

Proposed Filling Station and Truck Stop known as Meerkat



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A Report for: Royal
HaskoningDHV



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KNOWN AS MEERKAT ON PORTION 9 OF THE
FARM SMALKLOOF 122 HS

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TABLE OF CONTENTS

TABLE OF CONTENTS	1
1 INTRODUCTION	5
1.1 BACKGROUND	5
1.2 SCOPE OF WORK	5
1.3 PROJECT TEAM	7
1.4 PROJECT DESCRIPTION	7
2 APPLICABLE LEGISLATION	8
2.1 SOUTH AFRICAN LEGISLATIVE AND STANDARDS FRAMEWORKS	8
2.1.1 NATIONAL ENVIRONMENTAL MANAGEMENT: AIR QUALITY ACT 39 OF 2004	
2.1.2 NATIONAL AMBIENT AIR QUALITY STANDARDS	9
2.1.3 LICENSING REQUIREMENTS	10
2.1.4 HIGHVELD PRIORITY AREA	11
2.2 INTERNATIONAL LAWS AND CONVENTIONS	13
2.2.1 UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC)	
2.2.2 KYOTO PROTOCOL	13
2.2.3 THE VIENNA CONVENTION FOR THE PROTECTION OF THE OZONE LAYER	
2.2.4 THE MONTREAL PROTOCOL ON SUBSTANCES THAT DEplete THE OZONE LAYER	
2.2.5 THE STOCKHOLM CONVENTION ON PERSISTENT ORGANIC POLLUTANTS (POPs)	
2.2.6 INTERNATIONAL CONCERNS AROUND MERCURY	15
2.2.7 EQUATOR PRINCIPLES	15
2.2.8 INTERNATIONAL FINANCE CORPORATION	15
2.3 STANDARDS AND GUIDELINES	15
2.3.1 INHALABLE PARTICULATES	16
2.3.2 NUISANCE DUST	18
2.3.3 SULPHUR DIOXIDE	21
2.3.4 CARBON MONOXIDE (CO)	24
2.3.5 OXIDES OF NITROGEN	25
2.3.6 VOLATILE ORGANIC COMPOUNDS	26
3 BASELINE ENVIRONMENT	28
3.1 DESCRIPTION OF ENVIRONMENT	28
3.1.1 REGIONAL AND LOCAL CLIMATE AND ATMOSPHERIC DISPERSION POTENTIAL	
3.2 ATMOSPHERIC STABILITY	31
3.3 PRECIPITATION	31
3.4 TEMPERATURE AND HUMIDITY	32
3.5 OTHER POLLUTING SOURCES IN THE AREA	34
3.5.1 POWER STATIONS	34
3.5.2 VELD FIRES	35
3.5.3 VEHICLE ENTRAINED DUST	36
3.5.4 AGRICULTURE	37
3.5.5 MINING OPERATIONS	38
3.6 SENSITIVE RECEPTORS	39

4 ASSESSMENT OF ENVIRONMENT LIKELY TO BE AFFECTED	40
4.1 METHODOLOGY	40
4.2 DETAILED PROJECT DESCRIPTION	ERROR! BOOKMARK NOT DEFINED.
4.3 INPUT PARAMETERS	41
4.4 ASSUMPTIONS AND KNOWLEDGE GAPS	45
4.5 POTENTIAL IMPACTS	45
4.6 PROPOSED MITIGATION	12-1

List of Figures

FIGURE 1: LOCALITY MAP SHOWING LOCATION OF THE TRUCK STOP IN RELATION TO LOCAL TOWNS.	6
FIGURE 2: MAP SHOWING LOCATION AND EXTENT OF HIGHVELD PRIORITY AREA.	12
FIGURE 3: PERIOD WIND ROSE DERIVED FROM MONITORED DATA FROM THE MAJUBA POWER STATION (2006 TO 2007)	29
FIGURE 4: PERIOD WIND ROSE DERIVED FROM MODELED DATA SOURCED FROM THE SOUTH AFRICAN WEATHER SERVICES (2006 TO 2007).	29
FIGURE 5: FREQUENCY DISTRIBUTION DERIVED FROM MONITORED DATA (MAJUBA STATION: 2006 TO 2007)	30
FIGURE 6: FREQUENCY DISTRIBUTION DERIVED FROM MODELLED DATA (SOUTH AFRICAN WEATHER SERVICES: 2006 TO 2007).	30
FIGURE 7: MONTHLY RAINFALL FIGURES FOR AMERSFOORT REGION. MEAN ANNUAL RAINFALL 1008 MM (2007).	32
FIGURE 8: AVERAGE MONTHLY MAXIMUM AND MINIMUM TEMPERATURES RECORDED IN THE ARMESFOORT REGION (WEATHER SERVICES STATION, 2007)	33
FIGURE 9: AVERAGE MONTHLY RELATIVE HUMIDITY FOR THE AMERSFOORT REGION (WEATHER SERVICES STATION 2007).	34
FIGURE 10: AN INDICATION OF POTENTIAL EMISSIONS FROM POWER STATIONS	35
FIGURE 11: RECENTLY BURNT AND BURNING FIELDS NEAR MAJUBA POWER STATION	36
FIGURE 12: COMMONLY USED UNPAVED ROADS NEAR KOMATI TOWN.	37
FIGURE 13: DOMESTIC LIVESTOCK AND MAIZE AGRICULTURE ARE COMMON SOURCES OF EMISSIONS IN THE SURROUNDING AREA.	38
FIGURE 14: OPEN CAST MINING OPERATIONS IN THE AREA.	39
FIGURE 15: GENERAL LAYOUT PLAN OF THE SITE.	42
FIGURE 16: ARTISTS IMPRESSION OF SITE LAYOUT.	43
FIGURE 17: PREDICTED IMPACTS ASSOCIATED WITH BENZENE FOR AN ANNUAL AVERAGING PERIOD (STANDARD $10\mu\text{G}/\text{M}^3$)	46
FIGURE 18: PREDICTED IMPACTS ASSOCIATED WITH CARBON MONOXIDE FOR A 1 HOUR AVERAGING PERIOD (STANDARD $30\ 000\ \mu\text{G}/\text{M}^3$).	47
FIGURE 19: PREDICTED IMPACTS ASSOCIATED WITH NITROGEN DIOXIDE FOR A 1 HOUR AVERAGING PERIOD (STANDARD $200\ \mu\text{G}/\text{M}^3$).	48
FIGURE 20: PREDICTED IMPACTS ASSOCIATED WITH NITROGEN DIOXIDE FOR AN ANNUAL AVERAGING PERIOD (STANDARD $40\ \mu\text{G}/\text{M}^3$).	49
FIGURE 21: PREDICTED IMPACTS ASSOCIATED WITH DIESEL PARTICULATES FOR A 24 HOUR AVERAGING PERIOD (STANDARD $120\ \mu\text{G}/\text{M}^3$).	50
FIGURE 22: PREDICTED IMPACTS ASSOCIATED WITH DIESEL PARTICULATES FOR AN ANNUAL AVERAGING PERIOD (STANDARD $50\ \mu\text{G}/\text{M}^3$).	51
FIGURE 23: PREDICTED IMPACTS ASSOCIATED WITH SULPHUR DIOXIDE FOR A 1 HOUR AVERAGING PERIOD (STANDARD $350\ \mu\text{G}/\text{M}^3$).	52
FIGURE 24: PREDICTED IMPACTS ASSOCIATED WITH SULPHUR DIOXIDE FOR A 24 HOUR AVERAGING PERIOD (STANDARD $125\ \mu\text{G}/\text{M}^3$).	53
FIGURE 25: PREDICTED IMPACTS ASSOCIATED WITH SULPHUR DIOXIDE FOR AN ANNUAL AVERAGING PERIOD (STANDARD $50\ \mu\text{G}/\text{M}^3$).	54

List of Tables

TABLE 1: NATIONAL STANDARDS ($\mu\text{G}/\text{M}^3$) WITH ALLOWABLE FREQUENCIES OF EXCEEDANCE FOR IMMEDIATE COMPLIANCE. 10	
TABLE 2: PERMISSIBLE EMISSION STANDARDS AS INDICATED IN THE NEM:AQA LISTED ACTIVITIES	11
TABLE 3: MONITORING WITHIN THE HIGHVELD PRIORITY AREA TAKES PLACE AT THE FOLLOWING DEPARTMENT OF ENVIRONMENTAL AFFAIRS STATIONS	11
TABLE 4: AVAILABLE LOCAL AND INTERNATIONAL STANDARDS USED FOR THE EVALUATION OF INHALABLE PARTICULATE MATTER (PM10).	17
TABLE 5: AVAILABLE LOCAL STANDARDS USED FOR THE EVALUATION OF INHALABLE PARTICULATE MATTER (PM2.5).	18
TABLE 6: FOUR BAND SCALE EVALUATION CRITERIA FOR DUST DEPOSITION (SANS, 2005).	20
TABLE 7: TARGET, ACTION AND ALERT THRESHOLDS FOR DUST DEPOSITION (SANS, 2005).	20
TABLE 8: ACCEPTABLE DUST FALL RATES AS MEASURED (USING ASTM D1739:1970) AT AND BEYOND THE BOUNDARY OF THE PREMISES WHERE DUST ORIGINATES	21
TABLE 9: AVAILABLE LOCAL AND INTERNATIONAL STANDARDS FOR SULPHUR DIOXIDE	21
TABLE 10: INJURY TO PLANTS DUE TO VARIOUS DOSES OF SULPHUR DIOXIDE ⁽¹⁾	23
TABLE 11: THRESHOLDS SPECIFIED BY CERTAIN COUNTRIES AND ORGANISATIONS FOR VEGETATION AND ECOSYSTEMS	23
TABLE 12: AIR QUALITY GUIDELINES AND STANDARDS FOR CARBON MONOXIDE	24
TABLE 13: AMBIENT AIR QUALITY GUIDELINES AND STANDARDS FOR NITROGEN DIOXIDE.	25
TABLE 14: AVAILABLE LOCAL STANDARDS USED FOR THE EVALUATION OF BENZENE (NO EXCEEDANCES)	27
TABLE 15: ATMOSPHERIC STABILITY CLASSES	31
TABLE 16: VEHICLE EMISSIONS BASED ON SA EMISSION FACTORS.	44
TABLE 17: TANK VENTING EMISSIONS DATA (USEPA – TANKS 4.0).	44
TABLE 18: TABLE INDICATING MAXIMUM PREDICTED ON-SITE CONCENTRATIONS ($\mu\text{G}/\text{M}^3$).	12-1

1 INTRODUCTION

1.1 Background

TOWB Trading cc proposes the construction of a Truck Stop including overnight facilities and a diesel filling station approximately 8 km outside Volksrust, Mpumalanga. The proposed development is expected to take place on portion 9 of the Farm Smalkloof 122 HS (Figure 1).

The total development footprint is approximately 8 ha in size on a site 8 ha in extent. Phase 1 will consist of a Truck Stop (consisting of shower facilities without accommodation) while Phase 2 will consist of a diesel filling station. Fuel storage is expected to be contained in 12 storage tanks (6 tanks of 45 000 litres diesel fuel each, 2 tanks of 45 000 litres of ULP each, 2 tanks of 45 000 litres of leaded fuel each, and 2 tanks of 25 000 litres of paraffin each). Thus the combined capacity of fuel storage is 500 000 litres.

1.2 Scope of Work

On 23 November 2007 the Highveld was declared a priority area, referred to as the Highveld Priority Area, in terms of section 18(1) of the National Environmental Management: Air Quality Act, 2004 (Act No 39 of 2004). This implies that the ambient air quality within the Highveld Priority Area exceeds or may exceed ambient air quality standards, alternatively, that a situation exists within the Highveld Priority Area, which is causing or may cause a significant negative impact on air quality in the area, and that the area requires specific air quality management action to rectify the situation.

The area declared as such, includes inter alia the local municipalities of Govan Mbeki, Dipaleseng, Lekwa, Msukaligwa, and Pixley ka Seme. The declaration of the Highveld Priority Area allows for the implementation of stricter ambient air quality standards than those currently promulgated under the Air Quality Act. To date however, no such additional standards have been proposed or implemented.

This project aims to identify the potential air quality impacts associated with the operation of a truck stop within the Highveld Priority Area, to determine if the emissions generated from the vehicles is likely to cause significant air quality concerns in the area, as well as the development of a monitoring programme for the site to ensure compliance and identify where additional mitigation may be required.

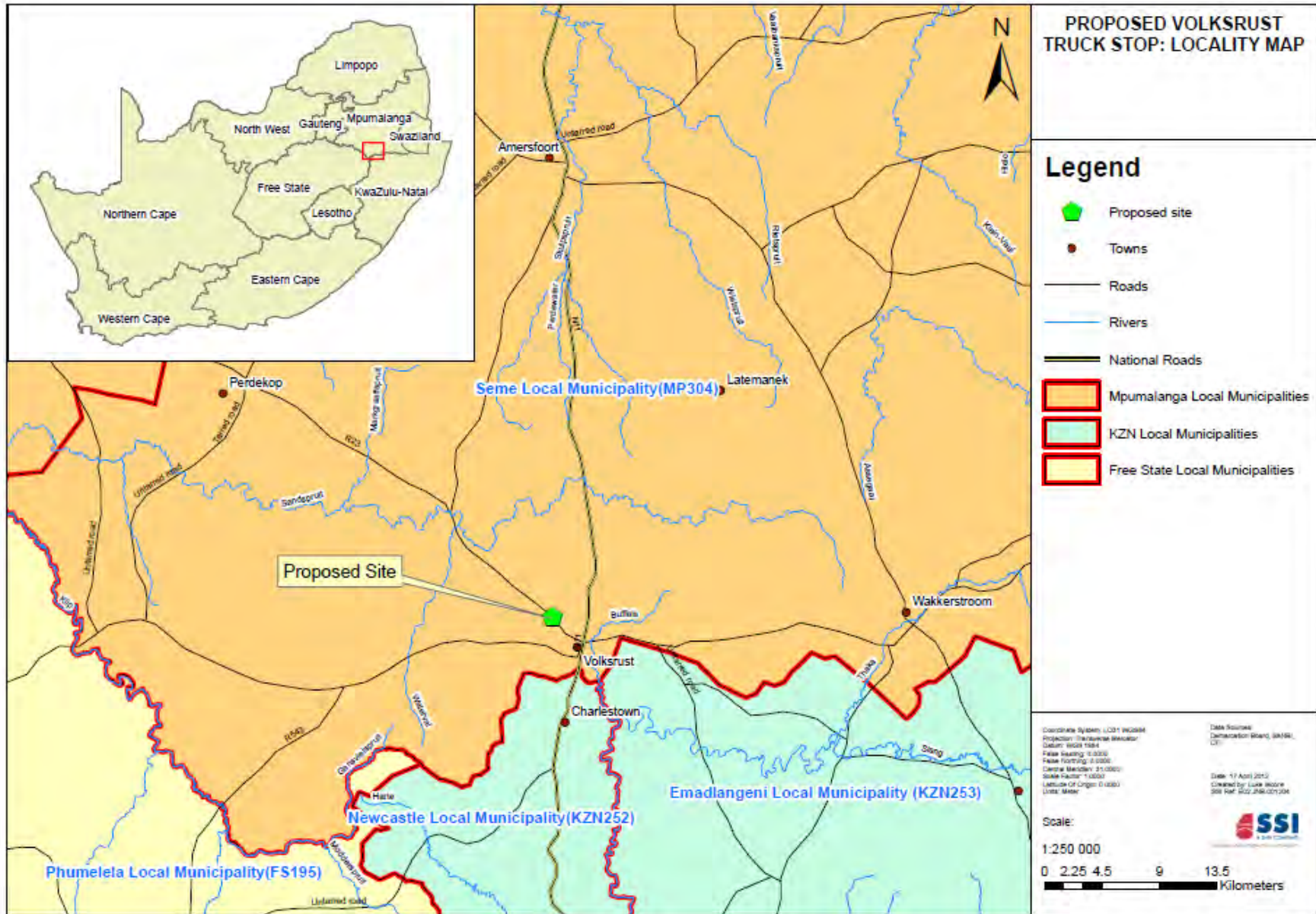


FIGURE 1: LOCALITY MAP SHOWING LOCATION OF THE TRUCK STOP IN RELATION TO LOCAL TOWNS.

1.3 Project Team

Raylene Watson is currently employed as the Environmental Sector Group Manager for Royal HaskoningDHV in South Africa. Her key responsibilities are to manage the Environmental Division and to promote Royal HaskoningDHV as a Company within South Africa and the rest of Africa.

She completed her Bachelor of Science Degree (BSc) in 1994 at the Rand Afrikaans University (now called University of Johannesburg), majoring in Botany and Zoology. Her BSc (Honours - Zoology) course was subsequently completed at the same institution (1995). She was awarded an NRF scholarship to undertake her Masters Studies in Ecotoxicology. This Thesis focused on the assessment of heavy metal bioaccumulation in fish, found in the Olifants River Catchment area (one of the main river systems in South Africa). Her Masters was completed in 1997, this work was used to supplement further studies, culminating in the completion of a Doctorate in 2000, which focused on the assessment of a Fish Health Assessment Index. Her Doctorate was awarded the Nights Awards by the Parasitological Association of South Africa for its contribution to the Field of Parasitology in 2001.

After completing her studies she worked as an air quality impact assessor at Airshed Planning Professional, where after 5 years of service she moved over to Royal HaskoningDHV to start up the air quality unit for Royal HaskoningDHV. The air quality unit has now been in existence for 6 years, and has developed into a team of 4 individuals. During her work as an air quality specialist she has undertaken over 200 assessments focusing primarily on industrial related source impacts. Key studies undertaken focused on the assessment of impacts related to mining operations, smelters, landfill sites, sewage works, airports, harbour developments, residential developments and the expansion of road networks. Work has been undertaken in South Africa and further afield on the African Continent, including countries like, Angola, Mozambique, Zimbabwe, Zambia, Namibia, Democratic Republic of the Congo, Botswana and Mauritius.

Stuart Thompson is a senior environmental consultant for Royal HaskoningDHV, and a specialist in the field of air quality assessments. Qualified as an Applied Environmental Scientist (BSc. Hons) and a Member of the South African Geophysical Association (SAGA) as well as the Society of South African Geographers (SSAG), Stuart has 8 years experience in the environmental field, including 6 years in the field of air quality. He has managed and contributed to a variety of project in South Africa, as well as further afield on the African continent, including Tanzania, Malawi, DRC, Mozambique, Mauritius, Swaziland, Zambia, Sierra Leone and Botswana on assessments ranging from large-scale commercial developments and Power Generation Projects to numerous mining operations. Stuart spent 6 months working at the head office based in Amersfoort, Netherlands. During this time he worked on several projects for the European Union, as well as acting as a specialist technical advisor for a large scale environmental project in India.

1.4 Project Description

TOWB Trading cc proposes the construction of a Truck Stop including overnight facilities and a diesel filling station approximately 8 km outside Volksrust, Mpumalanga. The proposed development is expected to take place on portion 9 of the Farm Smalkloof 122 HS (Figure 1).

The air quality assessment aims to determine the potential impacts associated with the construction, operation, and eventual decommissioning, caused by the truck stop. Only operational impacts have been discussed in the report.

2 APPLICABLE LEGISLATION

The information presented in the section which follows details the local legislation within South Africa, as well as a list of international laws and conventions to which South Africa is a signatory.

2.1 South African Legislative and Standards Frameworks

2.1.1 National Environmental Management: Air Quality Act 39 of 2004

The National Environmental Management: Air Quality Act (39 of 2004) represents a move to an air pollution control strategy that is based on receiving air quality management. It focuses on the adverse impacts of air pollution on the ambient environment and sets standards as the benchmark for air quality management performance. At the same time it sets emission standards to minimize the amount of pollution that enters the environment. The Act regulates the control of noxious and offensive gases emitted by industrial processes, the control of smoke and wind borne dust pollution, and emissions from diesel vehicles.

The promulgation of the National Air Quality Act (2004) resulted in a shift from National air pollution control based on source based controls to decentralised air quality management through an effects-based approach. An effects based approach requires the meeting of ambient air quality standards. These ambient standards are to be set by the local and district municipalities which govern air quality management in the area. The Municipality of concern for this project is the Pixley ka Seme Local Municipality. If these standards have not been set yet the National ambient air quality standards will need to be adhered to. Such standards provide the objectives for air quality management.

Multiple levels of standards provide the basis for both ‘continued improvements’ in air quality and for long term planning in air quality management. Although maximum levels of ambient concentrations should be set at a National level, more stringent ambient standards may be implemented by provincial and local authorities.

The control and management of all sources of air pollution relative to their contributions to ambient concentrations is required to ensure that improvements in air quality are secured in the timeliest, even handed and cost-effective way. The need to regulate diverse source types reinforces the need for varied management approaches ranging from command and control methods to voluntary measures.

The objectives of the Air Quality Act as stated in Chapter 1 are as follows:

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

The National Framework is one of the significant functions detailed in Chapter 2 of the Air Quality Act. The Framework serves as a blueprint for air quality management and aims to achieve the air quality objectives as described in the preamble of the Air Quality Act. The National Framework for Air Quality Management in the Republic of South Africa was published on 11 September 2007.

Chapter 3 of the Air Quality Act covers institutional and planning matters, and is summarised as follows:

- The Minister may establish a National Air Quality Advisory Committee as a subcommittee of the National Environmental Advisory Forum established in terms of the National Environmental Management Act (NEMA);
- Air Quality Officers must be appointed at each level of Government (National, Provincial, Municipal);
- Each National Department or Province preparing an Environmental Implementation Plan or Environmental Management Plan in terms of NEMA must include an Air Quality Management Plan (AQMP). Each Municipality preparing an Integrated Development Plan must include an AQMP;
- The contents of the AQMPs are prescribed in detail; and
- Each organ of state is required to report on the implementation of its AQMP in the annual report submitted in terms of NEMA.

In Chapter 4 of the Air Quality Act, air quality management measures are outlined in terms of:

- The declaration of Priority Areas, where ambient air quality standards are being, or may be, exceeded;
- The listing of activities that result in atmospheric emissions and which have or may have a significant detrimental effect on the environment;
- The declaration of Controlled Emitters;
- The declaration of Controlled Fuels;
- Other measures to address substances contributing to air pollution, that may include the implementation of a Pollution Prevention Plan or an Atmospheric Impact Report; and
- The requirements for addressing dust, noise and offensive odours.

Licensing of Listed Activities through an Atmospheric Emission Licence is addressed in Chapter 5 of the Air Quality Act. On 31 March 2010, the Minister of Water and Environmental Affairs published the Listed Activities and Minimum Emission Standards (Government Gazette No 33064) with an amended list of activities published on 23 November 2012 (Government Gazette No 35894). International air quality management is outlined in Chapter 6 and offences and penalties in Chapter 7.

2.1.2 National Ambient Air Quality Standards

The Air Quality Act makes provision for the setting and formulation of National ambient air quality standards for substances or mixtures of substances which present a threat to health, well-being or the environment. On 24 December 2009, the Minister of Water and Environmental Affairs established National ambient air quality standards (Table 1). These standards prescribe the allowable ambient concentrations of pollutants which are not to be exceeded during a specified time period in a defined area. If the air quality standards are exceeded, the ambient air quality is poor and the potential for health effects is greatest.

TABLE 1: NATIONAL STANDARDS ($\mu\text{G}/\text{M}^3$) WITH ALLOWABLE FREQUENCIES OF EXCEEDANCE FOR IMMEDIATE COMPLIANCE.

Pollutant	Averaging Period	Concentration	Frequency of Exceedance
Sulphur dioxide SO_2	10-min average	500	526
	1-hr average	350	88
	24-hr average	125	4
	Annual average	50	0
Nitrogen dioxide NO_2	1-hr average	200	88
	Annual average	40	0
Carbon monoxide CO	1-hr average	30 000	88
	8-hourly running average	10 000	11
Ozone O_3	8-hourly running average	120	11
Particulate Matter PM_{10}	24-hr average	120 75 (from 2015)	4
	Annual average	50 40 (from 2015)	0
Particulate Matter $\text{PM}_{2.5}$	24-hr average	65 40 (from 2016)	4
	Annual average	25 20 (from 2016)	0
Lead Pb	Annual average	0.5	0
Benzene C_6H_6	Annual average	10 5 (from 2015)	0

2.1.3 Licensing Requirements

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

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

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

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

AQA Implementation

Listed Activities and Minimum Emission Standards Identified in Terms of Section 21 of the National Environmental Management Air Quality Act (39 of 2004)

Listed Activities schedule for Section 21 Air Quality Act (31 March 2010) as published on Government Notice 33064. With an amended listed activities have been issued on the 23 November 2012 (GN35894).

TABLE 2: PERMISSIBLE EMISSION STANDARDS AS INDICATED IN THE NEM:AQA LISTED ACTIVITIES.

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Description:	Petroleum product storage tanks and product transfer facilities, except those used for liquefied petroleum gas.		
Application:	All permanent immobile liquid storage tanks larger than 1000 cubic meters cumulative tankage capacity at a site.		
Substance or mixture of substances		Plant status	mg/Nm ³ under normal conditions of 273 Kelvin and 101.3 kPa.
Common name	Chemical symbol		
Total volatile organic compounds from vapour recovery/ destruction units using thermal treatment.	N/A	New	150
		Existing	150
Total volatile organic compounds from vapour recovery/ destruction units using non thermal treatment.	N/A	New	40 000
		Existing	40 000

Should this category be triggered an Atmospheric Emission License is required.

2.1.4 Highveld Priority Area

The Highveld Priority Area is the area illustrated on the map below (Figure 2), which includes the area contained within the boundaries of: the Ekurhuleni Metropolitan Municipality In Gauteng Province; Lesedi Local Municipality (Sedibeng) in Gauteng Province; Govan Mbeki Local Municipality (Gert Sibande) in Mpumalanga Province; Dlpaleseng Local Municipality (Gert Sibande) in Mpumalanga Province; Lekwa Local Municipality (Gert Sibande) in Mpumalanga Province; Msukaiigwa Local Municipality (Gert Sibande) in Mpumalanga Province; Pixley ka Seme Local Municipality (Gert Sibande) in Mpumalanga Province; Delmas Local Municipality (Nkangala) in Mpumalanga Province; Emalahleni Local Municipality (Nkangala) in Mpumalanga Province; and the Steve Tshwete Local Municipality (Nkangala) in the Mpumalanga Province.

TABLE 3: MONITORING WITHIN THE HIGHVELD PRIORITY AREA TAKES PLACE AT THE FOLLOWING DEPARTMENT OF ENVIRONMENTAL AFFAIRS STATIONS.

Station Data					
Station	GPS coordinates	Monitoring period	Pollutants measured	Meteorological parameters measured	Averaging period
Ermelo	S26°29,579' E29°58,111'	Aug 2008 to present	PM ₁₀ , PM _{2.5} , SO ₂ , NO, NO ₂ , NO _x , CO, O ₃ , benzene,	Wind speed and direction, ambient temperature and	5 seconds

			toluene, ethylbenzene, xylene.	pressure, rainfall, relative humidity, solar radiation.	
Hendrina	S26°09,084' E29°42,975'	Aug 2008 to present	PM ₁₀ , PM _{2.5} , SO ₂ , NO, NO ₂ , NO _x , CO, O ₃ , benzene, toluene, ethylbenzene, xylene.	Wind speed and direction, ambient temperature and pressure, rainfall, relative humidity, solar radiation.	5 seconds
Middelburg	S25°47,760' E29°27,840'	Aug 2008 to present	PM ₁₀ , PM _{2.5} , SO ₂ , NO, NO ₂ , NO _x , CO, O ₃ , benzene, toluene, ethylbenzene, xylene.	Wind speed and direction, ambient temperature and pressure, rainfall, relative humidity, solar radiation.	5 seconds
Secunda	S26°33,039' E29°04,747'	Aug 2008 to present	PM ₁₀ , PM _{2.5} , SO ₂ , NO, NO ₂ , NO _x , CO, O ₃ , benzene, toluene, ethylbenzene, xylene.	Wind speed and direction, ambient temperature and pressure, rainfall, relative humidity, solar radiation.	5 seconds
Witbank	S25°52,655' E29°11,246'	Aug 2008 to present	PM ₁₀ , PM _{2.5} , SO ₂ , NO, NO ₂ , NO _x , CO, O ₃ , benzene, toluene, ethylbenzene, xylene.	Wind speed and direction, ambient temperature and pressure, rainfall, relative humidity, solar radiation.	5 seconds



FIGURE 2: MAP SHOWING LOCATION AND EXTENT OF HIGHVELD PRIORITY AREA.

2.2 International Laws and Conventions

2.2.1 United Nations Framework Convention on Climate Change (UNFCCC1)

The Convention entered into force on 21 March 1994. The Convention on Climate Change sets an overall framework for intergovernmental efforts to tackle the challenge posed by climate change. It recognizes that the climate system is a shared resource whose stability can be affected by industrial and other emissions of carbon dioxide and other greenhouse gases. The Convention enjoys near universal membership, with 192 countries having ratified including South Africa.

Under the Convention, governments gather and share information on greenhouse gas emissions, national policies and best practices launch national strategies for addressing greenhouse gas emissions and adapting to expected impacts, including the provision of financial and technological support to developing countries and cooperate in preparing for adaptation to the impacts of climate change.

2.2.2 Kyoto Protocol

The Kyoto Protocol is an international agreement linked to the United Nations Framework Convention on Climate Change. The major feature of the Kyoto Protocol is that it sets binding targets for 37 industrialized countries and the European community for reducing greenhouse gas (GHG) emissions. This amounts to an average of five per cent against 1990 levels over the five-year period 2008-2012.

The Kyoto Protocol is generally seen as an important first step towards a truly global emission reduction regime that will stabilize GHG emissions, and provides the essential architecture for any future international agreement on climate change. The Kyoto Protocol was adopted in Kyoto, Japan, on 11 December 1997 and entered into force on 16 February 2005. 180 nations including South Africa have ratified the treaty to date. Under the Treaty, countries must meet their targets primarily through national measures. However, the Kyoto Protocol offers them an additional means of meeting their targets by way of three market-based mechanisms.

The Kyoto mechanisms are:

- Emissions trading – known as "the carbon market"
- the clean development mechanism (CDM)
- joint implementation (JI).

These mechanisms help stimulate green investment and help Parties meet their emission targets in a cost-effective way.

2.2.3 The Vienna Convention for the Protection of the Ozone Layer

The ultimate objective of the Convention is to protect human health and the environment against adverse effects resulting from human activities which modify or are likely to modify the ozone layer and urges the Parties to take appropriate measures in accordance with the provisions in the Convention and its Protocols which are in force for that party. To achieve the aforementioned objectives, the Parties, within their capabilities, are expected to: cooperate to better understand and assess the effects of human activities on the ozone layer and the effects of the modification of the ozone layer; adopt appropriate measures and cooperate in harmonizing appropriate

¹www.UNFCCC.org

policies to control the activities that are causing the modification of the ozone layer; cooperate in the formulation of agreed measures for the implementation of this Convention; and cooperate with competent international bodies to implement effectively this Convention and protocols to which they are party.

2.2.4 The Montreal Protocol on Substances that deplete the Ozone Layer

This protocol controls production of ozone depleting substances: The Montreal Protocol on Substances that Deplete Ozone Layer is a protocol under the Vienna Convention. The Protocol controls the production and consumption of the most commercially and environmentally significant ozone-depleting substances - those listed in the Annexes to the Protocol. One feature of the Montreal Protocol which makes it unique, is Article 6 that requires the control measures to be revised at least every four years (starting 1990), based on the review and assessment of latest available-information on scientific, environmental, technical and economic aspects of the depletion of the ozone layer. Based on reports of assessment panels appointed by the Parties and taking into consideration the needs and situation of the developing countries, the Protocol has already been adjusted and amended twice.

At present, 191 nations have become party to the Montreal Protocol. The Montreal Protocol on Substances that Deplete the Ozone Layer is an international treaty designed to protect the ozone layer by phasing out the production of a number of substances believed to be responsible for ozone depletion. The treaty was opened for signature on September 16, 1987 and entered into force on January 1, 1989 followed by a first meeting in Helsinki, May 1989. Since then, it has undergone seven revisions, in 1990 (London), 1991 (Nairobi), 1992 (Copenhagen), 1993 (Bangkok), 1995 (Vienna), 1997 (Montreal), and 1999 (Beijing).

2.2.5 The Stockholm Convention on Persistent Organic Pollutants (POPs)

The Stockholm Convention is an international legally binding agreement on persistent organic pollutants (POPs). In 1995, the Governing Council of the United Nations Environment Programme (UNEP) called for global action to be taken on POPs, which it defined as "chemical substances that persist in the environment, bio-accumulate through the food web, and pose a risk of causing adverse effects to human health and the environment".

Following this, the Intergovernmental Forum on Chemical Safety (IFCS) and the International Programme for Chemical Safety (IPCS) prepared an assessment of the 12 worst offenders. Known as the Dirty Dozen, this list includes eight organo-chlorine pesticides: aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, mirex and toxaphene; two industrial chemicals: hexachlorobenzene (HCB) and the polychlorinated biphenyl (PCB) group; and two groups of industrial by-products: dioxins and furans.

The negotiations for the Stockholm Convention on Persistent Organic Pollutants were completed on May 23rd 2001 in Stockholm, Sweden. The convention entered into force on May 17th, 2004 with ratification by an initial 128 parties and 151 signatories. Co-signatories agreed to outlaw nine of the "dirty dozen" chemicals, limit the use of DDT to malaria control, and curtail inadvertent production of dioxins and furans. Parties to the convention have agreed to a process by which persistent toxic compounds can be reviewed and added to the convention, if they meet certain criteria for persistence and trans boundary threat. Several other substances are being considered for inclusion in the Convention. These are: hexabromobiphenyl, octaBDE, pentaBDE, pentachlorobenzene, short-chained chlorinated paraffin's, lindane, α - and β -hexachlorocyclohexane, dicofol, endosulfan, chlordane and PFOS.

The Convention sets out several objectives including:

- the elimination from commerce of identified POPs and others that may be identified in the future;
- encouraging the transition in commerce to safer alternatives;
- identifying additional POPs;
- the clean-up of old stockpiles and equipment containing POPs; and
- encouraging all stakeholders to work towards a POP-free environment.

2.2.6 International Concerns Around Mercury

There are international initiatives to address mercury but to date no international policy has been developed. A recent programme backed by the United Nations (UN) that aims to reduce the health and environmental impacts of mercury includes a two-year period of voluntary action to reduce emissions and an evaluation to determine whether an international treaty is necessary. It aims to develop partnerships between government, industry and other key groups to reduce emissions.

2.2.7 Equator Principles

The Environmental Assessment report required needs to address baseline environmental and social conditions, requirements under host country laws and regulations, applicable international treaties and agreements, sustainable development and use of renewable natural resources, protection of human health, cultural properties, and biodiversity, including endangered species and sensitive ecosystems, use of dangerous substances, major hazards, occupational health and safety, fire prevention and life safety, socio-economic impacts, land acquisition and land use, involuntary resettlement, impacts on indigenous peoples and communities, cumulative impacts of existing projects, the proposed project, and anticipated future projects, participation of affected parties in the design, review and implementation of the project, consideration of feasible environmentally and socially preferable alternatives, efficient production, delivery and use of energy, pollution prevention and waste minimization, pollution controls (liquid effluents and air emissions) and solid and chemical waste management.

2.2.8 International Finance Corporation

The International Finance Corporation (IFC) recommends the following in regards to air pollution. “Emissions do not result in pollutant concentrations that reach or exceed relevant ambient quality guidelines and standards by applying national legislation standards, or in their absence, the current World Health Organization (WHO) Air Quality Guidelines (AQGs) or other internationally recognized sources. As a general rule, this guideline suggests 25 percent of the applicable air quality standards to allow additional, future sustainable development in the same airshed.”

2.3 Standards and Guidelines

The main pollutant of concern which may pose a health risk to surrounding sensitive receptors and possible communities during the current investigation is particulate matter. Gaseous pollutants such as benzene, SO₂, NO₂ and CO will also have an impact on the surrounding communities. An overview is provided of the available local regulations and standards (SANS), and then for comparison, international guidelines and standards prescribed for inhalable particulates, nuisance dust exposure and gaseous pollutants. These include the World Bank (WB), European Union (EU), United Kingdom (UK), World Health Organisation (WHO), and the United States Environmental Protection Agency (USEPA).

2.3.1 Inhalable Particulates

Particulate matter (PM) is a collective name for fine solid or liquid particles added to the atmosphere by processes at the earth's surface. Particulate matter includes dust, smoke, soot, pollen and soil particles (Kemp, 1998).

Particulate has been linked to a range of serious respiratory and cardiovascular health problems. The key effects associated with exposure to ambient particulate matter include: premature mortality, aggravation of respiratory and cardiovascular disease, aggravated asthma, acute respiratory symptoms, chronic bronchitis, decreased lung function, and increased risk of myocardial infarction (USEPA, 1996).

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

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

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

Fine and coarse particles are distinct in terms of the emission sources, formation processes, chemical composition, atmospheric residence times, transport distances and other parameters. Fine particles are directly emitted from combustion sources and are also formed secondarily from gaseous precursors such as sulphur dioxide, nitrogen oxides, or organic compounds. Fine particles are generally composed of sulphate, nitrate, chloride and ammonium compounds, organic and elemental carbon, and metals. Combustion of coal, oil, diesel, gasoline, and wood, as well as high temperature process sources such as smelters and steel mills, produce emissions that contribute to fine particle formation. Fine particles can remain in the atmosphere for days to weeks and travel through the atmosphere hundreds to thousands of kilometres, while most coarse particles typically deposit to the earth within minutes to hours and within tens of kilometres from the emission source. Some scientists have postulated that ultra fine particles, by virtue of their small size and large surface area to mass ratio may be especially toxic. There are studies which suggest that these particles may leave the lung and travel through the blood to other organs, including the heart.

Coarse particles are typically mechanically generated by crushing or grinding and are often dominated by resuspended dusts and crustal material from paved or unpaved roads or from construction, farming, and mining activities (USEPA, 1996). Table 4 outlines the local and international health risk criteria used for the assessment of inhalable particulate matter (PM10). Guidelines and standards are provided for a 24-hour exposure and annual average exposure period respectively.

TABLE 4: AVAILABLE LOCAL AND INTERNATIONAL STANDARDS USED FOR THE EVALUATION OF INHALABLE PARTICULATE MATTER (PM10).

Origin	24-Hour Exposure ($\mu\text{g}/\text{m}^3$)	Annual Average Exposure ($\mu\text{g}/\text{m}^3$)	Number of Exceedances Allowed per year
RSA⁽¹⁾	120 ⁽¹⁾	50 ⁽¹⁾	4 daily exceedances
RSA⁽²⁾	75 ⁽²⁾	40 ⁽²⁾	0 daily exceedances
Australia	50		5 daily exceedances
World Bank⁽³⁾	500	100	NA
EU⁽⁴⁾	50	20	7 daily exceedances
US-EPA⁽⁵⁾	150	50 ⁽⁶⁾	1 daily exceedance
UK⁽⁷⁾	50	40	35 daily exceedances
WHO^{(8) (9) (10)}	50	20	NA

Notes: ⁽¹⁾ Standard laid out in the National Environment Management: Air Quality Act. No. 39 of 2004

⁽²⁾ Compliance by 1 January 2015

⁽³⁾ World Bank Air Quality Standards summary obtainable at URL <http://www.worldbank.org/html/fpd/em/power/standards/airqstd.stm#paq>.

⁽⁴⁾ European Union Air Quality Standards summary obtainable at URL http://europa.eu.int/smartapi/cgi/sqa_doc?smartapi!celexplus!prod!DocNumber&lg=en&type_doc=Directive&an_doc=1999&nu_doc=30.

⁽⁵⁾ United States Environmental Protection Agencies National Air quality Standards obtainable at URL <http://www.epa.gov/air/criteria.html>

⁽⁶⁾ 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 $\mu\text{g}/\text{m}^3$.

⁽⁷⁾ United Kingdom Air Quality Standards and objectives obtainable at URL <http://www.airquality.co.uk/archive/standards.php>

⁽⁸⁾ WHO = World Health Organisation

⁽⁹⁾ Guidance on the concentrations at which increasing, and specified mortality responses due to PM are expected based on current scientific insights (WHO, 2005).

⁽¹⁰⁾ Air quality guideline

TABLE 5: AVAILABLE LOCAL STANDARDS USED FOR THE EVALUATION OF INHALABLE PARTICULATE MATTER (PM2.5).

Origin	24-Hour Exposure ($\mu\text{g}/\text{m}^3$)	Annual Average Exposure ($\mu\text{g}/\text{m}^3$)	Number of Exceedances Allowed per year
RSA ⁽¹⁾	65	25	4 daily exceedances 0 annual exceedances
RSA ⁽²⁾	40	20	
RSA ⁽³⁾	25	15	

Notes: ⁽¹⁾ Standard laid out in the National Environment Management: Air Quality Act. No. 39 of 2004

⁽²⁾ Compliance by 1 January 2016

⁽³⁾ Compliance by 1 January 2030

2.3.2 Nuisance Dust

Nuisance dust is known to result in the soiling of materials and has the potential to reduce visibility. Atmospheric particulates change the spectral transmission, thus diminishing visibility by scattering light. The scattering efficiency of such particulates is dependent upon the mass concentration and size distribution of the particulates. Various costs are associated with the loss of visibility, including: the need for artificial illumination and heating; delays, disruption and accidents involving traffic; vegetation growth reduction associated with reduced photosynthesis; and commercial losses associated with aesthetics. The soiling of building and materials due to dust frequently gives rise to damages and costs related to the increased need for washing, cleaning and repainting. Dustfall may also impact negatively on sensitive industries, e.g. bakeries or textile industries. Certain elements in dust may damage materials. For instance it was found that sulphur and chlorine if present in dust may cause damage to copper (Maeda *et al.*, 2001).

The physical smothering of the leaf surface of plants by dust particles causes reduced light transmission, affecting photosynthetic processes resulting in growth reduction (Thompson *et al.*, 1984; Pyatt and Haywood, 1989; Farmer, 1993).

Increases in the temperature of particle-covered leaves result in a positive impact on respiration and a negative impact on photosynthesis and productivity (Eller, 1977). The physical obstruction of the stomata has been observed to reduce stomatal resistance, resulting in the potential for higher uptake of pollutant gases, and it may also affect the exchange of water vapour (CEPA/FPAC Working Group, 1999). Particle accumulation on leaf surfaces may cause plants to become more susceptible to other stresses such as disease (CEPA/FPAC Working Group, 1999). A review of the effects of cement dust on trees showed that the dust caused physical damage to the leaves, reduced fruit setting and generally reduced growth (Farmer, 1993). Several studies in Europe and the United States have indicated that a decline in species diversity may be linked to declining air quality around urban and industrial areas (Gunnarsson, 1988; Hallingbäck, 1992; Vána, 1992; Van Zanten, 1992; Finizio *et al.*, 1998; Jones and Paine, 2006; Motiejūnaitė, in press; Otnyukova, in press). Currently in South Africa, two studies are underway, the first is to determine the potential impacts of sulphur and nitrogen from power stations, on the forestry industry in the lowveld of Mpumalanga, with the second being a study between the Kruger Park and

Foskor to determine impacts associated with phosphate contamination at the Phalaborwa Mine. Neither of these studies have to date yielded publishable results.

Particulate matter is a recognized health hazard for man and domestic animals (Newman *et al.*, 1979). Air pollutants have had a worldwide effect on both wild birds and wild mammals, often causing marked decreases in local animal populations (Newman *et al.*, 1979). The major effects of industrial emissions on wildlife include direct mortality, debilitating industrial-related injury and disease, physiological stress, anaemia, and bioaccumulation. Some air pollutants have caused a change in the distribution of certain wildlife species. As with all air quality studies very little work has been undertaken to determine the impacts on species other than humans.

South Africa is one of the only countries who have issued guideline limits for the evaluation of nuisance dust levels. A four banding system has traditionally been used which describes the dust deposition as resulting in a slight, moderate, heavy or very heavy nuisance impact. These criteria are summarised as follows:

Slight	: < 250 mg/m ² /day
Moderate	: > 250 mg/m ² /day < 500 mg/m ² /day
Heavy	: > 500 mg/m ² /day < 1200 mg/m ² /day
Very Heavy	: > 1200 mg/m ² /day

The South African Department of Mineral Resources (DMR) use the 1 200 mg/m²/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/m²/day constitute a layer of dust thick enough to allow a person to "write" words in the dust with their fingers. Local experience, gained from the assessment of impacts due to dust from mine tailings dams in Gauteng, has shown that complaints from the public will be activated by repeated dustfall in excess of ~2000 mg/m²/day. Dustfall in excess of 5000 mg/m²/day impacting on residential or industrial areas generally provoke prompt and angry complaints.

The main limitation in using this type of classification system is that it is purely descriptive and does not provide an indication as to what action needs to be taken to remediate the problem. The South African Bureau of Standards in their SANS 1929:2005 publication, "Ambient air quality – limits for common pollutants", provides additional criteria which can be used for the evaluation of fallout dust deposition. A four banded scale has been provided, with target, action and alert thresholds indicated. Permissible margins of tolerances are outlined with possible exceptions noted.

Table 6 and Table 7 detail these evaluation criteria.

TABLE 6: FOUR BAND SCALE EVALUATION CRITERIA FOR DUST DEPOSITION (SANS, 2005).

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

TABLE 7: TARGET, ACTION AND ALERT THRESHOLDS FOR DUST DEPOSITION (SANS, 2005).

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

An enterprise may submit a request to the authorities to operate within band 3 (action band), as specified in

Table 6, for a limited period, provided that this is essential in terms of the practical operation of the enterprise and provided that and appropriate control technology is applied for the duration. No margin of tolerance will be granted for operations that result in dustfall rates which fall within band 4 (alert band) as specified in Table 7 (SANS, 2005).

Dustfalls that exceed the specified rates but that can be shown to be the result of some extreme weather or geological event shall be discounted for the purpose of enforcement and control. Such an event might typically result in excessive dustfall rates across an entire metropolitan region, and not be localised to a particular operation. Natural seasonal variations, for example, the naturally windy months each year, will not be considered extreme events for this definition (SANS, 2005).

Table 8 provides an indication as to the draft of the National Dust Control Regulations which were issued on 7 December 2012. These standards have not as yet been passed, and are still in draft form, however it is recommended that these be the target that an industry should aim for, as the standard is likely to be similar.

TABLE 8: ACCEPTABLE DUST FALL RATES AS MEASURED (USING ASTM D1739:1970) AT AND BEYOND THE BOUNDARY OF THE PREMISES WHERE DUST ORIGINATES.

Restriction Areas	Dust fall rate (mg/m ² /day, 30-days average)	Permitted frequency of exceeding dust fall rate
Residential area	D < 600	Two within a year, not sequential months.
Non-residential area	600 < D < 1200	Two within a year, not sequential months.

2.3.3 Sulphur dioxide

SO₂ is an irritant that is absorbed in the nose and aqueous surfaces of the upper respiratory tract, and is associated with reduced lung function and increased risk of mortality and morbidity. Adverse health effects of SO₂ include coughing, phlegm, chest discomfort and bronchitis.

Most information on the short-term (<24 hours) acute effects of SO₂ comes from controlled chamber experiments on volunteers exposed to SO₂ for periods ranging from a few minutes up to one hour (WHO, 2000). Acute responses occur within the first few minutes after commencement of inhalation. Effects include reductions in the mean forced expiratory volume over one second, increases in specific airway resistance, and symptoms such as wheezing or shortness of breath. These effects are enhanced by exercise that increases the volume of air inspired, as it allows SO₂ to penetrate further into the respiratory tract. A wide range of sensitivity has been demonstrated, both among normal subjects and among those with asthma. People with asthma are the most sensitive group in the community (Table 9).

TABLE 9: AVAILABLE LOCAL AND INTERNATIONAL STANDARDS FOR SULPHUR DIOXIDE.

3 Pollutant	4 Limits	Tanzania	South Africa	WHO	EU	UK	US
Sulphur Dioxide (SO₂)	Annual Average	40-60 µg/m ³	50 µg/m ³	10-30 µg/m ³	20 µg/m ³	20 µg/m ³	80 µg/m ³

3 Pollutant	4 Limits	Tanzania	South Africa	WHO	EU	UK	US
	24-hour Average	100 $\mu\text{g}/\text{m}^3$	125 $\mu\text{g}/\text{m}^3$	20 $\mu\text{g}/\text{m}^3$	125 $\mu\text{g}/\text{m}^3$	125 $\mu\text{g}/\text{m}^3$	365 $\mu\text{g}/\text{m}^3$

Information on the effects of exposure averaged over a 24-hour period is derived mainly from epidemiological studies in which the effects of SO₂, suspended particulate matter and other associated pollutants are considered. Exacerbation of symptoms among panels of selected sensitive patients seems to arise in a consistent manner when the concentration of SO₂ exceeds 250 $\mu\text{g}/\text{m}^3$ in the presence of suspended particulate matter. Several more recent studies in Europe have involved mixed industrial and vehicular emissions now common in ambient air. At low levels of exposure (mean annual levels below 50 $\mu\text{g}/\text{m}^3$; daily levels usually not exceeding 125 $\mu\text{g}/\text{m}^3$) effects on mortality (total, cardiovascular and respiratory) and on hospital emergency admissions for total respiratory causes and chronic obstructive pulmonary disease (COPD), have been consistently demonstrated. These results have been shown, in some instances, to persist when black smoke and suspended particulate matter levels were controlled for, while in others no attempts have been made to separate the pollutant effects. In these studies no obvious threshold levels for SO₂ has been identified.

Earlier assessments, using data from the coal-burning era in Europe judged the lowest-observed-adverse-long-term effect level of SO₂ to be at an annual average of 100 $\mu\text{g}/\text{m}^3$, when present with suspended particulate matter. More recent studies related to industrial sources of SO₂, or to the changed urban mixture of air pollutants, have shown adverse effects below this level. There is, however, some difficulty in finding this value. Based upon controlled studies with asthmatics exposed to SO₂ for short periods, the World Health Organisation (WHO, 2000) recommends that a value of 500 $\mu\text{g}/\text{m}^3$ (0.175 ppm) should not be exceeded over averaging periods of 10 minutes. Because exposure to sharp peaks depends on the nature of local sources, no single factor can be applied to estimate corresponding guideline values over longer periods, such as an hour. Day-to-day changes in mortality, morbidity, or lung function related to 24-hour average concentrations of SO₂ are necessarily based on epidemiological studies, in which people are in general exposed to a mixture of pollutants; and guideline values for SO₂ have previously been linked with corresponding values for suspended particulate matter. This approach led to a previous guideline 24-hour average value of 125 $\mu\text{g}/\text{m}^3$ (0.04 ppm) for SO₂, after applying an uncertainty factor of two to the lowest-observed-adverse-effect level. In more recent studies, adverse effects with significant public health importance have been observed at much lower levels of exposure. However, there is still a large uncertainty with this and hence no concrete basis for numerical changes of the 1987-guideline values for SO₂.

High concentrations of SO₂ over short periods may result in acute visible injury symptoms in plants. Such symptoms are usually observed on broad-leaved plants as relatively large bleached areas between the larger veins which remain green. On grasses acute injury, usually caused by exposures to sub-lethal long-term intermittent episodes of relatively low concentrations, may be observed as general chlorosis of the leaves (Lacasse and Treshow, 1976). This visible injury may decrease the market value of certain crops and lower the productivity of the plants. Sulphur dioxide impairs stomatal functioning resulting in a decline in photosynthetic rates, which in turn causes a decrease in plant growth. Reduction in plant yields can occur, even in the absence of visible foliar symptoms (Mudd, 1975).

Species that are sensitive to SO₂ include spinach, cucumber and oats. These species may show decreases in growth at concentrations of 0.01 to 0.5 ppm (26 to 1309 µg/m³) (Mudd, 1975). Visible SO₂ injury can occur at dosages ranging from 0.05 to 0.5 ppm (131 to 1309 µg/m³) for 8 hours or more (Manning and Feder, 1976). Maize, celery and citrus show much less damage at these low concentrations (Mudd, 1975). Air quality criteria issued by the European Community (EC), United Kingdom (UK) and World Health Organisation (WHO) for the protection of ecosystems against sulphur dioxide exposures are summarised in Table 10. Ambient air quality guidelines and standards for sulphur dioxide for various countries and organisations are presented in Table 11.

TABLE 10: INJURY TO PLANTS DUE TO VARIOUS DOSES OF SULPHUR DIOXIDE⁽¹⁾.

Symptoms	Concentrations	Concentrations	Duration of Exposure
	(µg/m ³)	(ppm)	
Visible foliar injury to vegetation in arid regions	26179	10	2 hr
Coverage of 5% of leaf area of sensitive species with visible necrosis ⁽²⁾	1309 – 2749	0.5 - 1.05	1 hr
Visible injury to sensitive vegetation in humid regions	2618	1	5 min
Coverage of 5% of leaf area of sensitive species with visible necrosis ⁽²⁾	785 – 1571	0.3 - 0.6	3 hr
Visible injury to sensitive vegetation in humid regions	1309	0.5	1 hr
Visible injury to sensitive vegetation in humid regions	524	0.2	3 hr
Visible injury to sensitive species	131 – 1309	0.05 - 0.5	8 hrs
Decreased growth in sensitive species	26 – 1309	0.01 - 0.5	-
Coverage of 5% of leaf area of sensitive species with visible necrosis ⁽²⁾	524 – 680	0.2 - 0.26	6 - 8 hrs
Yield reductions may occur	524	0.2	monthly mean
Growth of conifers and yield of fruit trees may be reduced	262	0.1	monthly mean
Yield reductions may occur	209	0.08	annual mean
Growth of conifers and yield of fruit trees may be reduced	131	0.05	annual mean
Critical level for agricultural crops, forest trees and natural vegetation ⁽³⁾	79	0.03	24-hrs
Critical level for agricultural crops ⁽³⁾	26	0.01	annual mean
Critical level for forest trees and natural vegetation ⁽³⁾	21	0.008	annual mean

Notes:

⁽¹⁾References: Laccasse and Treshow, 1976; Mudd, 1975; Manning and Feder, 1976; Harrison, 1990; Godish, 1991; Ferris, 1978

⁽²⁾Resistant species found to have threshold levels at three times these concentrations.

⁽³⁾Refer to critical levels used by the United National Economic Commission for Europe to map exceedence areas. These represent levels at which negative responses have been noted for sensitive receptors.

TABLE 11: THRESHOLDS SPECIFIED BY CERTAIN COUNTRIES AND ORGANISATIONS FOR VEGETATION AND ECOSYSTEMS.

Pollutant		Averaging Period	Threshold (ppb)	Threshold ($\mu\text{g}/\text{m}^3$)
5	Sulphur dioxide	6 annual average	7 3.7 - 11.1 ppb(a)	9 10 - 30 $\mu\text{g}/\text{m}^3$ (a)
			8 7.4 ppb(b)	10 20 $\mu\text{g}/\text{m}^3$ (b)

Notes:

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

(b) EC and UK limit value to protect ecosystems

10.1.1 Carbon Monoxide (CO)

Carbon monoxide absorbed through the lungs reduces the blood's capacity to transport available oxygen to the tissues. Approximately 80-90 % of the absorbed CO binds with haemoglobin to form carboxyhaemoglobin (COHb), which lowers the oxygen level in blood. Since more blood is needed to supply the same amount of oxygen, the heart needs to work harder. These are the main causes of tissue hypoxia produced by CO at low exposure levels. At higher concentrations, the rest of the absorbed CO binds with other heme proteins such as myoglobin and with cytochrome oxidase and cytochrome P-450.

CO uptake impairs perception and thinking, slows reflexes, and may cause drowsiness, angina, unconsciousness, or death. An exposure to concentrations of 45 mg/m^3 for more than two hours adversely affects a person's ability to make judgements. Two to four hours of exposure at 200 mg/m^3 raises the COHb level in the blood to 10-30 % and increases the possibility of headaches. Exposure to 1 000 mg/m^3 raises the COHb level in the blood to 30 % and causes a rapid increase in pulse rate leading to coma and convulsions. One to two hours of exposure at 1 830 mg/m^3 results in 40 % COHb in blood, which may cause death (MARC 1991). Endogenous production of CO results in COHb levels of 0.4-0.7% in healthy subjects (WHO 2000). During pregnancy, elevated maternal COHb levels of 0.7-2.5% have been reported, mainly due to increased endogenous production. The COHb levels in non-smoking general populations are usually 0.5-1.5% due to endogenous production and environmental exposures. Non-smoking people in certain occupations (car drivers, policemen, traffic wardens, garage and tunnel workers, firemen etc.) can have long-term COHb levels up to 5%, and heavy cigarette smokers have COHb levels up to 10%. Well-trained subjects engaging in heavy exercise in polluted indoor environments can increase their COHb levels quickly up to 10-20%. Epidemic CO poisonings in indoor ice arenas have been reported. To protect non-smoking, middle-aged and elderly population groups with documented or latent coronary artery disease from acute ischemic heart attacks, and to protect fetuses of non-smoking pregnant mothers from untoward hypoxic effects, a COHb level of 2.5% should not be exceeded (WHO 2000).

The guideline values, and periods of time-weighted average exposures, have been determined in such a way that the COHb level of 2.5% is not exceeded, even when a normal subject engages in light or moderate exercise. The guideline values for CO are 100 mg/m^3 for 15 minutes, 60 mg/m^3 for 30 minutes, 30 mg/m^3 for 1 hour, and 10 mg/m^3 for 8 hours (WHO 2000). These ambient air quality guidelines and other standards issued for various countries and organisations for carbon monoxide are given in Table 12.

TABLE 12: AIR QUALITY GUIDELINES AND STANDARDS FOR CARBON MONOXIDE.

Averaging Period	South Africa		UK		World Health Organisation		US-EPA	
	$\mu\text{g}/\text{m}^3$	ppm	$\mu\text{g}/\text{m}^3$	ppm	$\mu\text{g}/\text{m}^3$	ppm	$\mu\text{g}/\text{m}^3$	ppm
Max. 8-hour Ave	10 000	9	11 600(a)	10(a)	10 000	9	10 000	9
Max. 1-hour Ave	30 000	26	-	-	30 000	26	40 000	35

10.1.2 Oxides of Nitrogen

Air quality guidelines and standards issued by most other countries and organisations tend to be given exclusively for NO_2 concentrations as NO_2 is the most important species from a human health point of view. International and South African standards for NO_2 are presented in Table 13.

TABLE 13: AMBIENT AIR QUALITY GUIDELINES AND STANDARDS FOR NITROGEN DIOXIDE.

Averaging Period	South Africa		WHO		EC		Australia	
	$\mu\text{g}/\text{m}^3$	ppm	$\mu\text{g}/\text{m}^3$	ppm	$\mu\text{g}/\text{m}^3$	ppm	$\mu\text{g}/\text{m}^3$	ppm
Annual Ave	40	0.021	40	0.021	40 ⁽¹⁾	0.021 ⁽¹⁾	57 ⁽³⁾	0.03 ⁽³⁾
Max. 1-hr	200	0.10	200	0.10	200 ⁽²⁾	0.10 ⁽²⁾	240 ⁽⁴⁾	0.12 ⁽⁴⁾

Notes:

- ⁽¹⁾ Annual limit value for the protection of human health, to be complied with by 1 January 2010.
- ⁽²⁾ Averaging times represent 98th percentile of averaging periods; calculated from mean values per hour or per period of less than an hour taken through out year; not to be exceeded more than 8 times per year. This limit is to be complied with by 1 January 2010.
- ⁽³⁾ Standard set in June 1998. Goal within 10 years given as being no exceedances.
- ⁽⁴⁾ Standard set in June 1998. Goal within 10 years given as maximum allowable exceedances of 1 day a year.

NO is one of the primary pollutants emitted by aircraft and motor vehicle exhausts. NO_2 is formed through oxidation of these oxides once released in the air. NO_2 is an irritating gas that is absorbed into the mucous membrane of the respiratory tract. The most adverse health effect occurs at the junction of the conducting airway and the gas exchange region of the lungs. The upper airways are less affected because NO_2 is not very soluble in aqueous surfaces. Exposure to NO_2 is linked with increased susceptibility to respiratory infection, increased airway resistance in asthmatics and decreased pulmonary function.

Available data from animal toxicology experiments indicate that acute exposure to NO_2 concentrations of less than $1\ 880\ \mu\text{g}/\text{m}^3$ (1 ppm) rarely produces observable effects (WHO 2000). Normal healthy humans, exposed at rest or with light exercise for less than two hours to concentrations above $4\ 700\ \mu\text{g}/\text{m}^3$ (2.5 ppm), experience pronounced decreases in pulmonary function; generally, normal subjects are not affected by concentrations less than $1\ 880\ \mu\text{g}/\text{m}^3$ (1.0 ppm). One study showed that the lung function of subjects with chronic obstructive pulmonary disease is slightly affected by a 3.75-hour exposure to $560\ \mu\text{g}/\text{m}^3$ (0.3 ppm) (WHO 2000).

Asthmatics are likely to be the most sensitive subjects, although uncertainties exist in the health database. The lowest concentration causing effects on pulmonary function was reported from two laboratories that exposed mild asthmatics for 30 to 110 minutes to $565\ \mu\text{g}/\text{m}^3$ (0.3 ppm) NO_2 during intermittent exercise. However, neither of these laboratories was able to replicate these responses with a larger group of asthmatic subjects. NO_2 increases

bronchial reactivity, as measured by the response of normal and asthmatic subjects following exposure to pharmacological bronchoconstrictor agents, even at levels that do not affect pulmonary function directly in the absence of a bronchoconstrictor. Some, but not all, studies show increased responsiveness to bronchoconstrictors at NO₂ levels as low as 376-565 µg/m³ (0.2 to 0.3 ppm); in other studies, higher levels had no such effect. Because the actual mechanisms of effect are not fully defined and NO₂ studies with allergen challenges showed no effects at the lowest concentration tested (188 µg/m³; 0.1 ppm), full evaluation of the health consequences of the increased responsiveness to bronchoconstrictors is not yet possible.

Studies with animals have clearly shown that several weeks to months of exposure to NO₂ concentrations of less than 1 880 µg/ m³ (1ppm) causes a range of effects, primarily in the lung, but also in other organs such as the spleen and liver, and in blood. Both reversible and irreversible lung effects have been observed. Structural changes range from a change in cell type in the tracheobronchial and pulmonary regions (at a lowest reported level of 640 µg/m³), to emphysema-like effects. Biochemical changes often reflect cellular alterations, with the lowest effective NO₂ concentrations in several studies ranging from 380-750µg/m³. NO₂ levels of about 940 µg/m³ (0.5ppm) also increase susceptibility to bacterial and viral infection of the lung. Children of between 5-12 years old are estimated to have a 20% increased risk for respiratory symptoms and disease for each increase of 28 µg/m³ NO₂ (2-week average), where the weekly average concentrations are in the range of 15-128 µg/m³ or possibly higher. However, the observed effects cannot clearly be attributed to either the repeated short-term high-level peak, or to long-term exposures in the range of the stated weekly averages (or possibly both). The results of outdoor studies consistently indicate that children with long-term ambient NO₂ exposures exhibit increased respiratory symptoms that are of longer duration, and show a decrease in lung function.

10.1.3 Volatile Organic Compounds

It is noted that some organic compounds have little or no known direct human health effects, while others are extremely toxic and/or carcinogenic. Little is known about how various organic compounds combine in the atmosphere or in the human body, or what the cumulative impacts of exposure might be.

Although standards for exposure to volatile organic compounds (VOCs) in non-industrial settings do not exist, a number of exposure limits have been recommended. The European Collaborative Action (ECA) Report No. 11 titled *Guidelines for Ventilation Requirements in Buildings* (CEC, 1992) lists the following total volatile organic compound (TVOC) concentration ranges as measured with a flame ionisation detector calibrated to toluene. These recommendations are based on Mølhave's toxicological work on mucous membrane irritation (Mølhave, 1990).

Comfort range:	<200 µg/m ³
Multi-factoral exposure range:	200 to 3 000 µg/m ³
Discomfort range:	3 000 to 25 000 µg/m ³
Toxic range:	>25 000 µg/m ³

The same European report also lists a second method based on Seifert's work (Seifert, 1990). This method established TVOC guidelines based on the ten most prevalent compounds in each of seven chemical classes. The concentrations in each of these classes should be below the maximums listed below.

Alkanes:	100 µg/m ³
Aromatic hydrocarbons:	50 µg/m ³
Terpenes:	30 µg/m ³
Halocarbons:	30 µg/m ³
Esters:	20 µg/m ³

Aldehydes and ketones (excl. formaldehyde):	20 µg/m³
Other:	50 µg/m³

The TVOC concentration is calculated by adding the totals from each class. Seifert gives a target TVOC concentration of 300 µg/m³ which is the sum of the above listed target concentrations. The author also states that no individual compound concentration should exceed 50 percent of the guideline for its class or 10 percent of the TVOC guideline concentration. However, Seifert states that "...the proposed target value is not based on toxicological considerations but – to the author's best judgement."

Table 14 provides for the South African annual standards for Benzene.

TABLE 14: AVAILABLE LOCAL STANDARDS USED FOR THE EVALUATION OF BENZENE (NO EXCEEDANCES).

Averaging Period	Annual Average Exposure (µg/m³)	Compliance date
Annual	10	Immediate
Annual	5	1 January 2015

11 BASELINE ENVIRONMENT

11.1 Description of Environment

11.1.1 Regional and Local Climate and Atmospheric Dispersion Potential

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

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

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

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

The study area is situated in a semi-arid zone within the central Highveld, a region that is characterized by cool, dry winters (May to August) and warm, wet summers (October to March), with April and September being transition months.

Wind roses comprise of 16 spokes which represent the directions from which winds blew during the 2006 – 2007 period. The colours reflect the different categories of wind speeds. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories.

The information presented in the subsections follows detail of the dispersion potential of the area under investigation. Majuba Power Station (30km from site) has its own meteorological station, however data from the South African Weather Services has been included to ensure the Majuba data is correct. Comparison was made between data sourced from the Majuba station and data taken from the South African Weather Services (Amersfoort – 39km from site). The period wind rose for the Majuba station is presented in Figure 3 and the period wind rose for the data sourced from the South African Weather Services is presented in Figure 4.

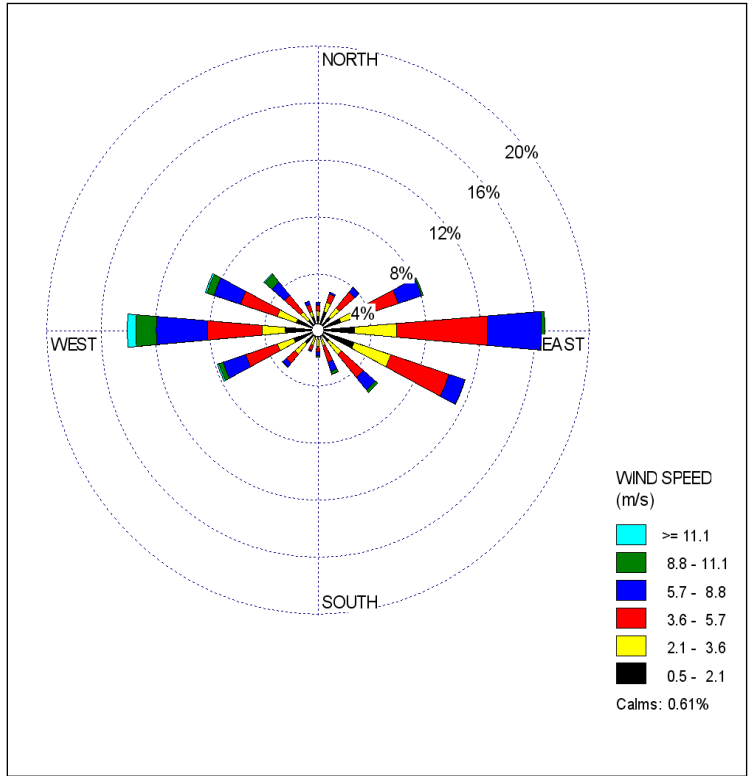


FIGURE 3: PERIOD WIND ROSE DERIVED FROM MONITORED DATA FROM THE MAJUBA POWER STATION (2006 TO 2007).

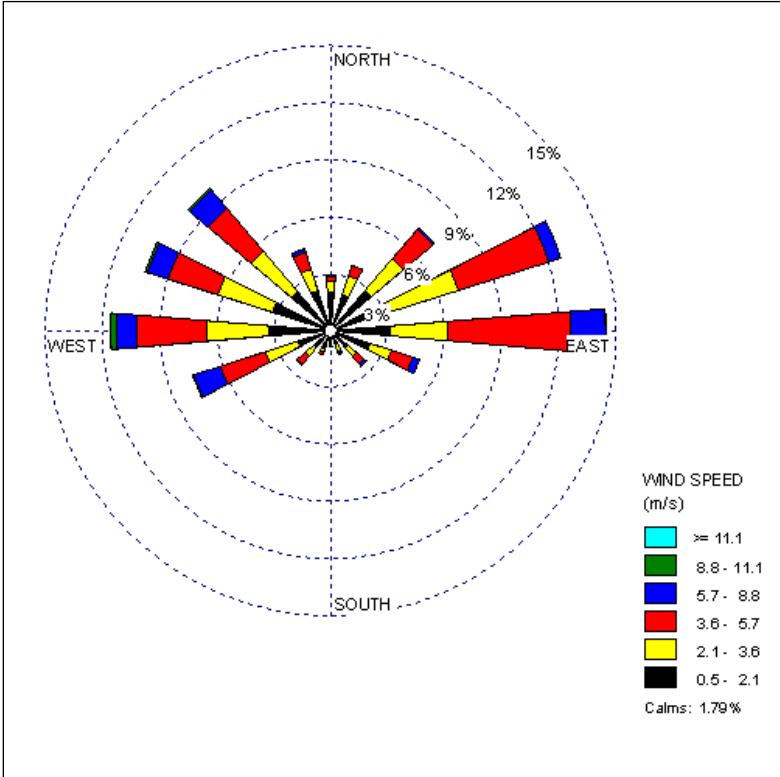


FIGURE 4: PERIOD WIND ROSE DERIVED FROM MODELLED DATA SOURCED FROM THE SOUTH AFRICAN WEATHER SERVICES (2006 TO 2007).

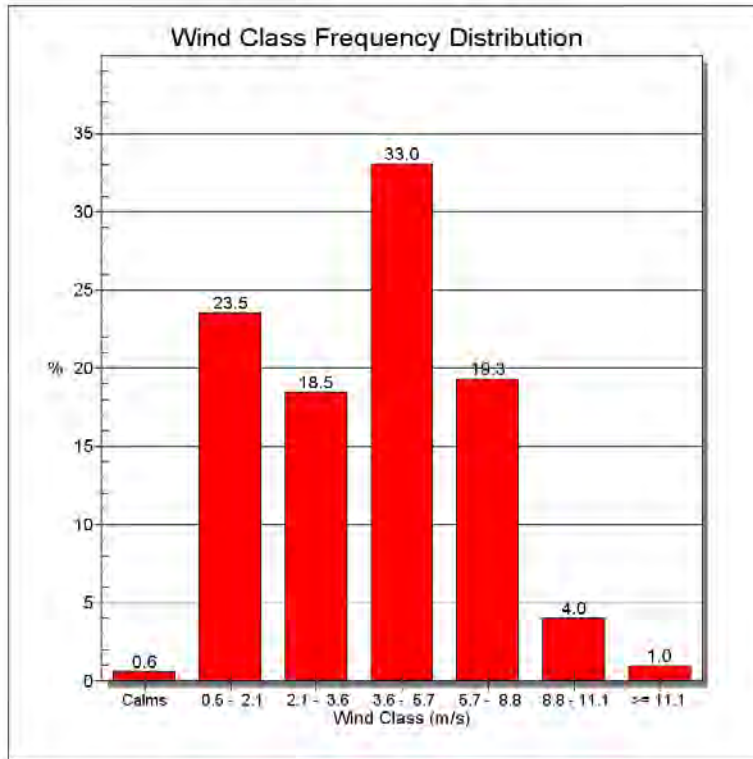


FIGURE 5: FREQUENCY DISTRIBUTION DERIVED FROM MONITORED DATA (MAJUBA STATION: 2006 TO 2007).

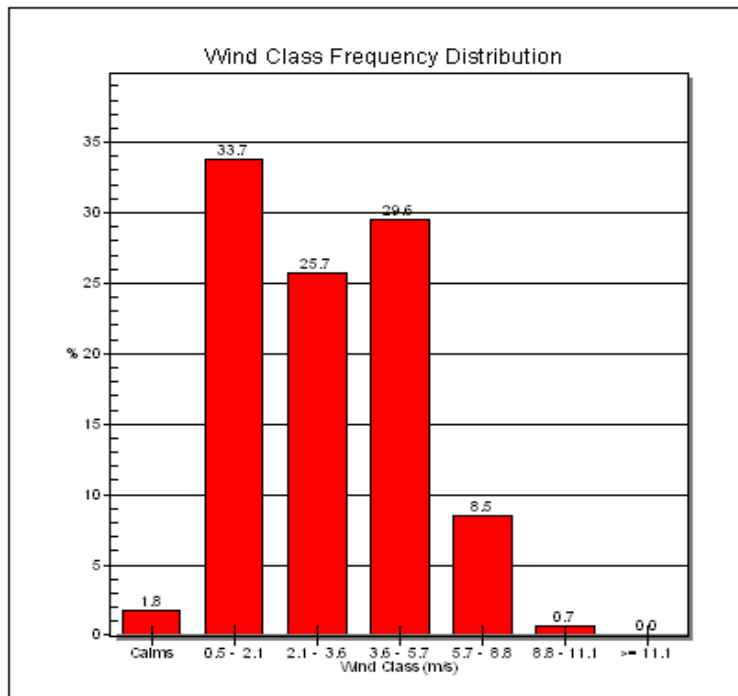


FIGURE 6: FREQUENCY DISTRIBUTION DERIVED FROM MODELLED DATA (SOUTH AFRICAN WEATHER SERVICES: 2006 TO 2007).

For the period assessed, winds predominated from the western and eastern sectors. The wind rose profile is typical of that experienced by low lying areas surrounded by an escarpment. From the eastern vector, wind

speeds of between 5.7-8.8 m/s occurred most of the time. The same wind speeds occurred but were less common from the south easterly and north eastern sectors. Stronger winds of greater than 8.8 m/s were also experienced from the west.,with a higher frequency of strong winds recorded at the Majuba station compared to the Amersfoort station.

The average wind speed for the Amersfoort area is 3.24 m/s, with the highest recorded wind speeds (between 8 and 11 m/s) coming from the west. Calm winds, representing periods of little dispersion, occur 0.61% and 1.79% of the time at Amersfoort and Majuba, respectively . Information pertaining to calm periods, average wind speeds and wind direction all play a significant role with regards to dispersion effects and will play a fundamental role during the modelling undertaken for the project.

11.2 Atmospheric Stability

Atmospheric stability is commonly categorised into one of six stability classes. These are briefly described in Table 15. The atmospheric boundary layer is usually unstable during the day due to turbulence caused by the sun's heating effect on the earth's surface. The depth of this mixing layer depends mainly on the amount of solar radiation, increasing in size gradually from sunrise to reach a maximum at about 5-6 hours after sunrise. The degree of thermal turbulence is increased on clear warm days with light winds. During the night a stable layer, with limited vertical mixing, exists. During windy and/or cloudy conditions, the atmosphere is normally neutral.

Within the Amersfoort area, very unstable to stable conditions predominates within most sectors. The highest frequencies of such winds occurring were mainly from the east-north-east and east sectors, and the next highest from the west-south-west and west-north-west sectors.

TABLE 15: ATMOSPHERIC STABILITY CLASSES

Rating	Category	Description
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

11.3 Precipitation

Precipitation cleanses the air by washing out particles suspended in the atmosphere (Kupchella & Hyland, 1993). It is calculated that precipitation accounts for about 80-90% of the mass of particles removed from the atmosphere (CEPA/FPAC Working Group, 1999). Total monthly rainfall figures for the area are depicted in Figure 7, from the figure it is possible to see the marked seasonality of the rainfall, with a marked summer rainfall pattern.

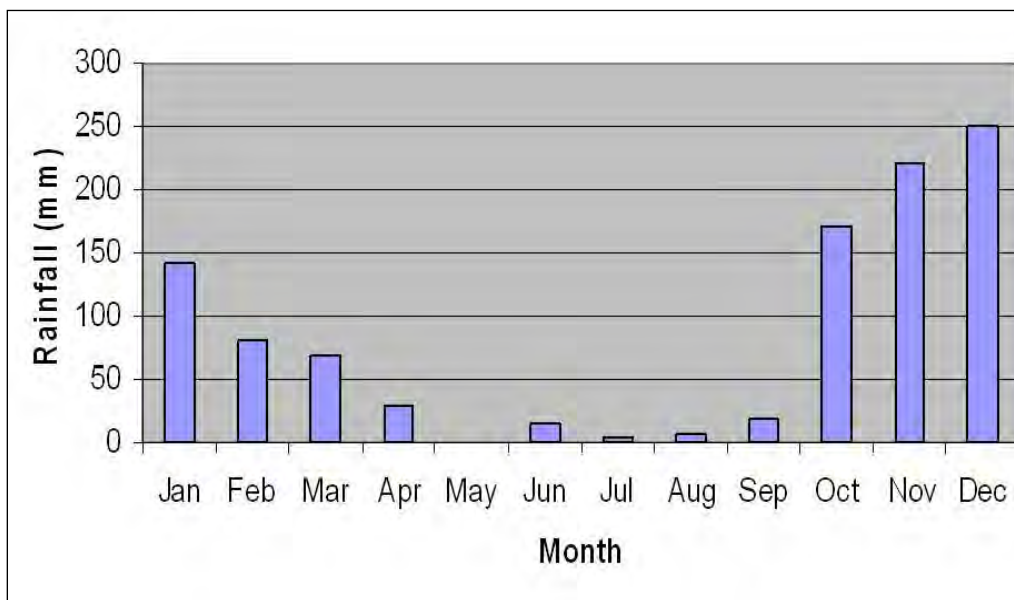


FIGURE 7: MONTHLY RAINFALL FIGURES FOR AMERSFOORT REGION. MEAN ANNUAL RAINFALL 1008 MM (2007).

11.4 Temperature and Humidity

Temperature affects the formation, action, and interactions of pollutants in various ways (Kupchella & Hyland, 1993). Chemical reaction rates tend to increase with temperature and the warmer the air, the more water it can hold and hence the higher the humidity. When relative humidity exceeds 70%, light scattering by suspended particles begins to increase, as a function of increased water uptake by the particles (CEPA/FPAC Working Group, 1999). This results in decreased visibility due to the resultant haze. Many pollutants may also dissolve in water to form acids.

Temperature also provides an indication of the rate of development and dissipation of the mixing layer. As can be seen in Figure 8 daily summer temperatures range between ~2 °C and ~32 °C with an average of ~17 °C. Winter temperatures range between ~-8 °C and ~23 °C with an average of ~7 °C.

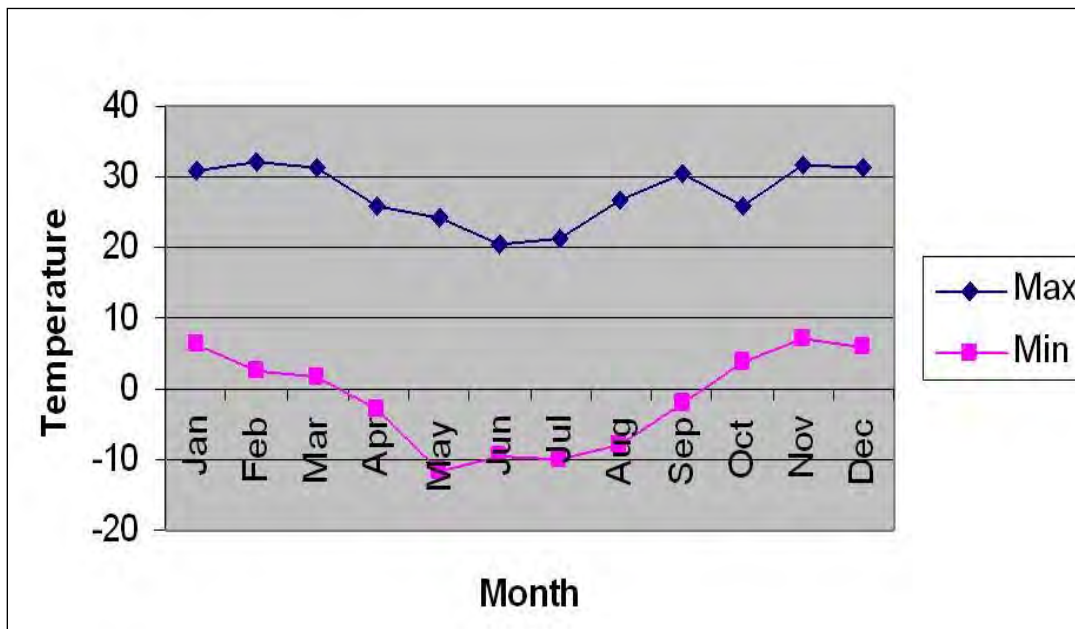


FIGURE 8: AVERAGE MONTHLY MAXIMUM AND MINIMUM TEMPERATURES RECORDED IN THE AMERSFOORT REGION (WEATHER SERVICES STATION, 2007).

Humidity is the content of water vapour in the atmosphere. Relative humidity is the ratio of actual vapour pressure to saturated vapour pressure, expressed as a percentage. The higher the temperature, the higher the saturated vapour pressure, and in particular in areas where there is a high availability of water, for instance humidity is generally high (Above 68%) in a narrow strip around the coast. Continental areas are generally characterized by low humidity's (Below 60%), but humidity also depends on the prevailing air masses (Schulze, 1997). The study area experiences high relative humidity's during the summer months, with a couple of lower relative humidity's months during winter Figure 9 shows the slight variations in humidity depending on the seasons.

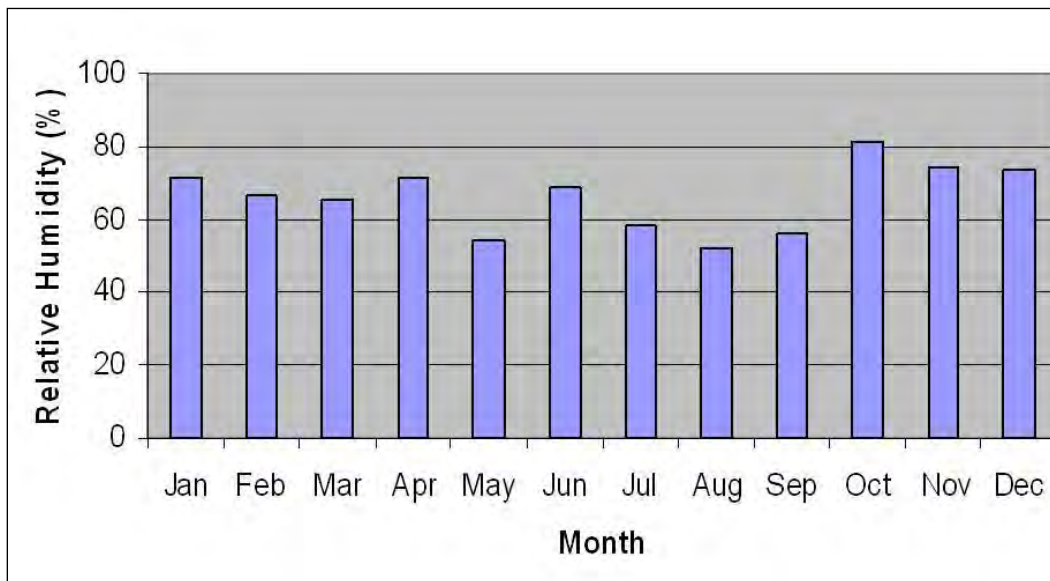


FIGURE 9: AVERAGE MONTHLY RELATIVE HUMIDITY FOR THE AMERSFOORT REGION (WEATHER SERVICES STATION 2007).

11.5 Other Polluting Sources in the Area

Currently a detailed emissions inventory for the area under investigation has not been undertaken. Based on aerial photo's and a site description of the area, the following sources of potential air pollution have been identified:

- Power stations (Majuba)
- Veld fires;
- Vehicle entrainment;
- Agriculture; and
- Mining operations.

A qualitative discussion on each of these source types is provided in the subsections which follow. These subsections aim to highlight the possible extent of cumulative impacts which may result due to the proposed operations.

11.5.1 Power Stations

The burning of coal for power generation results in significant emissions being generated. At the power stations surrounding the truck stop site, various mitigation measures have been put in place at the stations to reduce emissions before entering the atmosphere. These include bag filters or electrostatic precipitator (ESPs) for the removal of particulate matter and ash, scrubbers for sulphur dioxide and over air burners for oxides of nitrogen. Based on Figure 10 below however, emissions which are released can still be significant enough to result in increased particulate or chemical concentrations in the atmosphere surrounding the plant.



FIGURE 10: AN INDICATION OF POTENTIAL EMISSIONS FROM POWER STATIONS.

11.5.2 Veld Fires

A veld fire is a large-scale natural combustion process that consumes various ages, sizes, and types of flora growing outdoors in a geographical area. Consequently, veld fires are potential sources of large amounts of air pollutants that should be considered when attempting to relate emissions to air quality. The size and intensity, even the occurrence, of a veld fire depends directly on such variables as meteorological conditions, the species of vegetation involved and their moisture content, and the weight of consumable fuel per hectare (available fuel loading).

Once a fire begins, the dry combustible material is consumed first. If the energy released is large and of sufficient duration, the drying of green, live material occurs, with subsequent burning of this material as well. Under suitable environmental and fuel conditions, this process may initiate a chain reaction that results in a widespread conflagration. It has been hypothesized, but not proven, that the nature and amount of air pollutant emissions are directly related to the intensity and direction (relative to the wind) of the veld fire, and are indirectly related to the rate at which the fire spreads. (Figure 11) The factors that affect the rate of spread are (1) weather (wind velocity, ambient temperature, relative humidity); (2) fuels (fuel type, fuel bed array, moisture content, fuel size); and (3) topography (slope and profile). However, logistical problems (such as size of the burning area) and difficulties in safely situating personnel and equipment close to the fire have prevented the collection of any reliable emissions data on actual veld fires, so that it is not possible to verify or disprove the hypothesis.

The major pollutants from veld burning are particulate matter, carbon monoxide, and volatile organics. Nitrogen oxides are emitted at rates from 1 to 4 g/kg burned, depending on combustion temperatures. Emissions of sulphur oxides are negligible (USEPA, 1996). A study of biomass burning in the African savanna estimated that the annual flux of particulate carbon into the atmosphere is estimated to be of the order of 8 Tg C, which rivals particulate carbon emissions from anthropogenic activities in temperate regions (Cachier *et al*, 1995).



FIGURE 11: RECENTLY BURNT AND BURNING FIELDS NEAR MAJUBA POWER STATION.

11.5.3 Vehicle entrained dust

The force of wheels of vehicles travelling on unpaved roadways causes the pulverisation of the surface material. Particles are lifted and dropped from the rotating wheels and the road surface is exposed to strong air currents in turbulent shear with the surface. The turbulent wake behind the vehicle continues to act on the road surface after the vehicle has passed. The quantity of dust emissions from unpaved roads varies linearly with the volume of traffic as well as the speed of the vehicles.

Figure 12 provides an indication of the unpaved roads in the area. These types of roads will also be used and new ones created to ensure access to the truck stop where access cannot be obtained from the main roads in the area. The movement of construction vehicles and the transportation of pipe sections will result in unusually heavy loads being placed on the roads, which is likely to result in additional damage to the road surface (USEPA, 1996).



FIGURE 12: COMMONLY USED UNPAVED ROADS NEAR KOMATI TOWN.

11.5.4 Agriculture

Agricultural activity can be considered a significant contributor to particulate emissions, although tilling, harvesting and other activities associated with field preparation are seasonally based. Figure 13 provides an indication of the types of agricultural activities which take place in and around the Witbank area. The main crop grown in the area is maize with cattle farming being smaller in extent. The figure also shows bare ground areas, indicating poor soil conditions, which can increase the dust blown from the surface.

The main focus internationally with respect to emissions generated due to agricultural activity is related to animal husbandry, with special reference to malodours generated as a result of the feeding and cleaning of animal. The types of livestock assessed included pigs, sheep, goats and chickens. Emissions assessed include ammonia and hydrogen sulphide (USEPA, 1996).

Little information is available with respect to the emissions generated due to the growing of crops. The activities responsible for the release of particulates and gasses to atmosphere would however include:

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



FIGURE 13: DOMESTIC LIVESTOCK AND MAIZE AGRICULTURE ARE COMMON SOURCES OF EMISSIONS IN THE SURROUNDING AREA.

11.5.5 Mining Operations

BHP Billiton, Exxaro and Total Coal are some of the companies which are currently operating both open cast and underground mining operations in the area. The majority of these mines produce low grade coal for the use in the nearby power stations, while high grade coal is trucked to the Richards Bay Rail link for export. All aspects from blasting, to materials handling and transport of coal can result in particulate emissions to atmosphere from these areas. These mines need to ensure their own environmental obligations are met, by compliance to criteria outlined in their EMPs and air quality permits.



FIGURE 14: OPEN CAST MINING OPERATIONS IN THE AREA.

11.6 Sensitive Receptors

Residential, educational and recreational land uses are considered to be sensitive receptors. For this study, the position of houses/dwellings on the farms was taken off 1:50 000 topographical cadastral maps and verified as far as possible using Google Earth and site visits. Even though the latest editions were used, the relevant maps are out of date and there may be new dwellings and/or some of the existing shown buildings may be derelict.

There are a number of human settlements in the areas as well as farmers and labourers working on surrounding farms, which would need to be accounted for and based on the distances from the proposed site, may be impacted on during construction and operation.

- Exel garage
(Amajuba Service Station)
Cnrn Govan Mbeki/Adelaide Tambo
Ashraf 082 558 5515
Yacoob 082 378 6044
- Caltex garage
(Yacoob's Auto Caltex)
Cnrn Adelaide Tambo/Smit
Ashraf 082 558 5515
Yacoob 082 378 6044
- Engen 1 Plus
(Aveling Convenience Centre)
Cnrn Adelaide Tambo/Dr Nelson Mandela
Sandra Aveling 082 469 1100
- Total garage
(Afgri)
- Adelaide Tambo Str
Fanie De Bruyn 017 735 5175 or 079 928 9697
- Engen garage
(Midway Service Centre)
Cnrn Sarel Cilliers/Dr Nelson Mandela Dr
Aisha 017 735 1358/2254
- Shell garage
(Smit Motors)
Cnrn Sarel Cilliers/Dr Nelson Mandela
Gerrit Smit 017 735 5106
- Total garage
(Total Volksrust)
Cnrn Dr Nelson Mandela Dr/President Str
017 735 4169

The diesel depot information is:
FPS Bulk Diesel
Charlestown N17
Herman Brelage
017 735 2927 or 082 922 5336

The information for the farmer bordering our north
and west sides is:
Morné Myburg 082 456 8284
Riaan Kock
Director
Kock & Associates Inc.
Tel: 011 958 0700
Fax: 086 540 4561
Cell: 082 321 3800

Other sensitive receptors within the area would be the local fauna and flora. It has been identified that dust settling on the leaves of plants can result in damage to plants and inhalation of dust may result in sickness and associated lung diseases for wildlife and humans which will be present in the vicinity of the construction.

12 ASSESSMENT OF ENVIRONMENT LIKELY TO BE AFFECTED

The impact assessment phase of this investigation assesses the impact associated with the commencement of operations at the truck stop and filling station is likely to have an impact on the surrounding areas.

This section of the report outlines the predicted impacts associated with the truck stop. Modelling was undertaken of the various activities taking place during the operation of the truck stop which could have an impact on the ambient PM10, SO₂, NO₂, CO and benzene ground level concentrations.

12.1 Methodology

Dispersion modelling was undertaken using the US-EPA approved AERMOD Dispersion Model. This model is based on the Gaussian plume equation and is capable of providing ground level concentration estimates of various averaging times, for any number of meteorological and emission source configurations (point, area and volume sources for gaseous or particulate emissions).

The AERMOD View model is used extensively to assess concentrations and deposition from a wide variety of sources. AERMOD View is a true, native Microsoft Windows application and runs in Windows 2000/XP and NT4 (Service Pack 6).

The AERMOD (dispersion model used during the current investigation, is a steady state Gaussian plume model which can be used to assess pollutant concentrations and /or deposition fluxes from a wide variety of sources associated with an industrial source complex. Some of the modelling capabilities are summarised as follows:

- AERMOD may be used to model primary pollutants and continuous releases of toxic hazardous waste pollutants;
- AERMOD model can handle multiple sources, including point, volume, area and open pit source types. Line sources may also be modelled as a string of volume sources or as elongated area sources;
- Source emission rates can be treated as constant or may be varied by month, season, hour of day, or other periods of variation, for a single source or for a group of sources;
- The model can account for the effects aerodynamic downwash due to nearby buildings on point source emissions;

- The model contains algorithms for modelling the effects of settling and removal (through dry deposition) of large particulates and for modelling the effects of precipitation scavenging from gases or particulates;
- Receptor locations can be specified as gridded and/or discrete receptors in a Cartesian or polar coordinate system;
- AERMOD incorporates the COMPLEX1 screen model dispersion algorithms for receptors in complex terrain;
- The model uses real-time meteorological data to account for the atmospheric conditions that affect the distribution of impacts on the modelling area; and
- Output results are provided for concentration, total deposition, dry deposition, and/or wet deposition flux.

Input data to the AERMOD model includes: source and receptor data, meteorological parameters, and terrain data. The meteorological data includes: wind velocity and direction, ambient temperature, mixing height and stability class.

The uncertainty of the AERMOD model predictions is considered to be equal to 2, thus it is possible for the results to be over predicting by double or under predicting by half, it is therefore recommended that monitoring be carried out at the proposed more during operation to confirm the modelled results, to ensure legal standards are maintained.

12.2 Input parameters

The emissions inventory details below provide information as to the input parameters which were used for the modelling runs. The base information for this inventory was provided by the client, and used directly in the model or used within calculations based on the US-EPA AP42 emission factor guidelines.

Site layout information was obtained from Figure 15 and Figure 16.

Meteorological input parameters used for Aermod include: (assume modelled SAWS data used for the dispersion modelling simulations?)

- Wind Speed
- Wind Direction
- Temperature
- Humidity
- Air Pressure
- Rainfall
- Cloud cover
- Ceiling Height

The topography of the greater study area is relatively flat and stable with little agricultural potential. The greater study area falls within the Karoo Supergroup, however the proposed site is highly transformed. The highest point of the site elevation is 1600 m above sea level.

Terrain included in modelling simulations?

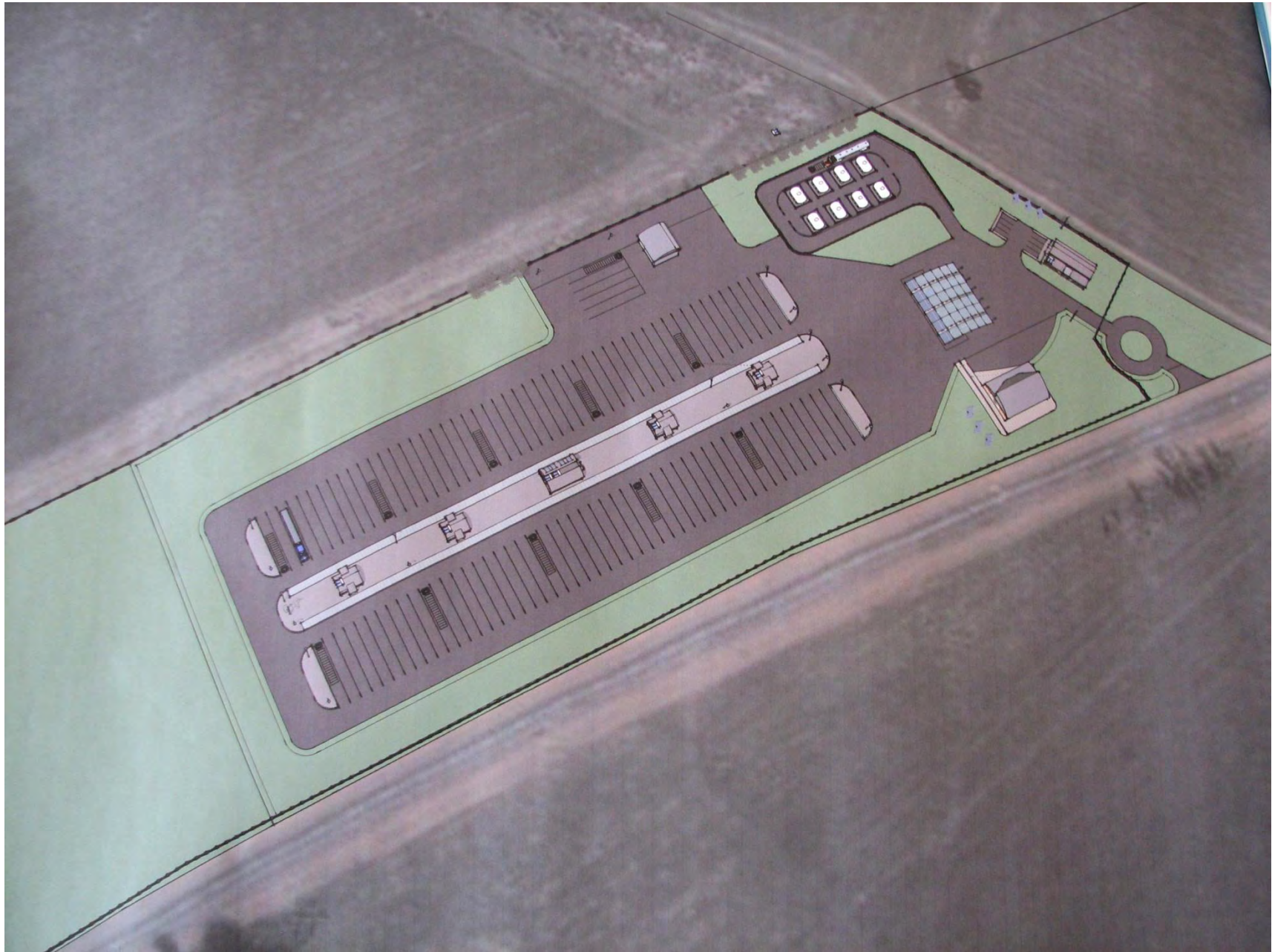


FIGURE 15: GENERAL LAYOUT PLAN OF THE SITE.



FIGURE 16: ARTISTS IMPRESSION OF SITE LAYOUT.

South African vehicle emission factors have been developed by Stone and Wong (DATE) from UCT to estimate vehicle emissions for heavy-duty vehicles under typical local conditions. It is expected that between 20 and 30 trucks will be using the truck stop at any given time. Calculated emission rates are given in Table 16.

TABLE 16: VEHICLE EMISSIONS BASED ON SA EMISSION FACTORS.

SA Factors	g/kWh	g/km/veh	t/a/km
CO	7.43	4.12	0.045
NO _x	11.42	6.33	0.069
VOC	0.9	0.49	0.005
PM	1.35	0.75	0.008
Fuel Consumption	245.02	135.85	1.487
Methane	0	0	0
SO ₂	2.54	1.416	0.0151
CO ₂	765	424.151	4.644

Storage tank parameters and estimated VOC emission rates are given in Table 17. Fuel storage is expected to be contained in 12 storage tanks (6 tanks of 45 000 litres diesel fuel each, 2 tanks of 45 000 litres of ULP each, 2 tanks of 45 000 litres of Leaded fuel each, and 2 tanks of 25 000 litres of Paraffin each). Thus the combined capacity of fuel storage is 500 000 litres.

TABLE 17: TANK VENTING EMISSIONS DATA (USEPA – TANKS 4.0).

Tanks Data	Dimensions (LxWxH mm)	Vapour pressure	Breathing losses (kg/a)	Breathing losses (g/s)
Diesel - 45 000 litre (six)	8500 x 3000 x 2200	0.76	309.5085	0.009814
Unleaded Petrol 45 000 litre (two)	8500 x 3000 x 2200	4.22	495.1909	0.015702
Leaded Petrol 45 000 litre (two)	8500 x 3000 x 2200	4.22	495.1909	0.015702
Paraffin 25 000 litre (two)	6058 x 2438 x 2896	1.16	Values?	Values?

Tank Specifications:

- All above ground;
- Horizontal Installation;
- Silver in colour; and
- Unheated.

12.3 Assumptions and Knowledge Gaps

- For the modelling process a worst case scenario was chosen for all dispersion modelling, assuming 30 trucks at any given time.
- All information provided is assumed to be correct.

12.4 Potential Impacts

This section aims to deal with the predicted air quality impacts which result due to the predicted operations on site. Details regarding the source characteristics were provided from site layout plans and process specific information provided by the client. The sources to be included in this assessment can be categorised as follows:

- HDV Trucks; and
- Fuel Storage Tanks.

Figure 17 provides an indication of the proposed impacts for benzene. For the annual averaging period, the maximum predicted off-site concentration is $1.84 \mu\text{g}/\text{m}^3$, which falls well below the National annual average standard of $10 \mu\text{g}/\text{m}^3$. Predicted CO concentrations over a one hour averaging period are given in Figure 18. The National hourly average standard is set at $30\,000 \mu\text{g}/\text{m}^3$ with the maximum predicted concentration off-site being $19\,475.30 \mu\text{g}/\text{m}^3$, falling well below the National hourly average CO standard.

Figure 19 provides an indication of the proposed impacts for nitrogen dioxide. For the 1 hour averaging period the maximum predicted concentration is $2\,292.87 \mu\text{g}/\text{m}^3$, which exceeds the National hourly average standard of $200 \mu\text{g}/\text{m}^3$. Figure 20 provides the predicted NO_2 concentrations over an annual averaging period, with a maximum predicted concentration of $7.73 \mu\text{g}/\text{m}^3$, well below the National annual average standard of $40 \mu\text{g}/\text{m}^3$.

Figure 21 and Figure 22 provide an indication of PM10 concentrations. Predicted PM10 concentrations show no off-site exceedances of either the daily or annual average PM10 National standards. Figure 23 shows the 1 hour averaging period concentrations for sulphur dioxide, with a maximum predicted off-site concentration of $602.44 \mu\text{g}/\text{m}^3$ which exceeds the National hourly average standard of $350 \mu\text{g}/\text{m}^3$. Predicted daily and annual average SO_2 concentrations show no exceedances of their respective standards (Figure 24 and Figure 25).

Where exceedances occur, reference needs to be made to

Table 1 in regards to the number of allowable exceedances allowed per pollutant. Legally 88 exceedances are allowed per year for hourly NO₂ and SO₂ concentrations. Based on the results for the proposed truck stop, hourly average SO₂ concentrations will exceed 9 times during a year and is therefore still within the permissible allowance. Hourly average NO₂ concentrations, however exceed 238 times during the course of a year and are in non-compliance.

Is the frequency of exceedence for SO₂ and NO₂ given for 2006 or 2007?



FIGURE 17: PREDICTED IMPACTS ASSOCIATED WITH BENZENE FOR AN ANNUAL AVERAGING PERIOD (STANDARD 10 μ G/M³)



FIGURE 18: PREDICTED IMPACTS ASSOCIATED WITH CARBON MONOXIDE FOR A 1 HOUR AVERAGING PERIOD (STANDARD 30 000 $\mu\text{G}/\text{M}^3$).

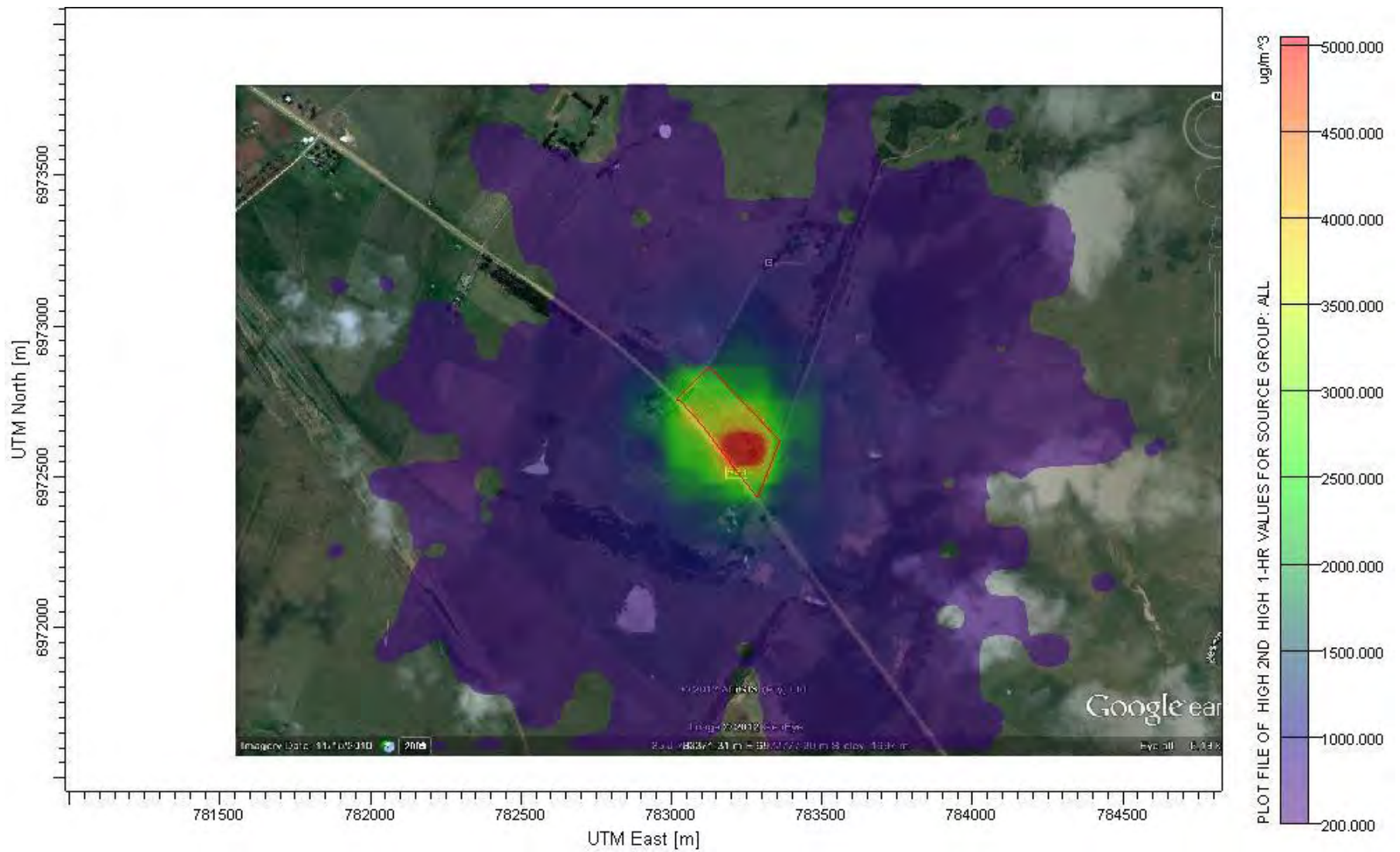


FIGURE 19: PREDICTED IMPACTS ASSOCIATED WITH NITROGEN DIOXIDE FOR A 1 HOUR AVERAGING PERIOD (STANDARD 200 $\mu\text{G}/\text{M}^3$).

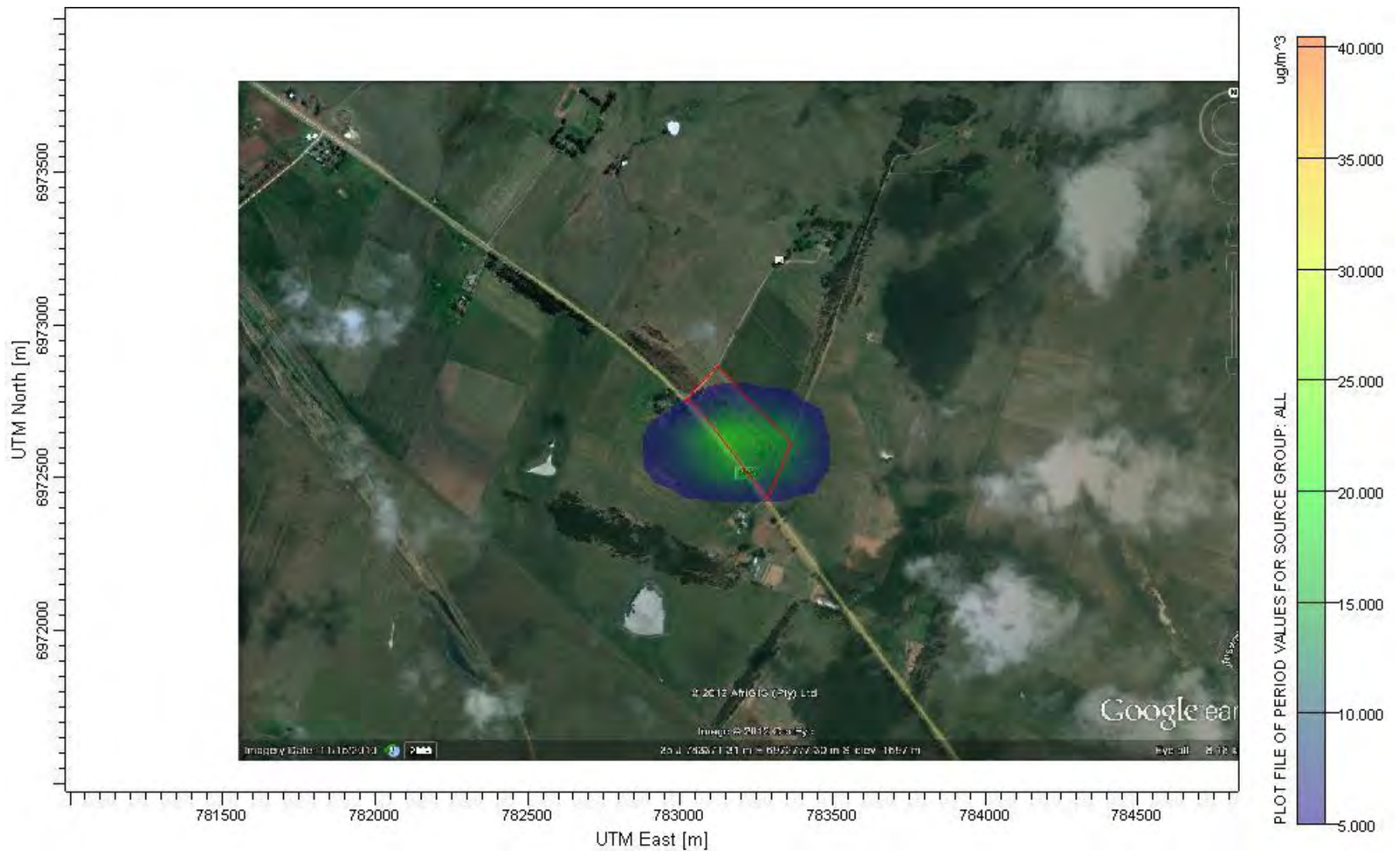


FIGURE 20: PREDICTED IMPACTS ASSOCIATED WITH NITROGEN DIOXIDE FOR AN ANNUAL AVERAGING PERIOD (STANDARD 40 $\mu\text{G}/\text{M}^3$).



FIGURE 21: PREDICTED IMPACTS ASSOCIATED WITH DIESEL PARTICULATES FOR A 24 HOUR AVERAGING PERIOD (STANDARD 120 $\mu\text{G}/\text{M}^3$).

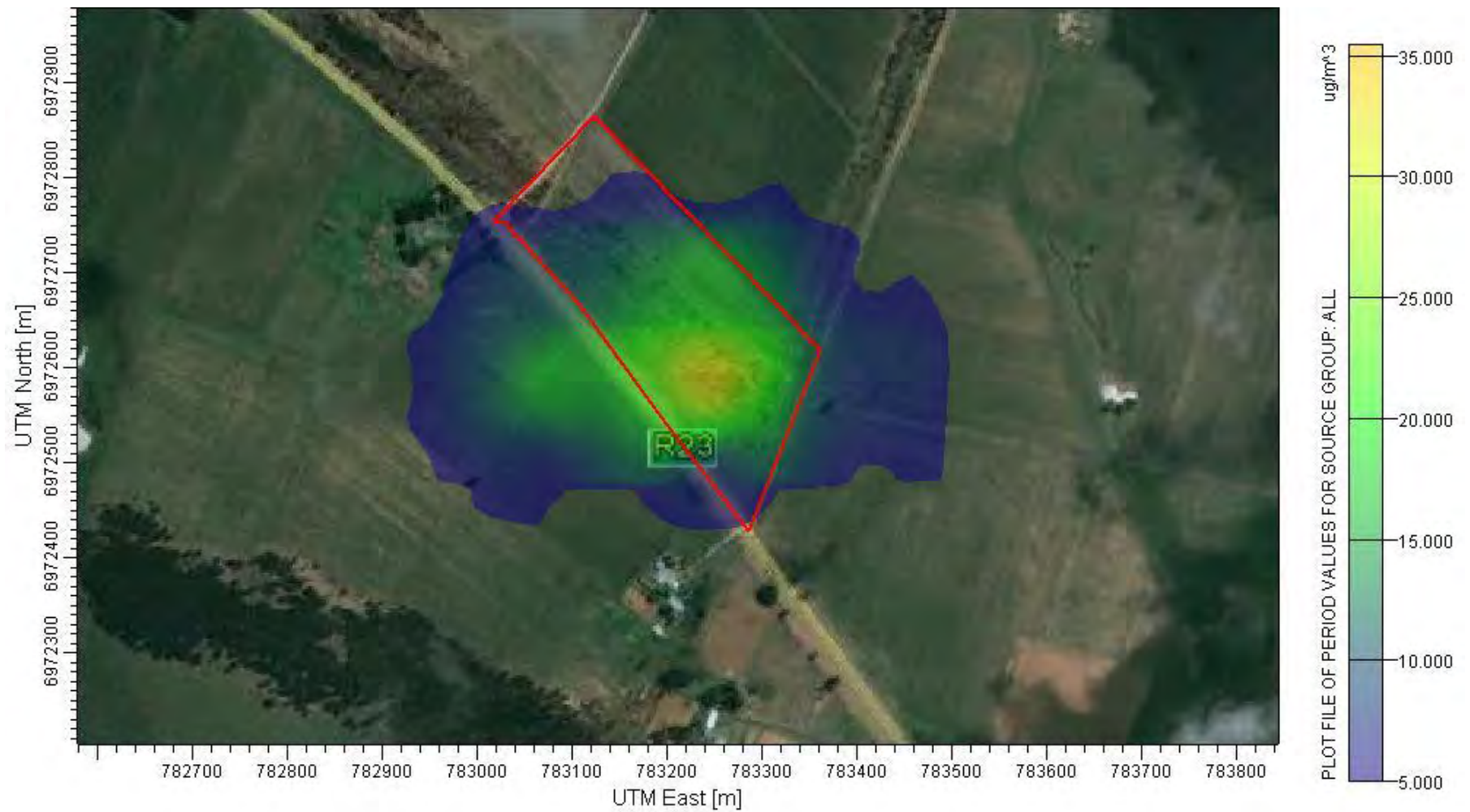


FIGURE 22: PREDICTED IMPACTS ASSOCIATED WITH DIESEL PARTICULATES FOR AN ANNUAL AVERAGING PERIOD (STANDARD 50 $\mu\text{G}/\text{M}^3$).



FIGURE 23: PREDICTED IMPACTS ASSOCIATED WITH SULPHUR DIOXIDE FOR A 1 HOUR AVERAGING PERIOD (STANDARD 350 µG/M³).

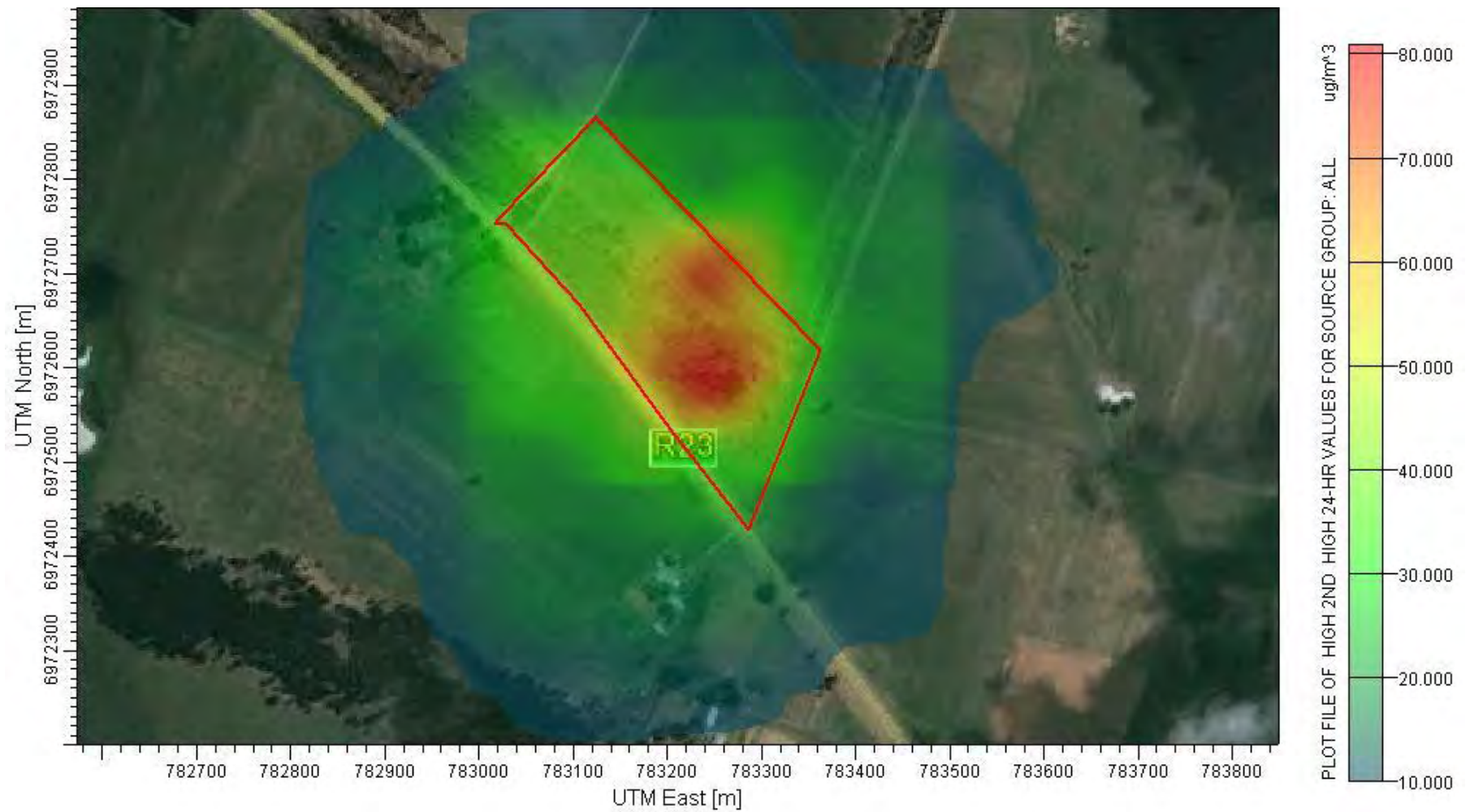


FIGURE 24: PREDICTED IMPACTS ASSOCIATED WITH SULPHUR DIOXIDE FOR A 24 HOUR AVERAGING PERIOD (STANDARD 125 $\mu\text{G}/\text{M}^3$).

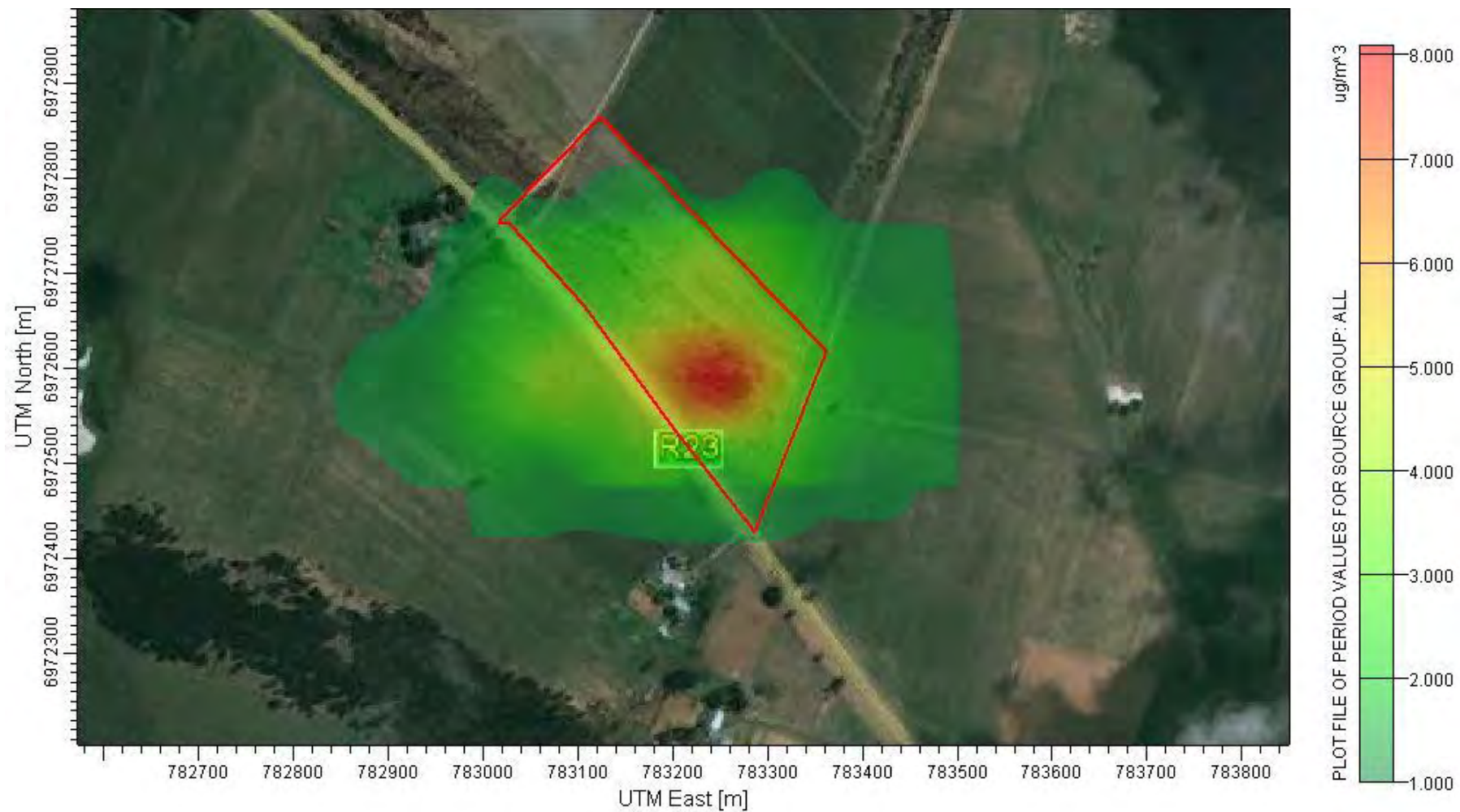


FIGURE 25: PREDICTED IMPACTS ASSOCIATED WITH SULPHUR DIOXIDE FOR AN ANNUAL AVERAGING PERIOD (STANDARD 50 $\mu\text{G}/\text{M}^3$).

TABLE 18: TABLE INDICATING MAXIMUM PREDICTED ON-SITE AND OFF-SITE CONCENTRATIONS ($\mu\text{G}/\text{M}^3$).

	Onsite Maximum	Offsite Maximum	Standard
Benzene			
Annual Average	3.92	1.84	10
Carbon monoxide			
Hourly Average	47 197.52	19 475.30	30 000
Nitrogen dioxide			
Hourly Average	7 253.07	2 292.87 (238 exceedances)	200 (88 exceedances)
Annual Average	37.07	7.73	40
Diesel Particulates			
Daily Average	326.73	111.98	120
Annual Average	32.97	16.74	50
Sulphur dioxide			
Hourly Average	1604.65	602.44 (9 exceedances)	350 (88 exceedances)
Daily Average	81.27	33.01	125
Annual Average	8.20	4.17	50

Note: Onsite concentrations are determined based on the maximum predicted concentration. The South African Air Quality Standards are based on a site boundary (off-site) figure and not necessarily on a maximum predicted figure.

12.5 Proposed mitigation

The NO_2 exceedances noted above are as a result of vehicle exhaust emissions, as the modelling exercise assumes the trucks will remain idling for the duration of the time at the truck stop. This is noted as the one hour values exceed the standards, however the daily and annual concentrations are well within the National standards.

Mitigation to this effect would be to ensure and instruct all drivers to switch off their vehicles once correctly parked, and to avoid idling as much as possible.

13 CONCLUSION

It is recommended that ambient monitoring be undertaken across the site to validate the modelled results and to determine whether the mitigation measures recommended ensure that the number of NO_2 exceedances is kept to below 88 per year.

Based on the above study, the air quality concerns in relation to this project are such that with the correct management and mitigation, all standards should be adhered to, and do not pose a risk to the local receiving environment.

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Stone and Wong

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15 GLOSSARY

Air quality – A measure of exposure to air which is not harmful to your health. Air quality is measured against health risk thresholds (levels) which are designed to protect ambient air quality. Various countries including South Africa have Air Quality Standards (legally binding health risk thresholds) which aim to protect human health due to exposure to pollutants within the living space.

Ambient air - the air of the surrounding environment.

Atmospheric pressure - the pressure created by the mass of air above a point or level, the total force per unit is the pressure.

Baseline - the current and existing condition before any development or action.

Boundary layer - the layer directly influenced by a surface.

Concentration - when a pollutant is measured in ambient air it is referred to as the concentration of that pollutant in air. Pollutant concentrations are measured in ambient air for various reasons, i.e. to determine whether concentrations are exceeding available health risk thresholds (air quality standards); to determine how different sources of pollution contribute to ambient air concentrations in an area; to validate dispersion modelling conducted for an area; to determine how pollutant concentrations fluctuate over time in an area; and to determine the areas with the highest pollution concentrations.

Condensation - the growth of water or ice by diffusion from contiguous water vapour.

Dispersion model - a mathematical model which can be used to assess pollutant concentrations and deposition rates from a wide variety of sources. Various dispersion modelling computer programs have been developed.

Dispersion potential - the potential a pollutant has of being transported from the source of emission by wind or upward diffusion. Dispersion potential is determined by wind velocity, wind direction, height of the mixing layer, atmospheric stability, presence of inversion layers and various other meteorological conditions.

Emission - the rate at which a pollutant is emitted from a source of pollution.

Emission factor - a representative value, relating the quantity of a pollutant to a specific activity resulting in the release of the pollutant to atmosphere.

Erosion – the lowering of the land surface by agents such as gravity, river flow, waves, currents, wind, etc that involve the transport of rock debris.

Evaporation - the opposite of condensation.

Front - a synoptic-scale swath of cloud and precipitation associated with a significant horizontal zonal temperature gradient. A front is warm when warm air replaces cold on the passage of the front; with a cold front cold air replaces warm air.

Fugitive dust - dust generated from an open source and is not discharged to the atmosphere in a confined flow stream.

High pressure cells - regions of raised atmospheric pressure.

Inversion - an increase of atmospheric temperature with an increase in height.

Mesoscale - a spatial scale intermediate between small and synoptic scales of weather systems.

Mixing layer - the layer of air within which pollutants are mixed by turbulence. Mixing depth is the height of this layer from the earth's surface.

Nitrogen fixation – the process by which atmospheric nitrogen is converted to forms usable by organisms. It is carried out only by certain micro-organisms such as free-living soil bacteria and bacteria or microbes in symbiotic associations with fungi, ferns or in the roots of legume plants.

Particulate matter (PM) - the collective name for fine solid or liquid particles added to the atmosphere by processes at the earth's surface and includes dust, smoke, soot, pollen and soil particles. Particulate matter is classified as a criteria pollutant, thus national air quality standards have been developed in order to protect the public from exposure to the inhalable fractions. PM can be principally characterised as discrete particles spanning several orders of magnitude in size, with inhalable particles falling into the following general size fractions:

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

Photosynthesis - the synthesis in green plants of carbohydrate from carbon dioxide as a carbon source and water as a hydrogen donor with the release of oxygen as a waste product, using light energy.

Pioneer plants – plants that are initial invaders of disturbed sites or the early seral stages of succession. Succession is the replacement of one plant community by another, often progressing to a stable terminal community called a climax.

PM10 - refers to particulate matter that is 10µm or less in diameter. PM10 is generally subdivided into a fine fraction of particles 2.5µm or less (PM2.5), and a coarse fraction of particles larger than 2.5µm. Particles less than 10µm in diameter are also termed inhalable particulates.

Productivity – in plants is the amount of organic matter fixed over a period of time and is related to rate of photosynthesis.

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

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

Respiration - the process used by organisms to generate metabolically useable energy from the oxidative breakdown of foodstuffs.

Solar radiation - electromagnetic radiation from the sun.

Stomata - minute openings on the surface of aerial parts of plants through which air and water vapour enters the intercellular spaces, and through which water vapour and carbon dioxide from respiration are released.

Synoptic scale - the minimum horizontal spatial scale of weather observations defined in a synoptic observation network. Synoptic observations are simultaneous observations taken at recognised weather stations.

Total suspended particulates (TSP) - all particulates which can become suspended and generally noted to be less than 75µm in diameter (TSP).

Vehicle entrainment - the lifting of dust particles in the turbulent wake of a vehicle passing over an unpaved road or exposed area. The force of the wheels on the road causes pulverisation of the surface material and the particles are lifted and dropped by the rolling wheels



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09 May 2013

Royal HaskoningDHV
P.O Box 867
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Dear Ntseketsi,

Re: Review of the Air Quality Impact Assessment undertaken for the Proposed Filling Station and Truck Stop known as Meerkat

A peer review of the Air Quality Impact Assessment for the Proposed Filling Station and Truck Stop known as Meerkat (Report Number E02.JNB.001204) has been undertaken on behalf of Royal HaskoningDHV. The methodological approach used in the report follows an acceptable standard format for an Air Quality Impact Assessment. The Guideline for Air Dispersion Modelling for Air Quality Management in South Africa, which outlines the required methodologies and reporting for Air Quality Modelling and Impact Assessments, has not yet been published. Emission inventory calculations and subsequent modelled results are taken to be correct as these were not available for review purposes. The report has been amended as per the changes and comments provided during the initial review. The aim of the project was to assess the potential impacts associated with the operation of the Proposed Filling Station and Truck Stop. This requirement is considered to have been fulfilled.

Yours sincerely,

A handwritten signature in black ink that reads "N. Enstin".

Nicola Enstin
Pr.Sci.Nat (400209/09)