APPENDIX E

Air Quality Assessment

BOHLWEKI SSI Environmental

AIR QUALITY IMPACT ASSESSMENT FOR A PROPOSED CONCENTRATING SOLAR PLANT IN THE NORTHERN CAPE

09 NOVEMBER 2010

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1. INTRODUCTION

The Air Quality Unit at SSI Engineers and Environmental Consultants was appointed by SolAfrica Thermal Energy (Pty) Ltd to undertake an Air Quality Impact Assessment for a proposed 11.5 megawatt boiler at the proposed Concentrating Solar Thermal Power Plant (CSP) in the Northern Cape.

As part of the air quality assessment for the proposed boiler, a baseline assessment is undertaken through a review of available meteorological data. The potential impact of emissions from the proposed project on the surrounding environment is evaluated through the compilation of an emissions inventory and subsequent dispersion modelling simulations using the AERMOD dispersion model. Comparison with the South African ambient air quality standards is made to determine compliance in terms of the potential human for health impacts.

The proposed CSP Plant is located approximately 80 km to the south-south-east of the town of Upington on the Farm Bokpoort 390 in the Northern Cape Province (Figure 1-1). Two sites have been proposed for the location of the CSP Plant on the Farm Bokpoort 390 as shown in Figure 1-1. Land-use surrounding the proposed site is semi-desert with cultivated crops grown along the flood plains of the Orange River. Sheep and cattle farming occur on the proposed site, with a number of game farms to the north of the proposed site.

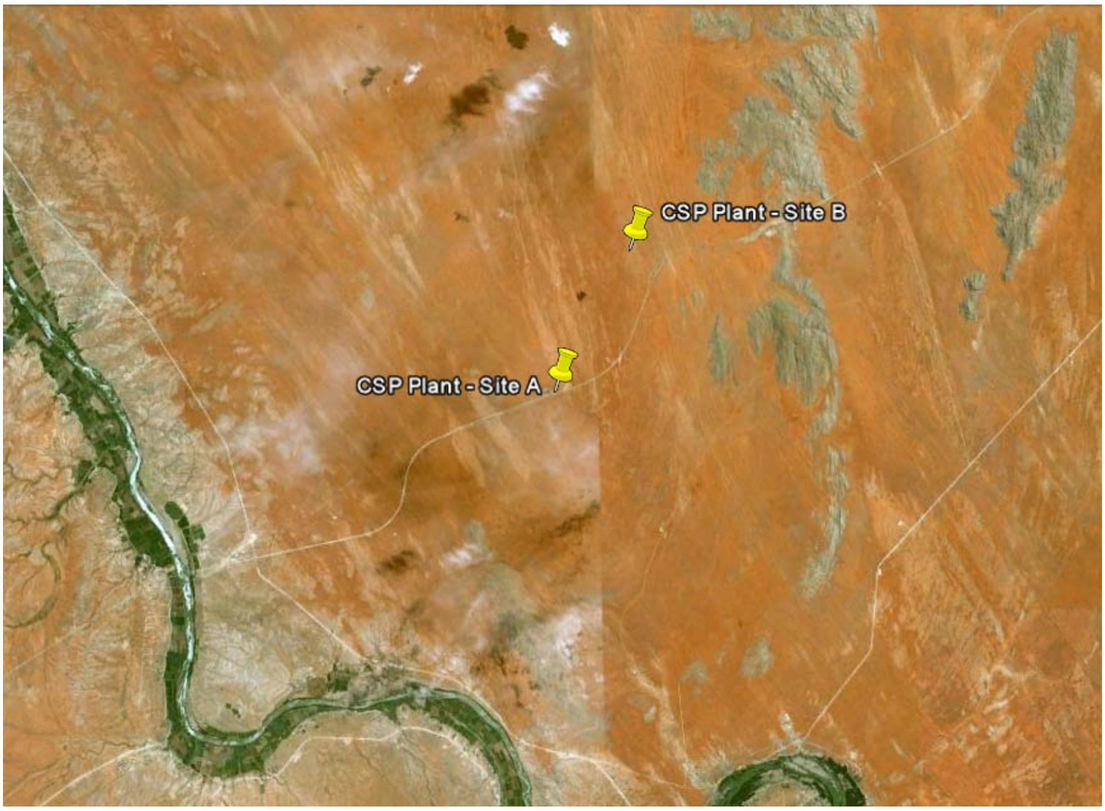


Figure 1-1: Location of the proposed CSP Plant in the Northern Cape.

1.1. Terms of Reference

The terms of reference for the Air Quality Impact Assessment for the proposed project can briefly be summarised as follows:

- Review of the current air quality legislative and regulatory requirements;
- Overview of the dispersion potential of the region;
- Identification of sensitive receptors, such as local communities, surrounding the proposed site;
- Identification of existing sources of emission surrounding the proposed site;
- Compilation of an emissions inventory for identified sources of emission;
- Dispersion modelling simulations of ground level particulate and gaseous emissions;
- Recommendations for appropriate mitigation measures.

1.2. Methodology

An overview of the methodological approach to be followed during the Air Quality Impact Assessment is outlined in the section which follows.

1.2.1. Baseline Assessment

During the baseline assessment, a qualitative approach was used to assess the baseline conditions in the project area. Modelled meteorological data was obtained for the period Jan 2005 – Dec 2009 to determine the atmospheric dispersion potential of the area. Sensitive receptors, such as local communities, in close proximity to the site were identified using satellite imagery.

1.2.2. Air Quality Impact Assessment

During this phase, an emissions inventory was compiled to estimate emissions from the proposed boiler. Dispersion modelling simulations were undertaken using the AERMOD dispersion model and presented graphically as isopleths plots. Comparison with the National ambient air quality standards was be made to determine compliance.

1.3. Report Structure

Section 1 of the report provides the background to the project. The meteorological overview of the region is described in **Section 2**. The emissions inventory and dispersion modelling results and impact assessment are presented in **Section 3**. **Section 4** gives a summary of the general conclusions and recommendations presented in the report. The references and glossary are provided **in Section 5** and **Section 6** respectively.

2. BASELINE DESCRIPTION OF THE AREA

2.1. Meso-Scale Meteorology

The nature of local climate will determine what will happen to pollution when it is released into the atmosphere (Tyson and Preston-Whyte, 2000). Pollution 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 of pollution.

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 climate and atmospheric dispersion potential of the interior of South Africa is determined by atmospheric conditions associated with the continental high pressure cell located over the interior. The continental high pressure present over the region in the winter months results in fine conditions with little rainfall and light winds with a northerly flow. Elevated inversions are common in such high pressure areas due to the subsidence of air. This reduces the mixing depth and suppresses the vertical dispersion of pollutants, causing increased pollutant concentrations (Tyson and Preston-Whyte, 2000).

Seasonal variations in the positions of the high pressure cells have an effect on atmospheric conditions over the region. For most of the year the tropical easterlies cause an air flow with a north-easterly to north-westerly component. In the winter months the high pressure cells move northward, displacing the tropical easterlies northward resulting in disruptions to the westerly circulation. The disruptions result in a succession of cold fronts over the area in winter with pronounced variations in wind direction, wind speeds, temperature, humidity, and surface pressure. Airflow ahead of a cold front passing over the area has a strong north-north-westerly to north-easterly component, with stable and generally cloud-free conditions. Once the front has passed, the airflow is reflected as having a dominant southerly component (Tyson and Preston-Whyte, 2000).

Easterly and westerly wave disturbances cause a southerly wind flow and tend to hinder the persistence of inversions by destroying them or increasing their altitude, thereby facilitating the dilution and dispersion of pollutants. Pre-frontal conditions tend to reduce the mixing depth. The potential for the accumulation of pollutants during pre-frontal conditions is therefore enhanced over the plateau (Tyson and Preston-Whyte, 2000).

2.2. Site-Specific Dispersion Potential

Given the remote location of the proposed site, local meteorological data required for modelling purposes is not available. Use was therefore made of site-specific modelled MM5 meteorological data for the period Jan 2005 – Dec 2009 from Lakes Environmental.

Wind roses comprise of 16 spokes which represent the directions from which winds blew during the 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.

Based on an evaluation of the meteorological data provided, winds originate predominantly from the north-north-east (10% of the time) and north (9% of the time) (Figure 2-1). Moderate to fast winds are generally recorded over the monitoring period. Calm wind speeds, which are designated as wind speeds less than 0.5 m/s, occur infrequently (4 % of the time).

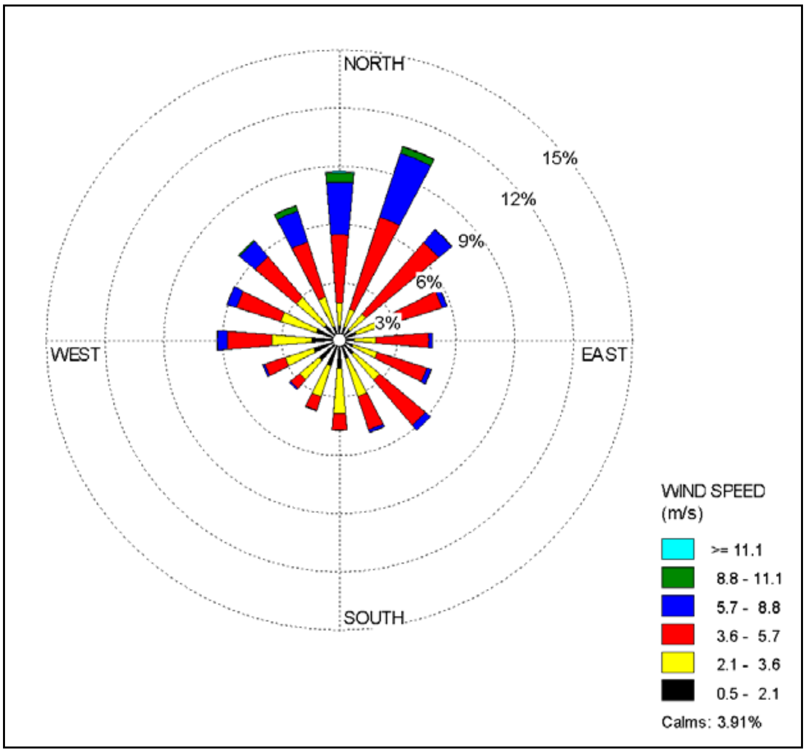


Figure 2-1: Period wind rose for the proposed site for the period Jan 2005 – Dec 2009.

A diurnal trend in the wind field is recorded at the proposed site (Figure 2-2). During the day-time (06:00 – 18:00), moderate to fast winds originate predominantly from the westerly and northerly sectors. During the night-time (12:00 – 18:00), winds originate from all sectors with a shift observed to the north-north-east and north-east between 00:00 – 06:00. As would be expected, faster winds are recorded during the day-time period compared to the night-time.

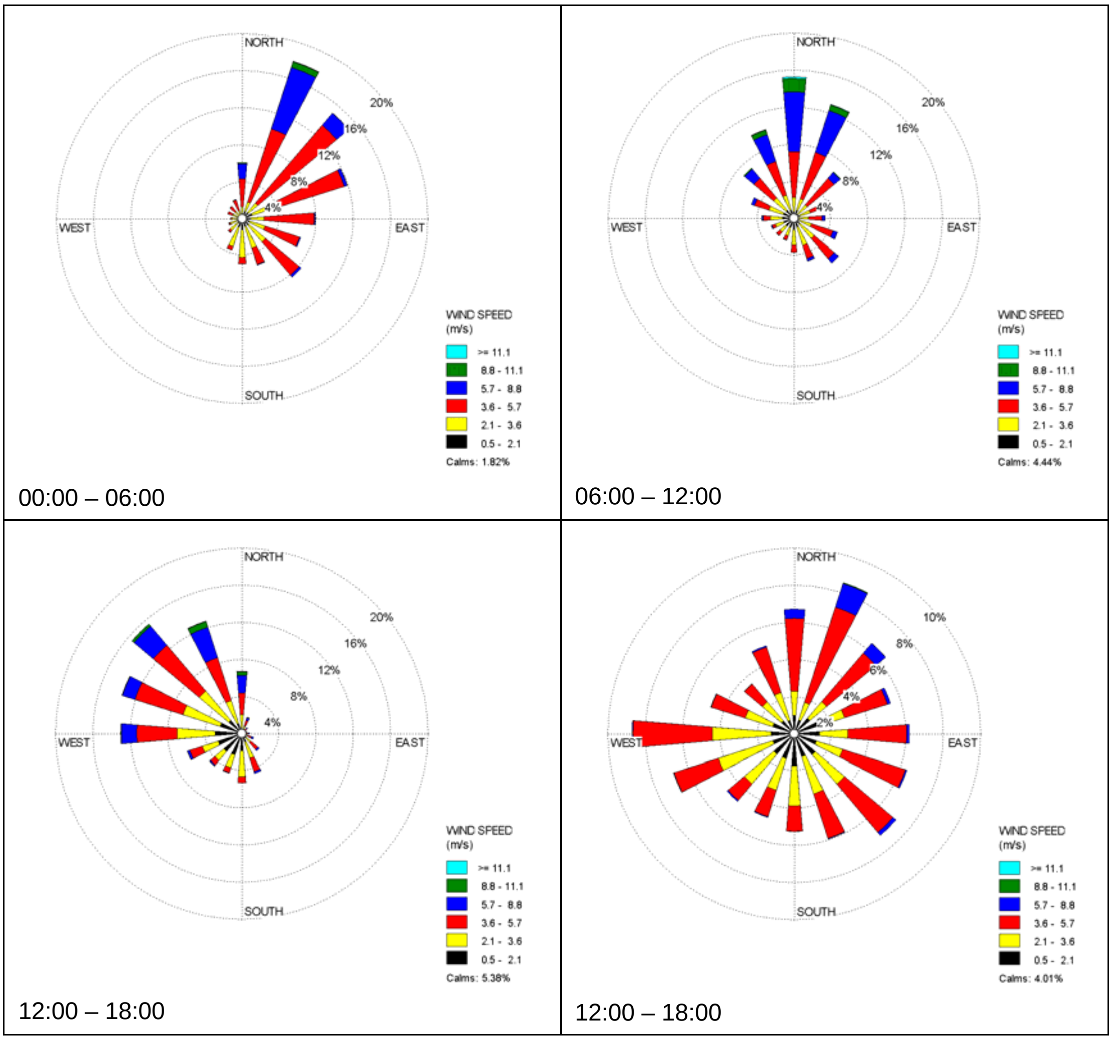


Figure 2-2: Diurnal wind roses for the proposed site for the period Jan 2005 – Dec 2009.

The seasonal variability in the wind field at the proposed site is shown in Figure 2-3. During the summer months (Dec, Jan and Feb), winds originate predominantly from the west. During autumn (Mar, Apr and May), a shift is observed with winds originating predominantly from the north-north-east and north-east. A similar pattern to the autumn months is observed during the winter months (Jun, Jul and Aug). During spring (Sep, Oct and Nov), winds originate from all sectors, with the highest frequency recorded from the westerly sector.

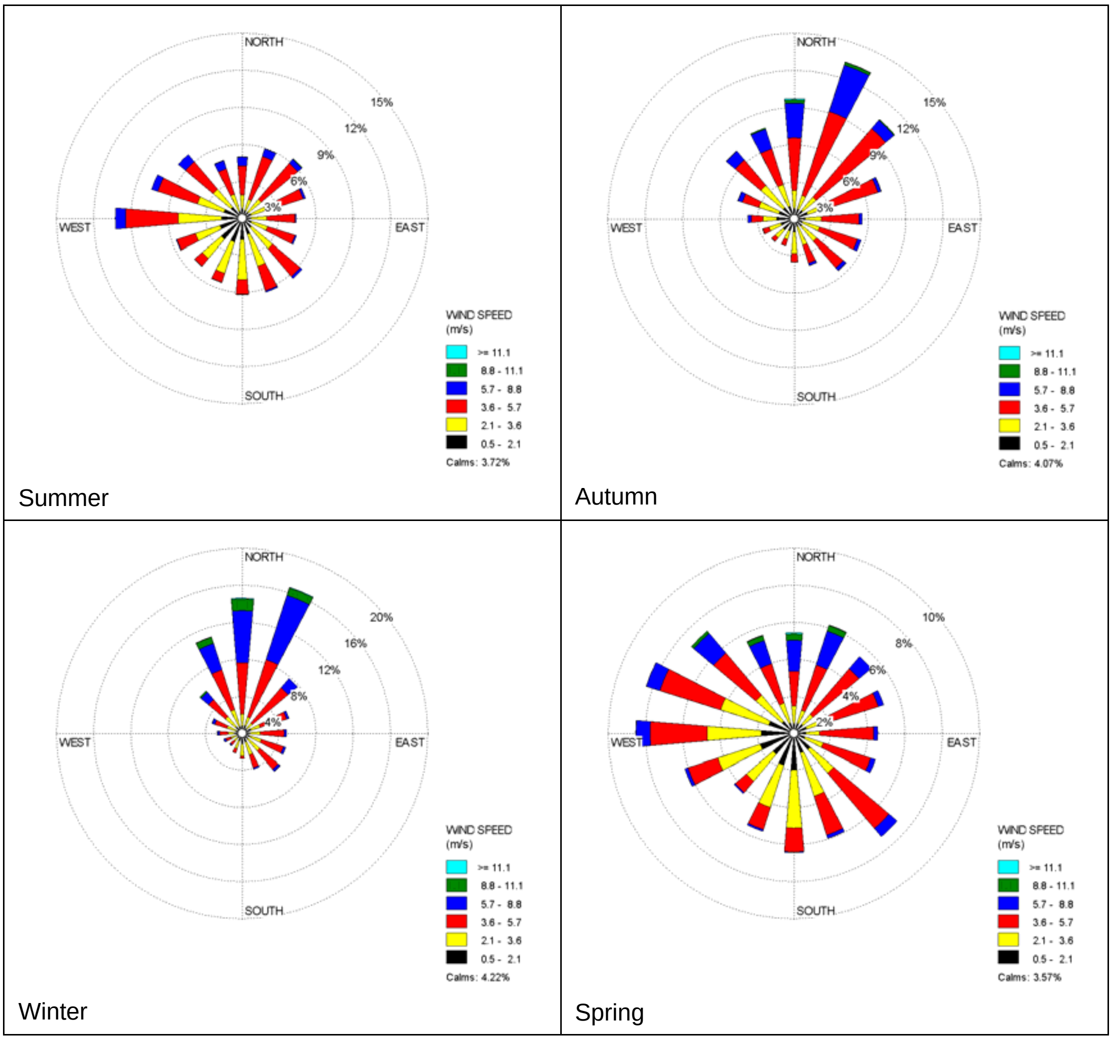


Figure 2-3: Seasonal wind roses for the proposed site for the period Jan 2005 – Dec 2009.

Based on the prevailing meteorological conditions for the area, emissions released from the proposed site will be transported predominantly in a south-south-westerly and southerly direction from the proposed site. The prevalence of moderate to fast winds will transport emissions several kilometres from the proposed site.

2.3. Atmospheric Stability

Atmospheric stability is commonly categorised into six stability classes (Table 2-1). 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-time a stable layer, with limited vertical mixing, exists. During windy and/or cloudy conditions, the atmosphere is normally neutral.

Table 2-1: Atmospheric stability classes.

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

In general, the proposed site experiences neutral (Class D) to stable (Class E) atmospheric conditions (Figure 2-4). This is expected given the predominance of a high-pressure anticyclone over South Africa which produces stable, clear conditions.

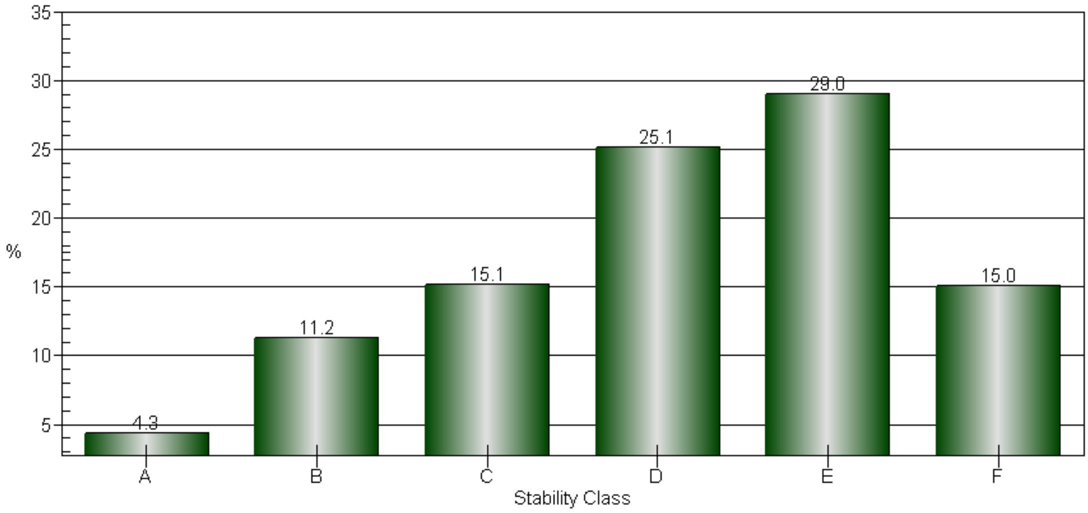


Figure 2-4: Stability class frequency distribution for the proposed site for the period Jan 2005 – Dec 2009.

2.4. Temperature and Humidity

Temperature affects the formation, action, and interactions of pollutants in various ways (Kupchella and 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.

Average monthly temperature and humidity at the proposed site for the period 2005 – 2009 is given in Figure 2-5. Daily average summer temperatures range between ~24 °C and ~26 °C while winter temperatures range between ~11 °C and ~13 °C. Relative humidity peaks during the winter months.

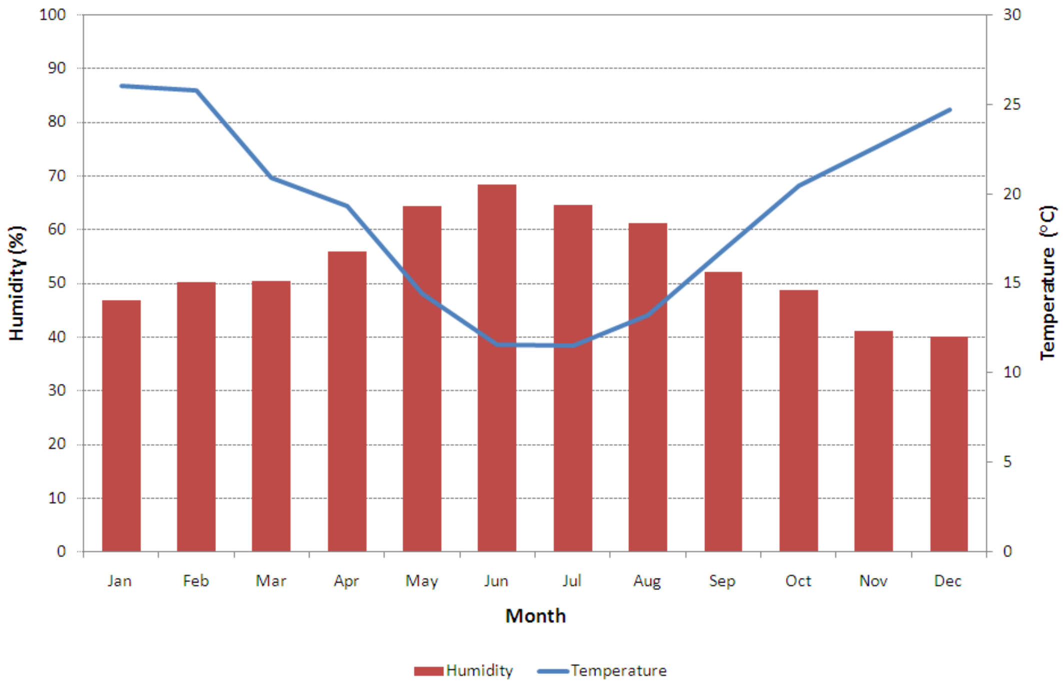


Figure 2-5: Average monthly temperature and humidity for the proposed site for the period 2005 – 2009.

2.5. Health Risk Evaluation Criteria

South African ambient air quality standards have been issued by the Department of Environmental Affairs and will be used as a basis for comparison for this assessment. However, reference will be made to international guidelines to ensure complete compliance. The pollutants assessed during the current investigation included the criteria pollutants: inhalable particulate matter (PM), sulphur dioxide (SO_2) and nitrogen dioxide (NO_2).

2.5.1. Particulate Matter

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

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.

Table 2-2 outlines the various 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 2-2: Ambient air quality guidelines and standards for particulate matter.

Origin	24-Hour Exposure (µg/m³)	Annual Average Exposure (µg/m³)	Number of Exceedance Allowed per year
South Africa(1)	120	50	4 daily exceedance
World Bank(6)	500	100	NA
EU(3)	50	30 20(2)	25 daily exceedance By 2010 only 7 daily exceedance
US-EPA(4)	150	50(5)	1 daily exceedance
UK(6)	50	40	35 daily exceedance
WHO(7) (8) (9)	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 2010.

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

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

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

(5) To attain this standard, the 3-year average of the weighted annual mean PM_{10} concentration at each monitor within an area must not exceed 50 ug/m^3.

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

(7) WHO = World Health Organisation.

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

(9) Air quality guideline.

2.5.2. 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 2-3.

Table 2-3: Ambient air quality guidelines and standards for nitrogen dioxide.

Averaging Period	South Africa		WHO		EC		Australia	
	$\mu g/m^3$	ppm	$\mu g/m^3$	ppm	$\mu g/m^3$	ppm	$\mu g/m^3$	ppm
Annual Ave	40	0.021	40	0.021	40[(b)]	0.021[(b)]	57[(d)]	0.03[(d)]
Max. 1-hr	200	0.10	200	0.10	200[(c)]	0.10[(c)]	240[(e)]	0.12[(e)]

Notes:

[(a)] Annual arithmetic mean.

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

[(c)] 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.

[(d)] Standard set in June 1998. Goal within 10 years given as being no exceedances.

[(e)] 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. As discussed previously, 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 $\mu g/m^3$ (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 $\mu g/m^3$ (2.5 ppm), experience pronounced decreases in pulmonary function; generally, normal subjects are not affected by concentrations less than 1 880 $\mu g/m^3$ (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 $\mu g/m^3$ (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 $\mu g/m^3$ (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 NO_2 levels as low as 376-565 μg/m^3 (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 NO_2 studies with allergen challenges showed no effects at the lowest concentration tested (188 μg/m^3; 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 NO_2 concentrations of less than 1 880 μg/ m^3 (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/m^3), to emphysema-like effects. Biochemical changes often reflect cellular alterations, with the lowest effective NO_2 concentrations in several studies ranging from 380-750μg/m^3. NO_2 levels of about 940 μg/m^3 (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/m^3 NO_2 (2-week average), where the weekly average concentrations are in the range of 15-128 μg/m^3 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 NO_2 exposures exhibit increased respiratory symptoms that are of longer duration, and show a decrease in lung function.

2.5.3. Sulphur Dioxide

SO_2 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 SO_2 include coughing, phlegm, chest discomfort and bronchitis.

Short-period exposures (less than 24 hours): Most information on the acute effects of SO_2 comes from controlled chamber experiments on volunteers exposed to SO_2 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. Further exposure does not increase effects. Effects include reductions in the mean forced expiratory volume over one second (FEV_1), 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 SO_2 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. Continuous exposure-response relationships, without any clearly defined threshold, are evident.

Sub-chronic exposure over a 24-hour period: Information on the effects of exposure averaged over a 24-hour period is derived mainly from epidemiological studies in which the effects of SO_2, 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 SO_2 exceeds 250 µg/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 µg/m^3; daily levels usually not exceeding 125 µg/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 SO_2 has been identified.

Long-term exposure: Earlier assessments, using data from the coal-burning era in Europe judged the lowest-observed-adverse-effect level of SO_2 to be at an annual average of 100 µg/m^3, when present with suspended particulate matter. More recent studies related to industrial sources of SO_2, 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 SO_2 for short periods, the WHO (WHO 2000) recommends that a value of 500 µg/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 SO_2 are necessarily based on epidemiological studies, in which people are in general exposed to a mixture of pollutants; and guideline values for SO_2 have previously been linked with corresponding values for suspended particulate matter. This approach led to a previous guideline 24-hour average value of 125 µg/m^3 (0.04 ppm) for SO_2, 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 SO_2.

The EC's air quality criteria represent standards to be achieved by the year 2005, and would supersede the EU standards. The ambient air quality standards of the US-EPA are based on clinical and epidemiological evidence. These standards were established by determining concentrations with the lowest-observed-adverse effect, adjusted by an arbitrary margin of safety factor to allow for uncertainties in extrapolating from animals to humans and from small groups of humans to larger populations. The standards of the US-EPA also reflect the technological feasibility of attainment.

Ambient air quality guidelines and standards issued for various countries and organisations for SO_2 are given in Table 2-4.

Table 2-4: Ambient air quality guidelines and standards for sulphur dioxide.

Country	Annual Average (μg/m^3)	Maximum 24-hour Ave (μg/m^3)	Maximum 1-hour Ave (μg/m^3)	<1-hour Maximum (μg/m^3)
RSA	50	125	350	500 (10 min average)
WHO	50[(a)] 10-30[(b)]	125[(a)]	-	500[(a)] (10 min average)
EC	20[(c)]	125[(d)]	350[(e)]	
UK	20[(f)]	125[(g)]	350[(h)]	266[(i)] (15 min mean)
World Bank	50[(j)]	125[(j)]	-	-
US-EPA	80	365	-	-
Australia	53[(k)]	209[(l)]	520[(m)]	-

Notes:

(a) Air quality guidelines (issued by the WHO for Europe) for the protection of human health (WHO, 2000).

(b) 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.

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

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

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

(f) Given as annual and winter (1 Oct to 31 March) mean, to be complied with by 31 December 2000.

(g) 24-hour mean, not to be exceeded more than 24 times a year. Compliance required by 31 December 2004.

(h) 1-hour mean, not to be exceeded more than 24 times a year. Compliance required by 31 December 2004

(i) 15-minute mean, not to be exceeded more than 35 times a year. Compliance required by 31 December 2005.

(j) Ambient air concentration permissible at property boundary.

(k) Standard set in June 1998 as 0.02 ppm. Goal within 10 years is to have no exceedances.

(l) Standard set in June 1998 as 0.08 ppm. Goal within 10 years is to have maximum allowable exceedances of 1 day per year.
(m) Standard set in June 1998 as 0.20 ppm. Goal within 10 years is to have maximum allowable exceedances of 1 day per year.
(n) 90% of hourly observation to be less than 300 µg/m^3

2.6. Identified Sensitive Receptors

A sensitive receptor for the purposes of the current investigation is defined as a person or place where involuntary exposure to pollutants released by the proposed project could take place. Receptors surrounding the proposed sites (Sites A and B) were identified from satellite images of the area (Table 2-5). The residential areas of Groblershoop, Sutterheim and Wegdraai are the closest residential areas to the proposed sites. The town of Upington is located approximately 80 km to the west-north-west of the proposed sites. A neighbouring farmhouse is located in close proximity (approximately 2 km) to the proposed sites.

Table 2-5: Identified receptors surrounding the proposed site (as determined from Site A).

Receptor	Distance (km)	Direction from Site
Wegdraai	~ 17 km	SW
Groblershoop	~ 18 km	S
Stutterheim	~ 19 km	S
Boegoberg	~ 24 km	SSE
Upington	~ 80 km	WNW

2.7. Existing Sources of Air Pollution

Based on satellite imagery and a site description of the area, the following surrounding sources of air pollution have been identified in the area:

- Agriculture;
- Domestic fuel burning;
- Veld fires.

A qualitative discussion of each identified sources is provided in the subsections below. The aim is to highlight the potential contribution of surrounding sources to the overall ambient air quality situation in the area. These sources have not been quantified as part of this assessment.

2.7.1. 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.

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 gases to atmosphere would however include:

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

Land-use along the Orange River is predominantly agricultural with crops such as grapes and raisins grown in the flood plains of the Orange River. Agricultural activities along the Orange River would likely contribute to the ambient particulate and gaseous pollutant concentrations in the area.

2.7.2. Domestic Fuel Burning

Due to the close proximity of residential developments it is anticipated that low income households in the area are likely to use coal and wood for space heating and/ or cooking purpose. Exposure to indoor air pollution (IAP) from the combustion of solid fuels is an important cause of morbidity and mortality in developing countries. Biomass and coal smoke contain a large number of pollutants and known health hazards, including particulate matter, carbon monoxide, nitrogen dioxide, sulphur oxides (mainly from coal), formaldehyde, and polycyclic organic matter, including carcinogens such as benzo[*a*]pyrene (Ezzati and Kammen, 2002).

Exposure to indoor air pollution (IAP) from the combustion of solid fuels has been implicated, with varying degrees of evidence, as a causal agent of several diseases in developing countries, including acute respiratory infections (ARI) and otitis media (middle ear infection), chronic obstructive pulmonary disease (COPD), lung cancer (from coal smoke), asthma, cancer of the nasopharynx and larynx, tuberculosis, perinatal conditions and low birth weight, and diseases of the eye such as cataract and blindness (Ezzati and Kammen, 2002).

Monitoring of pollution and personal exposures in biomass-burning households has shown concentrations are many times higher than those in industrialized countries. The latest International Ambient Air Quality Standards, for instance, required the daily average concentration of PM10 to be < 180 µg/m^3 (annual average < 60 µg/m^3). In contrast, a typical 24-hr average concentration of PM10 in homes using bio fuels may range from 200 to 5 000 µg/m^3 or more throughout the year, depending on the type of fuel, stove, and housing. Concentration levels, of course, depend on where and when monitoring takes place, because significant temporal and spatial variations may occur within a house. Field measurements, for example, recorded peak concentrations of > 50 000 µg/m^3 in the immediate vicinity of the fire, with concentrations falling significantly with increasing distance from the fire. Overall, it has been estimated that approximately 80% of total global exposure to airborne particulate matter occurs indoors in developing nations. Levels of CO and other pollutants also often exceed international guidelines (Ezzati and Kammen, 2002).

Given the remote location of the area, the burning of domestic fuels such as coal, wood and paraffin for heating and cooking purposes is likely to occur in surrounding residential areas such as Wegdraai, Groblershoop, Stutterheim and Boegoberg.

2.7.3. 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 fires depend 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 amounts 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. 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 of 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 savannah 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).

3. IMPACT ASSESSMENT

This section of the report outlines the potential ambient air quality impacts associated with the proposed CSP Plant. A detailed emissions inventory was compiled as part of this assessment to determine emissions released from the proposed boiler. Dispersion modelling simulations were undertaken using the AERMOD dispersion model and presented graphically as isopleths plots.

3.1. Construction Phase

During the construction assessment phase it is expected that the main sources of impact will result due to the construction of new infrastructure associated with the proposed plant. These predicted impacts cannot be directly quantified, primarily due to the lack of detailed information related to scheduling and positioning of construction related activities. Instead a qualitative description of the impacts will be provided. This will involve the identification of possible sources of emissions and the provision of details related to their impacts.

Construction is commonly of a temporary nature with a definite beginning and end. Construction usually consists of a series of different operations, each with its own duration and potential for dust generation. Dust emission will vary from day to day depending on the phase of construction, the level of activity, and the prevailing meteorological conditions (USEPA, 1996).

The following possible sources of fugitive dust have been identified as activities which could potentially generate dust during construction operations at the site:

- Vehicle activities associated with the transport of equipment to the site;
- Preparation of the surface areas which will be required prior to the set up of new infrastructure; and
- The removal of construction equipment from site after the set up of new infrastructure.

3.2. Operational Phase

3.2.1. Model Overview

AERMOD, a state-of-the-art Planetary Boundary Layer (PBL) air dispersion model, was developed by the American Meteorological Society and USEPA Regulatory Model Improvement Committee (AERMIC). AERMOD utilizes a similar input and output structure to ISCST3 and shares many of the same features, as well as offering additional features. AERMOD fully incorporates the PRIME building downwash algorithms, advanced depositional parameters, local terrain effects, and advanced meteorological turbulence calculations.

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

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

3.2.2. Model Requirements

Given the remote location of the proposed site, local meteorological data is not available. Use was therefore made of site-specific modelled meteorological data (MM5) for the period Jan 2005– Dec 2009 and includes hourly observations of wind speed, wind direction, temperature and humidity. Source and emission parameters for the model are given in the section below.

3.3. Emissions Inventory

Sources of emissions identified as occurring due to the proposed project and which need to be addressed from an air quality perspective are summarized as follows:

3.3.1. Proposed Boiler

Source parameters and fuel consumption values for the proposed boiler were provided by Hatch for the purpose of this assessment (Table 3-1). It is proposed that either diesel or LPG will be used to fuel the boiler. The boiler will operate for a total of 6 months per year. Emission rates for the proposed boiler were calculated using the USEPA AP-42 emission factors for Fuel Oil Combustion and LPG Combustion (Table 3-2).

Table 3-1: Source parameters for the Proposed Boiler.

Site	Latitude (°S)	Longitude (°E)	Stack height (m)	Stack diameter (m)	Exit velocity (m/s)	Temp (° C)
Site A	28° 44' 22.28"	21° 59' 51.00"	30	1.5	6	180
Site B	28° 42' 04.73"	22° 01' 16.65"	30	1.5	6	180

Table 3-2: Emission rates for the Proposed Boiler.

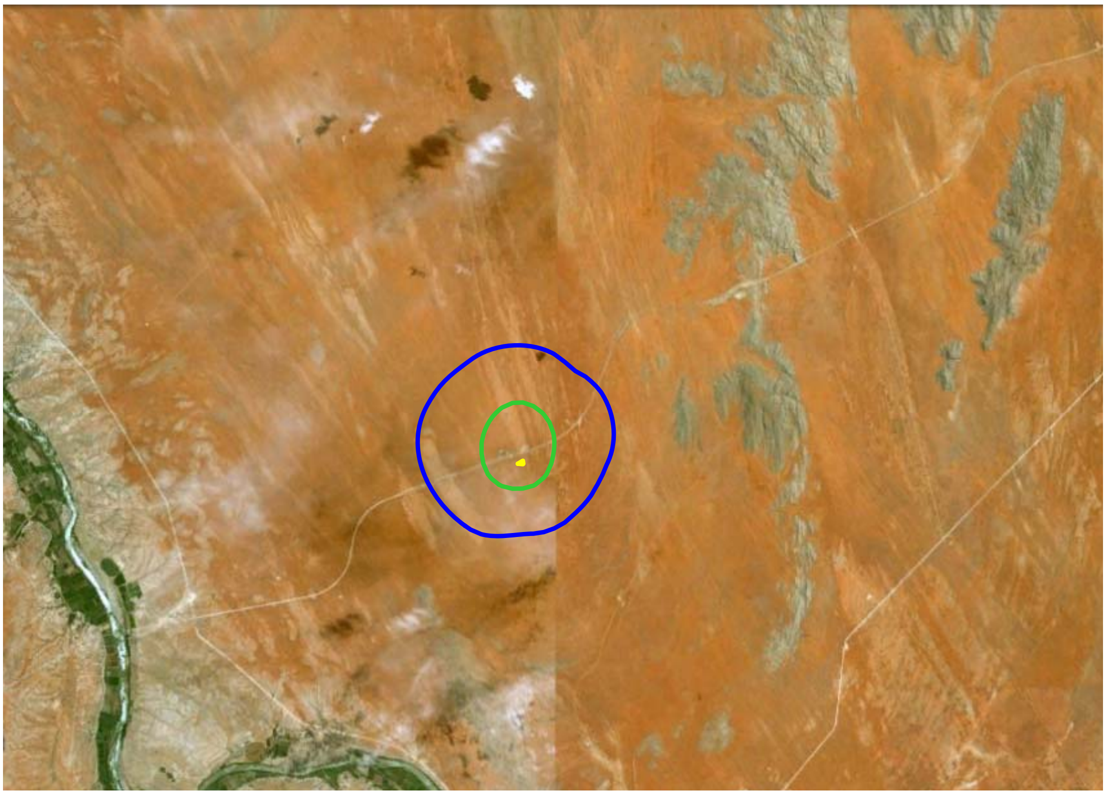
Fuel Type	Fuel Usage (m^3/yr)	Emission rate (g/s)		
		PM10	SO_2	NO_2
Diesel	3100	0.024	0.838	0.236
LPG	2900	0.002	0.001	0.143

3.4. Impact Assessment

Dispersion modelling simulations were undertaken to determine the potential air quality impacts associated with emissions from the proposed boiler. Dispersion modelling simulations were undertaken for each proposed site (Site A and Site B). Results are presented graphically as isopleth plots in the figures below. Isopleth plots reflect gridded contours which represent zones of impact at various distances from the contributing sources. The patterns generated by the contours are representative of the maximum predicted ground level concentrations for the averaging period being represented. Maximum hourly, daily and annual average concentrations for PM10, SO_2 and NO_2 are represented in Figure 3-4 to Figure 3-6.

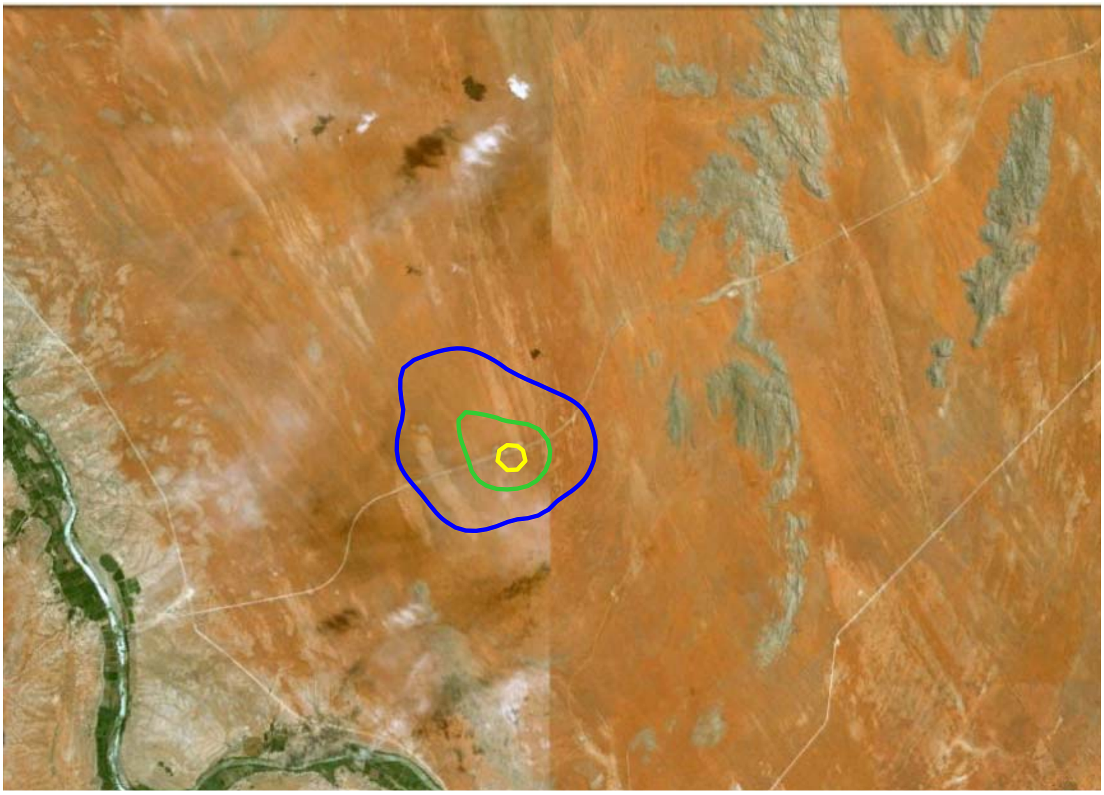
3.4.1. Proposed Site A

Predicted maximum hourly, daily and annual average concentrations due to emissions from the proposed boiler are low and fall well below the National standards for all modelled pollutants (Figure 3-1 to Figure 3-3). The neighbouring farmhouse will not be influenced by elevated pollutant concentrations due to emissions from the boiler. Although higher concentrations are predicted when using diesel as compared to LPG, concentrations remain very low.



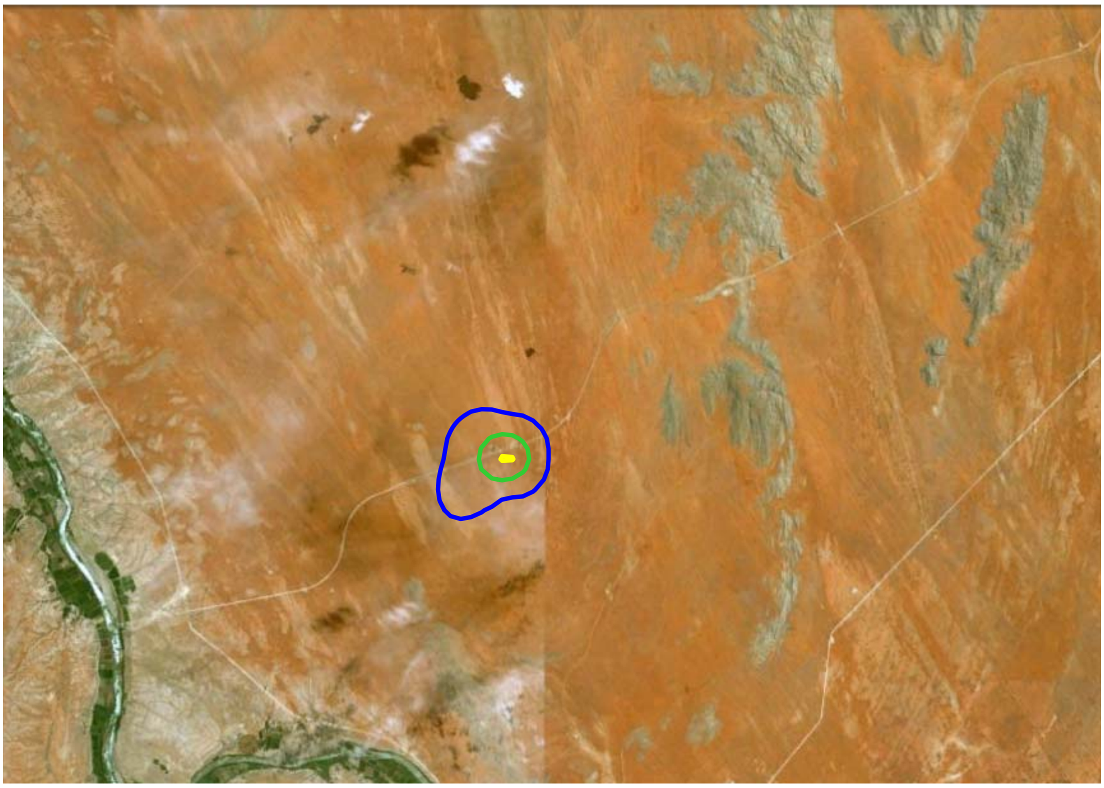
Hourly	(blue)	(green)	(yellow)
Diesel			
PM	0.060	0.108	0.156
SO_2	2.094	3.771	5.447
NO_2	0.590	1.062	1.534
LPG			
PM	0.005	0.009	0.013
SO_2	0.003	0.005	0.007
NO_2	0.358	0.644	0.930

Figure 3-1: Hourly average predicted ground level concentrations (µg/m^3) from the proposed boiler at Site A.



Daily	(blue)	(green)	(yellow)
Diesel			
PM	0.014	0.029	0.043
SO_2	0.503	1.006	1.508
NO_2	0.142	0.283	0.425
LPG			
PM	0.001	0.002	0.004
SO_2	0.0006	0.001	0.002
NO_2	0.086	0.172	0.257

Figure 3-2: Daily average predicted ground level concentrations (µg/m^3) from the proposed boiler at Site A.

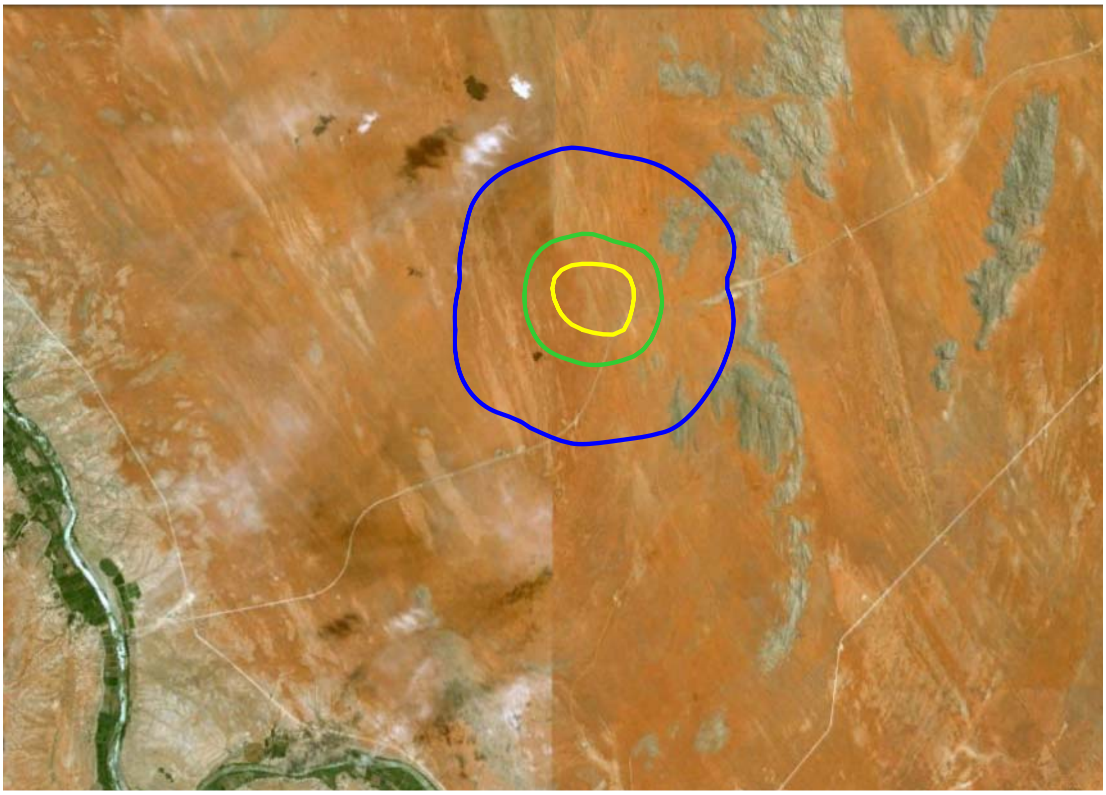


Annual			
Diesel			
PM	0.002	0.005	0.007
SO_2	0.084	0.168	0.251
NO_2	0.024	0.047	0.071
LPG			
PM	0.0002	0.0004	0.006
SO_2	0.0001	0.0002	0.0003
NO_2	0.014	0.029	0.043

Figure 3-3: Annual average predicted ground level concentrations (µg/m^3) from the proposed boiler at Site A.

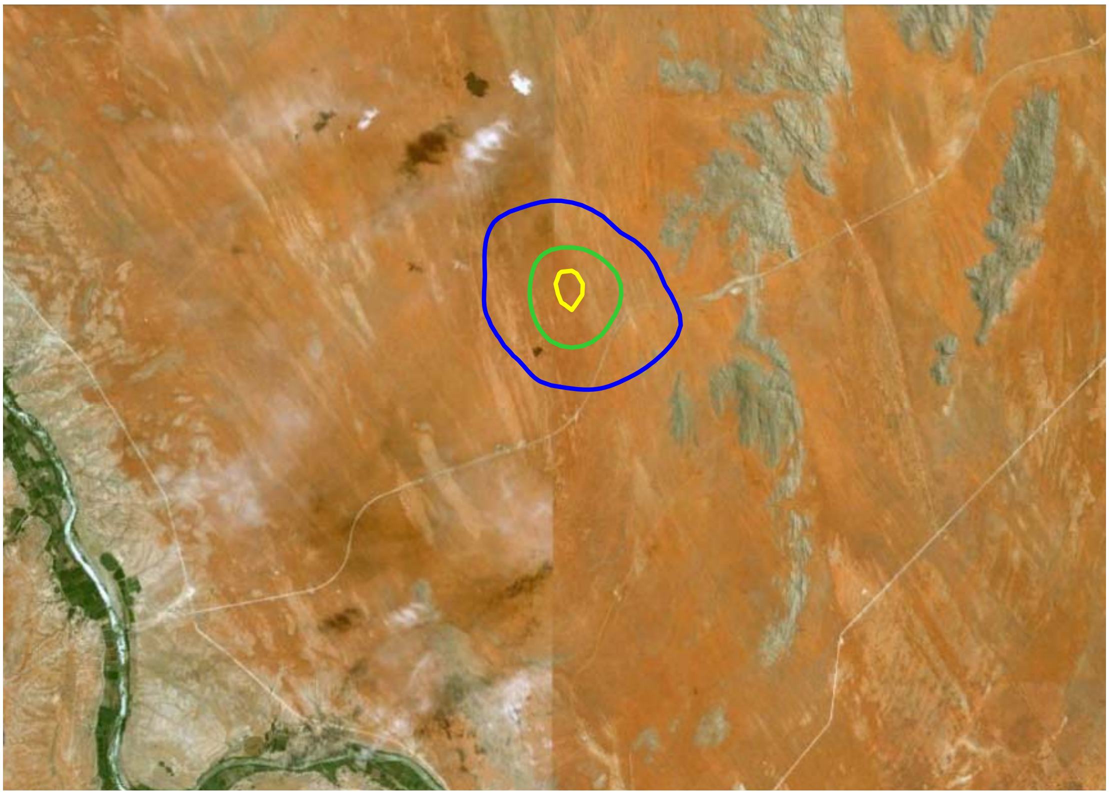
3.4.2. Proposed Site B

As observed at the proposed Site A, maximum hourly, daily and annual average concentrations are low and fall well below the National standards for all modelled pollutants at proposed Site B (Figure 3-4 to Figure 3-6). The neighbouring farmhouse will not be influenced by elevated pollutant concentrations due to emissions from the boiler.



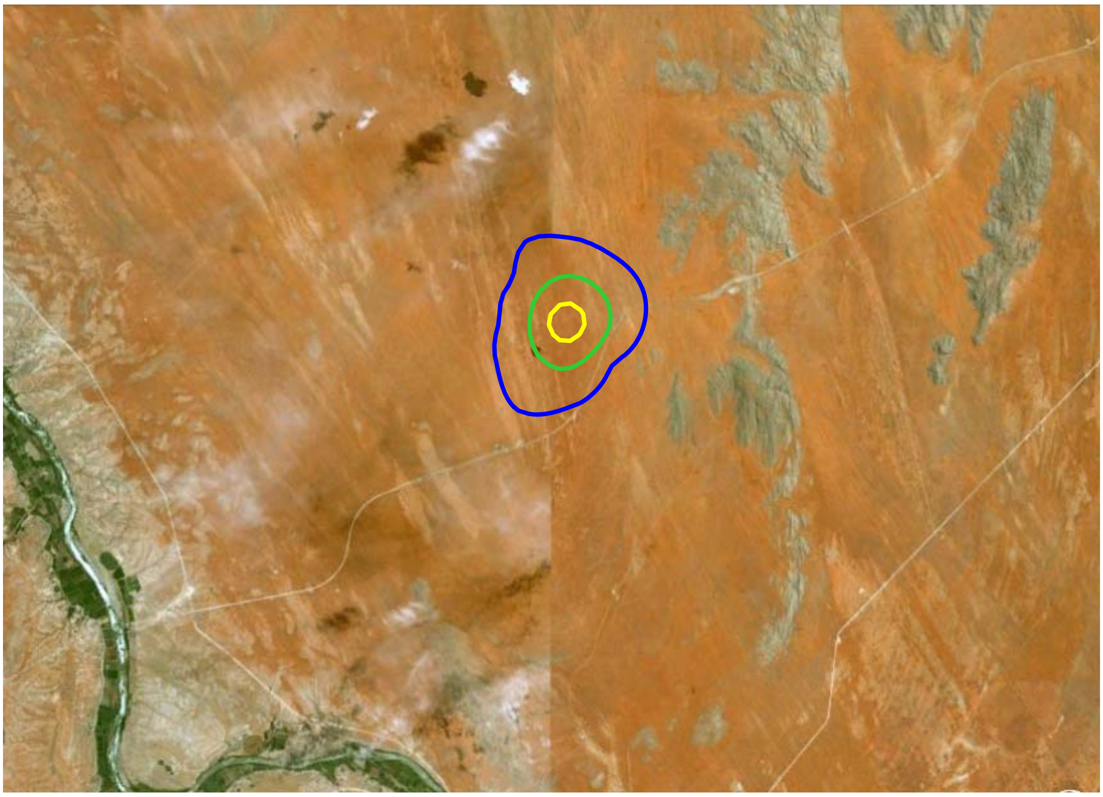
Hourly			
Diesel			
PM	0.048	0.077	0.106
SO_2	1.676	2.682	3.687
NO_2	0.472	0.755	1.038
LPG			
PM	0.004	0.006	0.009
SO_2	0.002	0.003	0.004
NO_2	0.286	0.458	0.629

Figure 3-4: Hourly average predicted ground level concentrations (µg/m^3) from the proposed boiler at Site B.



Daily	(blue)	(green)	(yellow)
Diesel			
PM	0.014	0.029	0.043
SO_2	0.503	1.006	1.508
NO_2	0.1412	0.283	0.425
LPG			
PM	0.001	0.002	0.004
SO_2	0.0006	0.001	0.002
NO_2	0.086	0.172	0.257

Figure 3-5: Daily average predicted ground level concentrations (µg/m^3) from the proposed boiler at Site B.



Annual	(blue)	(green)	(yellow)
Diesel			
PM	0.001	0.003	0.004
SO_2	0.050	0.102	0.151
NO_2	0.014	0.028	0.042
LPG			
PM	0.0001	0.0002	0.0004
SO_2	0.00006	0.0001	0.0002
NO_2	0.009	0.017	0.026

Figure 3-6: Annual average predicted ground level concentrations (µg/m^3) from the proposed boiler at Site B.

3.5. Decommissioning Phase

The decommissioning phase is associated with activities related to the demolition of infrastructure and the rehabilitation of disturbed areas. The following activities are associated with the decommissioning phase (USEPA, 1996):

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

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

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

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

3.6. Assumptions and Limitations

Due to the unavailability of information required for the modelling studies, the following assumptions were made as part of this assessment:

- Use was made of site-specific modelled meteorological data as hourly surface observations from a nearby meteorological station was not available;
- Emissions were estimated using the USEPA AP-42 emission factors for Fuel Oil Combustion and Liquefied Petroleum Gas Combustion;
- The sulphur content of the diesel fuel was assumed to be 0.55%, as per the South African diesel specification (SABS 342);
- The composition of the LPG fuel was assumed to be 100% propane for the calculation of emission rates. The composition of the LPG to be used at the proposed site is approximately 30% butane and 70% propane;
- All particulate (PM) was modelled in the filterable fraction (PM10 and less);
- The boiler was assumed to operate for a 12 month period based on provided annual diesel and LPG consumption rates. During normal operating conditions at the proposed site, it is anticipated that the boiler will only be operational for 6 months.
- Emissions from the proposed storage tank were not included in the dispersion simulations. Based on the design parameters provided, the storage tank is not anticipated to be a significant air pollution source and is not classified as a listed activity in terms of the Listed Activities and Associated Minimum Emission Standards (Government Gazette No 32434).

3.7. Mitigation Measures

3.7.1. Construction Phase

Control techniques for fugitive dust sources during the construction phase include watering, chemical stabilisation or reduction or surface wind speed with windbreaks or source enclosures. Watering is the most common and least inexpensive method although it only provides temporary dust control. Wet suppression of unpaved areas can achieve dust emission reductions of approximately 70% or more, which can be increased by up to 95% through the use of chemical stabilisation. The use of chemicals provides for longer dust suppression but is more costly and may have adverse environmental effects. Windbreaks and source enclosures are often impractical because of the size of fugitive dust sources (USEPA, 1995). A summary of dust control measures for the proposed plant is provided in Table 3-3 below. Wet suppression is the recommended method for the proposed plant to control dust emissions during the construction phase.

Table 3-3: Proposed measures to control dust emissions during construction.

Source	Suggested Control Method
Debris handling	Wind speed reduction (e.g wind-breaks)
	Wet suppression
Truck transport	Wet suppression
	Paving of roads
Bulldozers	Wet suppression
Pan scrapers	Wet suppression
Cut/fill materials handling	Wind speed reduction
	Wet suppression
Cut/fill haulage	Wet suppression
	Paving of roads
General construction	Wind speed reduction
	Wet suppression
	Early paving of haul/access road

3.7.2. Operational Phase

Based on the low concentrations predicted in this assessment, no mitigation measures are required during the operational phase to reduce emissions from the proposed boiler.

In addition, based on the design parameters provided for the proposed boiler, the proposed boiler would not classify as a listed activity as per the Listed Activities and associated Minimum Emission Standards issued by the Department of Environmental Affairs on 24 July 2009 (Government Gazette No 32434), and will therefore not require an Atmospheric Emission Licence to operate.

4. CONCLUSION

The Air Quality Impact Assessment undertaken for the proposed boiler at the proposed CSP Plant includes a meteorological overview of the area. Given the unavailability of local surface meteorological data, use was made of site-specific modelled MM5 data. An emissions inventory was undertaken with the aim of quantifying emissions associated with the proposed boiler. Dispersion modelling simulations were then undertaken using AERMOD to evaluate PM10, SO_2 and NO_2 concentrations due to emissions from the proposed boiler.

Predicted maximum hourly, daily and annual average concentrations due to emissions from the proposed boiler are low and fall well below the National standards for all modelled pollutants. The neighbouring farmhouse will not be influenced by elevated pollutant concentrations due to emissions from the boiler. Although higher concentrations are predicted when using diesel as compared to LPG, concentrations remain very low.

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6. 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.

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

Boundary layer - the layer directly influenced by a surface.

Climatology - the study of the long term effect of weather over a certain area during a certain period.

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.

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.

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.

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.

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

INDEPENDENT REVIEW OF AIR IMPACT ASSESSMENT SPECIALIST STUDY IN SUPPORT OF BOKPOORT II SOLAR POWER DEVELOPMENT: Proposed 75 MW Photovoltaic (PV1) Solar Power

Review done on behalf of Golder Associates Africa (Pty) Ltd

Reviewer:
L W Burger

Report No: 16GOL01a Rev 0. | Date: May 2016

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Review Details

Reference No.	16GOL01a
Status	Rev 0.0
Report Title	Independent Review of Air Impact Assessment Specialist Study in Support of Bokpoort II Solar Power Development: Proposed 75 MW Photovoltaic (PV1) Solar Power
Date	May 2016
Client	Golder Associates Africa (Pty) Ltd
Reviewer	Lucian Burger, PhD (Natal) MSc Eng (Chem), BSc Eng (Chem)
Notice	Airshed Planning Professionals (Pty) Ltd is a consulting company located in Midrand, South Africa, specialising in all aspects of air quality, ranging from nearby neighbourhood concerns to regional air pollution impacts as well as noise impact assessments. The company originated in 1990 as Environmental Management Services, which amalgamated with its sister company, Matrix Environmental Consultants, in 2003.
Declaration	Airshed is an independent consulting firm with no interest in the project other than to fulfil the contract between the client and the consultant for delivery of specialised services as stipulated in the terms of reference.

Revision Record

Revision Number	Date	Reason for Revision
Rev 0.0	12 May 2016	Initial Release

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1 INTRODUCTION

ACWA Power Africa Holdings (Pty) Ltd is proposing to establish a solar power facility (Bokpoort II) on the north-eastern portion of the Remaining Extent of the Farm Bokpoort 390, which is 20 km north-west of the town of Groblershoop within the !Kheis Local Municipality in the ZF Mgcawu District Municipality, Northern Cape Province.

The proposed development has three parts each of which constitutes an independent project in terms of the Independent Power Producer (IPP) programme. Consequently, each of these three proposed projects occupies different parts of the same site and is subject to their own Environmental Impact Assessment (EIA) process and standalone specialist studies. Golder Associates Africa (Pty) Ltd (Golder) is leading the EIA. The current review is of the air quality section for the

Proposed 75 MW Photovoltaic (PV1) Solar Power Development on the Remaining extent of Farm Bokpoort 390 - DEA Reference Number: 14/12/16/3/3/2/881

The air quality section of this report was based on an assessment completed in 2010 by Bohlweki SSI, which was compiled for the adjacent Bokpoort I solar facility (the Bohlweki-SSI Report):

Air Quality Impact Assessment for a Proposed Concentrating Solar Plant in the Northern Cape, Report Number E02.JNB.000674, Bohlweki SSI Environmental, 9 November 2010.

1.1 Objectives

The appointment for the current review resulted from a request by the Department of Environmental Affairs (DEA) that a third-party independent review be completed of the Air Quality section for the draft Environmental Impact Assessment report compiled by Golder for the Bokpoort II project. Golder's request was to conduct a technical review of the work completed with a view to expressing an independent opinion on the appropriateness and adequacy of the study conducted by the Golder specialist team. More specifically, it is required to produce comments on the following:

1. The baseline information in the Bohlweki SSI Air Quality report is applicable to the Bokpoort II project area;
2. The Impact statement and mitigation is appropriate to the nature and scale of the project.

1.2 Methodology

The following enabling tasks were identified to assist with the review:

1. Baseline Establishment
    a) Appropriateness of the meteorological dataset
    b) Period of meteorological data
    c) Baseline air quality
2. Impact Assessment
    a) Appropriateness of air emissions identified and quantified in the SSI Report
    b) Estimate of cumulative ground level concentration using a screening level model
    c) Comment on any impacts that more recent legislation may have on the project
3. Conclusion

1.3 Brief Biography of Specialist

LW Burger, PhD(Natal) MScEng (Chem) BScEng (Chem), FSACheE, FIChemE

Dr Burger holds an MSc and PhD in chemical engineering from the University of Natal. On completion of his bachelor's degree (cum laude) in chemical engineering in 1982, Dr Burger's experience in air pollution started in 1983 with the development and implementation of a real-time atmospheric dispersion model for processing industries (as partial fulfilment of his MSc Eng). A more complex dispersion model was subsequently developed in 1986, which contributed towards his PhD and later formed part of an international contract on the evaluation and validation of transport models as applied to the Chernobyl accident of April 1986 (International Atomic Energy Agency). Dr Burger is a Fellow of the South African Institute of Chemical Engineers (Fellow: No. 4533) and an Associate Fellow of the international Institute of Chemical Engineers (IChemE) (Fellow: No. 99963108).

He has been involved in several EIA projects and has conducted specialist studies for both quantified process risk assessments and air pollution impact components of EIAs. Dr Burger is a director of Airshed Planning Professionals (Pty) Ltd and Riscom (Pty) Ltd. Over the past three decades Dr Burger has been actively involved in the development of atmospheric dispersion modelling and its applications, air pollution compliance assessments, health risk assessments, mitigation measures, development of air quality management plans, meteorological and air quality monitoring programmes, strategy and policy development, training and expert witnessing.

Whilst most of his working experience has been in South Africa, a number of investigations were made in countries elsewhere, including Angola, Botswana, Central African Republic, Congo, Democratic Republic of Congo, England, Ethiopia, Equatorial Guinea, Ghana, Iran, Ireland, Lesotho, Liberia, Madagascar, Mozambique, Namibia, Suriname, Togo, Ukraine, Zimbabwe and Zambia.

A more comprehensive CV is provided in Appendix A.

2 REVIEW

2.1 Process

The PV solar power plant converts the sun's energy directly into electrical energy. The PV solar plant will consist of the following infrastructure:

- Solar generator comprised of polycrystalline PV modules (JINKO Solar modules JKM 310Wp) that will be able to deliver up to 75 MW to the Eskom National Grid;
- Inverters that convert direct current (DC) generated by the PV modules into alternating current (AC) to be exported to the electrical grid;
- A transformer that raises the system AC low voltage (LV) to medium voltage (MV);
- Transformer substation; and

Associated infrastructure includes:

- Mounting structures for the solar panels (will be either rammed steel piles or piles with pre-manufactured concrete footings to support the PV panels);
- Cabling between the structures, to be lain underground where practical;
- A new powerline which will connect the facility to the national grid via Eskom's existing Garona Substation;
- Internal access roads (4 – 6 m wide roads will be constructed but existing roads will be used as far as possible) and fencing (approximately 3 m in height); and
- Associated buildings, including a workshop area for maintenance, storage (i.e. fuel tanks, etc.), and offices.
- A 20 km water pipeline will be constructed within a 50 m buffer strip extending from the Orange River to the project site.
- Instrumentation and Control consisting of hardware and software for remote plant monitoring and operation of the facility.

2.2 Location

The approximate centre of the project area is 28°41'59.89"S and 22° 0'35.07"E. The project site is located 20 km north-west of the town of Groblershoop and approximately 77 km south-east of Upington (Figure 2-1). The Orange River is located approximately 12 km south-west of the site.

The main geographical feature in the area is the Orange River, which flows in a south-east to north-west direction along the southern boundary of the farm Bokpoort. The terrain is relatively flat across the farm. The land falls gently towards the Orange River. The Skurweberg and Prynnsberg lie to the north-east of the farm Bokpoort. There is also a range of low hills to the east of the farm.

2.3 Baseline Establishment

Given that the air quality, climatic and meteorological descriptions are essentially based on the information provided in the Bohlweki-SSI Report, it is essential that information is (a) relevant, (b) a good representation of the study area and (c) that it is still valid, given that the report was completed in 2010. Although not specifically requested from the review, it is believed that any gaps in the baseline description should also be pointed out.

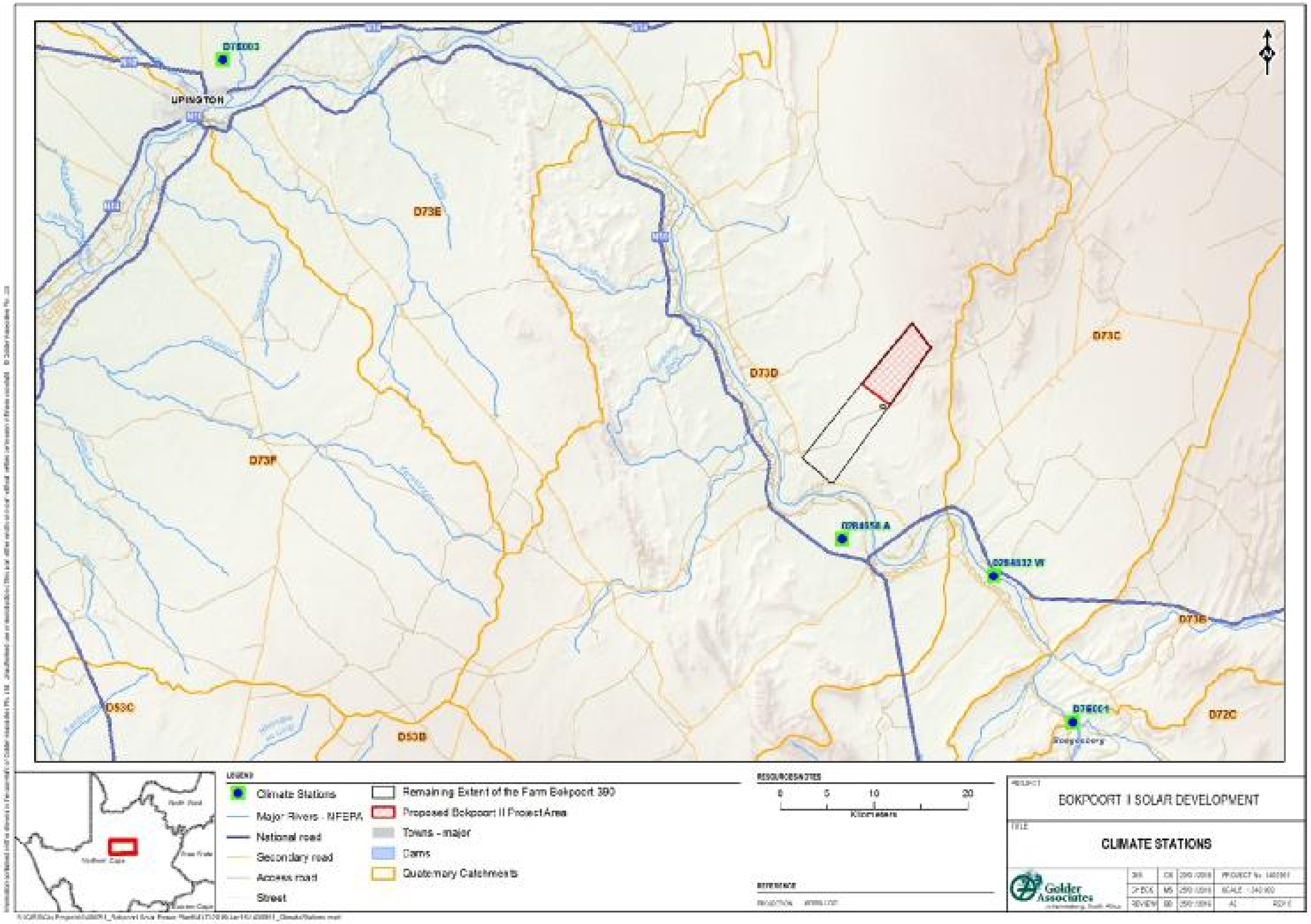

Figure 2-1: Locality map of the Bokpoort II project site relative to the nearest town of Upington

2.3.1 Climate

An adequate description of the climate for the study is provided and although there may be some casual argument for observable experiences in climate change, it is believed that the background information is nevertheless sound. The authors point out that the ZF Mgcawu District Municipal area is known for its extreme climate conditions. However, from the extent of the discussion, this appears to apply only to rainfall. Extreme wind and temperature conditions, as well as rare phenomena such as tornadoes, hail etc. are not discussed. Although these do not specifically have an impact on general air pollution, its inclusion may be considered for completes of the climate description.

2.3.2 Meteorological Parameters

The meteorological parameters included in the report were:

- Rainfall
- Temperature
- Evaporation
- Wind speed and direction
- Atmospheric stability classes

The rainfall and evaporation statistics clearly were not from the Bohlweki-SSI Report since this report did not include any discussion on these parameters. The information is from well referenced and reliable sources.

The temperature statistics were not the same as reported in the Bohlweki-SSI Report. Although not specifically referenced as such, it is assumed that the temperature statistics in the Bohlweki-SSI Report were extracted from simulated (MM5) meteorological data for the period January 2005 – December 2009 from Lakes Environmental. MM5 is an acronym for the Fifth-Generation NCAR/Penn State Mesoscale Model, which is a limited-area, nonhydrostatic, terrain-following sigma-coordinate model designed to simulate or predict mesoscale and regional-scale atmospheric circulation. Terrestrial and isobaric meteorological data are horizontally interpolated with observations from the standard network of surface and rawinsonde stations. The closest automatic weather stations near the study area include Upington (77 km north-west), Postmasburg (120 km east-north-east) and Prieska (130 km south-east). It is expected that the MM5 simulations would have incorporated the observations made at these weather stations. The Golder Report references the World Weather Online services, however, it is not clear whether the statistics are from an actual weather station or whether this data is also based on simulations. There are clear differences; however when compared with the long-term South African Weather Services (SAWS) weather station data at Upington (the daily average summer temperature ranges between 20.5^{0}C and 35.4^{0}C, and between 3.8^{0}C and 19.6^{0}C in winter), the information in the Golder Report is most likely more accurate, viz. daily average summer temperature ranges between 23^{0}C and 37^{0}C, and between 4^{0}C and 20^{0}C in winter.

Perhaps the most important meteorological parameter for establishing air pollution impacts is a representative wind field. Wind field data in the Bohlweki-SSI Report were also extracted from the MM5 simulations for the period January 2005 to December 2009. Based on an evaluation of this meteorological dataset, winds originate predominantly from the north-north-east (10% of the time) and north (9% of the time) (*Figure 8-7* of the Golder Report). In addition it is stated "….*that moderate to fast winds are generally extracted over the monitoring period. Calm wind speeds, which are designated as wind speeds less than 0.5 m/s, occur infrequently (4 % of the time)*". Strictly speaking the data was not "monitored" but extracted from the simulations. When compared with observations made by the SAWS in Upington and Prieska (Figure 2-2), the wind patterns are substantially different. The prevalent wind directions at Upington is south-westerly and northerly and at Prieska, north-westerly and westerly. The simulated data reveals winds predominantly from the northerly sector.

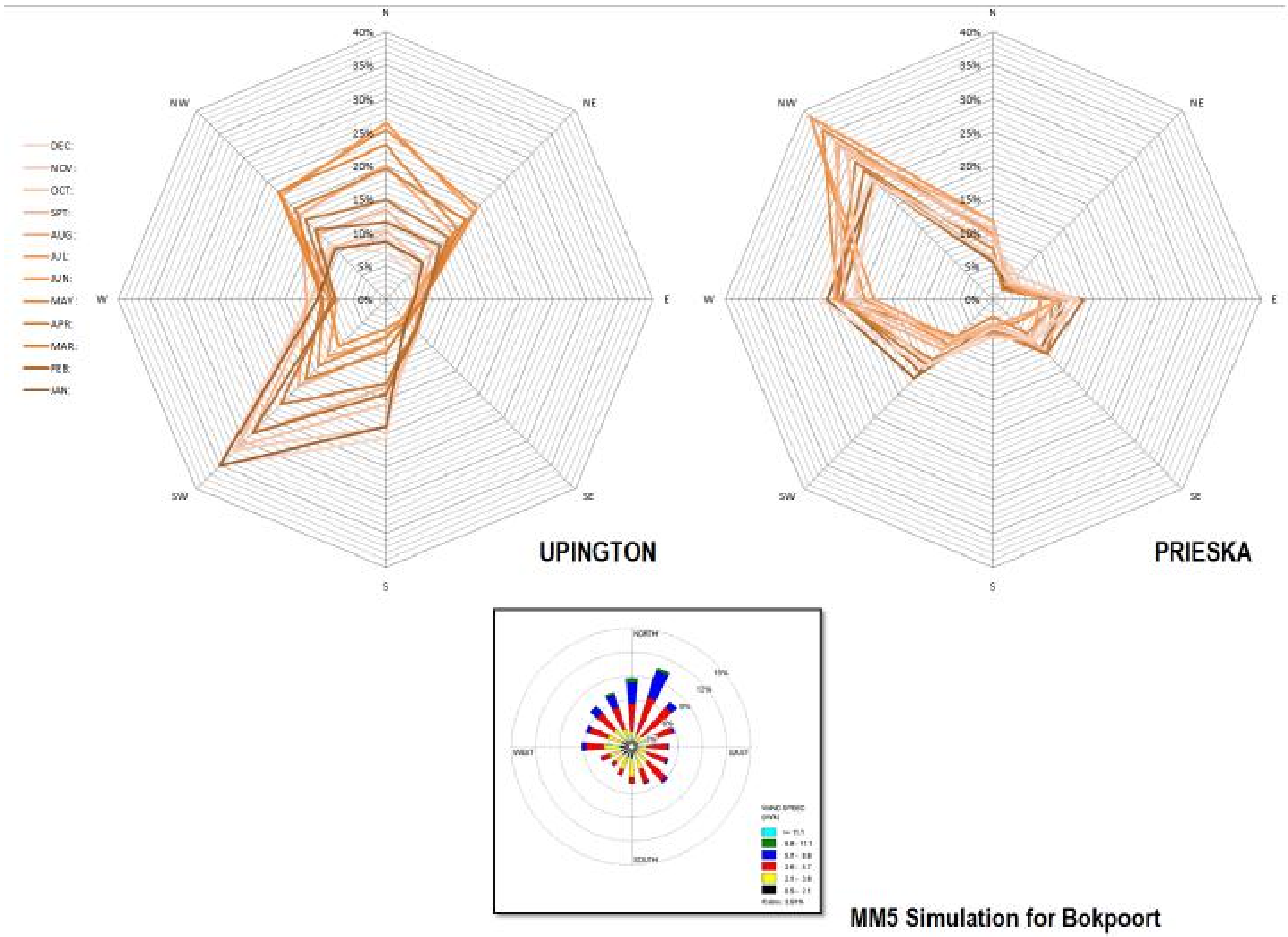

Figure 2-2: Wind directions observed at Upington and Prieska weather stations in comparison with simulated (MM5) data

Partly based on speculation, it is expected that some of the south-westerly winds observed at Upington should also occur in the study area. The Upington wind field also exhibits a bimodal distribution of wind direction, viz. northerly, north-westerly and north-easterly during the winter period and south-westerly during the summer and spring period. The MM5 data also display a seasonal difference with north and north-north-easterly winds during the winter and westerly (with some south-easterly) winds during the summer. The Prieska observations show predominant north-westerly winds during the autumn/winter season, with only a slight increase in other directions during the spring/summer season.

Calm wind conditions observed at Upington and Prieska are fairly high, i.e. 26.1%and 20.7%, respectively. This is significantly higher than the 4% in the MM5 data. In fact 65.9% of the data for Prieska shows wind speeds below 1.5 m/s. The Upington data shows 78.1% below 5.4 m/s.

Without doing further investigations or, preferably, onsite meteorological measurements, it is not evident whether the presence of the Skurweberg and Prynnsberg to the north-east of the site could result in the particular wind field differences between these datasets. Given the possibility of topographically induced flows, it is assumed that the wind description in the Golder Report (based on the Bohlweki-SSI Report) is an adequate description of the wind conditions in the study region. The data is also based over a period of 5 years, which would generally be regarded adequate. However, it must be pointed out that the Regulations regarding Air Dispersion Modelling (promulgated in Government Gazette No. 37804 vol. 589; 11 July 2014), require that atmospheric dispersion simulations predict air pollution impact assessments based on meteorological data that is no more than 5 years ago (*Regulation 4.4.3*):

Air dispersion modelling provides a cost-effective means for assessing the impact of air emission sources, the major focus of which is to determine compliance with the relevant ambient air quality standards. Dispersion modelling provides a versatile means of assessing various emission options for the management of emissions from existing or proposed installations. and recommend a suite of dispersion models to be applied for regulatory practices as well as guidance on modelling input requirements, protocols and procedures to be followed. The Regulations regarding Air Dispersion Modelling are applicable –

"A minimum of 1-year on-site specific data or at least three years of appropriate off-site data must be used for Level 2 assessments. For Level 3 assessments, meteorological data from a minimum of three consecutive years is required. The meteorological data must be from a period no older than five years to the year of assessment. "

Given the high occurrence of calm wind conditions at both Prieska and Upington one would have expected a higher frequency of unstable conditions than reported in the Golder Report. The latter is however fairly obvious given that the simulate data only simulated 4% calm wind conditions.

2.3.3 Baseline Air Quality

Existing sources of air pollution surrounding the site include dust and vehicle emissions from the construction of the Bokpoort I site. Other air pollution sources are agricultural activities, domestic fuel burning and occasional veld fires. The baseline air quality, generally speaking, is better than the national standards given the sparsely populated nature of the area and the short duration of emissions in the area. WHY?

It is stated in the report that the existing sources of air pollution surrounding the site include

- the operation of the Bokpoort I site which is limited to vehicles travelling along the gravel access road to the site
- from agricultural activities;

- domestic fuel burning; and
- occasional veld fires.

Furthermore, "…*Due to the sparsely populated nature of the area and the short duration times of emissions of air pollutants, the baseline air quality is generally better than the national standards.*"

Without having specifically been in the study area, knowledge of the greater area in general suggest that any air pollution from veld fires is probably not likely due to the type of vegetation and its sparseness. There is probably a better chance of dust storm developments. Therefore, although the original Bohlweki-SSI Report includes this as a baseline emission, its significance is negligible. Also, whilst domestic fuel burning, primarily wood, would be a source of air pollution, this would be minimal due to the separation distances from nearby residential developments.

The baseline air quality would most likely be dominated by the activities associated with the nearby Bokpoort I site. Other than mentioning vehicles travelling along the gravel access road, the Golder Report does not include any further details on the emissions from Bokpoort I. The Bohlweki-SSI Report also includes the presence of a diesel/LPG boiler, which would operate for approximately 6 months per year. The pollutants typically associated with combustion sources include carbon dioxide, carbon monoxide, particulates (soot), sulfur dioxide and oxides of nitrogen. Diesel fuel is considered the dirtier of the two options and, assuming that the emission rates in the Bohlweki-SSI Report is correct, could result in short-term (hourly average) sulfur dioxide concentrations of around 8 µg/m³ at a distance of approximately 340 m from the boiler, as shown in the figure below (Figure 2-3). At about 5 km from the boiler, the maximum sulfur dioxide concentrations would be around 4 µg/m³. The maximum concentrations for oxides of nitrogen and particulate matter are calculated to be 0.2 µg/m³and 2 µg/m³, respectively. Compared to the limit values contained in the National Ambient Air Quality Standards (NAAQS) (*Table 9.1* in Golder Report), these concentrations are quite low. Even if the additional vehicular exhaust emissions are added, it is expected that the current impacts would be low. Fugitive emissions from the gravel road due to wheel entrainment are expected to be more significant. Unfortunately, no attempt was made to illustrate these impacts in the Bohlweki-SSI Report.

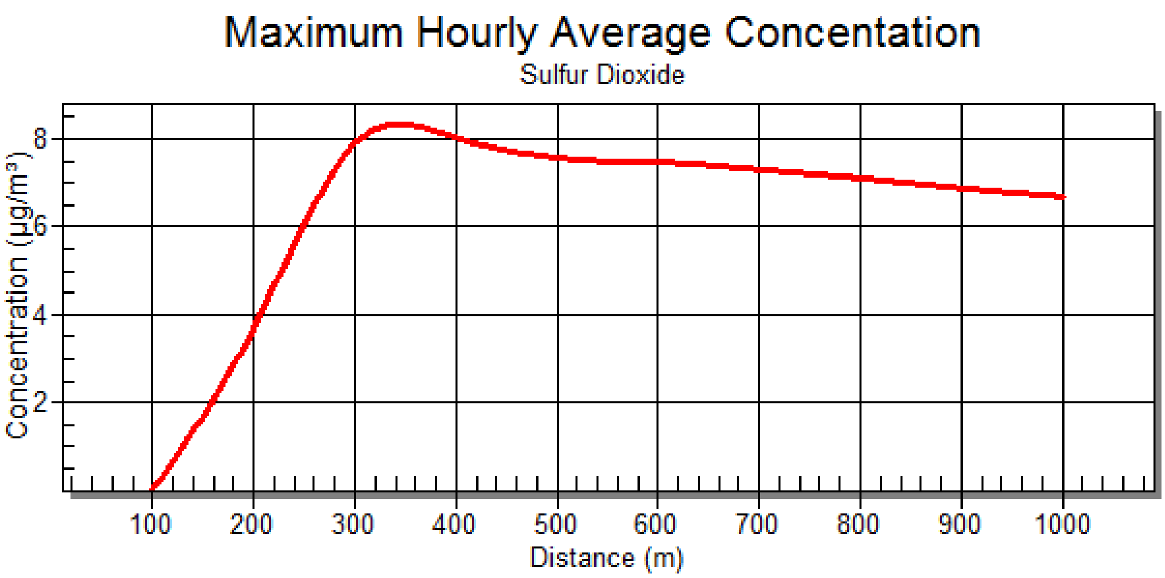

Figure 2-3: Calculated maximum hourly average ground level sulfur dioxide concentration (US EPA Screen 3 Model)

2.3.4 Impact Assessment

The air pollution sources identified for the proposed 75 MW Photovoltaic (PV1) Solar Power Development include air emissions during the construction and decommissioning phases and occasional vehicle emissions during the operational phase. Unlike the Bokpoort I project, there will not be any boilers.

Part of the associated activities includes a workshop area for maintenance, fuel storage tanks and offices. Whilst these would also emit some air emissions, these are expected to be of local (occupational) impact only.

The impact of dust and other debris (referred to as soiling) during the construction phase would also have a negative impact on the operation of the existing Bokpoort I, if adequate mitigation is not applied.

As in the Bohlweki-SSI Report, no attempt was made to estimate these impacts; however, mitigation measures have been provided to reduce emissions during the different phases. Monitoring of dust fall has also been recommended as a means of testing the performance of mitigation measures.

Although wetting of unpaved roads could be an effective manner to control fugitive dust emissions, the high evaporation rates and the practicability of obtaining water in this arid region may not be feasible. More permanent measure may have to be considered.

3 CONCLUSIONS AND RECOMMENDATIONS

The Golder Report is considered to be acceptable, provided the limitations of using the information from the Bohlweki-SSI Report are included. These together with some recommendations are discussed below.

3.1 Baseline Assessment

The baseline assessment includes a discussion on climate and meteorology which were extracted from a number of information sources, which is considered acceptable. Given the limitation of not having an onsite weather station, the baseline description is most likely an adequate reflection of the weather conditions in the study area. However, the parameter with the biggest uncertainty is the wind field. The baseline wind field was extracted from simulated data contained in the Bohlweki-SSI Report, which is significantly different from observations made at Upington (77 km north-west of site) and Prieska (130 km south-east of site). The differences may be due to the Skurweberg and Prynnsberg to the north-east of the site.

The baseline air quality description requires some revision, as discussed in Section2.3.3. For completeness, this includes the estimated air concentrations predicted for the boiler at Bokpoort I and included in the Bohlweki-SSI Report. The actual operating conditions should however be used in case it is different from the assumed specification in the Bohlweki-SSI Report.

3.2 Impact Assessment

No attempt was made to quantify air pollution impacts; instead, mitigation measures have been provided to reduce emissions during the different phases, i.e. construction, operational and decommissioning. Monitoring of dust fall has also been recommended as a means of testing the performance of mitigation measures.

Although wetting of unpaved roads could be an effective manner to control fugitive dust emissions, the high evaporation rates and the relatively limited water resources in this arid region may not be the most optimal solution. More permanent measure may have to be considered

FULL CURRICULUM VITAE

Name of Firm	Airshed Planning Professionals (Pty) Ltd
Name of Staff	Lucian Burger
Profession	Chemical Engineer/Air Quality and Process Risk Specialist
Date of Birth	24 May 1960
Years with Firm	25 years
Nationalities	South African

MEMBERSHIP OF PROFESSIONAL SOCIETIES

- Fellow of the South African Institute of Chemical Engineers (Fellow: No. 4533)
- Associate Fellow of the Institute of Chemical Engineers (IChemE) (Fellow: No. 99963108)
- National Association of Clean Air (NACA)
- Accredited Inspectorate Authority (AIA) for completion of risk assessments as partial fulfilment of Major Hazard Installation Regulations (Reference MHI013)
- SANAS Risk Assessment Specialist Technical Committee (2003 - 2010)
- Member of the Technical Committee on Air Quality Standards Setting (2002-2003)
- SABS Air Quality Standards Specialist Technical Committee (Chairman of Working Group 1)

KEY QUALIFICATIONS

30 years' experience in:

- Air Pollution Dispersion Modelling (use and development)
- Loss of Containment Simulations and Consequence Modelling (Fires, Explosions, Toxic Clouds)
- Process Failure Rate Analysis
- Micrometeorology
- Quantitative Risk Assessment
- Nuclear Site Safety Report Analysis – Meteorology and Dispersion Modelling
- Ambient Air Monitoring
- Chemical Engineering
- Development of Air Emissions Inventories (Mining and Ore Handling, Metal Recovery, Chemical Industry, Petrochemical Industry, Power Generation, Waste Disposal and Recycling, Transport [motor vehicles, aircraft, ships])
- Air Quality Management Programmes
- Formulation of National Strategies
- Project Management

RELEVANT EXPERIENCE

Policy, Strategic Planning and Air Quality Management:

- As chairman of Working Group 1, Lucian Burger was involved in the development of the South African Air Quality Standards Framework (SANS 69) and the Air Quality Standards for Criteria Pollutants (SANS 1929), in conjunction with the South African Bureau of Standards (SABS).
- Mercury emission limits - The South African Regulations for Mercury Waste Disposal was drafted in 2001. These regulations were completed together with Infotox (Pty) Ltd, specialists in toxicology.
- Dispersion modelling regulations – Chairman of the Dispersion Modelling Working Group for standardizing and setting requirements for the use of dispersion models for regulatory purposes, in conjunction with the South African Department of Environmental Affairs. Published in 2014 (National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) Regulation No. R 533, Government Gazette 37804).
- Guidelines For Thermal Treatment Of Wastewater Sludge – Development of the position paper and subsequent guidelines on the air emissions impact from thermal treatment options of wastewater sludge. The Water Research Commission published the complete set of guidelines in 2009 [*Herselman JE; Burger LW; Moodley P (2009) Guidelines for the utilisation and disposal of wastewater sludge Volume 5 of 5: Requirements for thermal sludge management practices and for commercial products containing sludge, ISBN No: 978-1-77005-711-1*].
- Review and Implementation of the new Air Emission License (National Environmental Management Air Quality Act) role out programme (2006-2008). This included the development of the framework, technical workshops with industry and training of local authorities. The tasks were divided between principal consultants within Airshed Planning Professionals. Lucian Burger was responsible for the Power Generation and Pulp & Paper sectors.
- List of Activities, Setting of Minimum Emission Standards. Served as technical advisor to the Department of Environmental Affairs for the development of air pollution emission rates for all major stationary industrial activities. Original published in 2010 (Government Gazette 33064)
- NEDLAC 'Dirty Fuels Project' - The project undertaken for NEDLAC comprised the development of emissions inventories for several major conurbations across South Africa, the prediction of resultant air pollutant concentrations and the quantification and costing of health risks due to inhalation exposures. Project was completed in 2004.
- Low Smoke Fuels Standards- Served on the Technical Committee on the Low Smoke Fuels Standards Development Committee administered by the Department of Minerals and Energy (1998-2003).
- Projects related to Air Quality Management
  - Saldanha Industrial Development Zone (IDZ) – Part of an integrated team of specialists that developed the proposed development and management strategies for the IDZ. Air quality guidelines were developed and a method of determining emissions for potential developers. The investigation included the establishment of the current air emissions and air quality impacts (baseline) with the objective to further development in the IDZ and to allow equal opportunity for development without exceeding unacceptable air pollution levels.
  - Vaal Triangle Airshed Priority Area Air Quality Management Plan– Served as technical advisor to the Department of Environmental Affairs for the development of South Africa's first air pollution priority area air quality management plan. This included the establishment of a comprehensive air pollution emissions inventory, atmospheric dispersion modelling, focusing on impact area "hotspots" and quantifying emission reduction strategies. The management plan was published in 2009 (Government Gazette 32263)
  - Cape Town - An air quality situation assessment was undertaken on behalf of the City of Cape Town in 2002 in support of their plans for the development of an air quality management plan for the City.
  - Johannesburg - An air quality baseline assessment was undertaken and an air quality management plan compiled for Johannesburg on behalf of the City. The project was completed during September 2003.

- Coega - An air pollution management strategy was developed in 1997 for the Coega IDZ. Air quality guidelines were developed and a method of determining emissions for potential developers. The objective was to allow equal opportunity for development without exceeding unacceptable air pollution levels. Developed an air-shed air quality management model for application at Coega in 1999. The model was developed in-house so as to assist the Coega Development Corporation in the proactive allocation of emission limits to prospective investors in the IDZ. The purpose being to maximise development opportunities whilst ensuring the maintenance of good air quality in the long-term.
- Gauteng - An air quality baseline assessment was completed for Gauteng in 1999 to inform their proposed air quality management plan. This project was funded by DANIDA.
- Gauteng - Part of the Environomics/Africon project team to develop industrial buffer zones for Gauteng was undertaken by members of our project team. These buffer zones have been implemented in a GIS system for DACEL and are meant as an early warning decision-support tool to indicate possible conflicts between sensitive activities (including residential development, hospitals, etc.) and pollution caused by industrial activities.
- Ekurhuleni – An air quality baseline study and an Air Quality Management Plan has been developed for the Ekurhuleni Metropolitan Municipality. This work was completed in 2005.
- UMhlathuze – An air quality situation analysis has being undertaken for the uMhlathuze District Municipality and guidance given in terms of the air quality implication of the municipality's spatial development framework. Work is was completed in 2005.
- Tswane – An air quality baseline study was completed for the Tswane Metropolitan Municipality (2005).

<u>Transport Sector:</u> Bakwena Toll Road Concession (Pretoria – Rustenburg); N1/N2 Protea Toll Road (Cape Town – Paarl – Somerset West); Protea Toll Road Tunnel Options; N14 (Germiston) On-/Offramp; N3TC Toll Road Concession De Beers Pass Alternatives; Gauteng Heavy Vehicles Freeway Re-Routing Study; SAPIA Vehicle Emissions Management Strategy; Gauteng Department of Transport Air Quality Management Plan; MMT Fuel Additive Monitoring Campaign (Afton); Sasol Vehicle Emissions Ambient Air Monitoring Campaign; Cape Town International Airport Air Quality Management Plan; OR Tambo International Airport Detailed Air Emission Inventory and Air Quality Management Plan; Sir Seretse Kama (Botswana) Air Impact Assessment; Iron Ore Train Transport (Sishen Mine to Saldanha Bay Iron Ore Port); Coal Train Transport (Moatize to Nicala Port, Mozambique); Bauxite Ore Long-haul Road Transport (Bakhuis to Nickerie, Suriname); Baseline Assessment of Iron Ore Transport (Zanaga Mine to Pointe Noir, Republic of Congo (Brazzaville)).

<u>Provision of Expert Testimony:</u> [e.g. Herbicide Contention Case: Victory Farm v HL&H Timber Products (Pty) Ltd, Rautenbach Aerial Spraying Ltd, Alan James McEwan; SAPREF Alkylation Unit Fire, Rhone-Poulenc Warehouse fire, Shell-Sasol Alcohol Reformulation Contention; Kudu Oils v Department of Environmental Affairs and Tourism), Global Forest Products (Pty) Ltd & Others v Lone Creak River Lodge (Pty) Ltd & Others; Pride Milling Company (Pty) Ltd v Klipspruit Colliery & Others; Triple S Diensstasie Edms Bpk / P Senekal; PetroSA v Langeberg Shopping Mall, PetroSA v Visigro Investments, Koedoeskloof Landfill in Uitenhage Nelson Mandela Municipality v Pentree.

<u>Quantitative Risk Assessments and Consequence Modelling</u>: Air Products Durban plant (Hydrogen); Comprehensive Risk Assessment of AECI (chlorine, ammonia, acrylonitrile, sulphur dioxide), Umbogintwini Factory Complex; Oleum Storage Tank Farm Lever Brothers. Boksburg; Ammonia Tank Farm Palabora Mining Company, Palaborwa; Ammonia Refrigeration Unit, Palabora Mining Company, Palaborwa; Chlorine Dosing facility Palabora Mining Company, Palaborwa; Accidental liquid Bromine spills and fugitive gas emissions at Delta-G Scientific, Halfway House; Accidental emissions and spills of organo-pesticides at Sanachem, Verulam. Burning of waste dumps in Botswana (Botswana Government). Chlorine Dosing Facility at mining operations (Rustenburg); Dispersion and Consequence Modelling of Toxic Liquid Spills (e.g. Acrylonitrile and Propylene Oxide), Combustion Products (e.g. Hydrogen Cyanide), Bund Fires and Vapour Cloud Explosions of a large number of storage tanks at Vopak Tank Terminals, Durban Harbour, Investigation of Fire at Sapref

Refinery Alkylation Unit; Risk assessment of ammonia, hydrogen fluoride and nitric acid Columbus Stainless (Middelburg); Natural Gas Pipeline from Mozambique to Secunda (Sasol Gas). Hydrogen gas pipeline from Vanderbijlpark to Springs (Air Products), Crude oil and white product pipelines from Chevron Refinery (Cape Town) to Cape Town Harbour, Crude oil and white product pipelines from Chevron Refinery (Cape Town) to Saldanha Bay, Liquid Fuels Transportation Infrastructure from Staatsolie Refinery To Ogane, Sol And Chevron Product Storage Depots, Suriname (Staatsolie Maatschappij Suriname N.V.) – Overland and Riverbed assessments; Liquid Fuels Transportation Infrastructure From Milnerton Refinery Area To Ankerlig Power Station (Atlantis Industrial Area), Western Cape Province (Eskom). Sunrise Liquid Petroleum Gas Ship Offloading and Pipeline Transportation Saldanha Bay – Sea and Land Spillages, Transnet Pipeline Greenvale Diesel Spill – Hillcrest, KwaZulu-Natal

Mining and Ore Handling (Blasting; quarrying; grinding; crushing; conveying; vehicles; tailings dams). BHP-Billiton Bauxite Mine (Suriname), Exxaro Heavy Minerals Mine and Processing (Madagascar), Tenke Copper Mine and Processing Plant (DRC), Sari Gunay Gold Mine (Iran), Zaldivar Copper Mine (Chile); Gold Mine at Omagh (Ireland); ZCCM Luancha Copper mine (Zambia); Skorpion Zinc mine (Namibia); Rossing Uranium (Namibia); Trekkopje Uranium (Namibia); Gokwe Coal Mine (Zimbabwe); Murowa Diamond Mine (Zimbabwe); Gamsberg Zinc Mine (Aggeneys); Prieska Copper mine (Prieska); Numerous coal collieries, including Riversdale (Tete Province Mozambique, Anglo Coal, Exxaro, Xstrata); Lime Quarries (La Farge, formerly Blue Circle, East London and Otjiwarongo, Namibia); Clinker Grinding and Cement Blending Plant (La Farge, Richards Bay); Bluff Mechanical Appliances – Durban Coal Terminal; Portnet's Saldanha Ore Port Facility; and others.

Metal Recovery (Smelting; electro-wining). Samancor Air Quality Baseline for all South African Chromium Smelter and Mines (Ferroveld, Ferrometals, MFC, Columbus, Tubatsi, Western Chrome Mines, Eastern Chrome Mines), Hexavalent Chromium Air Quality Reference Document (FAPA), Hartley Platinum Smelter (Zimbabwe); Mufulira Smelter (Zambia), Nkana Smelter (Kitwe, Zimbia); Waterval Smelter (Amplats, Rustenburg); Lonrho Smelter (Brits); Ergo (Anglo American Corporation, Springs); Coega Zinc Refinery (Billiton, Port Elizabeth); Hexavalent Chrome and Lead (Winterveld Chrome Mines); Hexavalent Chrome Xstrata (Rustenburg); Pitch releases from graphite electrode (EMSA, Union Carbide, Meyerton); Copper Smelting (Palabora Mining Company, Phalaborwa); Portland Cement Plant (La Farge, East London and Otjiwarongo, Namibia); Westplats – Mooinooi Smelter (Brits), Holcim Alternative Fuels Project (Lichtenburg, Ulco and Blending Plant – Roodepoort), PPC Riebeeck West Expansion Project, Expansion projects for ArcelorMittal South Africa Vanderbijlpark Works, Expansion projects for ArcelorMittal South Africa Saldanha Bay Works

Chemical Industry (bulk chemical; fertilizer; herbicides; pesticides). Comprehensive air pollution impact assessment of AECI (Pty) Ltd Operations, including Modderfontein, Umbogintwini, Somerset West, New Germany and Richards Bay; Kynoch Fertilizer plants in Milnerton and Potchefstroom; Fedmis Fertilizer Plant in Phalaborwa; Pesticides and Herbicides at Sanachem (Canelands); Chrome Impacts from various Bayer (Pty) Ltd operations (Newcastle and Durban); Fibre Production (Sasol Fibres, Durban); NCP Chloorkop Expansion project, NCP Chloorkop Contaminated Soils Recovery

Petrochemical Industry (Petroleum refineries, tank farms). Baseline and Expansion of Liquid Natural Gas Refinery (Equatorial Guinea); Site Selection for New South African Petroleum Refinery (DME), Proposed new Greenfields Petroleum Refinery at Coega (PetroSA), Hydrogen sulphide and sulphur dioxide emissions from SASOL operations (Sasolburg and Secunda); Sasol Coal to Gas Conversion Project (Sasolburg), Natref Refinery Expansion Project (Sasolburg); Engen Emissions Inventory Functional Specification (Durban); Air impact of air emissions from Sapref Refinery (Durban) Odour Impact assessment at ChevronTexaco Refinery (Cape Town); StaatsOlie expansion project (Suriname); Marathon LNG Expansion (Equatorial Guinea); PetroSA (Mossel Bay), Air impact of air emissions from Killarney, Milnerton and Saldanha Bay bulk storage tanks, Ambient air sampling campaign and Health Risk Analysis at Highway, Toll Plazas, Filing Stations & Taxi Ranks (Sasol), Air Products - Cryodrains at Sasol Secunda Oxygen Plants: Steam Ejector Vaporiser Vent Design

Pulp and Paper Industry. Expansion of Mondi Richards Bay, Odour Assessment and Panel Development for Mondi Richards Bay, Multi-Boiler Impact Assessment for Mondi Merebank (Durban), Impact Assessment for Sappi Ngodwana (Nelspruit), Impact Assessment for Sappi Stanger, Air Quality Monitoring Network and Air Pollution Management Plan for Sappi Saiccor (Umkomaas), Comprehensive Emissions Inventory and Screening Health Risk Assessment for Sappi Enstra (Springs), Impact Assessment for Sappi Tugela, Expansion Project for Cape Sawmills (Stellenbosch), Comprehensive Emissions Inventory and Screening Health Risk Assessment for Global Forest (Sabie), Air Impact Assessment for Pulp United (Richards Bay), MTO George Saw Mill (George)

Power Generation (stack emissions; coal and ash dump). Kelvin Power Station (Johannesburg);
Athlone Power Station (Cape Town); Tatuka, Kendal, Matimba, Duvha and Majuba Power Stations, ESKOM; Open Cycle Gas Turbine Peaking Power Station (Mosselbay), Inhambane Power Station, Mozambique, Combined Cycle Gas Turbine Power Plant In Moamba, Mozambique.

Waste Disposal (Incineration; landfill; evaporation; waste water treatment) All Enviroserv disposal sites (Chloorkop, Margolis, Umlazi, Vissershok, Shongweni, Aloes, Holfontein, Rosslyn), and city/district landfill facilities, including Cape Town City Council, Durban City Council, Johannesburg City Council; East London City Council; Port Elizabeth City Council, Eden District Municipality, Beluluane landfill facility [Matola, Mozambique])

Nuclear Installations. Participating member in the ATMES Phase 1 project to assess the emergency preparedness to nuclear accidents following the Chrenobyl Accident, Development and Implementation of a real-time emergency dispersion model for NECSA (Pelindaba); Development of a real-time emergency dispersion model for Koeberg Nuclear Power Station, Environmental Impact Assessment for the proposed demonstration Pebble Bed Modular Reactor (PBMR); Environmental Impact Assessment for the proposed Nuclear-1 Power Station; Meteorological monitoring and development of Meteorological Chapter of Site Safety Report for potential Nuclear-1 Power Station (Thyspunt, Bantamsklip and Duynefontein).

Software Development. Development of real time atmospheric dispersion model - HAWK: Atomic Energy Corporation of South Africa; CALTEX, Cape Town; NCP CHLOORKOP, Kempton Park; MOSSGAS, Mosselbay; PALABORA MINING COMPANY, Palaborwa; AECI, Umbogintwini; AECI, Modderfontein; SASOL, Secunda; SASOL, Sasolburg; SAPREF Refinery, Durban; ENGEN Refinery, Durban; ESKOM, Majuba Power Station; South Durban Air quality management system (Joint venture between major industries, authorities and community); SAPPI-SAICCOR, Umkomaas; HARTLEY PLATINUM, Zimbabwe, Richards Bay Air Quality Committee (Joint venture between major industries, authorities and community), ISCOR, Newcastle; ISCOR, Vanderbijlpark.

EDUCATION

University		
1984 - 1986	:	PhD student at the University of Natal (Department of Chemical Engineering), Durban. Completed December 1986. Degree awarded March 1987 Supervisor: Prof M Mulholland
1983 - 1984	:	MSc Eng student at the University of Natal (Department of Chemical Engineering), Durban. Completed April 1984. Degree awarded March 1985 Supervisor: Prof M Mulholland
1980 - 1982	:	BSc Eng student at the University of Natal, Durban. Completed a BSc Eng (Chemical Engineering) - Cum Laude
1979	:	BSc Eng student at the University of Port Elizabeth, 1st Year Chemical Engineering
Matriculated		
1978	:	Cradock High School, Cradock, South Africa. Aggregate: A

ADDITIONAL COURSES

1996 Risk Assessment for Environmental Decision Making - Presented by Harvard University School of Public Health at the CSIR, Pretoria, RSA.

1996 Risk Assessment for Environmental Decision Making - Presented by Harvard University School of Public Health at the CSIR, Pretoria, RSA.

COUNTRIES OF WORK EXPERIENCE

Central African Republic, Republic of Chile, Democratic Republic of Congo, Federal Democratic Republic of Ethiopia, Republic of Equatorial Guinea, Republic of Ghana, Kingdom of Lesotho, Republic of Liberia, Republic of Madagascar, Republic of Mozambique, Republic of Namibia, Republic of Congo, Republic of South Africa, Republic of Suriname Togolese Republic, Republic of Zambia, Republic of Zimbabwe

EMPLOYEMENT RECORD

Jan 1990 to 2014	Managing Director/Director. Airshed Planning Professionals (Pty) Ltd, Midrand (Previously known as Environmental Management Services 1990 to 2003)

A consulting firm providing services in the Air Quality and Noise Assessments and Management field to industry and national, provincial and local authorities. Work includes the preparation of emission inventories, dispersion modeling, impact assessment and mitigation planning in the mining, metallurgical and general industrial sectors. Legal compliance audits have been carried out.

Jan 1989 to Dec 1990	Process Engineer, AECI Engineering Department, Modderfontein, Johannesburg.

Part of process engineering team for the design of Coal to Liquid (CTL) processing plant, responsible for energy integration. Conceptual design of new Calcium Carbide smelter. Detailed engineering and commissioning of Gold Potassium Cyanide Plant.

Jul 1987 to Dec 1988	Research Engineer, Council for Scientific and Industrial Research (CSIR), Pretroria

Responsible for the development (design and construction) of a gas dynamic laser for industrial applications. Development of a real-time atmospheric dispersion model for emergency response applications

Jan 1984 to Dec 1986	Research Assistant, Department Chemical Engineering, University of Natal, Durban.

Development of prototype real-time atmospheric dispersion model for air pollution management applications at a petroleum refinery. Development of a new theoretical model for complex atmospheric applications.

CONFERENCE AND WORKSHOP PRESENTATIONS AND PAPERS

Burger L W and Mulholland M. Real-time prediction of point-source distributions using an anemometer-bivane and a microprocessor, Atmospheric Environment, Volume 22, Issue 7, 1988, Pages 1309–1317

Burger L W Air pollution modelling as part of an EIA study, Western Cape Annual Air Pollution Symposium, National Association for Clean Air, 11 September 1997

Burger, C.J.H. & Kornelius, G. Dust dispersion from a dust road and the attenuation thereof by tree plantations beside the road: A mathematical model. CEMSA '98 International Conference and Exhibition on Integrated Environmental Management. East London, February 1998

Burger, L.W., Coetzee, L.A., Sowden, M., Kornelius, G., Simpson, D., Swanepoel, P.A., van Niekerk, A.S., & van Niekerk, W.C.A. Development and implementation of the Integrated Energy Decision Support Model (IEDS) to improve health conditions in residential areas. Proc 11th World Clean Air and Environment Congress, Durban 1998.

Hurt Q E, Burger L W, Bell C. A Tool For Air Quality Management : The Importance Of Quality Assurance, Intelligent Assimilation Of Data And The Effective Representation Thereof To Industry, The Regulatory Authorities And The Community. Proc 11th World Clean Air and Environment Congress, Durban 1998.

Burger L W and Scorgie Y The Value Of A Quantitative Acute And Chronic Health Risk Assessment In Town Planning Around A Large Industrial Complex. Proc 11th World Clean Air and Environment Congress, Durban 1998

Burger L W, Coetzee L A, Sowden M, Kornelius G, Simpson D, Swanepoel P A , Van Niekerk A S and Van Niekerk WCA, Development And Implementation Of The Integrated Energy Decision Support Model (Ieds) To Improve Health Conditions In Residential Areas. Proc 11th World Clean Air and Environment Congress, Durban 1998

Burger L W and Hurt QE, A Tool for Air Quality Management: Real-Time Atmospheric Dispersion Modelling In Two Large Industrial Regions - South Durban And Richards Bay. Proc 11th World Clean Air and Environment Congress, Durban 1998

Burger L W and Terblanche A P, Atmospheric Dispersion Calculations Of Toxic Gases Originating From Waste Disposal Facilities, Proc 11th World Clean Air and Environment Congress, Durban 1998

Burger L W, Grundling A, Van Heerden J, Truter T, Rautenbach H. A Case Study: Predicting the Surface and Upper Atmospheric Dispersion Of Satellite Launching Rocket Exhaust Gases, Proc 11th World Clean Air and Environment Congress, Durban 1998

Burger L W. Quantifying Flue Gas Temperature to Minimise Condensation in Scrubber Stack Plumes, National Association for Clean Air Conference 2004

Burger L W and Scorgie Y, Air Quality Management Systems: Pitfalls and Harmonization, National Association for Clean Air Conference, 2005

Burger, L W, Uncertainty in Atmospheric Dispersion Modelling, National Association for Clean Air Conference, East London 2006

Burger L W, Stead M and Moldan A. Prediction Of Motor Vehicle Air Emission Reductions Through Intervention Policies, National

Association for Clean Air Conference, Vereenging 2009

Burger L W, Complexities In The Estimation Of Emissions And Impacts Of Wind Generated Fugitive Dust, National Association for Clean Air Conference, Polokwane 2010

Burger L W, A Dynamic Model for The Simulation Of Sulphur Dioxide Emissions From A Self-Propagating Sulphur Storage Fire, 16th IUAPPA World Clean Air Congress, 29 Sep to 4 Oct 2013, Cape Town

Herselman JE; Burger LW; Moodley P (2009) Guidelines for the utilisation and disposal of wastewater sludge Volume 5 of 5: Requirements for thermal sludge management practices and for commercial products containing sludge, ISBN No: 978-1-77005-711-1].

Liebenberg-Enslin, H, Annegarn, H.J and Burger, L.W (submitted Aeolian Research for publication in 2015), A Best Practice Prescription For Quantifying Wind-Blown Dust Emissions from Gold Mine Tailings Storage Facilities.

Scorgie Y, Burger L W and Sowden, M: Application of Source-Receptor Modelling to Regional Air Quality Management, National Association for Clean Air Conference, 'Into the Next Millennium', held at BMW Pavilion, Cape Town on 6-8 October 1999.

Scorgie Y, Burger L W and Annegarn, H.J: Air Quality Management within the Vaal Triangle, Air Pollution Action Committee (APAC) meeting, held at the Lethabo Power Station, Sasolburg, South Africa, 24 May 2000.

Scorgie Y, Burger L W, Annegarn, H.J and Piketh S: Background Study for the Development of an Air Quality Management Strategy for Gauteng: Characterisation of Existing Air Quality and Assessment of Future Trends and Driving Forces, National Environmental Research Institute of Denmark, 25 October 2000.

Scorgie Y, Burger L W and Annegarn, H.J: Air Quality Management System Development and Implementation in South Africa, paper to be presented at the Third International Conference on Urban Air Quality Conference entitled Measurement, Modelling and Management, 19-23 March 2001, Loutraki, Greece.

Scorgie Y, Annegarn, H.J and Burger L W: Air Quality Over South Africa – Persistent Problems And Emerging Issues, 14th IUAPPA World Congress, Brisbane, 2007

LANGUAGES

	Speak	Read	Write
English	Home language	Good	Good
Afrikaans	Good	Good	Good

CERTIFICATION

I, the undersigned, certify that to the best of my knowledge and belief, these data correctly describe me, my qualifications, and my experience.

_   13/11/2015

Signature of staff member   Date (Day / Month / Year)