of the proposed development sites include:

- existing Matimba Power Station and its associated ash dump,
- Grootegeluk coal mining operations
- potential veld fires
- sewage works (Farm Nelsonskop)
- wind blown dust from open areas and agricultural activities
- household fuel combustion
- vehicle exhaust releases and road dust entrainment along paved and unpaved roads in the area

During the air quality impact assessment stack emissions from the existing Matimba Power Station will be simulated together with the proposed power station in order to determine resultant cumulative concentrations of key pollutants such as sulphur dioxide and nitrogen dioxide.

- *Existing Matimba Power Station*

  Air pollutants released by coal-fired power stations primarily include particulates, sulphur dioxide (SO_2), nitrogen oxides (NO_x) – primarily as nitric oxide (NO) with smaller quantities of nitrogen dioxide (NO_2), carbon monoxide, carbon dioxide (CO_2), nitrous oxide (N_2O), and trace amounts of mercury. CO_2 and N_2O represent greenhouse gases (i.e. gases associated with global warming) and are therefore of concern despite not resulting in direct health effects. Air pollutants associated with health effects include SO_2, NO_x (primarily as NO_2) and particulates. South African coals have relatively high ash contents and therefore hold the potential for releasing significant particulate emissions. Eskom however currently implements highly effective particulate abatement technology which reduces its particulate emission concentrations substantially (> 99%). No SO_2 or NO_2 abatement measures are currently in place at the existing Matimba Power Station.

* Current Matimba Power Station Emissions
  The current Matimba Power Station has a capacity of 4080 MW. The main source of emissions from the Matimba Power Station comprises two stacks. Source parameters for these sources, required for input to the dispersion modelling study, include stack height and diameter, gas exit velocity and gas exit temperature. Such information, provided by Eskom personnel, is given in Table 9.10.

Table 9.10: Parameters for the current pulverised fuel (PF) power station at Matimba.

Number of Stacks	Height (m)	Diameter (m)	Exit Velocity (m/s)	Temperature (°K)
2	250	12.82	24.84	405

Emission rates for SO_2, NO_x, and PM10, calculated for each source on the basis of the existing data, are presented in Table 9.11. Monthly emission variations were calculated based on the energy outputs per month for 2001 to 2003 from the current pulverised fuel (PF) power station at Matimba. Eskom personnel provided the energy outputs as well as the total emissions per year. Although emissions were provided as total particulates released such emissions were assumed to comprise primarily of PM10 given the abatement measures in place and that courser particulates are readily removed by such devices.

Emission rates were also varied diurnally for the simulations undertaken in the current study. Eskom personnel provided a "typical" diurnal variation for summer and winter based on energy output. During the wintertime there is a distinct increase in electricity demand, hence energy output, during morning and evening hours. This trend is far less distinct during summer months.

Table 9.11: Emissions (in tonnes) for current Matimba Power Station operating conditions for the years 2001, 2002, and 2003.

SO_2			**PM**			**NO_x (1)**			**NO (2)**			**NO_2 (3)**		
2001	**2002**	**2003**	**2001**	**2002**	**2003**	**2001**	**2002**	**2003**	**2001**	**2002**	**2003**	**2001**	**2002**	**2003**
247 475	248 393	294 186	5 177	4 538	6 246	90 725	94 216	100 514	57 985	60 216	64 241	1 814	1 884	2 010

Notes:

(1) NO_x emissions reported as NO_2 (pers com. John Keir, 2 June 05).

(2) NO_x emissions (reported as NO_2) were converted to NO and 98% taken as being emitted from the stacks (pers com. John Keir, 2 June 05).

(3) 2% of the NO_x emissions (reported as NO_2) were taken as representing the NO_2 emissions from the stacks (pers com. John Keir, 2 June 05).

* Future Existing Matimba Power Station Emissions
  Eskom personnel provided total emissions for the period 2001, 2002 and 2003, with emissions from 2003 reflecting the highest rates. Future baseline emissions were calculated based on 2003 emissions (as a conservative approach) and scaled to reflect total coal tonnages predicted for 2009 (see Table 9.13). Source parameters for the pulverised fuel (PF) power station at Matimba under future baseline conditions were assumed to remain unchanged (see Table 9.12).

Table 9.12: Parameters for the pulverised fuel (PF) power station at Matimba for future baseline conditions.

Number of Stacks	Height (m)	Diameter (m)	Exit Velocity (m/s)	Temperature (°K)
2	250	12.82	24.84	405

Table 9.13: Emissions (in tonnes) for future baseline conditions.

SO_2	PM	NO_x (1)	NO (2)	NO_2 (3)
298 478	6 337	101 980	65 178	2 040

Notes:
(1) NO_x emissions reported as NO_2 (pers com. John Keir, 2 June 05).
(2) NO_x emissions (reported as NO_2) were converted to NO and 98% taken as being emitted from the stacks (pers com. John Keir, 2 June 05).
(3) 2% of the NO_x emissions (reported as NO_2) were taken as representing the NO_2 emissions from the stacks (pers com. John Keir, 2 June 05).

- *Coal Mining Operations*

  Open-cast coal mining operations, such as that undertaken at Grootegeluk, are frequently significant sources of fugitive dust emissions, particularly if poorly controlled. Sources of fugitive dust include operations such as drilling, blasting, dragline and/or truck and shovel activities, in addition to vehicle entrainment and materials handling operations. Depending on the type of explosives used, blasting operations are also associated with gaseous emissions, e.g. nitrogen oxides, carbon monoxide and smaller quantities of sulphur dioxide. Gaseous and particulate emissions may also occur as a result of spontaneous combustion of coal discards and dumps.

- *Sewage Works*

  Volatile organic compounds (VOCs) emissions are associated with wastewater treatment works. Species measured at local works have included: hydrogen sulphide, mercaptans, ammonia, formaldehyde, acetone, toluene, ethyl benzene, xylenes, perchloroethylene (tetrachloroethylene), butyric acid, propionic acid, valeric acid and acetic acid. Species that represent the most important odorants included: hydrogen sulphide, mercaptans, ammonia, and various fatty acids (butyric, propionic, valeric and acetic).

- *Household Fuel Burning*

It is likely that certain households within local communities, specifically Marapong residential area are likely to use coal, wood and paraffin for space heating and/or cooking purposes. According to the 2001 census information, Marapong (Ward 2) comprises about 5600 people living in ~1200 households (55% of which are classified as not being “formal” households, despite 80% of households using electricity for lighting purposes). Despite the high percentage of electrification it is feasible that fuel burning make take place within a portion of electrified households at certain times of the year due to it being potentially more cost-effective for space heating purposes.

Domestic coal burning emits a large amount of gaseous and particulate pollutants including sulphur dioxide, heavy metals, total and respirable particulates including heavy metals and inorganic ash, carbon monoxide, polycyclic aromatic hydrocarbons, and benzo(a)pyrene. Polyaromatic hydrocarbons are recognised as carcinogens. Pollutants arising due to the combustion of wood include respirable particulates, nitrogen dioxide, carbon monoxide, polycyclic aromatic hydrocarbons, particulate benzo(a)pyrene and formaldehyde. Particulate emissions from wood burning within South Africa have been found to contain about 50% elemental carbon and about 50% condensed hydrocarbons (Terblanche *et al*., 1992). The main pollutants emitted from the combustion of paraffin are NO_2, particulates, carbon monoxide and polycyclic aromatic hydrocarbons.

- *Veld Burning*

Crop-residue burning and general wild fires (veld fires) represent significant sources of combustion-related emissions associated with agricultural areas. Given that livestock agriculture prevails in the Lephalale area, it is anticipated that general wild fires are likely to be more important than controlled burning related to agricultural activities.

Biomass burning is an incomplete combustion process with carbon monoxide, methane and nitrogen dioxide being emitted during the process. About 40% of the nitrogen in biomass is emitted as nitrogen, 10% remains in the ashes and it is assumed that 20% of the nitrogen is emitted as higher molecular weight nitrogen compounds. Unlike N species, only small amount of sulphur dioxide and sulphate aerosols are emitted. The visibility of smoke plumes from vegetation fires is due to their aerosol content (Helas and Pienaar, 1996).

The extent of emissions from veld burning is dependent on the quantity of material (biomass) available for combustion. The quantity of dry, combustible matter per unit area is on average 4.5 ton per hectare for savanna areas.

- *Vehicle Exhaust Emissions*

  Air pollution from vehicle emissions may be grouped into *primary* and *secondary* pollutants. Primary pollutants are those emitted directly into the atmosphere, and secondary, those pollutants formed in the atmosphere as a result of chemical reactions, such as hydrolysis, oxidation, or photochemical reactions. The significant primary pollutants emitted by motor vehicles include carbon dioxide (CO_2), carbon monoxide (CO), hydrocarbons (HCs), sulphur dioxide (SO_2), oxides of nitrogen (NO_x), particulates and lead. Secondary pollutants include: nitrogen dioxide (NO_2), photochemical oxidants (e.g. ozone), HCs, sulphur acid, sulphates, nitric acid, sulphates, nitric acid and nitrate aerosols. Toxic hydrocarbons emitted include benzene, 1.2-butadiene, aldehydes and polycyclic aromatic hydrocarbons (PAH). Benzene represents an aromatic HC present in petrol, with 85% to 90% of benzene emissions emanating from the exhaust and the remainder from evaporative losses.

  Given the low population number living in the region it is anticipated that vehicle exhaust emissions will be relatively limited and its contribution to ambient air pollutant concentrations dispersed and relatively insignificant.

- *Fugitive Dust Emissions*

  Fugitive dust emissions may occur as a result of vehicle entrainment of dust from local paved and unpaved roads, wind erosion from open areas and dust generated by agricultural activities (e.g. tilling). The extent, nature and duration of agricultural activities, the moisture and silt content of soils and the extent of open areas is required to be know in order to quantify fugitive emissions from this source. The quantity of wind blown dust is similarly a function of the wind speed, the extent of exposed areas and the moisture and silt content of such areas.

9.6.2. Measured Baseline Air Quality

Eskom has undertaken recent continuous monitoring of ambient SO_2 and PM10 concentrations in the vicinity of the Matimba Power Station. This monitoring was conducted at Zwartwater for the period 2001 to September 2003. In September 2003 the Zwartwater monitoring station was relocated to Grootstryd. Various other historical monitoring campaigns were undertaken including:

- Sampling at five sites (M1-M5) during the August 1991 to January 1992 period; and
- Sampling at Waterberg station during the 1984 to 1989 period.

The data availability for the Zwartwater and Grootstryd monitoring stations is given in Table 9.14. Data availability for the monitoring campaigns undertaken is given in Table 9.15. The locations of the various stations are illustrated in Figure 9.5.

Maximum hourly, daily and period average air pollutant concentrations recorded at the Zwartwater and Grootstryd stations for the period 2001 to 2003 are given in Table 9.16. Maximum measured concentrations for the five-station monitoring campaign conducted between August 1991 and January 1992 are given in Table 9.17, and concentrations recorded at Waterberg station during the 1980s presented in Table 9.18. Air quality limit exceedances have been measured to occur for the following pollutants-stations-averaging periods:

- Sulphur dioxide – EC hourly limit – Zwartwater, Grootstryd, M1-M5 and Waterberg;
- Sulphur dioxide – SANS daily limit – M3;
- PM10 – daily limit – Zwartwater and Grootstryd (no measurements of PM10 at the M1-M5 and Waterberg stations).

In assessing recorded hourly sulphur dioxide concentrations reference was made to the EC hourly limit given that no SANS limit is issued for this averaging period. The EC limit is classified as an equivalent limit, i.e. hourly average sulphur dioxide concentrations of 350 µg/m³ are estimated to be associated with 10 minute peak sulphur dioxide concentrations of 500 µg/m³. An exceedanced of the EC hourly limit of 350 µg/m³ is therefore likely to signal and exceedance of the SANS 10-minute limit of 500 µg/m³.

The frequencies of exceedance of the EC hourly limit and SANS daily limit is summarised in Table 9.19. It is evident that the exceedances occur relatively infrequently, with the greatest frequency of occurrence having been recorded to occur at the M3 station.

NO_x and ozone was only measured at Waterberg during 1989. NO_x concentrations were recorded at Waterberg during this year to represent up to 9% of the SA guideline for NO_x and up to 17% of the guideline for NO_2. The measured NO_2 concentrations constitute ~30% of the more stringent SANS NO_2 annual and hourly limits. It should be noted that the validity of the NO_X data is questionable given that NO_2 concentrations were frequently recorded as being greater than the measured NO_x levels. Measured ozone concentrations were observed to comprise up to 74% of the SANS limit and 63% of the SA guideline.

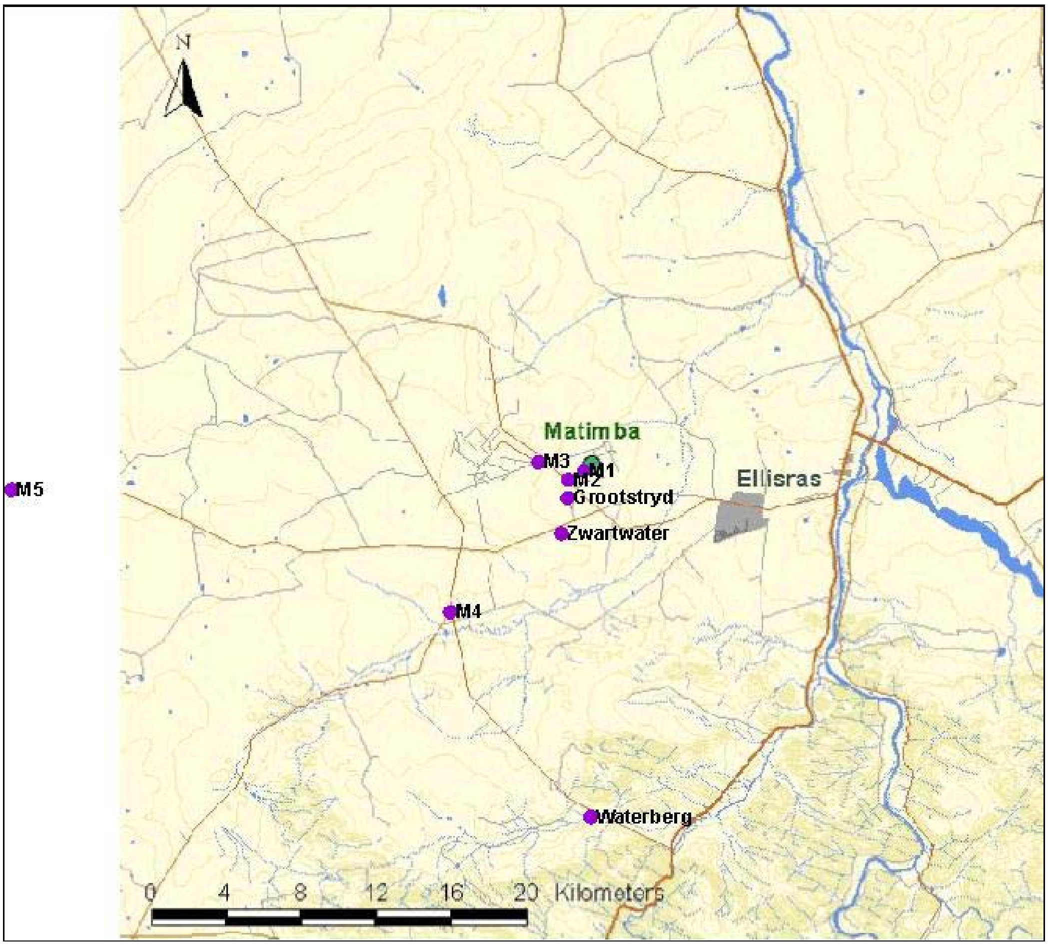

Figure 9.5: Location of the Eskom monitoring stations in the vicinity of the Matimba Power Station.

Table 9.14: Data availability for the Zwartwater and Grootstryd monitoring stations.

Monitoring Station	Pollutant	Data Availability		
		2001	2002	2003
Zwartwater	PM	16 %	0 %	0 %
	SO_2	71 %	37 %	55 %
Grootstryd	PM	-	-	61 %
	SO_2	-	-	83 %(a)

(a) Data availability from September to December 2004

Table 9.15: Data availability for the monitoring campaigns undertaken at stations M1-M5 and at Waterberg

Monitoring Period	Monitoring Station - Pollutant	Data Availability
Aug 1991 to Jan 1992	Matimba 1 (M1) – SO_2	89 %
	Matimba 2 (M2) – SO_2	93 %
	Matimba 3 (M3) – SO_2	70 %
	Matimba 4 (M4) – SO_2	73 %
	Matimba 5 (M5) – SO_2	64 %
Jan 1985 – Dec 1989	Waterberg – SO_2	69%
Jan – Dec 1989	Waterberg – NO_x	75%
Jan – Dec 1989	Waterberg – NO	37%
Jan – Dec 1989	Waterberg – NO_2	42%
Jan – Dec 1989	Waterberg – O_3	47%

Table 9.16: Monitored ground level concentrations (µg/m³) at the Eskom monitoring stations of Zwartwater and Grootstryd[(a)].

Monitoring Station	Pollutant	Highest Hourly Averages			Highest Daily Averages			Period Averages [(b)]		
		2001	2002	2003	2001	2002	2003	2001	2002	2003
Zwartwater (ZW)	PM10	153	-	-	73	-	-	9	-	-
	SO_2	563	825	387	68	98	6	10	14	-
Grootstryd (GS)	PM10	-	-	325	-	-	86	-	-	-
	SO_2	-	-	620	-	-	103	-	-	-

[(a)] Air quality limit value exceedances indicated in bold print, with reference made to the EC hourly SO_2 limit of 350 µg/m³, the DEAT, SANS, EC, WHO daily SO_2 limit of 125 µg/m³ and the SANS and EC daily PM10 limits of 75 µg/m³ and 50 µg/m³ respectively.

[(b)] Period averages do not actually represent annual averages due to poor data availability.

Table9.17: Monitored SO_2 ground level concentrations (µg/m³) for the monitoring campaign undertaken from August 1991 to January 1992

Monitoring Station	Highest Hourly Averages	Highest Daily Averages	Period Averages
Matimba 1 (M1)	398	72	10.6
Matimba 2 (M2)	560	69	14.8
Matimba 3 (M3)	806	176	19.0
Matimba 4 (M4)	487	87	13.4
Matimba 5 (M5)	662	112	13.5

[(a)] Air quality limit value exceedances indicated in bold print, with reference made to the EC hourly SO_2 limit of 350 µg/m³, the DEAT, SANS, EC, WHO daily SO_2 limit of 125 µg/m³ and the SANS and EC daily PM10 limits of 75 µg/m³ and 50 µg/m³ respectively.

Table 9.18: Monitored ground level concentrations (μg/m³) at the Eskom monitoring stations of Waterberg[(a)].

Year	SO_2			NOx[(b)]			NO			NO_2[(b)]			O_3		
	highest hourly (μg/m³)	highest daily (μg/m³)	Annual/period average (μg/m³)	highest hourly (μg/m³)	highest daily (μg/m³)	period average (μg/m³)	highest hourly (μg/m³)	highest daily (μg/m³)	period average (μg/m³)	highest hourly (μg/m³)	highest daily (μg/m³)	period average (μg/m³)	highest hourly (μg/m³)	highest daily (μg/m³)	period average (μg/m³)
1985	86	31	7	-	-	-	-	-	-	-	-	-	-	-	-
1986	35	22	6	-	-	-	-	-	-	-	-	-	-	-	-
1987	232	27	10	-	-	-	-	-	-	-	-	-	-	-	-
1988	330	56	6	-	-	-	-	-	-	-	-	-	-	-	-
1989	565	99	16	103	40	10	69	18	4	66	31	12	147	99	33

[(a)] Air quality limit value exceedances indicated in bold, with reference made to EC hourly SO_2 limit of 350 μg/m³.

[(b)] The validity of the NO_X data was found to be questionable given that NO_2 concentrations were frequently recorded as being greater than the measured NO_x levels.

Table 9.19: Frequencies of exceedance of sulphur dioxide limits recorded to occur at the various monitoring stations

Station	No. of Hours Exceeding the EC Hourly Limit Value of 350 μg/m³	No. of Days Exceeding the SANS Daily Limit of 125 μg/m³	Total Hours of Data Available	Total Days of Data Available	Frequencies of Exceedance (%) of the EC Hourly Limit Value of 350 μg/m³	Frequencies of Exceedance (%) of the SANS Daily Limit Value of 350 μg/m³
Grootstryd	4		2365		0.17	
Zwartwater	11		14995		0.07	
Waterberg (1989 only)	1		3714		0.03	
M1	1		3936		0.03	
M2	1		4113		0.02	
M3	7	3	3072	137	0.23	2.19
M4	1		3216		0.03	
M5	2		2810		0.07	

Although no obvious seasonal variations in sulphur dioxide concentrations were apparent, diurnal trends were evident in measured sulphur dioxide levels (Figure 9.6). Generally higher ground level sulphur dioxide concentrations were recorded to occur during the daytime (08h00 to 19h00) at most monitoring stations (with the exception of M5). Primary peaks in ground level sulphur dioxide concentrations were observed to occur during the morning (10h00 to 12h00) at Zwartwater and M4, whereas M1 and M2 recorded peaks at 13h00. The lower concentrations at M1 are to be expected given the stack height and the proximity of this station to the power station. It is interesting to note that the M3 station, located to the west of the Matima Power Station, recorded higher ground level concentrations during the afternoon (14h00 – 15h00).

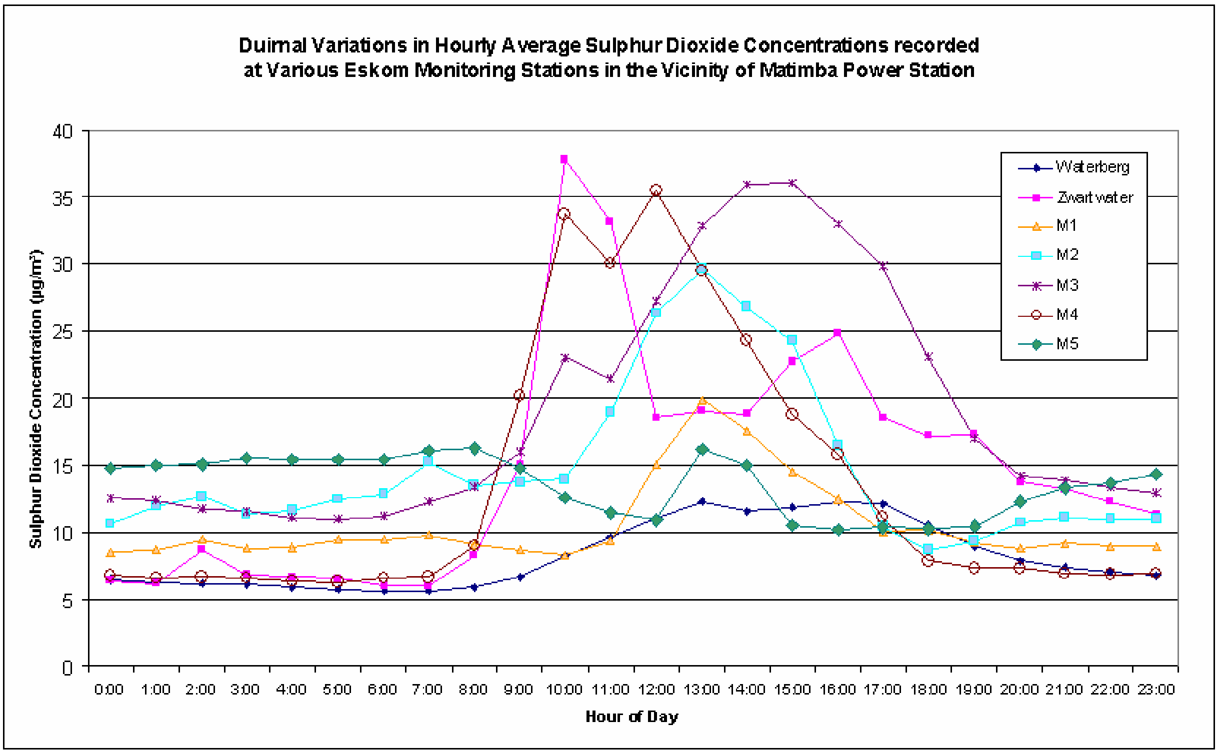

Figure 9.6: Diurnal variations in hourly average sulphur dioxide concentrations recorded at various Eskom monitoring stations located in the vicinity of Matimba Power Station

Ground level concentrations recorded at the distant M5 station were observed to be higher during the night-time hours with lower day-time concentrations coinciding with periods when the power station plume is more likely to be mixed down to ground within the vicinity of the power station.

Despite the Waterberg station also being situated at a more distant site it is notable that the diurnal variations in ground level sulphur dioxide concentrations were distinctly different from that measured at M5. The lower ground level sulphur dioxide concentrations recorded during the night-time at Waterberg are anticipated to be due to the increased frequency of occurrence of southwestern airflow at this site, associated with the onset of katabatic down-valley airflow. Generally higher ground level SO_2 concentrations were recorded at Waterberg during the daytime when airflow from the east to northeasterly sectors prevailed. Marginally higher concentrations occurred in the afternoon during which time the extent of downmixing in the immediate vicinity of the power station was likely to be reduced.

In conclusion, sulphur dioxide concentrations have been measured to exceed short-term air quality limits at various of the monitoring stations (Zwartwater, Grootstryd, Waterberg, M2, M3 and M5). The Matimba Power Station is likely to be the main contributing source to the ambient SO_2 ground level concentrations in the study area due to the magnitude of its emissions. This is being confirmed through atmospheric dispersion modelling of the power station's stack emissions. Although the power station contributes to ambient nitrogen dioxide concentrations in the region, nitrogen dioxide limit exceedances are not predicted to occur exclusively due to power station emissions. Other minor sources of SO_2 and NO_x anticipated to occur in the region are veld burning, vehicle exhaust emissions and possibly also household fuel burning. The highest ground level concentrations due to the Matimba Power Station stack emissions are expected to occur during unstable conditions when the plume is brought to ground in relatively close proximity to the power station.

Although PM10 concentrations were measured to be within the current lenient DEAT guidelines, exceedances of the SANS and EC limits were observed to occur. Various local and far-field sources are expected to contribute to the suspended fine particulate concentrations in the region with the Matimba Power Station predicted to contribute marginally to such concentrations. Local sources include wind erosion from exposed areas, fugitive dust from agricultural and mining operations, vehicle entrainment from roadways and veld burning. Household fuel burning may also constitute a local source of low level emissions. Long-range transport of particulates emitted from remote tall stacks and from large-scale biomass burning in countries to the north of RSA and the accumulation and recirculation of such regional air masses over the interior is well documented (Andreae *et al.*, 1996; Garstang *et al*., 1996; Piketh, 1996).

Given measured and/or predicted ambient sulphur dioxide and airborne fine particulate concentrations within the study region it is imperative that the potential for cumulative concentrations due to proposed developments be minimized and carefully considered.

9.7. Spect Identification and Site Consideration

9.7.1. Sources of Atmospheric Emissions

The proposed project will comprise the increase of coal mining activities, the construction and operation of a ~4000 MW coal-fired PF power station and its associated ancilliary operations including ash disposal. The potential sources of atmospheric emissions and nature of pollutants anticipated to be released are listed in Table 9.20

Table 9.20: Sources of atmospheric emission associated with the proposed development; pollutants likely to be emitted and potential for impacts

Operation:	Source:	Pollutants	Potential for Impacts(b) and Preliminary Mitigation Recommendations
Coal mining	Drilling	Particulates	Moderate potential due to cumulative airborne fine particulate concentrations. Mitigation/management strongly recommended.
	Blasting	Particulates, NO_x, CO, CH_4(a), SO_2	
	Dragline / truck & shovel	Particulates	
	Materials handling	Particulates	
	Vehicle entrainment	Particulates	
	Stockpiling	Particulates	
	Coal storage piles / discard dumps	Particulates, SO_2, NO_x, CO, CH_4(a), CO_2(a)	
Ash disposal operations	Ash dumps	Particulates	
Power station	Stacks	SO_2, NO_x, CO, CO_2(a), N_2O(a), particulates and trace amounts of mercury	High impact potential due to cumulative SO_2 concentrations; Moderate impact potential due to cumulative NO_x concentrations. Mitigation required for SO_2 and potentially also for NO_x.

(a) Greenhouse gases
(b) Taking into account potential for cumulative air pollutant concentrations given existing sources

9.8. Conclusions

9.8.1. Site Ranking

Four candidate sites were identified by the project proponent for consideration for the construction of the proposed ***power station*** (viz. Appelvlakte, Nelsonskop, Naauwontkomen, Eenzaamheid) and four associated sites for the ancilliary infrastructure including ashing facilities (viz. Droogeheuvel, Zongezien, Kruipersbult, Kromdraai). Specialists were tasked with selecting the most suitable of these sites based on the potential significance of the impact associated with the development of the proposed project at the site.

In assessing the air quality impact potentials associated with the proposed project attention was paid to the following main criteria:

- Potential for increased maximum ground-level concentrations of sulphur dioxide (regardless of where such maximums occur, i.e. compliance criteria);
- Potential for increased concentrations within areas of maximum possible human exposures (i.e. concentrated human settlements);
- Potential for resulting in the deterioration of areas which could be conducive to other land uses such as farming;
- Feasibility of sites given joint consideration of the impact potential of both power station and ashing operations.

In order to facilitate the ranking of the sites for the power station location based on the above criteria it was necessary to undertake preliminary dispersion modelling for the proposed 4000 MW power station. Source parameters used as input in the simulations were as follows (as informed by Eskom personnel):

Capacity (MW)	**Number of Stacks**	**Height (m)**	**Diameter (m)**	**Exit Velocity (m/s)**	**Temperature (°K)**
4000	2	220	12.82	26.00	403

The ranking of sites for the location of the ***power station*** based on the above-mentioned criteria is documented in the table below:

Ranking	Compliance (Maximum Cumulative Ground Level Concentrations)	Maximum Human Exposure Potentials	Maximum Area of Non-mining and Industrial Land Impacted	Feasibility given Need for Adjacent Ashing Operations
1 (best)	Appelvlakte	Eenzaamheid	Appelvlakte	Eenzaamheid
2	Eenzaamheid	Naauwontkomen	Nelsonskop	Naauwontkomen
3	Naauwontkomen	Appelvlakte	Eenzaamheid / Naauwontkomen	Appelvlakte
4 (worst)	Nelsonskop	Nelsonskop		Nelsonskop

Of the evaluation criteria emphasis was placed on the reduction of human exposure potentials in the final selection of the better site given the options available. On this basis, the **Farm Eenzaamheid** was selected as the preferred site option for consideration for the proposed power station.

The mitigation of fugitive dust emissions from ***ashing operations*** remains a significant challenge despite considerable progress having been made over the past few decades. Taking this into account, and given the predominance of northeasterly wind it is recommended that the ashing operations not be located upwind of Marapong or the adjacent settlements (i.e. excludes Zongezien and Nelsonskop and potentially also Droogeheuvel – located ~3 km away – from consideration). Given the Farm Eenzaamheid being the preferred site option to be considered for the power station (from an air quality perspective), it is recommended that the ashing operations and other ancilliary infrastructure be proposed for development on the **Farm Naauwontkomen**. This farm is situated adjacent to Eenzaamheid and is predicted to already be subject to high sulphur dioxide concentrations due to existing power station operations.

The relative rating of sites for power station and ashing operations based on the numerical system provided by the project team is given in the table below.

Site:	Power Station Operations	Ashing Operations
Appelvlakte	1 to 2	3 (4 if well mitigated)
Nelsonskop	1 to 2	1 to 2
Naauwontkomen	2	4
Eenzaamheid	2 (if not mitigated, if mitigated ?)	3
Droogeheuvel	1 to 2	2 (3 if very well managed)
Zongezien	1 to 2	1 to 2
Kuipersbult		3
Kromdraai		3

The site ranking, based on the above criteria, submitted for consideration by the entire project team during the site selection process are given in Tables 9.21 and 9.22 for the power station operation and associated ashing operations.

Table 9.21: Site ranking based on various potential air quality issues related to the proposed power station operation

Excluding mitigation for proposed power station				
ISSUES	**Appelvlakte**	**Nelsonskop**	**Naauwont-komen**	**Eenzaamheid**
Impacts on human health due to gaseous and particulate emissions	1	1	2	2
Impacts on vegetation / landuse potential (land not currently under mining or industry)	2	2	2	2
Non-compliance with air quality limits	1	1	2	2
Including mitigation for proposed power station				
ISSUES	**Appelvlakte**	**Nelsonskop**	**Naauwont-komen**	**Eenzaamheid**
Impacts on human health due to gaseous and particulate emissions	2	2	3	3
Impacts on vegetation / landuse potential (land not currently under mining or industry)	3	3	3	3
Non-compliance with air quality limits	2	1	2	3

Table 9.22: Site ranking based on various potential air quality issues related to the proposed ashing operations

ISSUES	Appelvlakte	Nelsonskop	Naauwontkomen	Eenzaamheid	Droogeheuvel	Zongezien	Kuiprsbult	Kromdraai
Impacts on human health due to particulate emissions	3	2	3	3	2	1	3	3
Impacts on vegetation / landuse potential (land not currently under mining or industry)	3	3	3	3	3	3	3	3
Non-compliance with air quality limits	3	3	4	3	3	3	3	3
Nuisance dust impact	3	2	4	3	2	1	3	3

9.9. Recommendations

It is recommended that a detailed air quality impact assessment is undertaken in the EIA phase. The ambient air quality impact assessment will comprise of the establishment of an emissions inventory for the proposed development, the simulation of ambient air pollutant concentrations and dustfall rates occurring due to project development and operation, and the evaluation of the resultant potential for impacts and non-compliance. The comparison of predicted concentrations with ambient air quality guidelines will facilitate a *preliminary* assessment of health risks.

The terms of reference of the *air quality impact assessment component* include the following:

- Qualitative assessment and ranking of various candidate sites from an air quality impact potential perspective;
- Compilation of an emissions inventory for the proposed development including the identification and quantification of all potentially significant source of atmospheric emission including stack and fugitive emissions (e.g. power station stack emissions; fugitive dust from ashing and coal handling operations);
- Application of an atmospheric dispersion model for the preferred power station technology alternative at the selected site and prediction of incremental air pollutant concentrations and dustfall rates occurring as a result of proposed operations;
- Air quality impact assessment including:
    - ∗ compliance evaluation of emissions and air pollutant concentrations based on both local and international 'good practice' limits,
    - ∗ analysis of the potential for local air quality impacts given sensitive receptor locations, and
    - ∗ review of the projects in terms of its contribution to national greenhouse gas emissions.