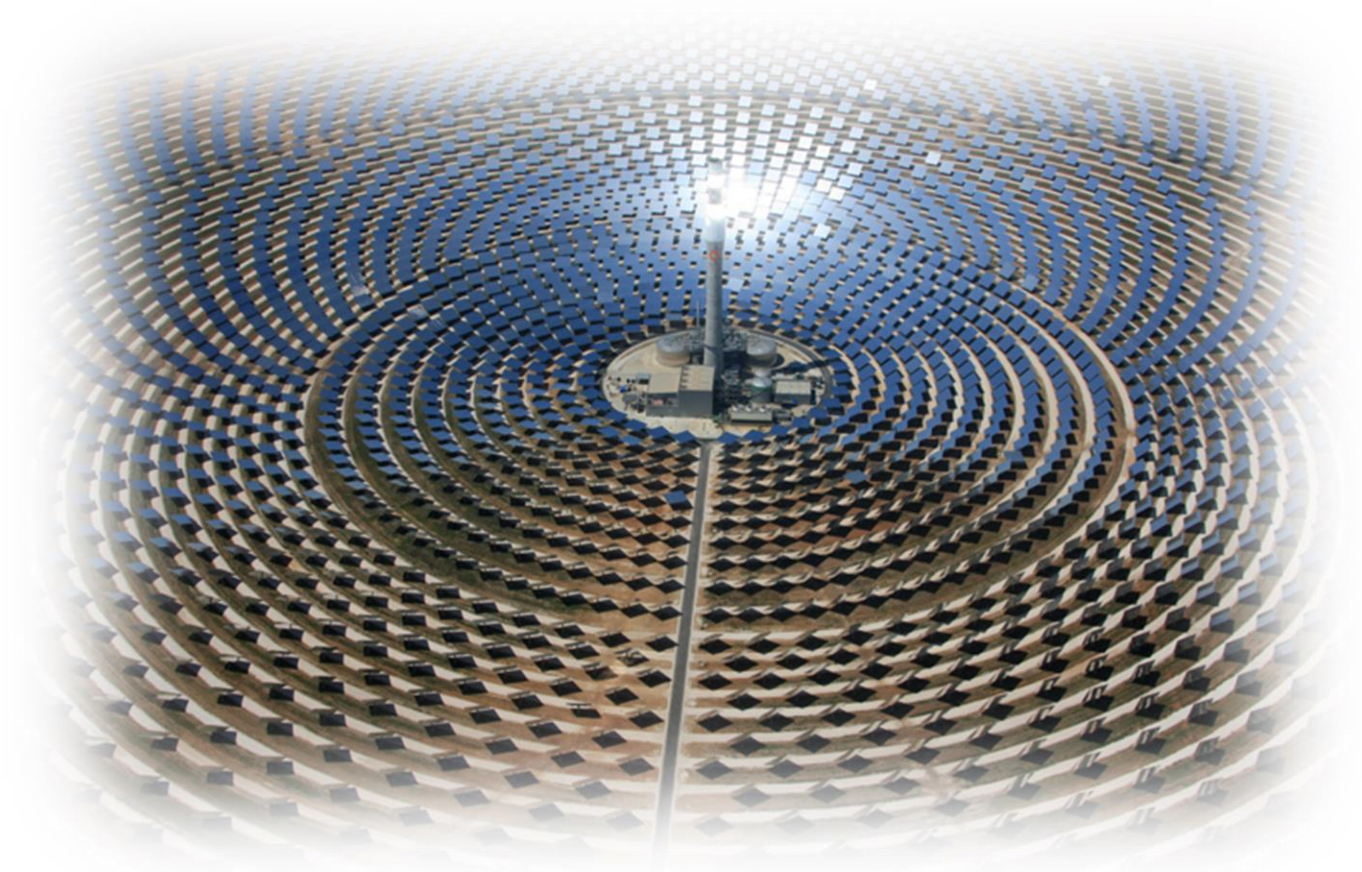
Air Quality Impact Assessment Report for the Sandraai Solar Project



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A Report for: SolAfrica

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Royal HaskoningDHV
Enhancing Society Together

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1 INTRODUCTION

1.1 Background

Royal HaskoningDHV was commissioned to undertake an Air Quality Impact Assessment for the proposed Concentrated Solar Park (CSP) located in the Kheis Local municipality, Northern Cape (Figure 1). The proposed site is located on the Sandraai farm, approximately 7km south from the Eskom substation. The development of the CSP project will entail the construction of 150 MW parabolic troughs and 150 MW central receiver tower.

This study aims to assist in the development of a scoping study to determine the potential air quality impacts associated during the construction, operation and eventual decommissioning of the site.

1.2 Scope of Work

As part of the report, a baseline assessment was undertaken which includes a review of available meteorological data to evaluate the prevailing meteorological conditions within the area. The baseline air quality situation was assessed through a review of meteorological data which was obtained from the South African Weather services for the period of Jan 2011 - Dec 2013. The potential impact of emissions from the proposed project on the surrounding environment has been evaluated through the compilation of an emissions inventory and subsequent dispersion modelling simulations using the AERMOD dispersion model. Comparisons with the South African and relevant international ambient air quality standards are made to determine exposure risks.

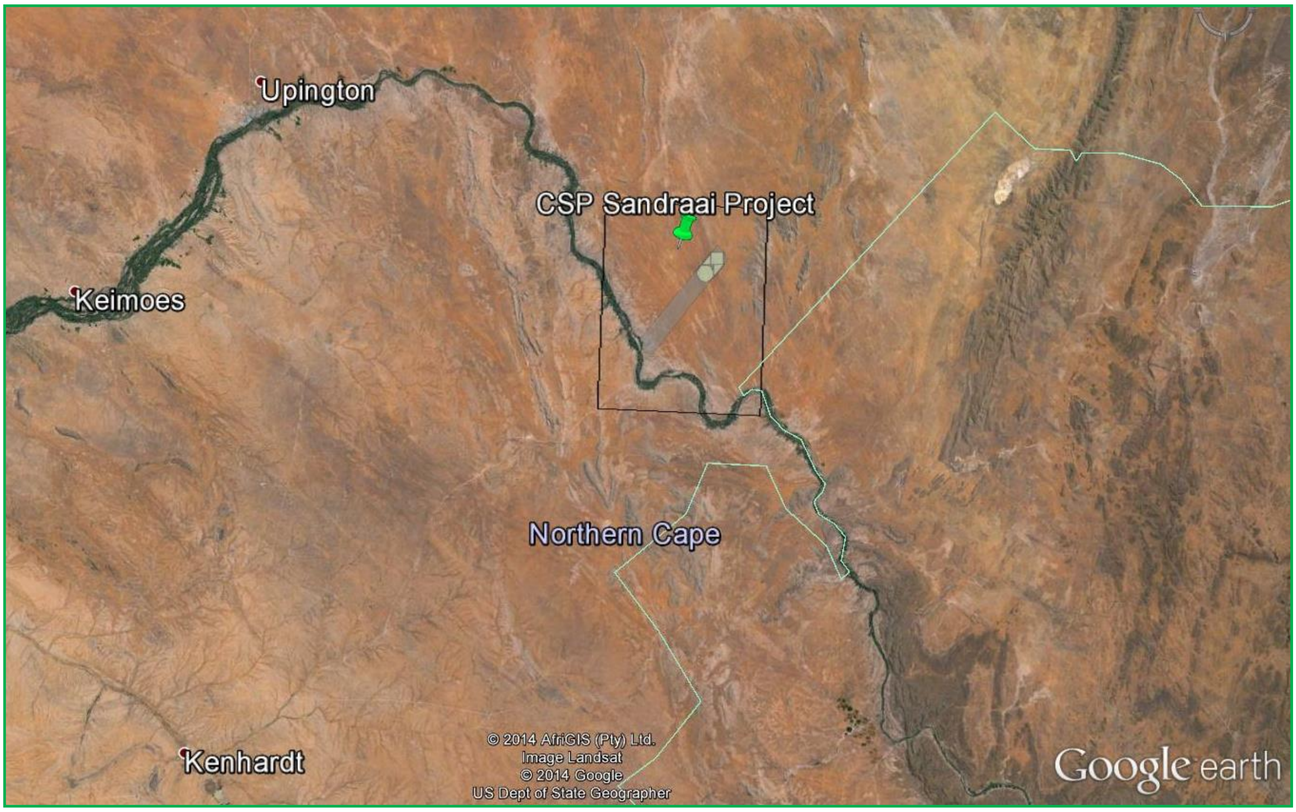


FIGURE 1: PROPOSED LOCATION OF THE SANDRAAI CONCENTRATED SOLAR PARK (CSP) PROJECT.

1.3 Project Description

Solar power generation is arguably the cleanest, most reliable form of renewable energy available. Concentrated Solar Power (CSP) produces no carbon dioxide (CO_2), thus reducing carbon emission from electricity generation by approximately 100kg per megawatt/hour. CSP technology is based on the principle of converting thermal energy into electrical energy.

Concentrated solar power uses mirrors or lenses to concentrate a large area of sunlight or solar thermal energy onto a small area. Electrical power is produced when the concentrated light is converted to heat, which drives a heat engine, usually a steam turbine connected to an electrical power generator. Concentrating technologies exists in five common forms namely; parabolic trough, enclosed trough, dish sterlings, concentrating linear Fresnel reflectors and solar power tower. Different type of concentrators produces different peak temperatures and correspondingly varying thermodynamic efficiencies due to differences in the way that they track the sun and focus light. The CSP and CPV (concentrated photovoltaic) technologies applicable to the Sandraai project will be discussed in the sections below.

- **Parabolic trough**

A parabolic trough consists of linear parabolic reflectors that concentrate light on to a receiver positioned along the reflectors focal line. The receiver is a tube positioned directly above the middle of the parabolic mirror and filled with a working fluid. The reflectors follow the sun during the daylight hours by tracking along a single axis. A working fluid such as molten salt is heated to 150 – 350 °C as it flows through the receiver and is then used as a heat source for a power generation system. Trough systems are the most developed CSP technology.

FIGURE 2: EXAMPLE OF A PARABOLIC TROUGH SYSTEM.

- **Solar Power Tower**

A solar power tower consists of an array of dual axis tracking reflectors known as heliostats that concentrate sunlight on a central receiver located at the top of a tower. The receiver contains a fluid deposit which is a salt water solution. The working fluid in the receiver is heated to 500 – 1000 °C and then used as a heat source for power generation or an energy storage system. The power tower development is less developed than the trough systems but it offers a higher efficiency and better energy storage capabilities.

FIGURE 3: EXAMPLE OF A SOLAR POWER TOWER SYSTEM

2 APPLICABLE LEGISLATION

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

2.1 South African legislative and standards frameworks

- **National Environmental Management: Air Quality Act 39 of 2004**

The National Environmental Management: Air Quality Act (No 39 of 2004, “NEM:AQA”) represents a move to an air pollution control strategy that is based on receiving air quality management. It focuses on the adverse impacts of air pollution on the ambient environment and sets standards as the benchmark for air quality management performance. At the same time it sets emission standards to minimize the amount of pollution that enters the environment. The Act regulates the control of noxious and offensive gases emitted by industrial processes, the control of smoke and wind borne dust pollution, and emissions from diesel vehicles.

The promulgation of the National Environmental Management: Air Quality Act (NEM:AQA) resulted in a shift from national air pollution, control based on source based controls to decentralised air quality management through an effects-based approach. An effects based approach requires the meeting of ambient air quality standards. These ambient standards are to be set by the Local and District Municipalities which govern air quality management in the area. The Municipality of concern here is the Waterberg District Municipality. If these standards have not been set yet the National Ambient Air Quality Standards will need to be adhered to. Such standards provide the objectives for air quality management.

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

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

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

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

The National Framework is one of the significant functions detailed in Chapter 2 of the NEM: Air Quality Act. The Framework serves as a blueprint for air quality management and aims to achieve the air quality objectives as described in the preamble of the AQA.

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

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

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

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

Licensing of Listed Activities through an Atmospheric Emission Licence is addressed in Chapter 5 of the Air Quality Act. On 31 March 2010, the Minister of Water and Environmental Affairs published the Listed Activities and Minimum Emission Standards. International air quality management is outlined in Chapter 6 and offences and penalties in Chapter 7.

- **National Ambient Air Quality Standards**

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

The Department of Environmental Affairs and Tourism (DEAT) have issued ambient air quality guidelines to support receiving environment management practices. Ambient air quality guidelines are only available for such criteria pollutants which are commonly emitted, such as Particulates, SO_2, Pb, NO_x, benzene and CO. The guidelines specific to the relevant pollutants during this assessment are detailed in the sections below.

2.1..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. Particulate matter includes dust, smoke, soot, pollen and soil particles (Kemp, 1998). Particulate matter 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).

Particulate matter 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).

Particulate Matter 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 1: AMBIENT AIR QUALITY STANDARDS AND GUIDELINES FOR PARTICULATE MATTER.

Pollutant	Averaging period (µg/m^3)	Guideline (µg/m^3)	Number of Exceedance Allowed Per Year
PM10	Daily average	75	4 4
	Annual average	40	0 0
PM2.5	Daily average	65 (1) 40 (2) 25 (3)	4 4 4
	Annual average	25 (1) 20 (2) 15 (3)	0 0 0

Notes: 1- Come into effect immediately until December 2015
2- Come into effect 1 January until 31 December 2029
3 –Come into effect 1 January 2030

2.1..2 Nuisance Dust

On the 7th of December 2012 the minister of Water and Environmental affairs published the new National Dust Control Regulations. This document now enforces the monitoring of dust fallout from activities that is suspected of contributing significantly to dust fallout in its region. The regulation provides a set standard for dust fallout to comply to, enforces that a baseline should be established to projects that would give rise to increased dust fallout, specifications for dust fallout monitoring and the format of reports if the activity should exceed the thresholds.

If an activity exceeds the standard the entity must submit a dust monitoring report to the air quality officer (local authority), before December 2013 (Section 4, GN1007 of 2012). The entity must develop a dust management plan, within three months after the submission of a dust monitoring report (Section 5, GN1007 of 2012). If the dust fallout is continued to be exceeded, the authority may request that continuous PM_{10} monitoring be conducted at the site.

TABLE 2: ACCEPTABLE DUST FALLOUT RATES AS MEASURED (USING ASTM D1739:1970 OR EQUIVALENT) AT AND BEYOND THE BOUNDARY OF THE PREMISES WHERE DUST ORIGINATES.

Restriction area	Dustfall rate, D (mg/m²/day, 30-day average)	Comment
Residential	D < 600	Two within a year, not sequential months.
Non residential	600 < D < 1200	Two within a year, not sequential months.

2.1..3 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 3.

TABLE 3: AMBIENT AIR QUALITY GUIDELINES AND STANDARDS FOR OXIDES OF NITROGEN

Averaging Period	South Africa		WHO		EC		Australia	
	µg/m³	ppm	µg/m³	ppm	µg/m³	ppm	µg/m³	Ppm
Annual Ave	40	0.021	40	0.021	40	0.021	57	0.03
Max. 1-hr	200	0.10	200	0.10	200	0.10	240	0.12

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 µg/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 µg/m^3 (2.5 ppm), experience pronounced decreases in pulmonary function; generally, normal subjects are not affected by concentrations less than 1 880 µg/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 µg/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 µg/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.

2.1..4 Methane

Methane is not toxic to humans but is of concern in terms of its explosion potential and its impact on the global climate. The most commonly accepted flammability ranges for methane in air mixtures are given as 5.3% to 14%. The flammability range becomes slightly extended to 5.0% to 15% when mixtures of methane in air are retained with a small void such as might occur should the gas collect within an enclosed void within buildings (Campbell, 1996). Methane is one of the most significant greenhouse gases known (21 times stronger than carbon dioxide). Over the last two centuries, methane concentrations in the atmosphere have more than doubled, largely due to human-related activities.

2.1..5 Listed Activities

The Air Quality Act requires all persons undertaking listed activities in terms of Section 21 of the Act to obtain an Atmospheric Emission Licence. The Listed Activities and Associated Minimum Emission Standards was issued by the Department of Environmental Affairs on 31 March 2010 (Government Gazette No 33064).

The following listed activties which have the potential to be triggered are listed below:

TABLE 4: CATEGORY 1. SUBCATEGORY 1.2: LIQUID FUEL COMBUSTION INSTALLATIONS (EXCLUDING ANY MATERIAL THAT IS REGARDED AS WASTE IN TERMS OF THE WASTE ACT, 2008).

Description	**Liquid fuels combustion installations used primarily for steam raising or electricity generation**		
Application	**All installations with design capacity equal to or greater than 50 MW heat input per unit, based on the lower calorific value of the fuel used.**		
Substance or mixture of substances		**Plant status**	**Mg/Nm^3 under normal conditions of 3% O_2, 273 kelvin and 101.3 kPa.**
Common name	**Chemical symbol**		
Particulate matter	N/A	New	50
		Existing	75
Sulphur dioxide	SO_2	New	500
		Existing	3500
Oxides of nitrogen	NO_x expressed as NO_2	New	250
		Existing	1100

a) The following special arrangements shall apply –

I. Reference conditions for gas turbine shall be 15% O_2, 273K and 101.3kPa

II. Continuous emission monitoring of PM, SO_2 and NO_x is required.

TABLE 5: SUBCATEGORY 1.4: GAS COMBUSTION INSTALLATIONS (EXCLUDING ANY MATERIAL THAT IS REGARDED AS WASTE IN TERMS OF THE WASTE ACT, 2008).

Description	Gas combustion (including gas turbines burning natural gas) used primarily for steam raising or electricity generation.		
Application	All installations with design capacity equal to or greater than 50 MW heat input per unit, based on the lower calorific value of the fuel used.		
Substance or mixture of substances		Plant status	Mg/Nm^3 under normal conditions of 3% O_2, 273 kelvin and 101.3 kPa.
Common name	Chemical symbol		
Particulate matter	N/A	New	10
		Existing	10
Sulphur dioxide	SO_2	New	400
		Existing	500
Oxides of nitrogen	NO_x expressed as NO_2	New	50
		Existing	300

a) The following special arrangements shall apply - Reference conditions for gas turbine shall be 15% O_2, 273K and 101.3kPa

TABLE 6: SUBCATEGORY 1.5: RECIPROCATING ENGINES

Description	Liquid and gas fuel stationary engines used primarily for steam raising or electricity generation.		
Application	All installations with design capacity equal to or greater than 50 MW heat input per unit, based on the lower calorific value of the fuel used.		
Substance or mixture of substances		Plant status	Mg/Nm^3 under normal conditions of 3% O_2, 273 kelvin and 101.3 kPa.
Common name	Chemical symbol		
Particulate matter	N/A	New	50
		Existing	50
Sulphur dioxide	SO_2	New	2000* 400**
		Existing	2000* 400**
Oxides of nitrogen	NO_x expressed as NO_2	New	1170*
		Existing	1170*
*Liquid fuels fired **Gas fired			

A) THE FOLLOWING SPECIAL ARRANGEMENTS SHALL APPLY –

I. Existing plants must comply with minimum emissions standards for existing plant as contained in Part 3 within 5 years of the date of publication of this notice.

Existing plant must comply with minimum emission standards for new plant as contained in Part 3 within 10 years of the date of publication of this notice.

3 BASELINE ENVIRONMENT

3.1 Description of Environment

- **Regional and Local Climate and Atmospheric Dispersion Potential**

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

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

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

- **Wind**

Wind roses comprise of 16 spokes which represents the direction from which the winds blew during the period under review. 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 site specific meteorological data obtained from the South African Weather Services in Upington, Northern Cape, the following deductions regarding the prevailing wind direction and wind frequency can be presented.

Based on Figure 4 below, the predominant wind direction for the area under review is multidirectional, with primary winds originating from the south-west and northern region. Secondary winds originated mainly from the north western and western regions.

Calms wind (<0.5 m/s) were experienced 6.30 % of the time. High wind speed of 5.7 - 8.8 m/s occurred less frequently than wind speeds of 3.6 - 5.7 m/s which occurred for 25.5 % of the time. The most frequent wind speed of 2.1 - 3.6 m/s were experienced for 36.6 % of the time, while wind speeds of 0.5 -2.1 m/s were experienced for 18.8 % of the time (Figure 5).

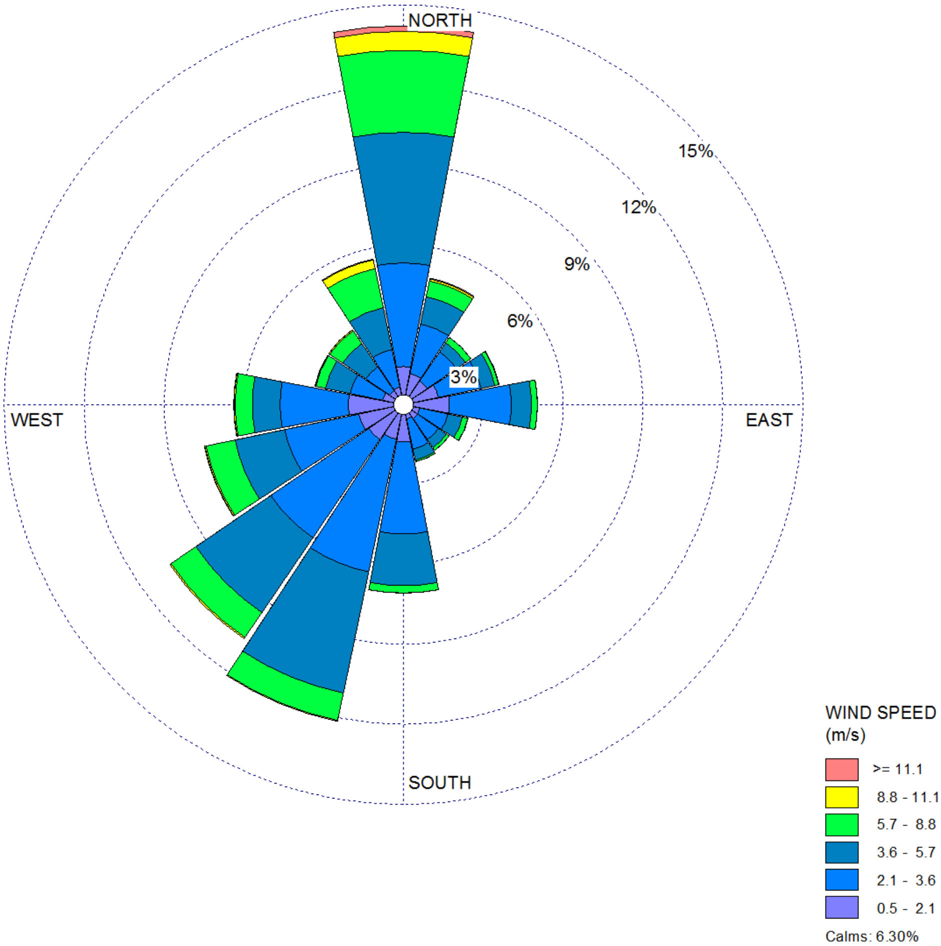


FIGURE 4: PERIOD WIND ROSE FOR THE SANDRAAI CSP PROJECT AREA FOR THE JAN 2011 – DEC 2013 MONITORING PERIOD.

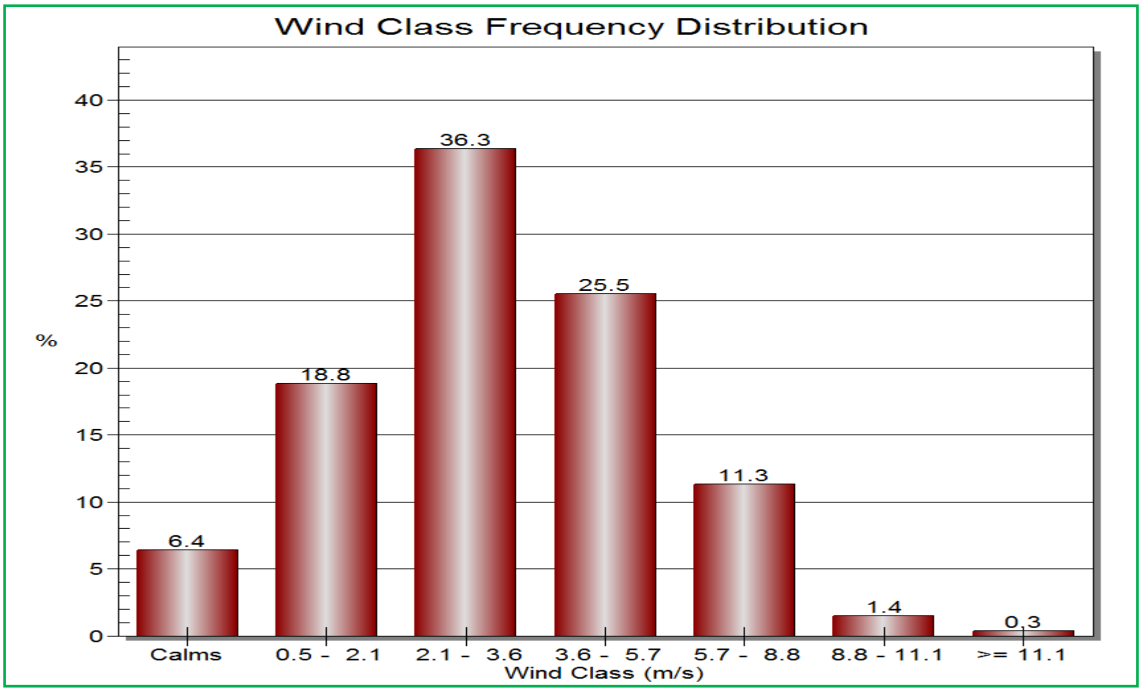
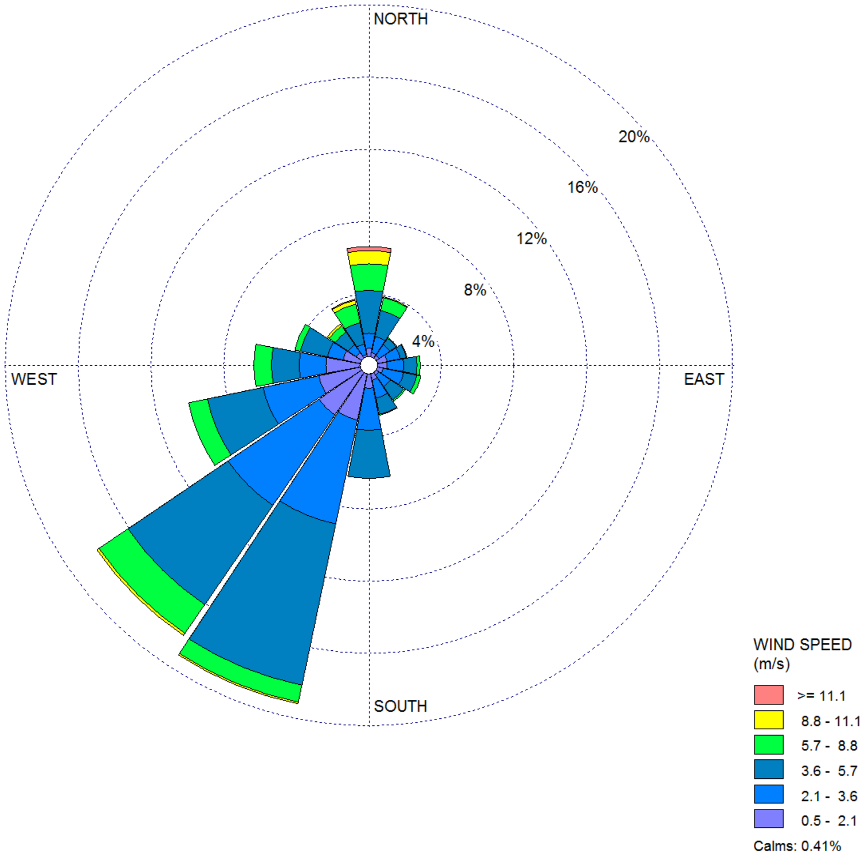


FIGURE 5: WIND CLASS FREQUENCY DISTRIBUTION

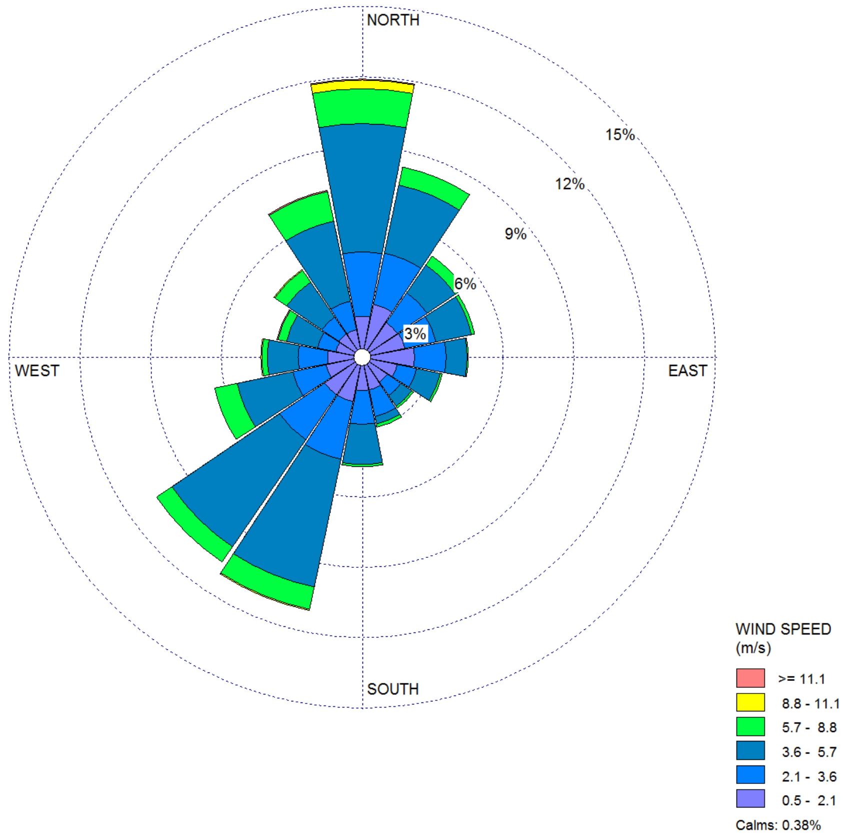
Seasonal variability in the wind field at the proposed site is shown in Figure 6 and Figure 7 below. During the spring months (September, October and November) the predominant wind direction originated mainly from the South western region. A slight shift in the wind field occurs during the summer months (December, January and February) with a predominant wind direction from the north and south western region, while secondary winds occurred from the north western region.

The autumn (March, April and May) and winter (June, July and August) wind field experienced a similar wind profile, with a predominant wind direction from the north region and secondary winds from the south western and western regions.

Diurnal trends in the wind field for the proposed CSP project is presented in Figure 8 and Figure 9. Between the 00:00 – 06:00, winds originate predominately from the northern and south western regions, with secondary winds from the north eastern region. A slight shift in the wind profile is observed during the morning hours (06:00 -12:00) towards the north western, west and south west region. During the afternoon and early evening (12:00 -18:00), winds originate predominately from the North West and south western region. A similar wind profile is observed during the evening (18:00- 00:00), slow to moderate winds originate from the south western and north western regions, with secondary winds from the northern region.

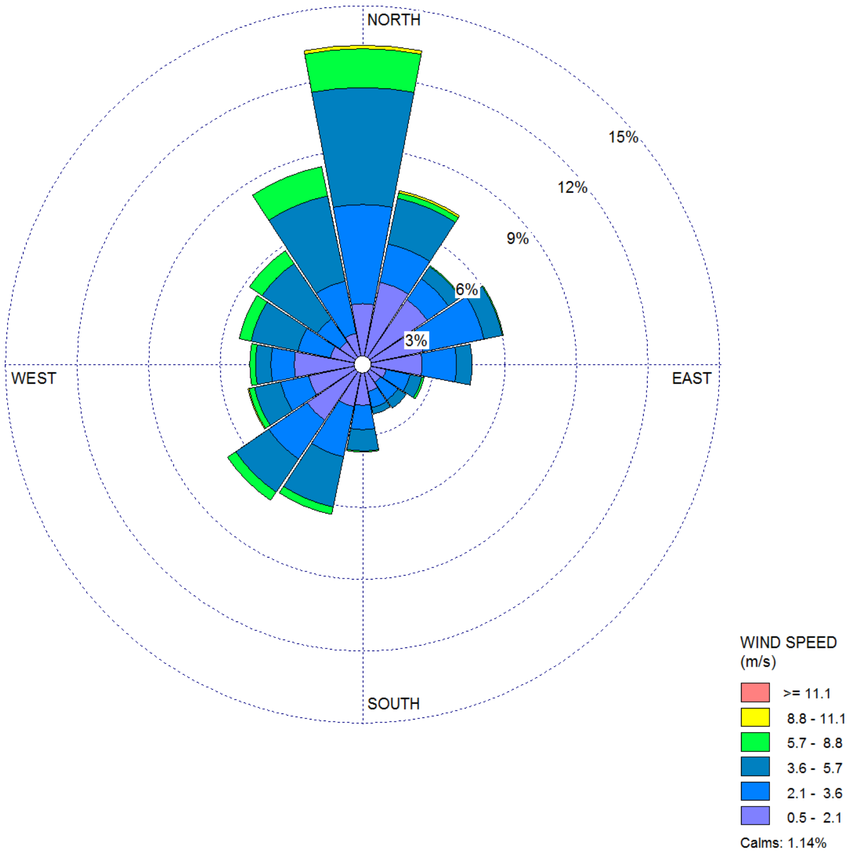


Spring

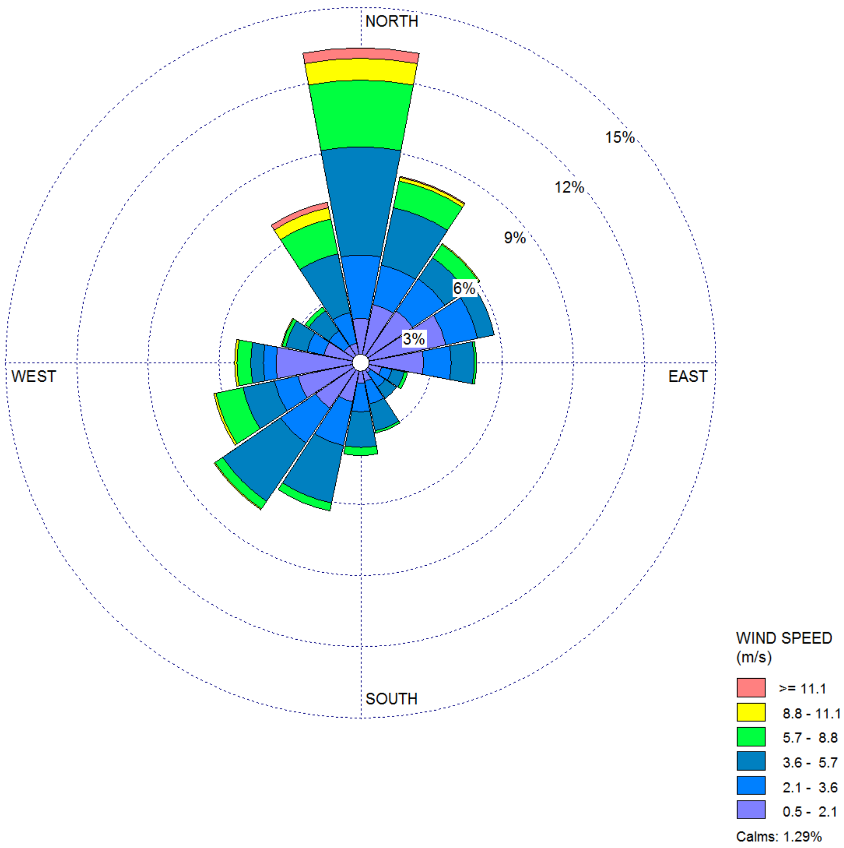


Summer

FIGURE 6: SEASONAL WIND ROSES (SPRING AND SUMMER) FOR THE JAN 2011 – DEC 2013 MONITORING PERIOD.

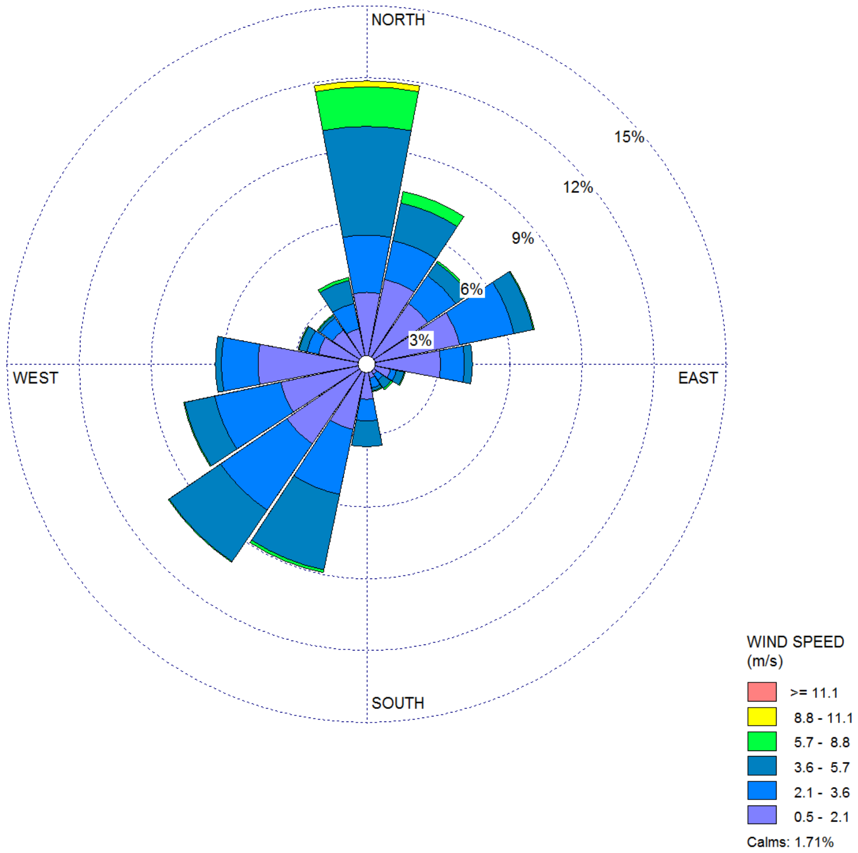


Autumn

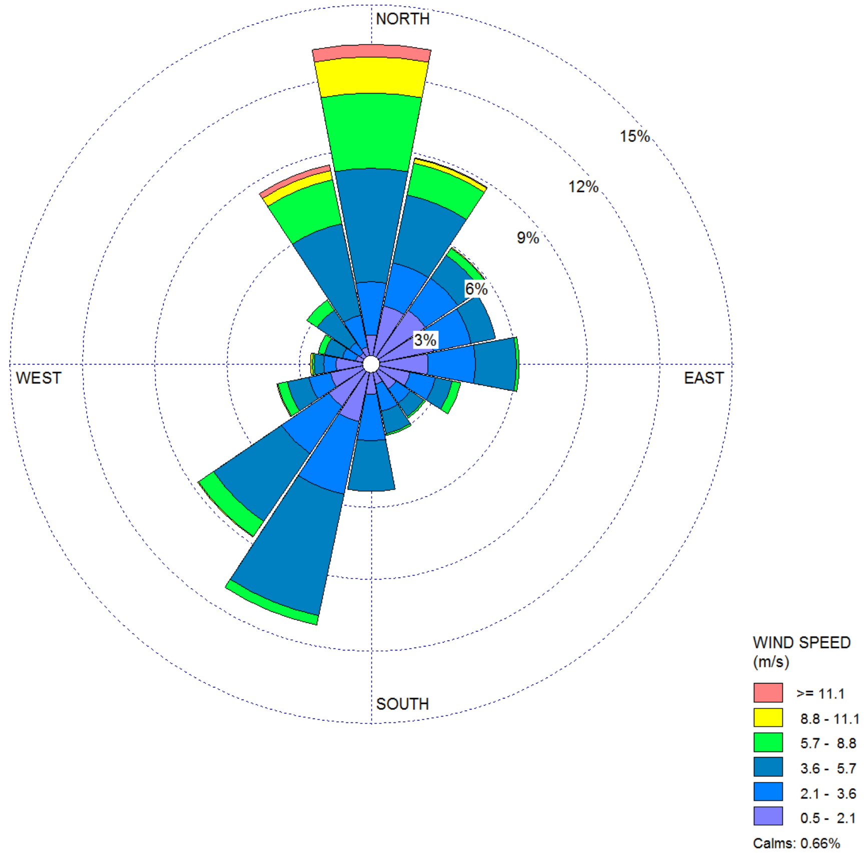


Winter

FIGURE 7: SEASONAL WIND ROSES (AUTUMN AND WINTER) FOR THE JAN 2011 – DEC 2013 MONITORING PERIOD

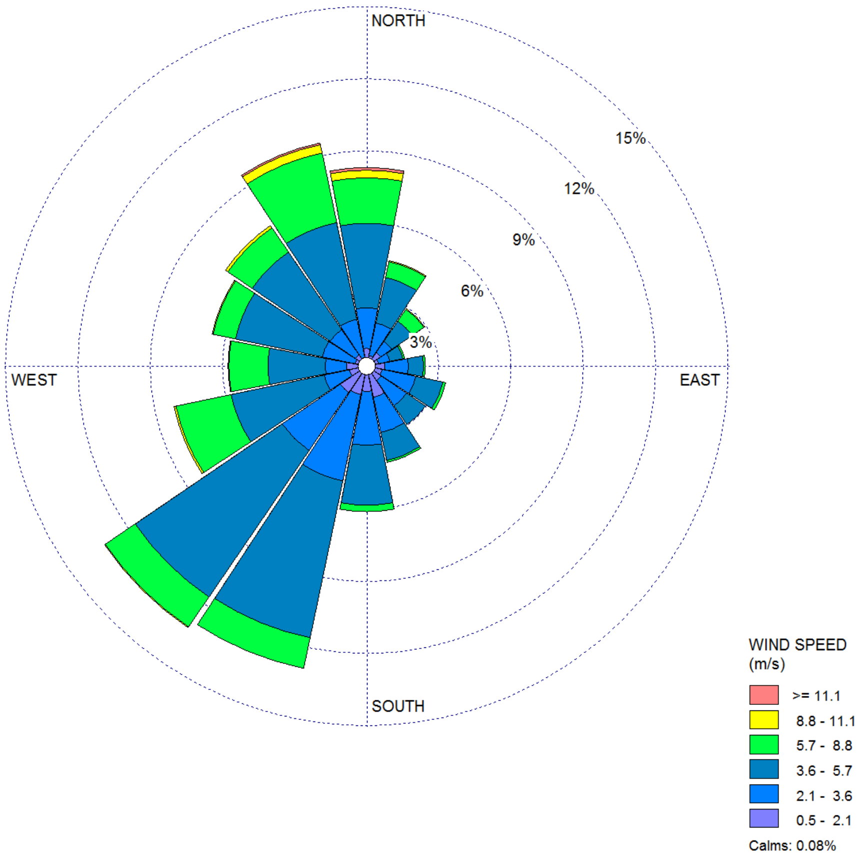


00:00 -06:00

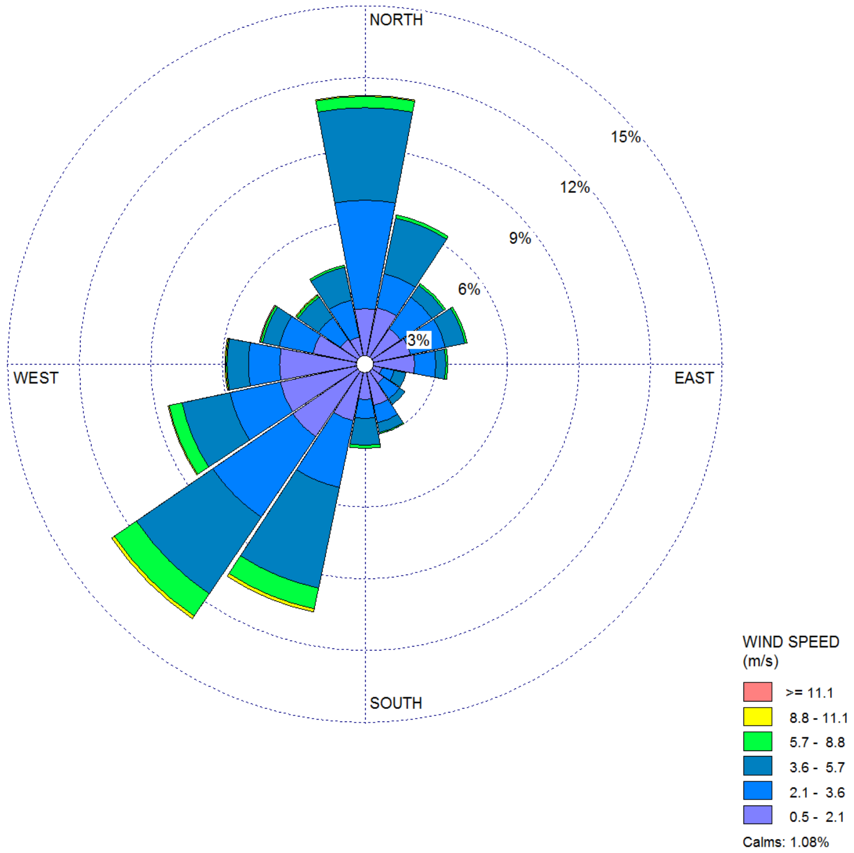


06:00 – 12:00

FIGURE 8: DIURNAL WIND ROSES (00:00 – 06:00) FOR THE JAN 2011 – DEC 2013 MONITORING PERIOD.



12:00 -18:00



18:00-24:00

FIGURE 9: DIURNAL PERIOD WIND ROSES FOR THE JAN 2011 – DEC 2013 MONITORING PERIOD.

- **Atmospheric stability**

Atmospheric stability is commonly categorised into one of seven stability classes. These are briefly described in Table 7 below. The atmospheric boundary layer is usually unstable during the day due to turbulence caused by the sun's heating effect on the earth's surface. The depth of this mixing layer depends mainly on the amount of solar radiation, increasing in size gradually from sunrise to reach a maximum at about 5-6 hours after sunrise. The degree of thermal turbulence is increased on clear warm days with light winds. During the night a stable layer, with limited vertical mixing, exists. During windy and/or cloudy conditions, the atmosphere is normally neutral. A neutral atmospheric potential neither enhances nor inhibits mechanical turbulences. An unstable atmospheric condition enhances turbulence, whereas a Stable atmospheric condition inhibits mechanical turbulence.

TABLE 7: ATMOSPHERIC STABILITY CLASS

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

The site experienced mostly neutral atmospheric conditions (22%) which are characteristic of high winds or cloudy days and nights. 17.3% of the time was attributed to moderately stable wind conditions which are characteristic of low winds, clear skies and cold night time conditions.

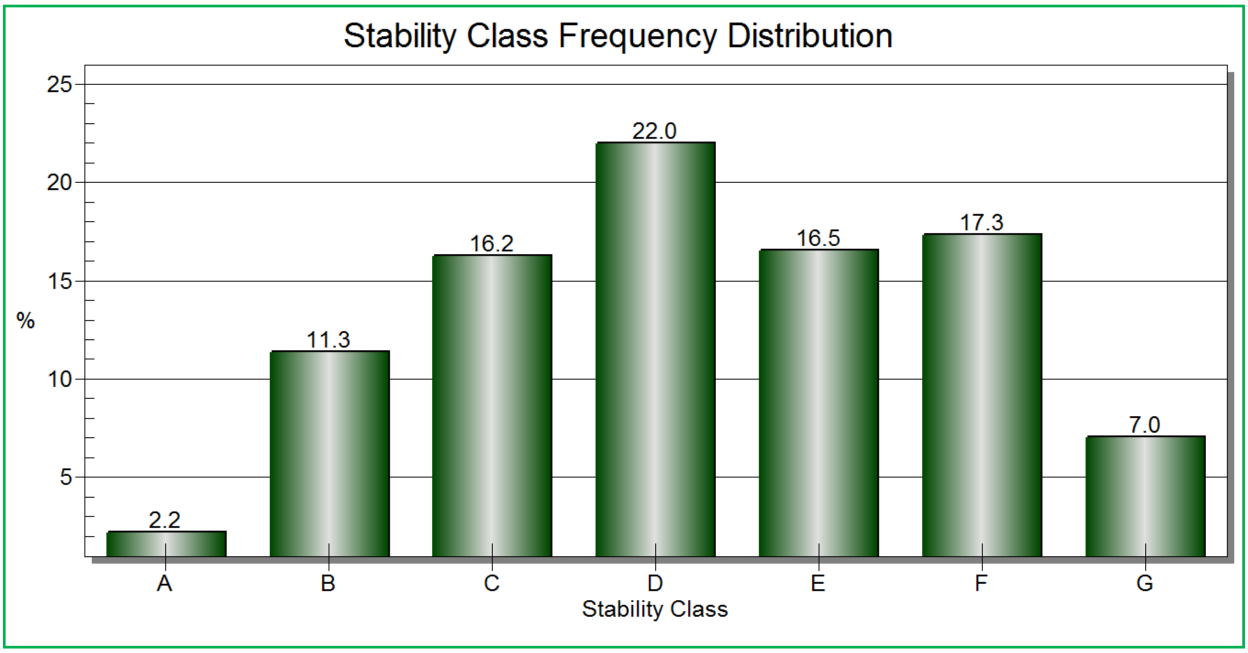


FIGURE 10: ATMOSPHERIC STABILITY CLASS.

- **Temperature and Humidity**

Temperature affects the formation, action, and interactions of pollutants in various ways (Kupchella & Hyland, 1993). Chemical reaction rates tend to increase with temperature and the warmer the air, the more water it can hold and hence the higher the humidity. Temperature also provides an indication of the rate of development and dissipation of the mixing layer as well as determining the effect of plume buoyancy; the larger the temperature difference between the plume and ambient air, the higher the plume is able to rise. Higher plume buoyancy will result in an increased lag time between the pollutant leaving the source, and reaching the ground. This additional time will allow for greater dilution and ultimately a decrease in the pollutant concentrations when reaching ground level.

Table 8 below indicates the average temperature profile experienced at the site for the Jan 2011 - Dec 2013 monitoring period. Daily average summer temperatures ranged between 27 – 29 ºC, with a maximum temperature range of 21 - 37 ºC. The average temperature range during the winter months ranged between 11.4 -13.4 ºC.

TABLE 8: TEMPERATURE PROFILE FOR THE CSP PROJECT FROM JAN 2011 – DEC 2013

		Temperature Average °C	Temperature Max °C	Temperature Min °C
January		29.0	37.0	21.0
February		27.0	35.0	20.0
March		26.0	34.0	18.1
April		20.0	28.0	12.0
May		16.0	25.0	8.4
June		11.4	21.0	4.2
July		11.2	21.0	4.0
August		13.4	23.0	5.0
September		17.2	27.0	8.0
October		21.3	30.0	12.2
November		25.0	34.0	16.0
December		27.0	35.0	19.0
Annual	**Average**	20.3	29.0	12.2
Winter	**Average**	16.2	25.1	9.0
Summer	**Average**	24.3	33.0	16.0

- **Relative Humidity**

Humidity is the mass of water vapour per unit volume of natural air. When temperatures are at their highest the humidity is also high, the moisture is trapped inside the droplets of the water vapour. This makes the moisture content of the air high. 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, as well as secondary pollutants within the atmosphere.

Figure 11 below illustrates the relative humidity for the CSP project for the Jan 2011 – Dec 2013 monitoring period. Humidity was highest during the winter months with an average of 45.8% and 31.6 % during the summer months.

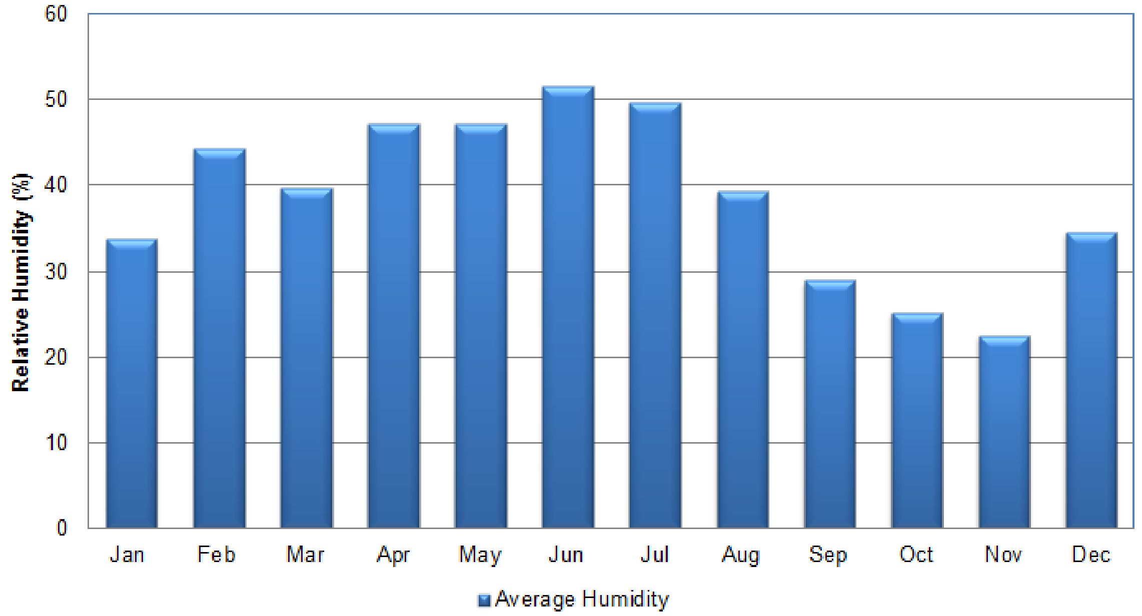


FIGURE 11: RELATIVE HUMIDITY FOR THE JAN 2011 – DEC 2013 MONITORING PERIOD.

- **Precipitation**

Precipitation cleanses the air by washing out particles suspended in the atmosphere (Kupchella & Hyland, 1993). It is calculated that precipitation accounts for about 80-90% of the mass of particles removed from the atmosphere (CEPA/FPAC Working Group, 1999). Summary of the total rainfall profile for the January 2011 – December 2013 monitoring period is illustrated in Figure 12 below. The average rainfall observed for the period under review was recorded at 300.2 mm. The highest rainfall was recorded during the summer months (Dec, Jan and Feb) with 152.2 mm, while the lowest rainfall was recorded during the spring months (Sep, Oct and Nov) with 14.6 mm and winter months (May, Jun and Jul) with 25.3 mm.

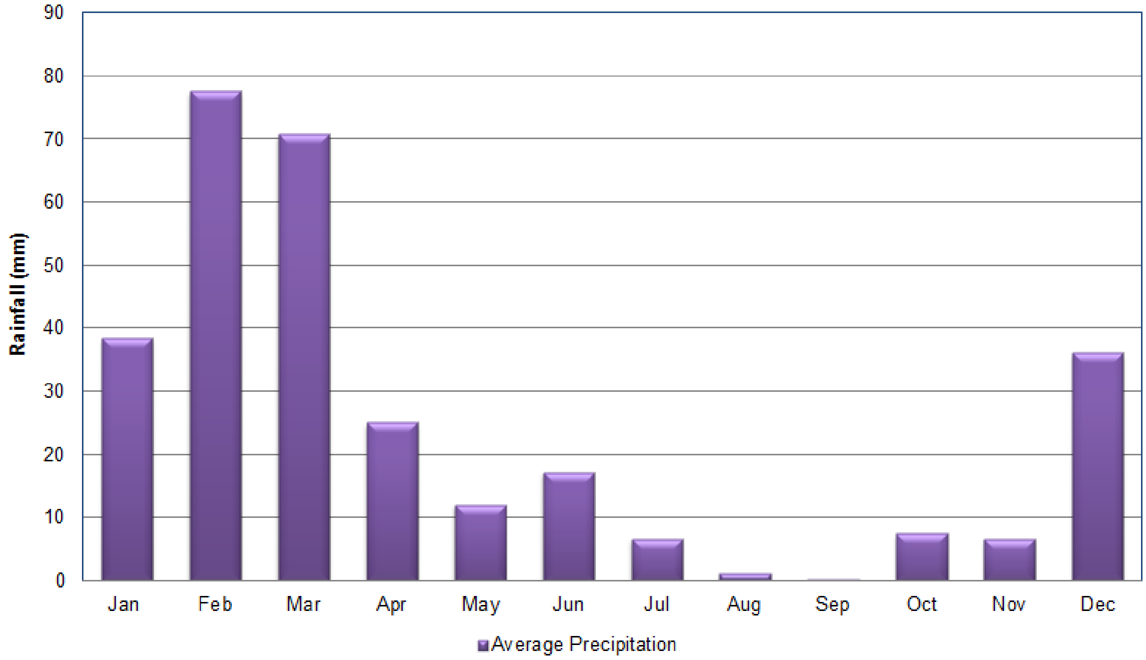


FIGURE 12: AVERAGE PRECIPITATION FOR THE JAN 2011 – DEC 2013 MONITORING PERIOD

3.2 Other Polluting Sources in the Area

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

- Domestic fuel burning;
- Vehicle entrained dust;
- Agriculture;
- Existing Solar Plants.

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

- **Domestic Fuel Burning**

It is anticipated that the lower income households in the area, along with local farms and farm labourers in the area surrounding the site are likely to use wood for space heating and/ or cooking purpose. Similar problems are reported around the world in poor communities which either lack access to electricity or lack the means to fully utilise the available supply of electricity (Van Horen et al. 1992).

Globally, almost 3 billion people rely on biomass (wood, charcoal, crop residues and dung) and coal as their primary source of domestic energy. Exposure to indoor air particulates (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).

Monitoring of exposures in biomass-burning households has shown concentrations are many times higher than those in industrialized countries. The latest Air Quality Objectives, for instance, required the monthly average concentration of PM_{10} (particulate matter < 10 µm in diameter) to be < 200 µg/m^3 (annual average < 100 µg/m^3). In contrast, a typical 24-hr average concentration of PM_{10} in homes using biofuels may range from 200 to 5000 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 ≥ 50000 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).

- **Vehicle entrained dust**

The force of wheels of vehicles travelling on unpaved roadways causes the pulverisation of the surface material. Particles are lifted and dropped from the rotating wheels and the road surface is exposed to strong air currents in turbulent shear with the surface. The turbulent wake behind the vehicle continues to act on the road surface after the vehicle has passed. The quantity of dust emissions from unpaved roads varies linearly with the volume of traffic as well as the speed of the vehicles. These types of roads could also be used and new ones may be created to ensure access to the site where access cannot be obtained from the main roads in the area. The movement of construction vehicles and other infrastructure parts will result in unusually heavy loads being placed on the roads, which are likely to result in additional damage to the road surface (USEPA, 1996).

- **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 crops grown in the area are grapes and maize with cattle farming being smaller in extent.

Little information is available with respect to the emissions generated due to the growing of crops. The activities responsible for the release of particulates matter 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;

- **Existing Solar Plants**

Existing solar plants can be considered a significant contributor to particulate emissions, although un-vegetated land within the heliostat fields. Little information is available with respect to the nuicence dust or particulate emissions generated due to the exposed areas, as this is dependant on the management of each plant. The activities responsible for the release of particulates matter 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 mirror cleaning and maintenance;
- Vehicle entrained dust on paved and unpaved road surfaces;

3.3 Sensitive Receptors

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

The area surrounding the proposed project is boarded by neighbouring farms. Sensitive receptors identified through Google Earth are presented in the Table 9 below. Other sensitive receptors within the area would be local fauna and flora. It has also been identified that dust settling on leaves on plants can result in damage to plants and inhalation of dust may result in sickness and associated lung disease for wildlife and humans which will be present in the vicinity of the site, especially during construction.

TABLE 9: IDENTIFIED SENSITIVE RECEPTOR SURROUNDING THE PROPOSED SITE

Sensitive receptor	Distance from site	Direction from site
Groblershoop	~ 19 km	SW
Gariep	~ 15 km	NW
Salskop	~ 11 km	W
Grootdrink	~ 9 km	NW
Upington	~ 70 km	NW

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4 ASSESSMENT OF ENVIRONMENT LIKELY TO BE AFFECTED

The impact assessment phase of the investigation assesses the potential impact the construction, operational and decommissioning phase of the proposed project could have on the surrounding areas.

This Section of the report outlines the potential impacts with the construction of the Solar project. To clearly detail the potential impacts in ambient ground level concentrations, only operational emissions will be included in the final model runs. The construction and decommissioning phases of the operation can only qualitatively be addressed due to the variability and unpredictable nature of the construction operations on site, and initial details are provided in the subsections to follow.

4.1 Potential impacts

- **Construction Phase**

During the construction assessment phase it is expected that, the main sources of impact will result due to the construction of infrastructure such as roads, building sites, and clearing of land for heliostat installation etc. 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 has been provided and this involves 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:

- Building sites; and
- Roads
- Land clearing for heliostat installation

4.1..1 Building Sites

Material removed from the surface where building and construction will be taking place, can increase wind blown dust from the site, as well as add to entrained dust for vehicles. To avoid these emissions only the minimum possible area should be disturbed and cleared. This will ensure that local vegetation remains intact and aids in dust suppression

4.1..2 Creation and Grading of Access Roads

Access roads are typically constructed by the removal of overlying topsoil, whereby the exposed surface is graded to provide a smooth compacted surface for vehicles to drive on. Material removed is often stored in temporary piles close to the road edge, which allows for easy access once the road is no longer in use, whereby the material stored in these piles can be re-covered for rehabilitation purposes. Often however, these unused haul roads are left as is in the event that sections of them could be reused at a later stage.

A large amount of dust emissions are generated by vehicle traffic over these temporary unpaved roads (USEPA, 1996). Substantial secondary emissions may be emitted from material moved out from the construction/clearing area during grading and deposited adjacent to roads (USEPA, 1996). Passing traffic can thus re-suspend the deposited material. To avoid these impacts material storage piles deposited adjacent to the road edge should be vegetated, with watering of the pile prior to the establishment of sufficient vegetation cover. Piles deposited on the verges during continued grading along these routes should also be treated using wet or chemical suppressants depending on the nature and extent of their impacts.

A positive correlation exists between the amount of dust generated (during vehicle entrainment) and the silt content of the soil as well as the speed and size of construction vehicles. Additionally, the higher the moisture content of the soil the lower the amount of dust generated.

4.1..3 Land Clearing

Material removed from the surface where construction will be taking place, specifically in the areas where mirrors will be installed, can increase wind blown dust from the site, as well as add to entrained dust for vehicles. To avoid these emissions only the minimum possible area should be disturbed and cleared, where possible only the actual heliostat footprint should be cleared, with site staff ensuring that surround vegetation is not disturbed. This will ensure that local vegetation remains intact and aids in dust suppression.

4.1..4 Overview of potential Impacts

The following components of the environment may be impacted upon during the construction phase:

- ambient air quality;
- local residents and neighbouring communities;
- employees;
- the aesthetic environment; and
- possibly fauna and flora

The impact on air quality and air pollution of fugitive dust is dependent on the quantity and drift potential of the dust particles (USEPA, 1996). Large particles settle out near the source causing a local nuisance problem. Fine particles can be dispersed over much greater distances. Fugitive dust may have significant adverse impacts such as reduced visibility, soiling of buildings and materials, reduced growth and production in vegetation and may affect sensitive areas and aesthetics. Fugitive dust can also adversely affect human health. It is important to note that impacts will be of a temporary nature, only occurring during the construction period.

Sensitive receptors were identified in Section 3.3. Given the relatively short duration, but bearing in mind that no quantitative emission figures exist, no long term adverse impacts are anticipated on these receptors during construction. Impact of fugitive dust emissions on employees on site could however be significant during the construction phase, but will vary between phases, with level of activity and meteorological conditions.

- **Operational Phase**

4.1..1 Project Alternatives

Two project alternatives have been provided for each of the technology options. These include two locations for the auxiliary boilers for the CSP installation, and two locations for the auxiliary boilers for the Parabolic Installation.

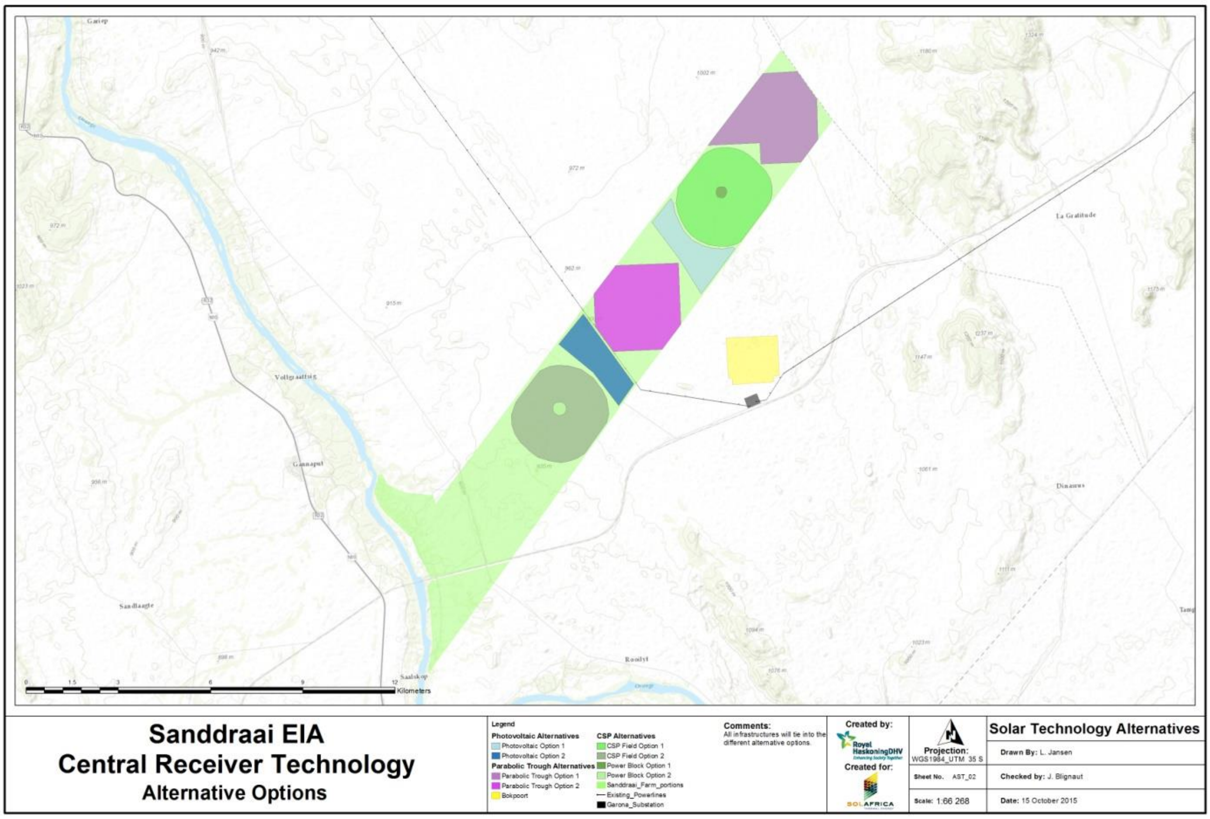


FIGURE 13: ALTERNATIVES OPTIONS FOR THE AUXILIARY BOILER LOCATIONS

Two road options have also been included in this assessment to determine the potential impacts based on the two access routes to the site. The first option being an access road from the N8 to the site and up the eastern edge of the site. With the second option being the Gariep road and up the western edge of the site.

4.1..2 Model Overview

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

The AERMOD View model can be used extensively to assess pollution concentrations and deposition from a wide variety of sources. AERMOD View is a true, native Microsoft Windows application and runs in Windows 2000/XP/7 and NT4 (Service Pack 6).

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

- AERMOD may be used to model primary pollutants and continuous releases of toxic hazardous waste pollutants;
- AERMOD model can handle multiple sources, including point, volume, area and open pit source types. Line sources may also be modelled as a string of volume sources or as elongated area sources;
- Source emission rates can be treated as constant or may be varied by month, season, hour of day, or other periods of variation, for a single source or for a group of sources;
- The model can account for the effects of aerodynamic downwash due to nearby buildings on point source emissions;
- The model contains algorithms for modelling the effects of settling and removal (through dry deposition) of large particulates and for modelling the effects of precipitation scavenging from gases or particulates;
- Receptor locations can be specified as gridded and/or discrete receptors in a Cartesian or polar coordinate system;
- AERMOD incorporates the COMPLEX1 screen model dispersion algorithms for receptors in complex terrain;
- The model uses real-time meteorological data to account for the atmospheric conditions that affect the distribution of air pollution impact on the modelling area; and
- Output results are provided for concentration, total deposition, dry deposition, and/or wet deposition flux.

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

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

4.1..3 Model Requirements

Input data requirements for AERMOD include meteorological and geophysical (terrain) data, model grid specifications as well as emissions source data. Local meteorological data has been obtained from the South African Weather services for the period Jan 2011 – Dec 2013 and includes hourly observations of wind speed, wind direction, temperature, relative humidity and pressure.

4.1..4 Emissions Inventory

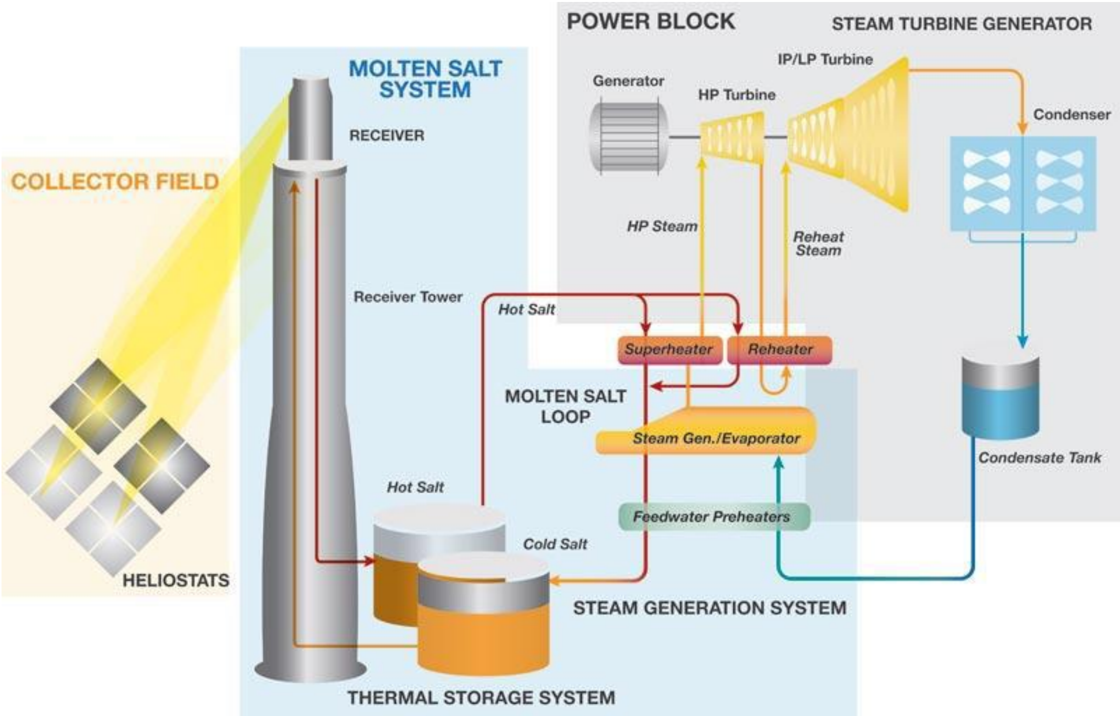
This section aims to deal with the predicted air quality impacts which result due to the proposed operations. Details regarding the source characteristics will be obtained from site layout plans and process specific information provided and a questionnaire filled in by the client. The sources to be included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

- Material handling;
- Plant Installation; and
- Equipment Transport

4.1..5 Process Description

The proposed project can be defined as a solar thermo-electric power plant that in embodied in the form of a CS plant. The electricity generation process can be summarised as follows:

- Heliostats reflect the solar radiation towards the central receiver tower where a large heat exchanger captures the solar heat.
- A molten salt mixture is pumped from the cold salt thermal storage tank to the central receiver where it is circulated in the heat exchanger until the temperature reaches 566ºC.
- The molten salt concentration is then transported to the hot salt thermal storage tank.
- Hot salt is pumped from the hot salt storage tank to the steam generator where heat is transferred from the salt to water in order to generate high pressure steam.
- The highly pressurised steam is then passed through a steam turbine, which is linked to an electric generator to generate electricity.



During the start-up phase of the plant, diesel/fuel/trucked in LPG will be used for plant start-up and the salt melting process. During the operational phase, diesel/fuel/trucked in LPG gas will be used for the initial salt heating process and oil for operating of the salt pumps. A diesel operated stand-by generator will be implemented on site, however it is not expected that this will be used. Fuel consumption estimations for a 150 MW plant are as follow:

- It is estimate that 50 to 70 days are required for initial salt melting for the 150 MW plant. During this period an estimated 35 400 m^3 of natural gas (final volume of fuel to be confirmed) will be consumed for the melting process
- It is estimated that roughly 15 000 m^3/hour of natural gas is required for auxiliary heating of the salt, with an added 2 015 litres of fuel per day for operating the molten salt pumps.

NO_x will not be generated during operation of the CSP. However, during plant commissioning, the initial melting, heating, and conditioning of the salt will result in limited NO_x emissions. For the melting and heating segments of the process, two small boilers each employing ultra low NO_x burners and flue gas recirculation, will be used to mitigate emissions from the combustion of LPG or natural gas. For the salt conditioning process, a multi-stage wet scrubber will be used to limit NO_x emissions from the decomposition sodium and potassium nitrates inherent in the salt mixture. This series of operations is limited to a one-time event, resulting in a closed loop system of liquid salt storage and circulation. At no other time will NO_x be generated during the operation of the CSP.

4.1..6 Input parameters

The emissions inventory has been developed for various sources. The information provided has been used in conjunction with the United Stated Environmental Protection Agency AP42 schedule to determine emission rates used for modelling. The inventory is developed based on plant operations and is based on information relating to plant processes.

TABLE 10: EMISSIONS EXPECTED FROM THE BURNING OF NATURAL GAS FOR THE HEATING OF SALT

Heating	Based on 529.719 scf	
Natural Gas	**T/a**	**g/s**
NO_x	2.32E+02	7.35667174
methane	1.07E+01	0.33929477
PM-total	3.53E+01	1.11935566

TABLE 11: EMISSIONS EXPECTED FROM THE BURNING OF NATURAL GAS FOR THE MELTING OF SALT

Melting	Based on 1041.782 scf	
Natural Gas	**T/a**	**g/s**
NO_x	2.32E+02	12.05662059
methane	1.07E+01	0.55605966
PM-total	3.53E+01	1.83447719

TABLE 12: EMISSIONS EXPECTED FROM DIESEL FUELED SALT PUMPS

Salt Pumps	Based on 3.087378763 mmbtu/h	
Diesel Fuel	**T/a**	**g/s**
NO_x	1.19E-01	0.00377347
PM10	8.39E-03	0.00026605
Methane	2.53E-05	0.00000080

4.1..7 Potential impacts at start-up

Start-up is expected to last between 50 and 70 days depending on weather and salt conditions. During this time natural gas and diesel fuel will be used to heat and melt the salt and begin pumping the salt through the system until the plant has reached its operational temperatures and pressures. During this time the emissions from the fuels will result in an increased pollution load within the atmosphere. As mentioned this process is not expected to last more than 70 days, and therefore the model has been adjusted to take this into consideration. Table 13 below indicated the maximum predicted ambient concentrations as a result of the start-up of the site. Figure 14 and Figure 15, provides a graphic illustration as to the movement of pollutants through the atmosphere once generated and in the natural environment.

TABLE 13: MAXIMUM PREDICTED OFFSITE CONCENTRATIONS FOR CSP AUXILIARY BOILER (µG/M³)

	1 Hour		24 Hour		Annual	
	Alt 1	**Alt 2**	**Alt 1**	**Alt 2**	**Alt 1**	**Alt 2**
Particulate Matter	107.33	120.62	32.01	11.69	1.23	0.48
Oxides of Nitrogen	70.54	109.97	4.65	6.14	0.46	0.39
Methane	325.33	507.17	27.27	35.43	1.29	1.46

TABLE 14: MAXIMUM PREDICTED OFFSITE CONCENTRATIONS FOR PARABOLIC AUXILIARY BOILER (µG/M³)

	1 Hour		24 Hour		Annual	
	Alt 1	**Alt 2**	**Alt 1**	**Alt 2**	**Alt 1**	**Alt 2**
Particulate Matter	219.49	229.39	13.49	13.10	1.09	0.89
Oxides of Nitrogen	85.07	80.26	8.86	6.53	1.04	1.99
Methane	392.33	328.22	40.88	30.12	3.31	2.16

TABLE 15: RESPECTIVE AMBIENT STANDARDS (µG/M³)

	1 Hour	24 Hour	Annual
Particulate Matter		75	40
Oxides of Nitrogen	200		40
Methane			5

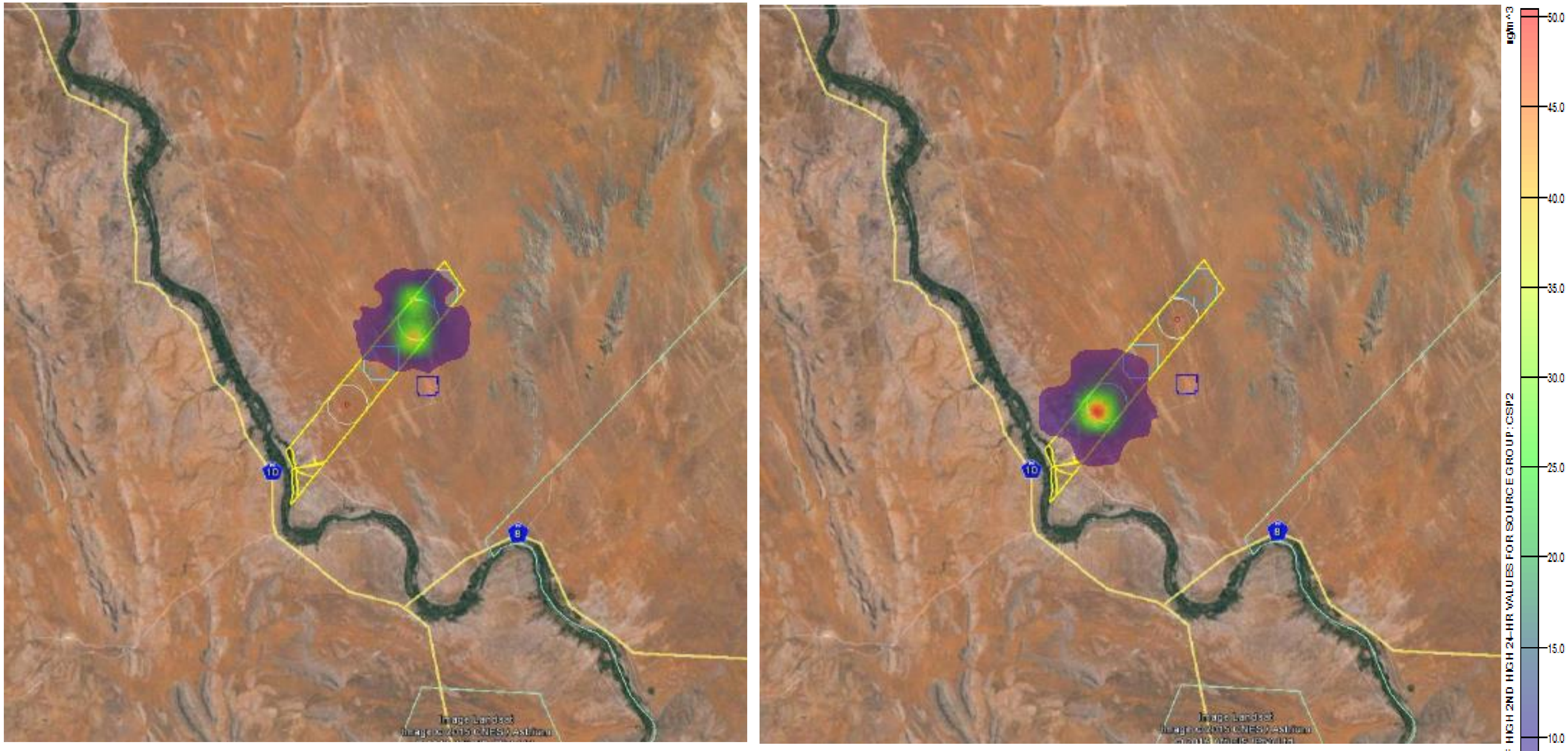


FIGURE 14: CSP AUXILIARY BOILER ALTERNATIVE LOCATIONS (PM10 DAILY AVERAGES, STANDARD 75µG/M³)

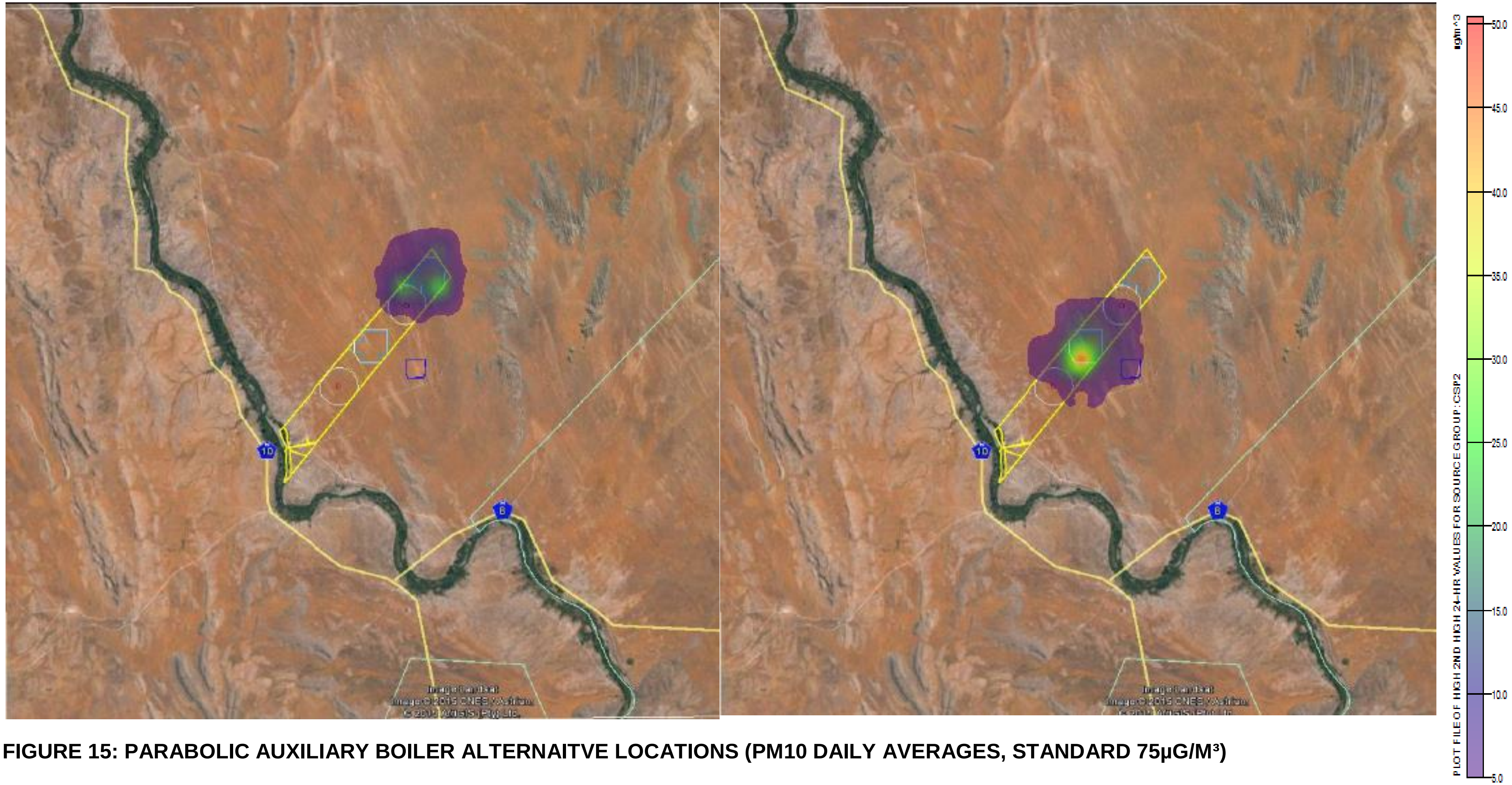


FIGURE 15: PARABOLIC AUXILIARY BOILER ALTERNAITVE LOCATIONS (PM10 DAILY AVERAGES, STANDARD 75µG/M³)

4.1..8 Potential impacts once operational

Once start-up is complete no fuels are required to ensure the on-going operations of the CSP plant, therefore all emissions as identified above will no longer be produced and the plant should continue to run on solar power. Should the plant be shut down in its entirety then emissions as described above will resume during start-up.

4.1..9 Heat Island Development

The development of a heat island has been noted to occur in areas where the natural environment "grasslands specifically" has been replaced by infrastructure for solar projects. This is particularly noted in projects of 50MW and greater.

It is expected that during the day at a height of 2.5m above the array, an increase in temperature is noted to reach up to 1.9°C warmer than the surrounding ambient air, with the thermal increase having completely dissipated 11.5m above the array. It is likely that by a distance of 300m from the edge of the array, the temperature is approximately 0.3°C above ambient temperature. It has also been noted that over night the array will completely cool and loose all thermal head. Figure 16 below shows thermal modelling to indicate how heat builds up within the array, which is also wind dependant. Access routes within the array are also noted to reduce the heat build-up substantially.

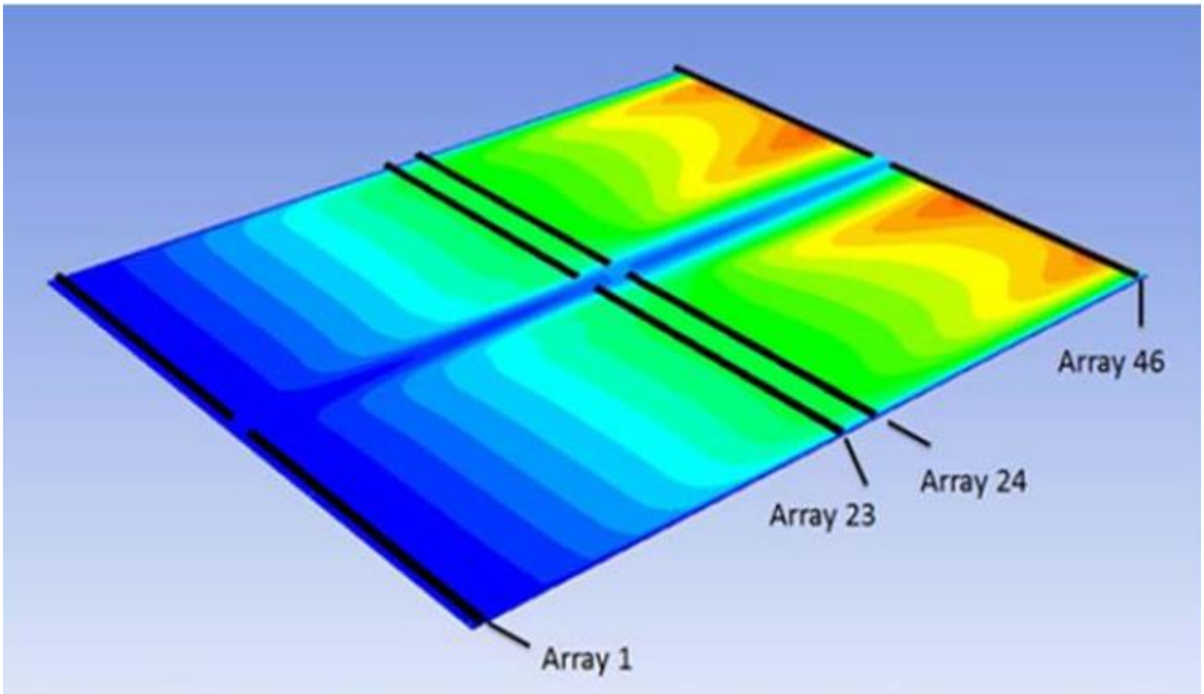


FIGURE 16: THERMAL MODELLING FOR SOLAR ARRAY INDICATING DAILY HEAT BULD-UP WITHIN THE ARRAY, WITH WIND BLOWING FROM A WESTERLY DIRECTION.

4.1..10 Road Access

Road access to the site has been identified via two alternatives, the N8 route which is approximately 18km of unpaved road and the Gariep Road via the N14, approximately 55km of unpaved road.

Figure 17 below illustrates the impact arising from the two alternative routes.

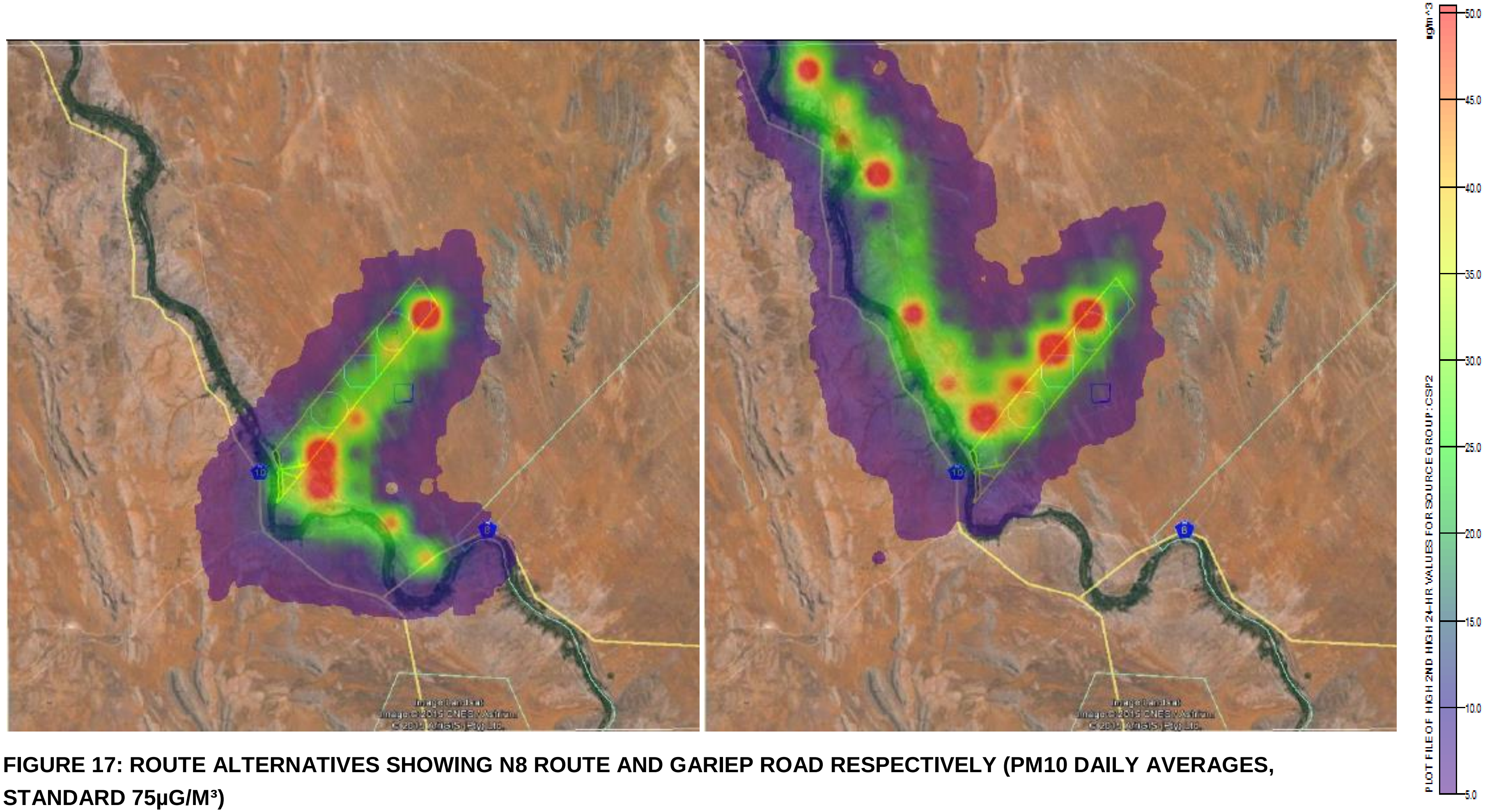


FIGURE 17: ROUTE ALTERNATIVES SHOWING N8 ROUTE AND GARIEP ROAD RESPECTIVELY (PM10 DAILY AVERAGES, STANDARD 75µG/M³)

TABLE 16: MAXIMUM PREDICTED OFFSITE CONCENTRATIONS FOR UNPAVED ROADS (µG/M³)

	1 Hour		24 Hour		Annual	
	Alt 1	**Alt 2**	**Alt 1**	**Alt 2**	**Alt 1**	**Alt 2**
Particulate Matter	300.64	311.02	73.71	80.44	34.09	35.10
Standard			75		40	

- **Decommissioning Phase**

The decommissioning phase is associated with activities related to the demolition of infrastructure and the rehabilitation of disturbed areas. The total rehabilitation will ensure that the total area will be a free draining covered with topsoil and grassed. The following activities are associated with the decommissioning phase (US-EPA, 1996):

- Existing buildings and structures demolished, rubble removed and the area levelled;
- Remaining exposed excavated areas filled and levelled; and
- Land and permanent waste piles re-vegetated.

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

- Smoothing of stockpiles by bulldozer;
- Transport and dumping of overburden for 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 or wind. The erodability of soil depends on the amount of rainfall and its intensity, wind speed and direction, soil type and structure, slope of the terrain and the amount of vegetation cover (Brady, 1974). Revegetation of exposed areas for long-term dust and 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.

4.2 Proposed mitigation

- **Construction Phase**

Due to the lack of quantitative dust emissions data for the site, such as vehicle movements and material handing during construction, it is recommended that the precautionary principle be followed and dust control measures be implemented. Recommendations for the control of fugitive dust emissions are given in Table 17 below. Wet suppression with water is the least expensive of the possible control measures but is temporary in nature.

TABLE 17: RECOMMENDATIONS FOR THE CONTROL OF FUGITIVE DUST EMISSIONS DURING THE CONSTRUCTION PHASE (USEPA, 1996).

Emission Source	Recommended Control Methods
Debris handling and debris piles	Wind speed reduction through wind breaks
	Wet Dust suppression [(1)]
Truck transport [(2)]	Wet suppression
	Paving
	Chemical stabilisation [(3)]
Bulldozers	Wet suppression
Pan scrapers	Wet suppression of travel routes
Cut/fill material handling	Wind speed reduction
	Wet suppression
Cut/fill haulage	Wet suppression
	Paving
	Chemical stabilisation
General construction	Wind speed reduction
	Wet suppression
	Early paving of permanent roads

Note: [(1)] Dust control plans should contain precautions against watering programs that compound track-out problems.

[(2)] Loads could be covered to avoid loss of material in transport, especially if material is transported offsite.

[(3)] Chemical stabilisation is usually cost-effective for relatively long-term or semi-permanent unpaved roads.

Water may be combined with a surfactant such as a wetting agent. Surfactants increase the surface tension of water, reducing the quantity of water required. Chemical stabilisation is of longer duration but is not cost effective for small-scale operations. Dust-A-Side (DAS) or Dustex represents an example of a chemical product, which is commercially available and widely used by mines and quarries. The DAS/Dustex product binds with the aggregate used to build on-site roads. It should be noted however, that the treatment with chemical stabilisers can have adverse effects on plant and animal life and can contaminate the treated material (USEPA, 1996).

Dust and mud should be controlled at vehicle exit and entry points to prevent the dispersion of dust and mud beyond the construction site boundary. Facilities for the washing of vehicles could be provided at the entry and exit points. A speed limit of 40 km/hr should be set for all vehicles travelling over exposed areas or near stockpiles. Traffic over exposed areas should be kept to a minimum (USEPA, 1996).

Any temporary storage piles should be maintained for as short a time as possible and should be enclosed by wind breaking enclosures of similar height to the storage pile. Storage piles should be situated away from the site boundary, water courses and nearby receptors and should take into account the predominant wind direction.

During the transfer of material to piles, drop heights should be minimised to control the dispersion of materials being transferred (USEPA, 1996).

Additional preventative techniques include the reduction of the dust source extent and adjusting work processes to reduce the amount of dust generation (USEPA, 1996).

- **Operational Phase**

Based on the results presented the following recommendations are outlined:

- Fallout monitoring should be undertaken to assess the level of nuisance dust associated with the site. Sampling of fallout should also undertaken within the neighbouring farming and community areas as well as on-site.

Water may be combined with a surfactant such as a wetting agent to increase the control efficiency for adequate control of dust. Surfactants increase the surface tension of water, reducing the quantity of water required. Chemical stabilisation is of longer duration but is not cost effective for small-scale operations. Dustex represents an example of a product, which is commercially available and widely used by mines and quarries. The Dustex product binds with the aggregate used to build on-site roads. (USEPA, 1996). Nozzles fitted on a spread bar behind trucks for a controlled spray opposed to a wide splash set-up shown in picture below.

FIGURE 18: EXAMPLES OF WATER SPRAY EQUIPMENT

- **Decommissioning and Post Closure Phase**

Revegetation 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 revegetation 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.

4.3 Impact Assessment

The potential environmental impacts associated with the project will be evaluated according to its nature, extent, duration, intensity, probability and significance of the impacts, whereby:

- ***Nature***: A brief written statement of the environmental aspect being impacted upon by a particular action or activity.
- ***Extent***: The area over which the impact will be expressed. Typically, the severity and significance of an impact have different scales and as such bracketing ranges are often required. This is often useful during the detailed assessment phase of a project in terms of further defining the determined significance or intensity of an impact. For example, high at a local scale, but low at a regional scale;
- ***Duration***: Indicates what the lifetime of the impact will be;
- ***Intensity***: Describes whether an impact is destructive or benign;
- ***Probability***: Describes the likelihood of an impact actually occurring; and
- ***Cumulative***: In relation to an activity, means the impact of an activity that in itself may not be significant but may become significant when added to the existing and potential impacts eventuating from similar or diverse activities or undertakings in the area.

TABLE 18: CRITERIA AND DESCRIPTION OF IMPACT

CRITERIA		DESCRIPTION			
EXTENT	**International (5)** International scale	**National (4)** The whole of South Africa	**Regional (3)** Provincial and parts of neighbouring provinces	**Local (2)** Within a radius of 2 km of the construction site	**Site (1)** Within the construction site
DURATION	**Permanent (5)** Mitigation either by man or natural process will not occur in such a way or in such a time span that the impact can be considered transient	**Long-term (4)** The impact will continue or last for the entire operational life of the development, but will be mitigated by direct human action or by natural processes	**Medium-term (3)** The impact will last for the period of the construction phase, where after it will be entirely negated	**Short-term (2)** The impact will either disappear with mitigation or will be mitigated through natural process in a span shorter than the construction phase (few	**Very Short-term (1)** The impact will either disappear with mitigation or will be mitigated through natural process in a span shorter than the construction phase (few days)

CRITERIA		DESCRIPTION			
		thereafter. The only class of impact which will be non-transitory		months)	
FREQUENCY	**Continuous (5)** Daily to a significant percentage every day	**Very Frequent (4)** Few times a week to daily	**Frequent (3)** Few times a month	**Unusual (2)** Once or twice every 5 years	**Very Rare (1)** Once or twice a decade
INTENSITY	**High (5)** Natural, cultural and social functions and processes are altered to extent that they permanently cease	**Medium High (4)** Natural, cultural and social functions and processes are altered to extent that they temporarily cease	**Medium (3)** Affected environment is altered, but natural, cultural and social functions and processes continue albeit in a modified way	**Low (2)** Impact affects the environment in such a way that natural, cultural and social functions and processes are not affected	**Very Low (1)** Impact does not affects the environment in such a way that natural, cultural and social functions and processes are not affected
PROBABILTY OF OCCURANCE	**Definite (5)** Impact will certainly occur	**Very Likely (4)** Most likely that the impact will occur	**Likely (3)** The impact may occur	**Probable (2)** Likelihood of the impact materialising is low	**Improbable (1)** Likelihood of the impact materialising is very low

Significance is determined through a synthesis of impact characteristics. Significance is also an indication of the importance of the impact in terms of both physical extent and time scale, and therefore indicates the level of mitigation required. The total number of points scored for each impact indicates the level of significance of the impact.

TABLE 19: SIGNIFICANCE TABLE

Low impact (0 -5 points)	A low impact has no permanent impact of significance. Mitigation measures are feasible and are readily instituted as part of a standing design, construction or operating procedure.
Medium impact (6 -10 points)	Mitigation is possible with additional design and construction inputs.
Medium to High impact (11 -15 points)	The design of the site may be affected. Mitigation and possible remediation are needed during the construction and/or operational phases. The effects of the impact may affect the broader environment.
High impact (16 - 20 points)	High consequences and mitigation is essential.
Extremely High	Permanent and important impacts. The design of the site may be affected. Intensive remediation is needed during construction and/or operational phases. Any activity which results in a “very high impact” is likely to be a fatal flaw.
Status	Denotes the perceived effect of the impact on the affected area.
Positive (+)	Beneficial impact.
Negative (-)	Deleterious or adverse impact.
Neutral (/)	Impact is neither beneficial nor adverse.

It is important to note that the status of an impact is assigned based on the status quo – i.e. should the project not proceed. Therefore not all negative impacts are equally significant.

The suitability and feasibility of all proposed mitigation measures will be included in the assessment of significant impacts. This will be achieved through the comparison of the significance of the impact before and after the proposed mitigation measure is implemented. Mitigation measures identified as necessary will be included in an EMPr.

TABLE 20: CSP AND PARABOLIC TROUGH PROPOSED MITIGATION AND SIGNIFICANCE RATING

POTENTIAL IMPACTS	SIGNIFICANCE RATING OF IMPACTS	PROPOSED MITIGATION	SIGNIFICANCE RATING OF IMPACTS AFTER MITIGATION:
Air Quality: Construction The following activities have been identified as possible sources of fugitive dust during construction operations at the site: • Dust from bare areas. • Material handling. • Emissions from construction machinery and equipment. • Trucks transporting material.	Extent: **Site (-1)** Duration: **Medium-term (-3)** Frequency: **Continuous (-5)** Intensity: **Moderate (-2)** Probability: **Very Likely (-4)** Significance: Medium to High (-15)	• There should be strict speed limits on site roads to prevent the liberation of dust into the atmosphere. • Dust must be suppressed on the construction site, temporary dirt roads and during the transportation of material during dry periods by the regular application of water or binding chemicals. Water used for this purpose must be used in quantities that will not result in the generation of run-off. • All site workers during construction will need to wear the appropriate PPE to avoid excessive exposure to dust particles.	Extent: **Site (-1)** Duration: **Medium-term (-3)** Frequency: **Very Frequent (-4)** Intensity: **Moderate (-2)** Probability: **Very Likely (-4)** Significance: Medium to High (-14)
Air Quality: Operation The following activities have been identified as possible sources of fugitive dust during operations at the site: • Emissions from machinery and equipment including Auxiliary Boilers.	Extent: **Site (-1)** Duration: **Short-term (-2)** Frequency: **Unusual (-2)** Intensity: **Low (-2)** Probability: **Likely (-3)** Significance: Medium (-10)	• All international best practice recommendations for the correct operation of the plant need to be followed to reduce the number of restarts to the plant, once operational	Extent: **Site (-1)** Duration: **Short-term (-2)** Frequency: **Unusual (-2)** Intensity: **Low (-2)** Probability: **Likely (-3)** Significance: Medium (-10)
Air Quality: Decommissioning The following activities have been identified as possible sources of fugitive dust at the site: • Dust from bare areas • Material handling for rehabilitation. • Emissions from construction machinery	Extent: **Site (-1)** Duration: **Medium-term (-3)** Frequency: **Continuous (-5)** Intensity: **Moderate (-2)** Probability: **Very Likely (-4)** Significance: Medium to High (-15)	• There should be strict speed limits on site roads to prevent the liberation of dust into the atmosphere. • Dust must be suppressed on the site, temporary dirt roads and during the transportation of material during dry periods by the regular application of water. Water used for this purpose must be used in quantities that will not result in the generation of run-off. • All site workers during construction will need to wear the appropriate PPE to avoid excessive	Extent: **Site (-1)** Duration: **Medium-term (-3)** Frequency: **Very Frequent (-4)** Intensity: **Moderate (-2)** Probability: **Very Likely (-4)** Significance: Medium to High (-14)

POTENTIAL IMPACTS	SIGNIFICANCE RATING OF IMPACTS	PROPOSED MITIGATION	SIGNIFICANCE RATING OF IMPACTS AFTER MITIGATION:
and equipment.		exposure to dust particles.	

TABLE 21: PROPOSED MITIGATION OF ROADS AND SIGNIFICANE RATINGS

POTENTIAL IMPACTS	SIGNIFICANCE RATING OF IMPACTS	PROPOSED MITIGATION	SIGNIFICANCE RATING OF IMPACTS AFTER MITIGATION:
Air Quality: Operation N8 Route Road The following activities have been identified as possible sources of fugitive dust during construction operations at the site: • Dust from Road	Extent: **Regional (-3)** Duration: **Long-term (-4)** Frequency: **Very Frequent (-4)** Intensity: **High (-5)** Probability: **Very Likely (-4)** Significance: High (-20)	• There should be strict speed limits on site roads to prevent the liberation of dust into the atmosphere. • Dust must be suppressed during vehicle movement • All site workers will need to wear the appropriate PPE to avoid excessive exposure to dust particles.	Extent: **Regional (-3)** Duration: **Long-term (-4)** Frequency: **Frequent (-3)** Intensity: **Medium High (-4)** Probability: **Likely (-3)** Significance: High (-18)
Air Quality: Operation Gariep Route Road The following activities have been identified as possible sources of fugitive dust during operations at the site: • Dust from Road	Extent: **Regional (-3)** Duration: **Long-term (-4)** Frequency: **Continuous (-5)** Intensity: **High (-5)** Probability: **Very Likely (-4)** Significance: Extremely High (-21)	• There should be strict speed limits on site roads to prevent the liberation of dust into the atmosphere. • Dust must be suppressed during vehicle movement • All site workers will need to wear the appropriate PPE to avoid excessive exposure to dust particles.	Extent: **Regional (-3)** Duration: **Long-term (-4)** Frequency: **Continuous (-5)** Intensity: **Medium High (-4)** Probability: **Very Likely (-4)** Significance: High (-20)

5 CONCLUSION

Based on the predicted model results and from the general condition of the area, there is very little difference between the alternatives provided in regards to the location of the auxiliary boilers, and therefore no preferred recommendation is provided.

Due to the distances travelled and the condition of local unpaved roads, the Gariep road is not considered to be a suitable alternative, due to the potential for dust generation. The N8 road and the alternative access route to site will need to be managed to mitigate dust, as mentioned above. An assessment into costs for the paving of the route should also be investigated as a possible option for future works.

6 REFERENCES

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