ENVIRONMENT
HEALTH
SAFETY

NOISE IMPACT ASSESSMENT

BASIC ASSESSMENT FOR THE PROPOSED DEVELOPMENT OF UP TO 325 MW KUDUSBERG WIND ENERGY FACILITY LOCATED WEST OF THE R354 BETWEEN MATJIESFONTEIN AND SUTHERLAND IN THE NORTHERN AND WESTERN CAPE

Report prepared for:
CSIR – Environmental Management Services
P O Box 320
Stellenbosch, 7599
South Africa

Report prepared by:
Dr Brett Williams
PO Box 27607
Greenacres
6057
Port Elizabeth
South Africa

19th October 2018

SPECIALIST EXPERTISE

Dr Brett Williams

Name of Organization: Safetech
Position in Firm: Owner
Date of Birth: 21/04/1963
Years with Firm: 25
Nationality: South African

MEMBERSHIP OF PROFESSIONAL BODIES

- Southern African Institute of Occupational Hygienists
- Institute of Safety Management
- Mine Ventilation Society
- National Clean Air Association

BIOGRAPHICAL SKETCH

Brett Williams has been involved in Health, Safety and Environmental Management since 1987. He has been measuring noise related impacts since 1996. Brett is the owner of Safetech who have offices in Pretoria and Port Elizabeth. He has consulted to many different industries including, mining, chemical, automotive, food production etc. He is registered with the Department of Labour and Chamber of Mines to measure environmental stressors, which include chemical monitoring, noise and other physical stresses.

PROJECT EXPERIENCE

Dr Williams has been assigned to various projects to assess environmental noise impacts.

The list below presents a selection of Brett Williams' project experience, relevant to noise:

- Arcus Gibb – Kouga Wind Energy Project
- CSIR – Umgeni Water Desalination Plant
- CSIR – Saldanha Desalination Plant
- CSIR – Atlantis Gas to Power Project (current)
- CSIR – Walvis Bay Port Extension
- CSIR – Noise Impact Study of Namwater Desalination Plant
- CSIR – Kouga Wind Energy Project – Background Noise Measurements
- CSIR – Kouga Wind Energy Project
- CSIR – Wind Current Wind Energy Project
- CSIR – Langefontein Wind Energy Project

- CSIR – Mossel Bay Wind Energy Project
- CSIR – Coega IDZ Wind Energy Project
- CSIR – Baakenskop Wind Energy Project
- CSIR – Biotherm Wind Energy Project
- CSIR – Innowind Mossel Bay
- CSIR – Langefontein Wind Energy Project
- CSIR – Bulk Manganese Terminal (Port of Ngqura)
- CSIR – Phyto Amandla Biodiesel Project
- CSIR – Vleesbaai Wind Energy Project
- CES – Coega IDZ Gas to Power Project (Current)
- CES – Coega IDZ Wind Energy Project
- CES – Middleton Wind Energy Project
- CES – Waainek Wind Energy Project
- CES – Ncora Wind Energy Project
- CES – Qunu Wind Energy Project
- CES – Nqamakwe Wind Energy Project
- CES – Plan 8 Wind Energy Project
- CES – Qumbu Wind Energy Project
- CES – Peddie Wind Energy Project
- CES – Cookhouse Wind Energy Project
- CES – Madagascar Heavy Minerals
- CES – Richards Bay Wind Energy Project
- CES – Hluhluwe Wind Energy Project
- CEN – Kwandwe Airport Development Project
- CEN – Swartkops Manganese Project
- CEN – N2 Petro Port Project

- Crown Chickens – The independent report review of a noise specialist report conducted as part of an EIA to establish a new broiler farm.
- BMW – The evaluation of the impact of the Rosslyn production facilities on the surrounding community.
- Victory Race Track - Specialist noise report conducted as part of an EIA to establish a new stock car racing track.
- Continental Tyre - The evaluation of the impact of production facilities on the surrounding community.
- Media 24 – The measurement portion of an investigation on the impact of a printing press on a local community. The main study was conducted by the University of Stellenbosch.
- Zwartebosh Quarry - Specialist noise report conducted as part of an EIA to establish a new quarry.
- Milo Granite - Specialist noise report conducted as part of an EIA to establish a new quarry.
- Dunlop Tyres - The evaluation of the impact of production facilities on the surrounding community.
- Sasol Secunda - Independent report review of a noise specialist report conducted to determine the impact of production facilities on the surrounding community.
- Barlow World Coatings - The evaluation of the impact of production facilities on the surrounding community.
- Western Platinum Refinery - The evaluation of the impact of production facilities on the surrounding community.

TERTIARY EDUCATION

- PhD - University of Pretoria (Environmental Management)
- Various Health & Safety Courses.
- National Diploma Health & Safety Management
- Harvard University – Applications of Industrial Hygiene Principles – including noise
- United States EPA Pollution Measurement course conducted at the University Of Cincinnati (EPA Training Centre)
- US EPA Air Dispersion Modelling Training Course
- Master of Business Administration (University of Wales) with dissertation on environmental reporting in South Africa.
- Environmental Auditor (ISO 14001:2004)

…………………..

SPECIALIST DECLARATION

I, Brett Williams, as the appointed independent noise specialist, in terms of the 2014 EIA Regulations, hereby declare that I:

- I act as the independent specialist in this application;
- I perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- regard the information contained in this report as it relates to my specialist input/study to be true and correct, and do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the NEMA, the Environmental Impact Assessment Regulations, 2014 and any specific environmental management Act;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I have no vested interest in the proposed activity proceeding;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- I have ensured that information containing all relevant facts in respect of the specialist input/study was distributed or made available to interested and affected parties and the public and that participation by interested and affected parties was facilitated in such a manner that all interested and affected parties were provided with a reasonable opportunity to participate and to provide comments on the specialist input/study;
- I have ensured that the comments of all interested and affected parties on the specialist input/study were considered, recorded and submitted to the competent authority in respect of the application;
- all the particulars furnished by me in this specialist input/study are true and correct; and
- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

Signature of the specialist: _ _

Name of Specialist: Brett Williams

Date: 28/08/2018

EXECUTIVE SUMMARY

Safetech were appointed to conduct an Environmental Noise Impact Assessment for the proposed construction of the Kudusberg Wind Energy Facility (WEF) between Matjiesfontein and Sutherland in the Northern and Western Cape Province. The facility will generate a maximum of 325 MW of electricity.

A literature review and desktop modelling were conducted. Baseline monitoring was done of the ambient noise levels at the site.

The results of the study indicate that the following conclusions can be drawn:

a) There will be a short-term increase in noise in the vicinity of the site during the construction phase as the ambient noise level will be exceeded by vehicle operations.
b) The area surrounding the construction sites will be affected for short periods of time in all directions, should numerous construction equipment be used simultaneously.
c) The number of construction vehicles that will be used in the project will add to the existing ambient levels and will most likely cause a disturbing noise for a limited time. The exact number of construction vehicles is not known at present. The duration of impact will however be short-term.
d) The day/night time SANS 10103:2008 noise limit of 45dBA will not be exceeded at any of the noise sensitive areas.
e) The night time guideline noise limit of 35dBA will not be exceeded at any of the noise sensitive areas.
f) All turbine positions met the 500 m setback distance from noise sensitive receptors.
g) The cumulative impacts will not exceed the day/night time SANS 10103:2008 noise limit of 45dBA.
h) The cumulative impacts will not exceed the night time SANS 10103:2008 noise limit of 35dBA.

The construction phase and operational phase will have a very low noise impact on the noise sensitive receptors.

The following is recommended:

a) The noise impacts are re-modelled when the final turbine layout and turbine type is determined only if the chosen turbine has a higher sound power level than the type modelled in this report or if a turbine is moved substantially closer to a noise sensitive receptor (< 100 m).
b) Periodic noise measurements are taken during the construction and operational phases as per the intervals described in Table 13 and 14.

Due to the potential low impacts associated with the construction and operational phases of the proposed Kudusberg WEF, it is recommended that the proposed WEF receives Environmental Authorisation from a noise perspective.

Dr Brett Williams

LIST OF ABBREVIATIONS

dB(A)	Decibels weighted A scale – Value of the sound pressure level in decibels, determined using a frequency weighting network A (with reference to 20 µPa unless otherwise indicated).
$L_{Aeq, T}$	The equivalent continuous A-weighted sound pressure level.
L_{90}	Sound pressure level exceeded for 90 percent of the measurement time
m	metres
m/s	metres per second
NSA	Noise Sensitive Area
MW	Mega Watt
WEF	Wind Energy Facility
WTG	Wind Turbine Generator

GLOSSARY

DEFINITIONS	
Ambient Noise (General meaning)	Means the reading on an integrating impulse sound level meter taken at a measuring point, in the absence of any alleged disturbing noise, at the end of a total period of at least 10 minutes after such meter was put into operation Authors Note: Ambient noise in layman's terms generally excludes the noise alleged to be causing a noise nuisance or disturbing noise. Ambient noise in this definition is equivalent to Residual Noise as defined in the SANS 10103:2008
Ambient Noise (SANS 10103:2008)	Totally encompassing sound in a given situation at a given time, and usually composed of sound from many sources, both near and far NOTE: Ambient noise includes the noise from the noise source under investigation.
Annoyance	General negative reaction of the community or person to a condition creating displeasure or interference with specific activities.
Disturbing Noise (Western Cape Noise Control Regulations (June 2013)	a noise, excluding the unamplified human voice, which: a) exceeds the rating level by 7 dBA; b) exceeds the residual noise level where the residual noise level is higher than the rating level; c) exceeds the residual noise level by 3 dBA where the residual noise level is lower than the rating level; or d) in the case of a low-frequency noise, exceeds the level specified in Annex B of SANS 10103.
Equivalent Continuous Rating Level ($L_{Req,T}$)	The equivalent continuous A-weighted sound pressure level ($L_{Aeq,\ T}$) during a specified time interval, plus specified adjustments for tonal character and impulsiveness of the sound, and derived from the applicable equation. $L_{Aeq,T} + Ci + C_t + kn$ where $L_{aeq,T}$ is the equivalent A-weighted sound pressure level in decibels Ci is the impulse correction C_t is the correction for tonal character Kn is the adjustment for day or night (0dB for day and +10dB for night measurements
Low Frequency Noise	Means sound which contains sound energy at frequencies predominantly below 100 Hz.
Noise Nuisance	Means any sound which impairs or may impair the convenience or peace of a reasonable person.
Noise Rating Level	Means the applicable outdoor equivalent continuous rating level indicated in Table 2 of SANS 10103.

Residual Noise (SANS 10103)	Means the all-encompassing sound in a given situation at a given time, measured as the reading on an integrated impulse sound level meter for a total period of at least 10 minutes, excluding noise alleged to be causing a noise nuisance or disturbing noise.

COMPLIANCE WITH THE APPENDIX 6 OF THE 2014 EIA REGULATIONS

Requirements of Appendix 6 – GN R326 EIA Regulations of 7 April 2017	Section where this is addressed in the Noise Specialist Report
1. (1) A specialist report prepared in terms of these Regulations must contain- a) details of- i. the specialist who prepared the report; and ii. the expertise of that specialist to compile a specialist report including a curriculum vitae;	Specialist Expertise
b) a declaration that the specialist is independent in a form as may be specified by the competent authority;	Specialist Declaration
c) an indication of the scope of, and the purpose for which, the report was prepared;	Section 1.1 Scope and Purpose
(cA) an indication of the quality and age of base data used for the specialist report;	Not applicable to noise studies
(cB) a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	Section 3 Description of the Affected Environment
d) the duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment;	Section 3.3 Ambient Noise at Proposed Site
e) a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;	Section 1.3 Approach and Methodology
f) details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives;	Section 6 Identification of Potential Impacts
g) an identification of any areas to be avoided, including buffers;	Section 6 Identification of Potential Impacts
h) a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Section 6 Identification of Potential Impacts
i) a description of any assumptions made and any uncertainties or gaps in knowledge;	Section 1.5 Assumptions and Limitations
j) a description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives on the environment or activities;	Section 6 Assessments of Impacts and Identification of Management Actions
k) any mitigation measures for inclusion in the EMPr;	Section 6.8 Input into the EMPr
l) any conditions for inclusion in the environmental authorisation;	Section 6.8 Input into the EMPr
m) any monitoring requirements for inclusion in the EMPr or environmental authorisation;	Section 6.8 Input into the EMPr
n) a reasoned opinion- i. as to whether the proposed activity, activities or portions thereof should be authorised; (iA) regarding the acceptability of the proposed activity or activities; and ii. if the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan;	Executive Summary
o) a description of any consultation process that was undertaken during the course of preparing the specialist report;	Section 1.6 Sources of Information
p) a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	No comments received yet. Comments which may be received during the review of the DBAR will be incorporated into the NIA.
q) any other information requested by the competent authority.	No comments received
2) Where a government notice gazetted by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply.	Noted

TABLE OF CONTENTS

List of Tables

List of Figures

NOISE IMPACT ASSESSMENT

1. INTRODUCTION AND METHODOLOGY

1.1 SCOPE AND OBJECTIVES

Kudusberg Wind Farm (Pty) Ltd proposes to construct a Wind Energy Facility (WEF) with an installed capacity of up to 325 Megawatts (MW) on several farms situated near Laingsburg in the Western and Northern Cape Provinces. The WEF will host up to approximately 56 turbines, each with a capacity of between 3 MW and 6.5 MW.

A Noise Impact Assessment (NIA) for the Basic Assessment (BA) was conducted in accordance with Section 8 of SANS 10328. The scope of the project is described below:

- Determine the land use zoning of surrounding land and identify noise sensitive receptors that could be impacted upon by activities relating to the construction, operation and decommissioning of the wind farm.
- Determine the existing ambient levels of noise within the study area.
- Determine the typical rating level for noise on surrounding land at identified noise sensitive receptors.
- Identify all noise sources, relating to the establishment and operation of the proposed wind farm that could potentially result in a noise impact on surrounding land and at the identified noise sensitive receptors.
- Determine the sound power emission levels and nature of the sound emission from the identified noise sources.
- Calculate the expected rating level of noise on surrounding land and at the identified noise sensitive receptors from the combined sound power levels emanating from identified noise sources in accordance with procedures contained in SANS 10357 or similar.
- Calculate and assess the noise impact on surrounding land and at the identified noise sensitive receptors in terms of SANS 10103; the Environment Conservation Act: National Noise Control Regulations (GNR 154 - 1992; and the Western Cape Noise Control Regulations.
- There are no noise control provincial regulations for the Northern Cape.
- Investigate alternative noise mitigation procedures, if required, in collaboration with the design engineers of the facility and estimate the impact of noise upon implementation of such procedures.

- Prepare and submit an environmental noise impact report in line with Appendix 6 of the EIA regulations, containing the procedures and findings of the investigation.
- Prepare and submit recommended noise mitigation procedures as part of a separate environmental noise management plan, if relevant.

1.2 TERMS OF REFERENCE

The Terms of Reference provided by CSIR for this noise study included the following:

- A key task for the specialists is to review the existing sensitivity mapping from the SEA for the project area and provide an updated sensitivity map for the Kudusberg WEF project site.
- Adhere to the requirements of specialist studies in terms of Appendix 6 of the NEMA EIA Regulations (2014), as amended.
- Identify and assess the potential impacts of the proposed Kudusberg WEF project and its associated infrastructure by assessing the impacts during the construction, operational and decommissioning phases.
- Identify and assess cumulative impacts from other Wind and Solar PV projects located within a 50 km radius from the Kudusberg WEF that already have received Environmental Authorisation (EA), are preferred bidders and/or may still be identified as having received a positive Environmental Authorisation at the start of this BA process.
- Propose mitigation measures to address possible negative effects and to enhance positive impacts to increase the benefits derived from the project.
- Use the Impact Assessment Methodology as provided by the CSIR.
- Assess the project alternatives and the no-go alternative.
- Provide a recommendation as to whether the project must receive Environmental Authorisation of not and Identify any aspects which are conditional to the findings of the assessment which are to be included as conditions of the Environmental Authorisation.

Specific ToR:

- Undertake an assessment in accordance with Section 7 of the South African National Standard (SANS) 10328:2008 (“Methods for environmental noise impact assessments in terms of NEMA”). This includes:
- Identification and description of the noise sources associated with the proposed development;
- Identification of potential noise sensitive areas or receptors that could be impacted upon by noise emanating from the proposed development;
- Estimation of the acceptable rating level of noise on identified noise sensitive areas;

- Estimation of the noise emissions from the identified noise sources and estimation of the expected rating level of noise at the identified noise sensitive areas;
- Estimation and assessment of the noise impacts on identified noise sensitive areas or receptors in accordance with SANS 10103:2008 and the National Noise Control Regulations;
- Consideration of possible alternative noise mitigation procedures;
- Determine whether the proposed development has significant noise impact implications;
- A description of the current environmental conditions from a noise perspective in sufficient detail so that there is a baseline description/status quo against which impacts can be identified and measured i.e. sensitive noise receptors, etc.;
- A review of detailed information relating to the project description, and the Wind and Solar SEA (CSIR, 2015) in order to precisely define the environmental risks in terms of noise emissions;
- Identification of issues and potential impacts related to noise emissions, which are to be considered in combination with any additional relevant issues that may be raised through public participation;
- Identification of relevant legislation and legal requirements;
- A description of the regional and local features;
- Calculation of baseline noise measurements (i.e. of the existing ambient noise (day and night time));
- Modelling of the future potential noise impacts during all phases of the proposed development taking into consideration sensitive receptors;
- Identification of buffer zones and no-go areas to inform the turbine layout (if relevant);
- Identify and assess all potential impacts (direct and indirect) of the construction, operational and decommissioning phases of the proposed development;
- Assess all alternatives, including the no-go alternative;
- Provide recommended mitigation measures, management actions, monitoring requirements, and rehabilitation guidelines for all identified impacts to be included in the EMPr; and
- Incorporate and address issues and concerns raised during the BA process where they are relevant to the specialist's area of expertise.

The required end-product from the noise assessment is to provide a comprehensive and detailed Noise Impact Assessment (NIA) that presents and evaluates the noise impact of the wind turbines under different operating conditions which will be incorporated into the BA Report.

1.3 APPROACH AND METHODOLOGY

The methodology used in the study consisted of three approaches to determine the noise impact from the proposed project and associated infrastructure:

- A desktop study to model the likely noise emissions from the site;
- Field measurements of the existing ambient noise at different locations in the vicinity of the project during the day and night-time; and
- The identification of potential noise sensitive areas.

The desktop study was done using the available literature on noise impacts from wind turbines as well as numerical calculations of the possible noise emissions. A Danish modelling program, EMD WindPro Software Version 3 was used which has been developed specifically for wind turbine noise. This program is used extensively worldwide and has been developed and validated in Denmark. The method described in SANS 10357:2004 version 2.1 (The calculation of sound propagation by the Concawe method) was used as a reference for further calculations where required.

WindPro uses the methods described in ISO 9613-2 (Acoustics – Attenuation of sound during propagation outdoors. Part 2 – General method of calculation). This method is very similar to SANS 10357:2004 and is used worldwide for modelling noise from various sources including wind turbine generators (Wind turbines). Where a tonal character is identified in the noise emitted from the turbines, a 5 dB(A) penalty is included in the modelling result.

The numerical results were then used to produce “noise maps” that visually indicate the extent of the noise emissions from the site. The noise emissions were modelled for various wind speeds from 3 m/s to 12 m/s. The direction of the wind was not taken into consideration as the wind could blow from any direction at the speeds that were modelled. The modelling is thus for worst-case scenarios and takes the topography around the turbine and noise sensitive area (NSA) into account. The site elevation data was sourced from the NASA STRM database and imported into WindPro. A comparison was done using the digital elevation data and the contour heights from a 1:50 000 topographical map. The comparison showed that the digital data and the map corresponded well. Furthermore, the digital data provided a better resolution.

1.4 FIELD STUDY

Measurements were taken by avoiding any large flat reflecting surfaces, by placing the noise meter on a tripod and ensuring that it was at least 1.2 m from floor level and 3.5 m.

All measurement periods exceeded at least 10 minutes, except where indicated. The noise meter was calibrated before and after the survey. At no time was the difference in calibration more than one decibel (If the difference is more than 1 decibel the meter is not calibrated properly, and the measurement was discarded). The weighting used was on the A scale and the meter placed on impulse correction, which is the preferred method as per Section 5 of SANS 10103:2008. No tonal correction was added to the data. Measurements were taken during the day and night-time. The meter was fitted with a windscreen, which is supplied by the manufacturer. The screen is designed to reduce wind noise around the microphone and not bias the measurements.

The test environment contained the following noise sources:

- Vehicular traffic that included trucks and cars;
- Birds and insects;
- Farm animals; and
- Wind noise;

The instrumentation that was used to conduct the study is as follows:

- Rion Precision Sound Level Meter (NL32) with 1/3 Octave Band Analyzer Serial No. 00151075;

o Microphone (UC-53A) Serial No. 307806; and

o Preamplifier (NH-21) Serial No. 13814.

All equipment was calibrated in November 2017. The next calibration is due in November 2018 (see Appendix B).

1.5 ASSUMPTIONS AND LIMITATIONS

The following assumptions and limitations are applicable to this study:

- The turbine positions were supplied by the applicant and are accepted as an accurate layout for the purposes of the environmental impact assessment.
- The worst-case scenario impacts were modelled i.e. wind from any direction, not only the prevailing wind, maximum turbine size as required for the site and the worst-case meteorological conditions.
- No wind noise masking effect is considered.
- The noise levels at the identified noise sensitive areas could thus be lower if the wind noise masks the turbine noise emissions.
- For the cumulative impact assessment, it was assumed that all proposed projects would enter into construction. Although this is very unlikely, the assumption was made in order to assess the worst-case scenario.

1.6 SOURCES OF INFORMATION

The main sources of information are as follow:

- The project technical information was provided by the applicant e.g. turbine model, turbine positions etc.
- The list of applicable legislation is listed below.
- The reference information to interpret noise impacts is listed in the list of References.
- The digital elevation data was downloaded from EMD in Denmark and is derived from the NSAS STRM.
- Data collected onsite.

2 DESCRIPTION OF PROJECT ASPECTS RELEVANT TO NOISE IMPACTS

The sources of sounds emitted from operating wind turbines can be divided into two categories, firstly mechanical sounds, from the interaction of turbine components, and secondly aerodynamic sounds, produced by the flow of air over the blades.

2.1 MECHANICAL SOUNDS

Mechanical sounds originate from the relative motion of mechanical components and the dynamic response among them. Sources of such sounds include:

- Gearbox;
- Generator;
- Yaw Drives;
- Cooling Fans; and
- Auxiliary Equipment (e.g., hydraulics).

Since the emitted sound is associated with the rotation of mechanical and electrical equipment, it tends to be tonal (of a common frequency), although it may have a broadband component. For example, pure tones can be emitted at the rotational frequencies of shafts and generators, and the meshing frequencies of the gears.

In addition, the hub, rotor, and tower may act as loudspeakers, transmitting the mechanical sound and radiating it. The transmission path of the sound can be air-borne or structure-borne. Air-borne means that the sound is directly propagated from the component surface or interior into the air. Structure-borne sound is transmitted along other structural components before it is radiated into the air.

Figure 1 below shows the type of transmission path and the sound power levels for the individual components for a 2 MW wind turbine (Wagner 1996).

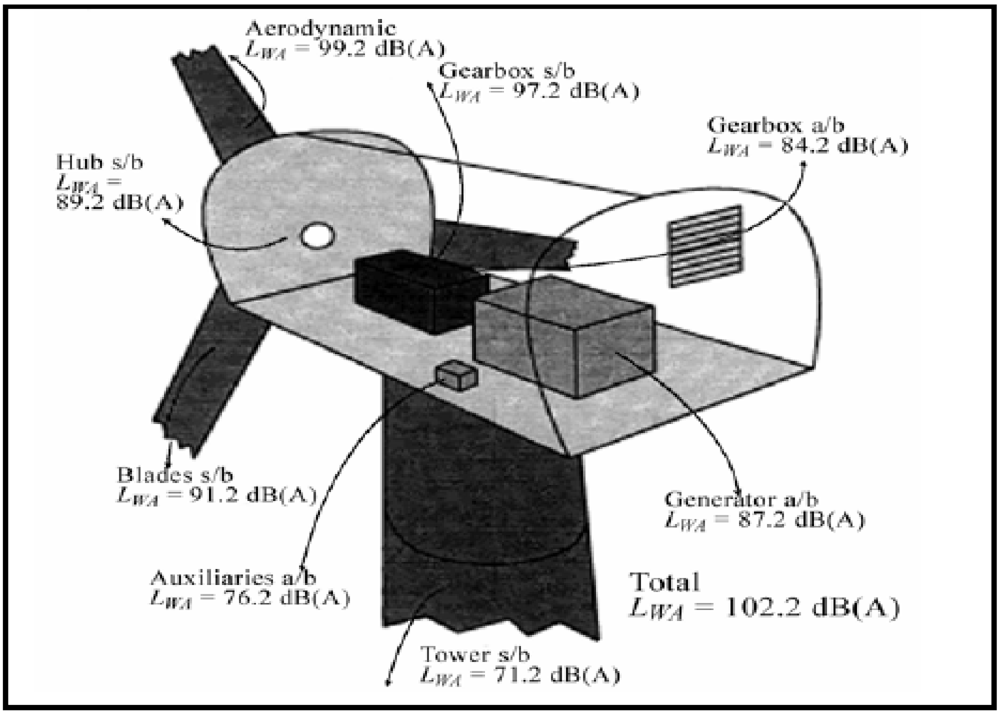

Figure 1 - Typical Sound Power Levels of a 2 MW Turbine

2.2 AERODYNAMIC SOUND

Aerodynamic broadband sound is typically the largest component of wind turbine acoustic emissions. It originates from the flow of air around the blades. A large number of complex flow phenomena occur, each of which might generate some sound (see Figure 2). Aerodynamic sound generally increases with rotor speed. The various aerodynamic sound generation mechanisms that have to be considered are divided into three groups:

- Low Frequency Sound: Sound in the low frequency part of the sound spectrum is generated when the rotating blade encounters localized flow deficiencies due to the flow around a tower, wind speed changes, or wakes shed from other blades;
- Inflow Turbulence Sound: Depends on the amount of atmospheric turbulence. The atmospheric turbulence results in local force or local pressure fluctuations around the blade; and

- Airfoil Self Noise: This group includes the sound generated by the air flow right along the surface of the airfoil. This type of sound is typically of a broadband nature, but tonal components may occur due to blunt trailing edges, or flow over slits and holes.

Source (Wagner 1996)

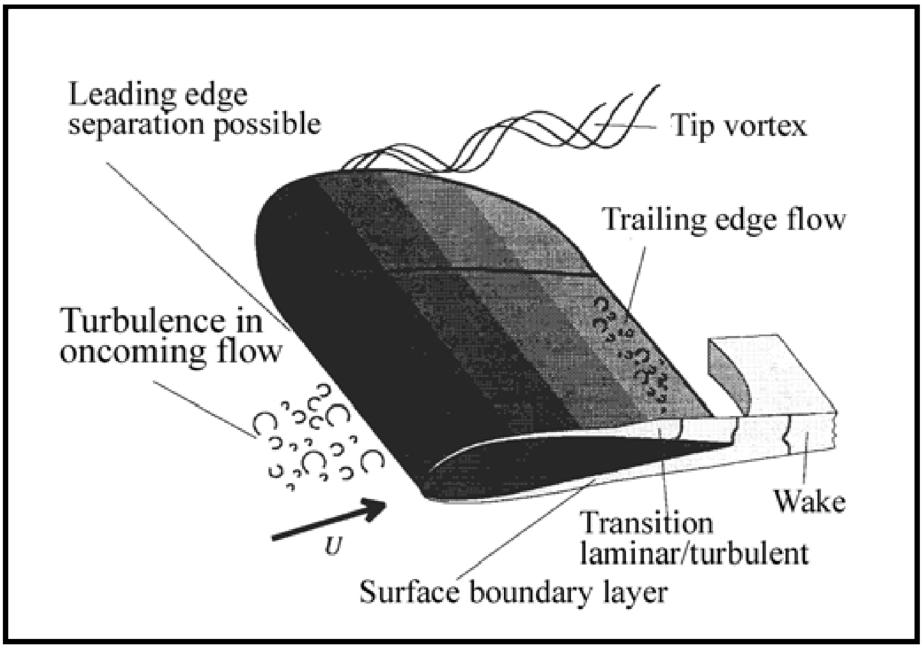

Figure 2 - Sources of Aerodynamic Noise

Modern airfoil design takes all of the above factors into account and is generally much quieter that the first generation of bade design.

2.2.1 Ambient Sound & Wind Speed

The ability to hear a wind turbine in a given installation depends on the ambient sound level. When the background sounds and wind turbine sounds are of the same magnitude, the wind turbine sound gets lost in the background. Both the wind turbine sound power level and the ambient sound pressure level will be functions of wind speed. Thus, whether a wind turbine exceeds the background sound level will depend on how each of these varies with wind speed.

The most likely sources of wind-generated sounds are interactions between wind and vegetation. A number of factors affect the sound generated by wind flowing over vegetation. For example, the total magnitude of wind-generated sound depends more on the size of the windward surface of the vegetation than the foliage density or volume.

The sound level and frequency content of wind generated sound also depends on the type of vegetation. For example, sounds from deciduous trees tend to be slightly lower and more broadband than that from conifers, which generate more sounds at specific frequencies. The equivalent A-weighted broadband sound pressure generated by wind in foliage has been shown to be approximately proportional to the base 10 logarithm of wind speed.

Sound levels from large modern wind turbines during constant speed operation tend to increase more slowly with increasing wind speed than ambient wind generated sound. As a result, wind turbine noise is more commonly a concern at lower wind speeds and it is often difficult to measure sound from modern wind turbines above wind speeds of 8 m/s because the background wind-generated sound masks the wind turbine sound above 8 m/s.

It should be remembered that average sound pressure measurements might not indicate when a sound is detectable by a listener. Just as a dog's barking can be heard through other sounds, sounds with particular frequencies or an identifiable pattern may be heard through background sounds that is otherwise loud enough to mask those sounds. Sound emissions from wind turbines will also vary as the turbulence in the wind through the rotor changes. Turbulence in the ground level winds will also affect a listener's ability to hear other sounds. Because fluctuations in ground level wind speeds will not exactly correlate with those at the height of the turbine, a listener might find moments when the wind turbine could be heard over the ambient sound.

2.2.2 Low Frequency Noise and Infrasound

Infrasound was a characteristic of some wind turbine models that has been attributed to early designs in which turbine blades were downwind of the main tower. The effect was generated as the blades cut through the turbulence generated around the downwind side of the tower. Modern designs generally have the blades upwind of the tower. Wind conditions around the blades and improved blade design minimize the generation of the effect.

Low frequency pressure vibrations are typically categorized as low frequency sound when they can be heard near the bottom of human perception (10-200 Hz), and infrasound when they are below the common limit of human perception. Sound below 20 Hz is generally considered to be infrasound, even though there may be some human perception in that range. Because the ranges of low frequency sound and infrasound overlap it is important to understand how the terms are applied in a given context.

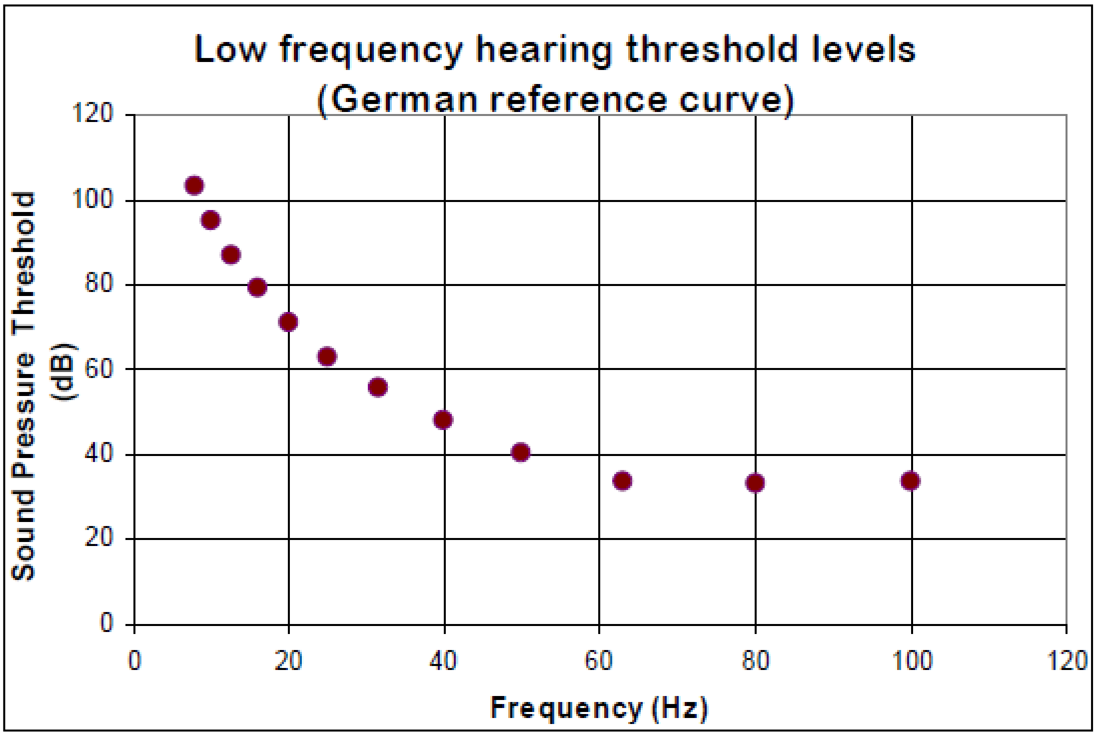

Figure 3 - Low frequency Hearing Threshold Levels

Infrasound is always present in the environment and stems from many sources including ambient air turbulence, ventilation units, waves on the seashore, distant explosions, traffic, aircraft, and other machinery. Infrasound propagates farther (i.e. with lower levels of dissipation) than higher frequencies. To place infrasound in perspective, when a child is swinging high on a swing, the pressure changes on their ears, from top to bottom of the swing, is nearly 120 dB at a frequency of around 1 Hz.

Some characteristics of the human perception of infrasound and low frequency sound are:

- Low frequency sound and infrasound (2-100 Hz) are perceived as a mixture of auditory and tactile sensations;
- Lower frequencies must be of a higher magnitude (dB) to be perceived, e.g. the threshold of hearing at 10 Hz is around 100 dB (see Figure 3 above);
- Tonality cannot be perceived below around 18 Hz; and
- Infrasound may not appear to be coming from a specific location, because of its long wavelengths.

The primary human response to perceived infrasound is annoyance, with resulting secondary effects. Annoyance levels typically depend on other characteristics of the infrasound, including intensity, variations with time, such as impulses, loudest sound, periodicity, etc. Infrasound has three annoyance mechanisms:

- A feeling of static pressure;
- Periodic masking effects in medium and higher frequencies; and
- Rattling of doors, windows, etc. from strong low frequency components.

Human effects vary by the intensity of the perceived infrasound, which can be grouped into these approximate ranges:

- 90 dB and below: No evidence of adverse effects';
- 115 dB: Fatigue, apathy, abdominal symptoms, hypertension in some humans;
- 120 dB: Approximate threshold of pain at 10 Hz; and
- 120 – 130 dB and above: Exposure for 24 hours causes physiological damage.

There is no reliable evidence that infrasound below the perception threshold produces physiological or psychological effects.

The typical range of sound power level for wind turbine generators is in the range of 100 to 105 dBA – a much lower sound power level (10 dB or more) than the majority of construction machinery such as bulldozers. For infrasound to be audible even to a person with the most sensitive hearing at a distance of 300 m would require a sound power level of at least 140 dB at 10 Hz and even higher emission levels than this at lower frequencies and at greater distances. There is no information available to indicate that wind turbine generators emit infrasound anywhere near this intensity.

Several studies have confirmed that there are no physiological effects from low frequency or infrasound from wind turbines (Bell Acoustic Consulting, 2004; DEFRA, 2003; DTI, 2006; ISO 9613-2; SANS 10103:2008 Version 6; Swedish Environmental Protection Agency, 2003 and University of Groningen, 2003).

3 DESCRIPTION OF THE AFFECTED ENVIRONMENT

The proposed Kudusberg WEF is to be constructed on farmland. The topography surrounding the site is characterised by steep hills and valleys.

3.1 SITE LOCATION

The client provided two turbine layouts, namely, Layout 1 and subsequent to the modelling, Layout 2. The Layout 2 option was to take into consideration the sensitive areas identified by the various specialist studies and relate mainly to changes to the road and pad layouts. The differences in the turbine layout are negligible and do not affect the modelling results. The location and position of the various wind turbines that were modelled are contained in the Table 1 and Figure 5 below.

Table 1 - Wind Turbine Location Co-ordinates for the proposed Kudusberg WEF

WTG Number	Latitude	Longitude
1	32°55'27.85"S	20°16'27.67"E
2	32°55'17.99"S	20°16'37.67"E
3	32°55'9.29"S	20°16'49.06"E
4	32°55'4.91"S	20°17'7.56"E
5	32°54'54.62"S	20°17'26.97"E
6	32°55'1.59"S	20°17'45.74"E
7	32°55'7.70"S	20°18'4.64"E
8	32°54'53.51"S	20°18'41.67"E
9	32°54'57.59"S	20°19'10.79"E
10	32°54'59.54"S	20°19'28.96"E
11	32°55'8.30"S	20°19'50.00"E
12	32°55'9.76"S	20°20'9.93"E
13	32°55'4.87"S	20°20'49.38"E
14	32°54'57.84"S	20°21'27.17"E
15	32°54'47.67"S	20°21'37.39"E
16	32°54'37.83"S	20°21'48.63"E
17	32°54'15.89"S	20°22'20.55"E
18	32°54'5.40"S	20°22'31.93"E
19	32°54'5.27"S	20°22'56.30"E
20	32°53'22.31"S	20°21'23.27"E
21	32°53'14.20"S	20°21'36.38"E
22	32°53'9.41"S	20°21'51.38"E

WTG Number	Latitude	Longitude
23	32°53'3.80"S	20°22'10.15"E
24	32°52'55.65"S	20°22'27.51"E
25	32°52'12.27"S	20°22'35.93"E
26	32°52'5.68"S	20°22'52.49"E
27	32°52'15.91"S	20°14'39.87"E
28	32°52'11.02"S	20°14'53.99"E
29	32°52'6.16"S	20°15'8.05"E
30	32°51'59.69"S	20°16'0.76"E
31	32°51'43.16"S	20°16'17.79"E
32	32°51'34.41"S	20°16'29.41"E
33	32°51'43.24"S	20°16'51.50"E
34	32°51'36.82"S	20°17'4.71"E
35	32°51'29.33"S	20°17'17.07"E
36	32°51'40.63"S	20°17'41.03"E
37	32°51'46.63"S	20°17'57.84"E
38	32°52'0.80"S	20°18'43.10"E
39	32°51'52.62"S	20°19'3.57"E
40	32°51'46.32"S	20°19'16.88"E
41	32°51'39.37"S	20°19'29.77"E
42	32°51'36.05"S	20°20'0.94"E
43	32°51'30.68"S	20°20'28.60"E
44	32°51'51.35"S	20°21'26.21"E
45	32°51'38.71"S	20°21'35.35"E
46	32°51'25.23"S	20°21'37.21"E
47	32°50'42.57"S	20°19'50.63"E
48	32°50'31.26"S	20°20'2.08"E
49	32°50'19.22"S	20°20'9.93"E
50	32°50'12.87"S	20°20'23.36"E
51	32°50'14.21"S	20°19'24.50"E
52	32°50'13.73"S	20°21'0.18"E
53	32°50'7.55"S	20°21'13.50"E
54	32°50'3.46"S	20°21'27.96"E
55	32°49'56.23"S	20°21'40.51"E
56	32°49'53.08"S	20°22'7.30"E

The positions of the turbines and noise sensitive areas are shown in Figures 5 below.

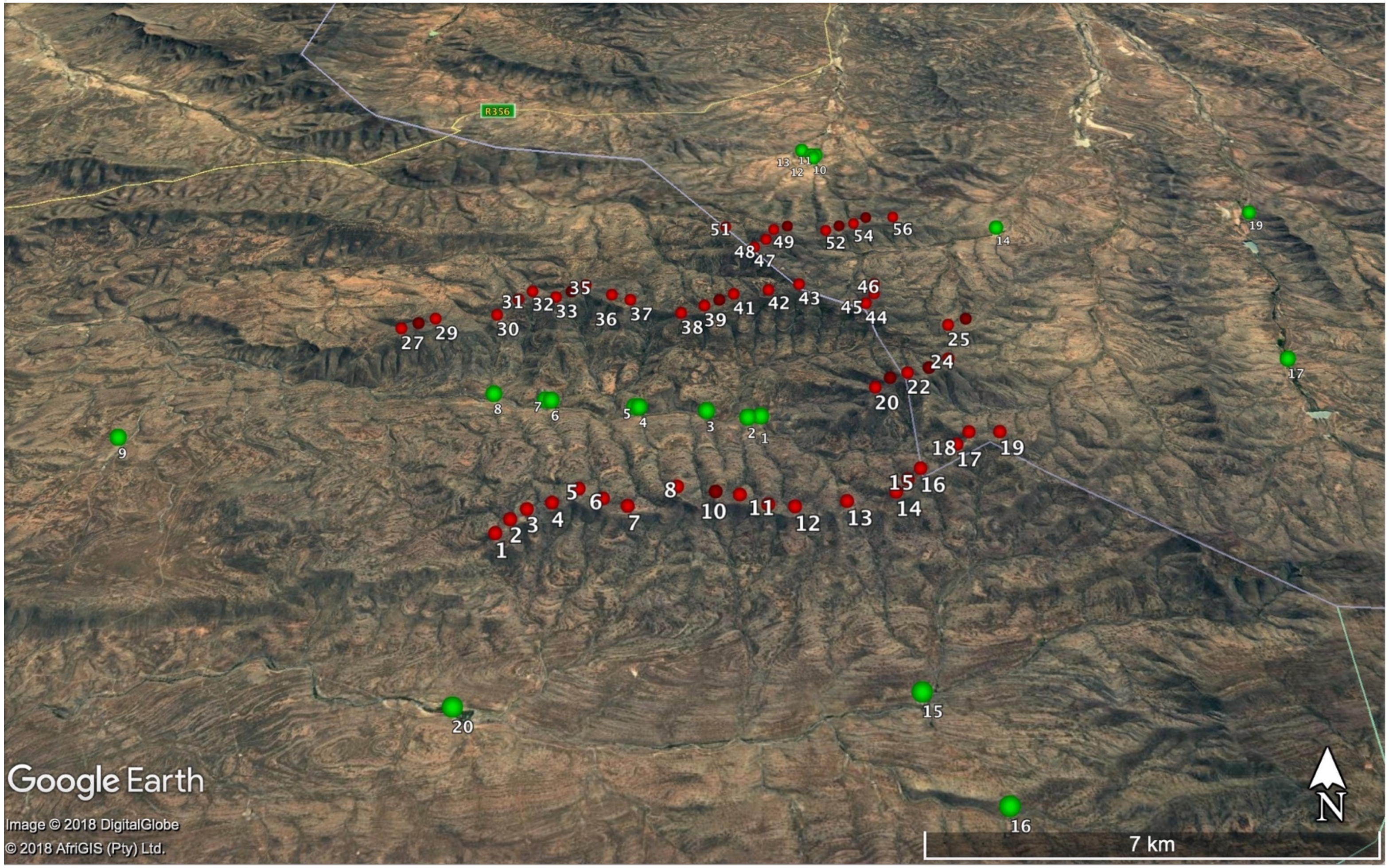

Figure 4 - The proposed positions of the wind turbines and Noise Sensitive Areas

Wind turbines (red dots) and Noise Sensitive Areas (green dots).

The potential sensitive receptors are discussed below. The main noise sensitive receptors that could be affected by noise pollution are humans, terrestrial fauna and avifauna.

3.2 NOISE SENSITIVE AREAS

Human Sensitive Receptors

The site is situated in a farming community. Several homesteads are located on the properties where the turbines will be erected as well as on neighboring farms. The sensitive noise receptors have been recorded in Table 2 below. The noise sensitive areas were mostly identified from Google Earth due to the distance from the project area. It is assumed that the structures listed in Table 2 below are thus all homesteads and are occupied or could be occupied.

Table 2 - Noise Sensitive Areas in relation to the proposed Kudusberg WEF

NSA No	Longitude	Latitude	Within the Project Area
1	20°19'48.49" E	32°53'44.77" S	Yes
2	20°19'38.07" E	32°53'46.13" S	Yes
3	20°19'04.76" E	32°53'38.85" S	Yes
4	20°18'09.44" E	32°53'34.20" S	Yes
5	20°18'05.89" E	32°53'34.01" S	Yes
6	20°16'56.53" E	32°53'26.60" S	Yes
7	20°16'51.71" E	32°53'26.16" S	Yes
8	20°16'08.06" E	32°53'19.21" S	Yes
9	20°11'11.85" E	32°54'00.50" S	No
10	20°20'59.15" E	32°48'14.26" S	Yes
11	20°20'57.03" E	32°48'09.55" S	Yes
12	20°21'02.30" E	32°48'09.53" S	Yes
13	20°20'48.16" E	32°48'01.63" S	No
14	20°23'47.58" E	32°50'00.78" S	Yes
15	20°21'25.27" E	32°57'21.97" S	Yes
16	20°22'07.75" E	32°58'30.41" S	Yes
17	20°27'23.33" E	32°52'42.15" S	No
18	20°19'04.30" E	33°00'15.86" S	No
19	20°28'03.61" E	32°49'35.63" S	No
20	20°16'15.80" E	32°57'29.91" S	Yes

Natural Environment Receptors

The vegetation around the site is characterised by grassy fynbos with thicket in areas of richer soil. The fauna includes bats, birds, commercial livestock and a variety of buck.

3.3 AMBIENT NOISE AT PROPOSED SITE

The ambient noise was measured at several locations as described in the methodology and results thereof are contained in Table 3 below. The author is confident that this represents the ambient noise at the project site at the noise sensitive receptors.

Table 3 - Ambient Noise Results 18th July 2018

DAY

Date:	**18/07/2018**	**18/07/2018**	**18/07/2018**
Position:	NSA 1 (11:00) 32°53'44.07"S 20°19'48.64"E	Between NSA 4 & 5 (11:40) 32°53'34.44"S 20°18'7.25"E	Between NSA 6 & 7 (12:10) 32°53'26.80"S 20°16'54.33"E
Leq dB(A)	50.1	46.0	48.7
Comments	Noise from: Aeroplane flying over; Windmill water pump; Sheep in the distance; Birds	Noise from: grass / bush blowing in the wind; Birds	Noise from: Aeroplane flying over; Grass / bush blowing in the wind; Birds

EVENING

Date:	**18/07/2018**	**18/07/2018**	**18/07/2018**
Position:	NSA 1 (18:10)	Between NSA 4 & 5 (18:40)	Between NSA 6 & 7 (19:10)
Leq dB(A)	46.8	45.3	45.7
Comments	Noise from: Windmill water pump turbine; Sheep in the distance; Birds	Noise from: grass / bush blowing in the wind; Birds	Noise from: Aeroplane flying over; Grass / bush blowing in the wind; Birds

NIGHT

Date:	**18/07/2018**	**18/07/2018**	**18/07/2018**
Position:	NSA 1 (22:00)	Between NSA 4 & 5 (22:40)	Between NSA 6 & 7 (23:20)
Leq dB(A)	45.8	45.7	45.9
Comments	Noise from: Wind noise wind; Grass / bush blowing in the wind	Noise from: Wind noise; Grass / bush blowing in the wind; Crickets	Noise from: Wind noise; Grass / bush blowing in the wind; Crickets

The general ambient noise at each location varies substantially as the ambient sound is influenced by human activities, vehicles, wind noise and animal sounds.

3.3.1 Wind Turbine Generators

The Wind Turbine Generator (WTG) that was modelled is described in Table 4 below. This turbine was chosen to represent the worst-case scenario of a wind turbine up to 4.5 MW and 140 m hub height. This model of turbine was chosen as it has published noise data in the WindPro catalogue of wind turbines. Furthermore, the noise data has been tested according to the methods described in IEC 61400-11 and are thus traceable. The modelled hub height is 125 m. If a higher or lower final hub height is chosen, the noise impacts could be reduced or increase depending on the sound power of the turbine. Furthermore, if the final turbine that is chosen has a maximum sound power level that is similar or lower than the turbine modelled in this report, it can be assumed that the noise impacts will be similar or lower, irrespective of the turbine manufacturer.

Table 4 - Modelled Turbine Specifications

Manufacturer	Nordex
Type / Version	N149/4.0-4.5
Rated Power	4.5 MW
Rotor Diameter	149m
Tower	Tubular
Grid Connection	50 Hz
Maximum Sound Power Level	108.1 dB
Hub Height	125m

Sound Power Level dB(A) reference to 1pW from WindPro 3.2 Catalogue

*The specifications of this turbine model were used as the data is available in WindPro. This does not bind the applicant to this specific model, and any turbine model with similar turbine specifications. An equal or lower maximum sound power level would be acceptable for the site without re-modelling.

4 APPLICABLE LEGISLATION AND PERMIT REQUIREMENTS

The South African Noise Control Regulations (National) describe a disturbing noise as any noise that exceeds the ambient noise by more than 7 dB. This difference is usually measured at the complainant's location should a noise complaint arise. Therefore, if a new noise source is introduced into the environment, irrespective of the current noise levels, and the new source is louder than the existing ambient environmental noise by more than 7 dB, the complainant will have a legitimate complaint. A noise disturbance or nuisance as defined in the national legislation means any sound which disturbs or impairs the convenience of any person. The Western Cape Noise Control Regulations are similar to the National Noise Control Regulations in that the definition of a disturbing noise also refers to any noise that exceeds the ambient noise by more than 7 dB.

The Western Cape Strategic Wind Initiative Document (May 2006) can be used for guidance. The Western Cape does not prescribe any specific noise limits for wind turbines other than to recommend a setback distance of 400 m from residences (including rural dwellings). It is recommended that a setback distance of 500 m be used for this project. This is based on this authors experience on similar projects. The closest turbine to the occupied NSA's is approximately 3 000 m from NSA 3.

The Western Cape Noise Control Regulations define a disturbing noise as:
a noise, excluding the unamplified human voice, which:
a) exceeds the rating level by 7 dB(A);
b) exceeds the residual noise level where the residual noise level is higher than the rating level;
c) exceeds the residual noise level by 3 dB(A) where the residual noise level is lower than the rating level; or
d) in the case of a low-frequency noise, exceeds the level specified in Annex B of SANS 10103.

4.1 NATIONAL STANDARDS

The most applicable standard for planning purposes used in this study is SANS 10103:2008 which provides typical rating levels for noise in various types of districts, as described in the Table 5 below. Ideally, in such areas one does not want to experience any anthropogenic noise pollution.

Table 5 - Typical rating levels for noise in various types of districts

Type of District	Equivalent Continuous Rating Level, LAeq,T for Noise					
	Outdoors (dB(A))			Indoors, with open windows (dB(A))		
	Day-night	Daytime	Night-time	Day-night	Daytime	Night-time
Rural Districts	45	45	35	35	35	25
Suburban districts with little road traffic	50	50	40	40	40	30
Urban districts	55	55	45	45	45	35
Urban districts with one or more of the following: Workshops; business premises and main roads	60	60	50	50	50	40
Central business districts	65	65	55	55	55	45
Industrial districts	70	70	60	60	60	50

SANS 10103:2008 defines Daytime as 06:00 to 22:00 hours and night time as 22:00 to 06:00 hours. The rating levels in the table above indicate that in rural districts the ambient noise should not exceed the guideline 35 dB(A) at night and 45 dB(A) during the day. The day / night (24-hour) rating limit is 45 dB(A). These levels can thus be seen as the maximum target levels for any noise pollution sources. If the current ambient (residual) noise exceeds the rating limit, then actual ambient (residual) limit will be used when a noise complaint arises in terms of the Environment Conservation Act - Noise Control Regulations and the Western Cape Noise Control Regulations.

SANS 10103: 2004 also provides a guideline for expected community responses to excess environmental noise above the ambient (residual) noise. These are reflected in the Table 6 below.

Table 6 - Categories of environmental community / group response (SANS 10103:2008)

EXCESS Lr dB(A)	ESTIMATED COMMUNITY/GROUP RESPONSE	
	CATEGORY	DESCRIPTION
0 - 10	Little	Sporadic complaints
5 - 15	Medium	Widespread complaints
10 - 20	Strong	Threats of community / group action
> 15	Very Strong	Vigorous community / group action

4.2 INTERNATIONAL STANDARDS

There are various international criteria levels for ambient sound from wind turbines. These are listed below:

- New Zealand – 40 dB(A)
- Denmark – 42 dB(A) (dwellings in open country)
- United Kingdom (L_{A90}) 35 – 40 dB(A)

Australia has set the following limits that wind turbine noise should not exceed:

- 35 dB(A) at relevant receivers in localities which are primarily intended for rural living, or
- 40 dB(A) at relevant receivers in localities in other zones, or the background noise (LA90) by more than 5 dB(A)

Germany has set the following standards

- Purely residential areas with no commercial developments 50 dBA (Day) and 35 dBA (Night)
- Areas with hospitals, health resorts, etc. 45 dBA (Day) 35 dBA (Night)

The rationale behind the criteria levels is that the design limit should be 5 dB below the ambient (residual) limit. This corresponds well with the South African guideline limit of 45 dB(A) (day/night limit) for rural districts.

5 IDENTIFICATION OF KEY ISSUES

5.1 KEY ISSUES IDENTIFIED

The key issues regarding the noise impact are as follow:

- What is the current noise ambient noise in the vicinity of the proposed Kudusberg WEF?
- What is the likely noise impact during construction and operation of the site and associated infrastructure?
- Where are local sensitive human receptors located and how is the noise going to affect them?
- Could low frequency sound and infra sound be a problem?

6 IDENTIFICATION OF POTENTIAL IMPACTS

6.1 PREDICTED NOISE LEVELS FOR THE CONSTRUCTION PHASE

The construction noise at the various sites will have a local impact. Safetech has conducted noise tests at various sites in South Africa and have recorded the noise emissions of various pieces of construction equipment. The results are presented in Table 7 below.

Table 7 - Typical Construction Noise

Type of Equipment	$L_{Req.T}$ dB(A)
CAT 320D Excavator measured at approximately 50 m.	67.9
Mobile crane measured at approximately 70 m	69.6
Drilling rig measured at approximately 70 m	72.6

The impact of the construction noise that can be expected at the proposed site can be extrapolated from the Tables above. As an example, if several pieces of equipment are used simultaneously, the noise levels can be added logarithmically and then calculated at various distances from the site to determine the distance at which the ambient level will be reached (refer to Tables 8 – 10 below).

Table 8 - Combining Different Construction Noise Sources – High Impacts (Worst Case)

Description	Typical Sound Power Level (dB)
Overhead and mobile cranes	109
Front end loaders	100
Excavators	108
Bull Dozer	111
Piling machine (mobile)	115
Total l*	117

*The total is a logarithmic total and not a sum of the values (at approximately 3 m).

Table 9 - Combining Different Construction Noise Sources – Low Impacts (at approximately 3 m)

Description	Typical Sound Power Level (dB)
Front end loaders	100
Excavators	108
Truck	95
Total	111

The information in Tables 8 and 9 above can then be used to calculate the attenuation by distance. Noise will also be attenuated by topography and atmospheric conditions such as temperature, humidity, wind speed and direction etc. but this is ignored for this purpose. Therefore, the distance calculated below would be representative of maximum distances to reach ambient noise levels.

An illustration of attenuation by distance from a noise of 117 dB measured from the source is presented in Table 10 below.

Table 10 - Attenuation by Distance

Distance from noise source (metres)	**Sound Pressure Level dB(A)**
10	89
20	83
40	77
80	71
160	65
320	59
640	53
1280	47

What can be inferred from Table 10 above is that if the ambient noise level is at 45 dB(A), the construction noise will be similar to the ambient level at approximately 1 280 m from the noise source, if the noise characteristics are similar. Beyond this distance, the noise level will be below the ambient noise and will therefore have little impact. The above only applies to the construction noise and light wind conditions. In all likelihood, the construction noise will have little impact on the surrounding community as it will most likely occur during the day when the ambient noise is louder and there are unstable atmospheric conditions.

6.1.1 Low frequency noise concerns

The effects of low frequency noise include sleep disturbance, nausea, vertigo etc. These effects are unlikely to impact upon residents due to the distance between the site and the nearest communities. Sources of low frequency noise also include wind and vehicular traffic.

6.1.2 Predicted noise levels for the Wind Turbines Generators

The tables and figures below indicate the isopleths for the noise generated by the turbines at wind speeds from 3 m/s to 12 m/s. It must be remembered that as the wind speed increases, so too does the background noise. Therefore, the predicted noise levels below 8 m/s are of more concern those above 8m/s.

The modelling results are contained in Table 11 below.

Table 11 - Table of Results of the Noise Impacts at the NSAs

NSA Number	Wind speed [m/s]	From WTGs [dB(A)]	Noise Limit (Night) [dB(A)]	Noise Limit complied with?
1	3	22.6	35	Yes
	4	24.0	35	Yes
	5	28.5	35	Yes
	6	32.5	35	Yes
	7	33.2	35	Yes
	8	33.3	35	Yes
	9	33.3	35	Yes
	10	33.3	35	Yes
	11	33.3	35	Yes
	12	33.3	35	Yes
2	3	22.1	35	Yes
	4	23.5	35	Yes
	5	28.0	35	Yes
	6	32.0	35	Yes
	7	32.7	35	Yes
	8	32.8	35	Yes
	9	32.8	35	Yes
	10	32.8	35	Yes
	11	32.8	35	Yes
	12	32.8	35	Yes
3	3	21.8	35	Yes
	4	23.2	35	Yes
	5	27.7	35	Yes
	6	31.7	35	Yes
	7	32.4	35	Yes
	8	32.5	35	Yes
	9	32.5	35	Yes
	10	32.5	35	Yes
	11	32.5	35	Yes
	12	32.5	35	Yes

NSA Number	Wind speed [m/s]	From WTGs [dB(A)]	Noise Limit (Night) [dB(A)]	Noise Limit complied with?
4	3	21.3	35	Yes
	4	22.7	35	Yes
	5	27.1	35	Yes
	6	31.1	35	Yes
	7	31.8	35	Yes
	8	31.9	35	Yes
	9	31.9	35	Yes
	10	31.9	35	Yes
	11	31.9	35	Yes
	12	31.9	35	Yes
5	3	21.3	35	Yes
	4	22.7	35	Yes
	5	27.1	35	Yes
	6	31.1	35	Yes
	7	31.8	35	Yes
	8	31.9	35	Yes
	9	31.9	35	Yes
	10	31.9	35	Yes
	11	31.9	35	Yes
	12	31.9	35	Yes
6	3	20.8	35	Yes
	4	22.2	35	Yes
	5	26.7	35	Yes
	6	30.7	35	Yes
	7	31.4	35	Yes
	8	31.5	35	Yes
	9	31.5	35	Yes
	10	31.5	35	Yes
	11	31.5	35	Yes
	12	31.5	35	Yes
7	3	20.8	35	Yes
	4	22.2	35	Yes
	5	26.6	35	Yes
	6	30.6	35	Yes
	7	31.3	35	Yes
	8	31.4	35	Yes
	9	31.4	35	Yes
	10	31.4	35	Yes
	11	31.4	35	Yes
	12	31.4	35	Yes
8	3	20.8	35	Yes

NSA Number	Wind speed [m/s]	From WTGs [dB(A)]	Noise Limit (Night) [dB(A)]	Noise Limit complied with?
	4	22.2	35	Yes
	5	26.7	35	Yes
	6	30.7	35	Yes
	7	31.4	35	Yes
	8	31.5	35	Yes
	9	31.5	35	Yes
	10	31.5	35	Yes
	11	31.5	35	Yes
	12	31.5	35	Yes
9	3	8.1	35	Yes
	4	9.5	35	Yes
	5	13.4	35	Yes
	6	17.4	35	Yes
	7	18.1	35	Yes
	8	18.2	35	Yes
	9	18.2	35	Yes
	10	18.2	35	Yes
	11	18.2	35	Yes
	12	18.2	35	Yes
10	3	16.8	35	Yes
	4	18.2	35	Yes
	5	22.6	35	Yes
	6	26.6	35	Yes
	7	27.3	35	Yes
	8	27.4	35	Yes
	9	27.4	35	Yes
	10	27.4	35	Yes
	11	27.4	35	Yes
	12	27.4	35	Yes
11	3	16.4	35	Yes
	4	17.8	35	Yes
	5	22.1	35	Yes
	6	26.1	35	Yes
	7	26.8	35	Yes
	8	26.9	35	Yes
	9	26.9	35	Yes
	10	26.9	35	Yes
	11	26.9	35	Yes
	12	26.9	35	Yes
12	3	16.4	35	Yes
	4	17.8	35	Yes

NSA Number	Wind speed [m/s]	From WTGs [dB(A)]	Noise Limit (Night) [dB(A)]	Noise Limit complied with?
	5	22.1	35	Yes
	6	26.1	35	Yes
	7	26.8	35	Yes
	8	26.9	35	Yes
	9	26.9	35	Yes
	10	26.9	35	Yes
	11	26.9	35	Yes
	12	26.9	35	Yes
13	3	15.8	35	Yes
	4	17.2	35	Yes
	5	21.4	35	Yes
	6	25.4	35	Yes
	7	26.1	35	Yes
	8	26.2	35	Yes
	9	26.2	35	Yes
	10	26.2	35	Yes
	11	26.2	35	Yes
	12	26.2	35	Yes
14	3	17.2	35	Yes
	4	18.6	35	Yes
	5	23.0	35	Yes
	6	27.0	35	Yes
	7	27.7	35	Yes
	8	27.8	35	Yes
	9	27.8	35	Yes
	10	27.8	35	Yes
	11	27.8	35	Yes
	12	27.8	35	Yes
15	3	14.1	35	Yes
	4	15.5	35	Yes
	5	19.6	35	Yes
	6	23.6	35	Yes
	7	24.3	35	Yes
	8	24.4	35	Yes
	9	24.4	35	Yes
	10	24.4	35	Yes
	11	24.4	35	Yes
	12	24.4	35	Yes
16	3	9.3	35	Yes
	4	10.7	35	Yes
	5	14.6	35	Yes

NSA Number	Wind speed [m/s]	From WTGs [dB(A)]	Noise Limit (Night) [dB(A)]	Noise Limit complied with?
	6	18.6	35	Yes
	7	19.3	35	Yes
	8	19.4	35	Yes
	9	19.4	35	Yes
	10	19.4	35	Yes
	11	19.4	35	Yes
	12	19.4	35	Yes
17	3	8.3	35	Yes
	4	9.7	35	Yes
	5	13.6	35	Yes
	6	17.6	35	Yes
	7	18.3	35	Yes
	8	18.4	35	Yes
	9	18.4	35	Yes
	10	18.4	35	Yes
	11	18.4	35	Yes
	12	18.4	35	Yes
18	3	5.9	35	Yes
	4	7.3	35	Yes
	5	11.1	35	Yes
	6	15.1	35	Yes
	7	15.8	35	Yes
	8	15.9	35	Yes
	9	15.9	35	Yes
	10	15.9	35	Yes
	11	15.9	35	Yes
	12	15.9	35	Yes
19	3	5.7	35	Yes
	4	7.1	35	Yes
	5	10.9	35	Yes
	6	14.9	35	Yes
	7	15.6	35	Yes
	8	15.6	35	Yes
	9	15.6	35	Yes
	10	15.6	35	Yes
	11	15.6	35	Yes
	12	15.6	35	Yes
20	3	13.7	35	Yes
	4	15.1	35	Yes
	5	19.3	35	Yes
	6	23.3	35	Yes

NSA Number	Wind speed [m/s]	From WTGs [dB(A)]	Noise Limit (Night) [dB(A)]	Noise Limit complied with?
	7	24.0	35	Yes
	8	24.1	35	Yes
	9	24.1	35	Yes
	10	24.1	35	Yes
	11	24.1	35	Yes
	12	24.1	35	Yes

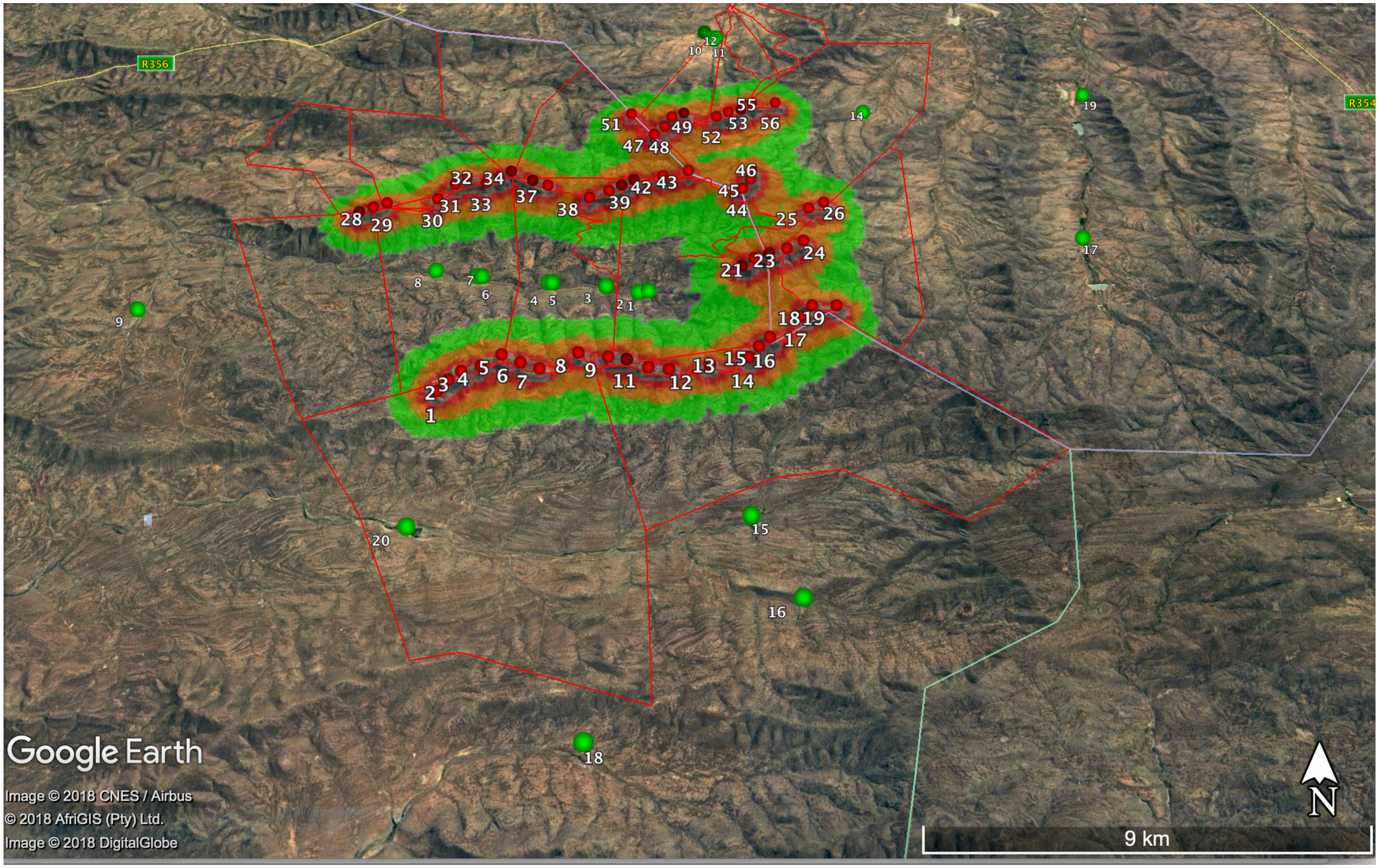

Figure 5 - Raster Image of Noise Isopleths & Noise Sensitive Areas

Green Dot = Noise Sensitive Area
Green Shading = 35-45 dB(A)
Orange Shading = >45 dB(A)

6.2 CUMULATIVE NOISE IMPACTS

The proposed windfarm is located adjacent to several other windfarms within 20 km of Kudusberg. This distance is appropriate from a noise impact perspective. There are other windfarms in the region (within 50 km), but theyare not listed below and were not taken into account due to their distance from the proposd development. The details of the windfarms that are applicable to assess cumulative noise impacts that were considered for the proposed Kudusberg WEF are listed below:

- Karreebosch WEF – 65 wind turbines
- Witberg WEF– 27 wind turbines
- Brandvalley WEF– 58 wind turbines
- Esizay WEF – 55 wind turbines
- Roggeveld WEF– 47 wind turbines
- Soetwater WEF– 43 wind turbines
- Karusa WEF– 43 wind turbines
- Rietkloof WEF– ~60 wind turbines

The locations of these turbines are recorded in Annexure D as a record of which positions informed the cumulative impact assessment. The same turbine data as described in Table 2 was used to model the cumulative impacts from all the adjacent windfarms. This is thus a worst-case scenario, as it is highly unlikely that all turbines will be operational simultaneously even if all the sites obtain the required regulatory approval. It is not anticipated that any future changes in the other windfarm layouts that were modelled (as included in Appendix A) will negatively impact these results, as future changes will most likely be a reduction in the number of turbines on those windfarms and not an increase in turbine numbers. If the final number of turbines is reduced or the layout changed such that no turbine is moved closer to a noise sensitive area, then remodelling will not be required, provided the final turbine choice sound power level is not greater than that that was used in this report (108.1 dBA).

The cumulative noise impact modelling result indicated the following:

Table 12 - Cumulative Noise Impacts

NSA Number	Maximum WTG noise from ALL wind farms including Kudusberg [dB(A)]	Noise Limit (Night) [dB(A)]	Noise Limit complied with?
1	33.8	35	Yes
2	33.7	35	Yes
3	32.9	35	Yes
4	32.3	35	Yes
5	32.1	35	Yes
6	31.8	35	Yes
7	31.7	35	Yes
8	31.9	35	Yes

NSA Number	Maximum WTG noise from ALL wind farms including Kudusberg [dB(A)]	Noise Limit (Night) [dB(A)]	Noise Limit complied with?
9	13.5	35	Yes
10	27.2	35	Yes
11	26.7	35	Yes
12	25.7	35	Yes
13	29.5	35	Yes
14	29.8	35	Yes
15	26.7	35	Yes
16	32.9	35	Yes
17	15.7	35	Yes
18	28.7	35	Yes
19	31.2	35	Yes
20	28.1	35	Yes

The modelling indicates that the cumulative impact will not exceed the night limit of 35 dB(A) or the day limit of 45 dB(A).

6.3 ASSESSMENT OF IMPACTS AND IDENTIFICATION OF MANAGEMENT ACTIONS

The impact of the noise pollution that can be expected from the site during the construction and operational phases is presented below. A summary of the noise impact assessment using the standard assessment criteria is provided in Tables 13 and Table 14.

6.4 ASSESSMENT AND MITIGATION FOR CONSTRUCTION PHASE

- There will be an impact on the immediate surrounding environment from the construction activities, especially if pile driving is to be done. This, however, will only occur if the underlying geological structure requires piling.
- The area surrounding the construction site will be affected for a short period of time in all directions by construction noise impacts, should several pieces of construction equipment be used simultaneously.
- The number of construction vehicles that will be used in the project will add to the existing ambient levels and will most likely cause a disturbing noise, albeit for a short period of time.

In conclusion, there will be a short-term increase in noise in the vicinity of the site during the construction phase as the ambient noise level will be exceeded. The impact during the construction phase will be difficult to mitigate. The significance of the construction noise impact is predicted to be very low (before and after mitigation).

The following mitigation measures are recommended for construction activities:

- All construction operations should only occur during daylight hours, if possible.
- No construction piling should occur at night. Piling should only occur during the hottest part of the day to take advantage of unstable atmospheric conditions.
- Construction staff should be given “noise sensitivity” training to mitigate the noise impacts caused during construction.

6.5 ASSESSMENT AND MITIGATION FOR OPERATIONAL PHASE

The ambient noise increases as the wind speed increases. Under very stable atmospheric conditions, a temperature inversion or a light wind, the turbines will in all likelihood not be operational as the cut-in speed is 3 m/s. As the wind speed increases above the cut-in speed the ambient noise will also increase. If the atmospheric conditions are such that the wind is very light (<4 m/s) at ground level but exceeds the cut-in speed at hub height i.e. the turbines will begin to operate, it is feasible that little ambient noise masking will occur. As the wind speed increases, the ambient noise also increases and masks the wind turbine noise. The critical wind speeds are thus between 4-6 m/s when there is little possibility of masking. Above 8m/s the wind noise starts masking the wind turbine noise. The noise modelling indicates that, in general, noise from the turbines will be below the SANS10103 limits for rural areas at a distance of approximately 500 m from the turbines. The significance of the potential noise impacts during the operational phase were assessed to be very low before mitigation.

6.6 RESULTS OF THE FIELD STUDY

The field study indicated that the ambient noise at the time of the survey was approximately 45 dB(A) with a wind speed of approximately 5.6 m/s (20 km/hr). The field study showed that there are natural noise sources that will provide a masking effect when the wind blows.

6.7 IMPACT ASSESSMENT SUMMARY

The assessment of impacts and recommendation of mitigation measures as discussed above and collated in Tables 13 - 16 below.

Table 13 - Impact assessment summary table for the Construction Phase

Impact pathway	Nature of potential impact/risk	Status[1]	Extent[2]	Duration[3]	Conse-quence	Probability	Reversibility of impact	Irreplaceability of receiving environment/ resource	Significance of impact/risk = consequence x probability (before mitigation)	Can impact be avoided?	Can impact be managed or mitigated ?	Potential mitigation measures	Significance of residual risk/ impact (after mitigation)	Ranking of impact/ risk	Confidence level
NOISE															
CONSTRUCTION PHASE															
Direct Impacts															
Noise emissions from the construction of the WEF	Noise impact	Negative	Local	Short Term	Slight	Very unlikely	High Reversibility	Resources are replaceable	Very Low	No	Yes	Staff to receive noise sensitivity training; Monitoring of noise; Limit high noise activities to daytime operations when possible, noting that operational requirements might not allow this due to various factors e.g. Crane use optimization, weather conditions etc.	Very Low	5	High, since based on actual measurements
Indirect Impacts															
None															

[1] Status: Positive (+) ; Negative (-)

[2] Site; Local (<10 km); Regional (<100); National; International

[3] Very short-term (instantaneous); Short-term (<1yr); Medium-term (1-10 years); Long-term (project duration); Permanent (beyond project decommissioning)

Table 14 - Impact assessment summary table for the Operational Phase

Impact pathway	Nature of potential impact/risk	Status	Extent	Duration	Conse-quence	Probability	Reversibility of impact	Irreplaceability of receiving environment/ resource	Significance of impact/risk = consequence x probability (before mitigation)	Can impact be avoided?	Can impact be managed or mitigated ?	Potential mitigation measures	Significance of residual risk/ impact (after mitigation)	Ranking of impact/ risk	Confidence level
NOISE															
OPERATIONAL PHASE															
Direct Impacts															
Noise emissions from the operation of the wind turbines	Noise impact	Negative	Local	Short Term	Slight	Very unlikely	High Reversibility	Resources are replaceable	Very Low	No	Yes	Ensure that noise monitoring is conducted during the commissioning phase to determine the actual noise impact during operations as per Table 15 below.	Very Low	5	High, since based on modelling and ambient measurements
Indirect Impacts															
None															

Table 15 - Impact assessment summary table for the Decommissioning Phase

Impact pathway	Nature of potential impact/risk	Status 4	Extent 5	Duration 6	Conse-quence	Probability	Reversibility of impact	Irreplaceability of receiving environment/ resource	Significance of impact/risk = consequence x probability (before mitigation)	Can impact be avoided?	Can impact be managed or mitigated ?	Potential mitigation measures	Significance of residual risk/ impact (after mitigation)	Ranking of impact/ risk	Confidence level
NOISE															
DECOMMISSIONING PHASE															
Direct Impacts															
Noise emissions from the decommissioning of the wind turbines	Noise impact	Negative	Local	Short Term	Slight	Very unlikely	High Reversibility	Resources are replaceable	Very Low	Yes	Yes	Staff to receive noise sensitivity training; Monitoring of noise; Limit high noise activities to daytime operations when possible, noting that operational requirements might not allow this due to various factors e.g. Crane use optimization, weather conditions etc.	Very Low	5	High, since based on actual measurements
Indirect Impacts															
None															

[4] Status: Positive (+) ; Negative (-)

[5] Site; Local (<10 km); Regional (<100); National; International

[6] Very short-term (instantaneous); Short-term (<1yr); Medium-term (1-10 years); Long-term (project duration); Permanent (beyond project decommissioning)

Table 16 - Cumulative impact assessment summary table

Impact pathway	Nature of potential impact/risk	Status	Extent	Duration	Conse-quence	Probability	Reversibility of impact	Irreplaceability of receiving environment/ resource	Significance of impact/risk = consequence x probability (before mitigation)	Can impact be avoided?	Can impact be managed or mitigated ?	Potential mitigation measures	Significance of residual risk/ impact (after mitigation)	Ranking of impact/ risk	Confidence level
NOISE															
CUMULATIVE IMPACTS															
Noise emissions from the operation of the wind turbines	Noise impact	Negative	Local	Short Term	Slight	Very unlikely	High Reversibility	Resources are replaceable	Very Low	Yes	Yes	Ensure that noise monitoring is conducted during the commissioning phase to determine the actual noise impact during operation.	Very Low	5	High, since based on modelling and ambient measurem ents

6.8 INPUT TO THE ENVIRONMENTAL MANAGEMENT PROGRAMME

Table 17 - Table of monitoring actions (Construction)

Impact	Mitigation/Management action	Monitoring		
		Methodology	***Frequency***	***Responsibility***
Reduce construction noise	Conduct noise sensitivity training for all construction staff	Training	Before construction commences	Holder of the EA
Monitor construction noise	Ambient noise monitoring to be conducted at the NSAs within the project area.	As per the requirements of SANS 10103	Four times during the construction phase	Specialist noise consultant

Table 18 - Table of monitoring actions (Operations)

Impact	Mitigation/Management action	Monitoring		
		Methodology	***Frequency***	***Responsibility***
Reduce operational noise	Confirm the noise impact by conducting monitoring.	As per the requirements of SANS 10103	Ambient noise monitoring to be conducted at the onsite at the noise sensitive area closest to a wind turbine when operations commence to verify the noise emissions meet the noise rating limit. Mitigation measures to be implemented if the noise impact exceeds the 35dB(A) noise rating limit. No further noise monitoring to be conducted if noise complaints are not received.	Specialist noise consultant

7 CONCLUSION AND RECOMMENDATIONS

Provided that the mitigation measures presented in the noise specialist study are implemented effectively, the noise from the turbines at the identified noise sensitive areas is predicted to be less than the 35 dB(A) night limit and 45 dB(A) day/night limit for rural areas presented in SANS 10103:2008. The overall noise impact with recommended mitigation is expected to be negative and of very low significance before and after mitigation.

The results of the study indicate that the following conclusions can be drawn:

- There will be a short-term increase in noise in the vicinity of the site during construction as the ambient level will be exceeded. The impact during construction will be difficult to mitigate.
- The impact of low frequency noise and infra sound will be negligible and there is no evidence to suggest that adverse health effects will occur as the sound power levels generated in the low frequency range are not high enough to cause physiological effects.

The following is recommended:

7.1.1 Construction Activities

- All construction operations should only occur during daylight hours if possible.
- No construction piling should occur at night. Piling should only occur during the hottest part of the day to take advantage of unstable atmospheric conditions.
- Ensuring that construction staff is given “noise sensitivity” training prior to construction commencing.

7.1.2 Operational Activities

a) Ambient noise monitoring is recommended at all noise sensitive areas once the turbines are erected. This is to determine whether or not the noise rating limits are being exceeded and to confirm the modelling results.

It is my recommendation that based on the results presented here, an Environmental Authorisation can be granted from a noise impact perspective irrespective of the alternatives that have been considered.

8 REFERENCES

1)	Australia Environmental Protect Agency - Wind farms - environmental noise guidelines. July 2009.
2)	Bell Acoustic Consulting. Low frequency noise and infrasound from Wind turbine generators: A literature review. George Bellhouse. June 2004.
3)	DEFRA – United Kingdom A Review of Published Research on Low Frequency Noise and its Effects. Geoff Leventhal. 2003
4)	DTI – United Kingdom The measurement of low frequency noise at 3 UK Wind Farms. Hayes Mackenzie. 2006
5)	Gold Coast Desalination Alliance (GCDA) – 2006 Environmental Impact Assessment Queensland Desalination Plant (Chapter 11).
6)	International Finance Corporation – 2007 General EHS Guidelines: Environmental Noise.
7)	ISO 9613-2 - Acoustics – Attenuation of sound during propagation outdoors. Part 2 – General method of calculation.
8)	Renewable Energy Research Laboratory - Department of Mechanical and Industrial Engineering. University of Massachusetts at Amherst. A White Paper on Wind Turbine Acoustic Noise. Authors: Anthony L. Rogers, Ph.D. James F. Manwell, Ph.D. Sally Wright. Amended January 2006
9)	South Africa - GNR.154 of January 1992: Noise control regulations in terms of section 25 of the Environment Conservation Act (ECA), 1989 (Act No. 73 of 1989)
10)	South Africa - GNR.155 of 10 January 1992: Application of noise control regulations made under section 25 of the Environment Conservation Act, 1989 (Act No. 73 of 1989)
11)	South Africa - SANS 10210:2004 Edition 2.2 – Calculating and predicting road traffic noise
12)	South Africa - SANS 10357:2004 Version 2.1 - The calculation of sound propagation by the Concawe method
13)	South Africa - SANS 10103:2008 Version 6 - The measurement and rating of environmental noise with respect to annoyance and to speech communication.
14)	Swedish Environmental Protection Agency – Noise Annoyance from Wind Turbines – a Review. Authors: Eja Pedersen, Högskolan i Halmstad. August 2003.
15)	University of Groningen - 11th International Meeting on Low Frequency Noise and Vibration and its Control. Do wind turbines produce significant low frequency sound levels? GP. van den Berg. September 2003.
16)	World Health Organization – Guidelines for Community Noise. 1999
17)	Larom, D, Garstang, M., Payne, K., Raspet, R. & Lindeque, M. 1997. The Journal of Experimental Biology 200, 421–431.
18)	Wagner, S., Bareib, R. and Guidati, G., Wind Turbine Noise, Springer, Berlin, 1996

APPENDICES

APPENDIX A - AIA Certificate

DEPARTMENT
OF LABOUR

Certificate

This is to certify that

SAFETRAIN CC
TRADING AS T\A SAFETECH

has been approved as an

APPROVED INSPECTION AUTHORITY

in terms of the Occupational Health and Safety Act, 1993,
for the monitoring of

Physical Stress Factors and Chemical Stress Factors (including Lead and Asbestos, Ergonomic hazards and Ventilation Installation) and Biological Factors

2009-08-27

DATE

CI 049 OH

CERTIFICATE NUMBER

CHIEF INSPECTOR

APPENDIX B – Calibration Certificate

sanas
Calibration Laboratory
148
1302

M AND N ACOUSTIC SERVICES (Pty) Ltd
Co. Reg. No: 2012/123238/07 VAT NO: 4300255876 BEE Status: Level 4
P.O. Box 61713, Pierre van Ryneveld, 0045
No. 15, Mustang Avenue
Pierre van Ryneveld, 0045
Tel: 012 689-2007 / 076 920 3070 • Fax: 086 211 4690
E-mail: admin@mnacoustics.co.za
Website: www.mnacoustics.co.za

CERTIFICATE OF CONFORMANCE

CERTIFICATE NUMBER	2017-AS-2098
ORGANISATION	SAFETRAIN T/A SAFETECH
ORGANISAION ADDRESS	P.O. BOX 27697, GREENACRES, PORT ELIZABETH, 6057
CALIBRATION OF	INTEGRATING SOUND LEVEL METER complete with ½" PRE-AMPLIFIER, ½" MICROPHONE and ⅓-OCTAVE/OCTAVE FILTER CARD
MANUFACTURERS	RION
MODEL NUMBERS	NL-32, NH-21, UC-53A and NX-22RT
SERIAL NUMBERS	00151075, 13814, 319366 and 00150957 V2.2
DATE OF CALIBRATION	07 NOVEMBER 2017
RECOMMENDED DUE DATE	-------------------------
PAGE NUMBER	PAGE 1 OF 5

This certificate is issued in accordance with the conditions of approval granted by the South African National Accreditation System (SANAS). This Certificate may not be reproduced without the written approval of SANAS and M and N Acoustic Services.

The measurement results recorded in this certificate were correct at the time of calibration. The subsequent accuracy will depend on factors such as care, handling, frequency of use and the amount of different users. It is recommended that re-calibration should be performed at an interval, which will ensure that the instrument remains within the desired limits and/or manufacturer's specifications.

The South African National Accreditation System (SANAS) is member of the International Laboratory Accreditation Cooperation (ILAC) Mutual Recognition Arrangement (MRA). This arrangement allows for mutual recognition of technical test and calibration data by member accreditation bodies worldwide. For more information on the arrangement please consult www.ilac.org

Calibrated by:	Authorized/Checked by:	Date of Issue:
W.S. SIBANYONI (CALIBRATION TECHNICIAN)	M. NAUDÉ (SANAS TECHNICAL SIGNATORY)	08 NOVEMBER 2017

Director: Marianka Naudé

Pages 2 to 4 available on request

APPENDIX C – Typical Sound Power and Sound Pressure Levels

Acoustic Power	Degree		Pressure Level	Source
32 GW	Deafening		225 dB	12” Cannon @ 12ft in front an below
25 to 40 MW			195 dB	Saturn Rocket
100 Kw			170 dB	Turbojet engine with afterburner
10 Kw			160 dB	Turbojet engine, 7000lb thrust
1 kW			150 dB	4 Propeller Airliner
100 W			140 dB	Artillery Fire
10 W	Threshold of pain		130 dB	Pneumatic Rock Drill
				130 dB causes immediate ea damage
3 W			125 dB	Small aircraft engine
1.0 W			120 dB	Thunder
100 Mw			110 dB	Close to train
10 mW	Very Loud		100 dB	Home lawn mower
1 mW			90 dB	Symphony or a Band
				85 dB regularly can cause ea damage
100 uW	Loud		80 dB	Police whistle
10 uW			70 dB	Average radio
1 uW	Moderate		60 dB	Normal conversational voice
100 nW			50 dB	Quiet stream
10 nW	Faint		40 dB	Quiet conversation
1 nW			30 dB	Very soft whisper
100 pW	Very faint		20 dB	Ticking of a watch
10 pW	Threshold of hearing		10 dB	
1 pW			0 dB	Absolute silence

Sound Perception

Change in Sound Level	Perception
3 dB	Barely perceptible
5 dB	Clearly perceptible
10 dB	Twice as loud

APPENDIX D – Adjoining Wind Farm WTG Positions

Rietkloof				Brandvalley				Karreebosch		
Longitude	Latitude	Elevation [m]		Longitude	Latitude	Elevation [m]		Longitude	Latitude	Elevation [m]
20°26'24.18"	33°04'57.38"	1198		20°23'36.20"	33°01'11.11"	1322		20°30'33.18"	32°47'27.95"	938
20°26'47.81"	33°04'48.70"	1200		20°23'37.82"	33°00'58.26"	1321		20°30'30.35"	32°47'39.93"	970
20°26'44.27"	33°04'27.49"	1180		20°23'45.84"	33°00'47.17"	1289		20°30'25.50"	32°46'06.06"	970
20°27'13.28"	33°04'47.13"	1240		20°23'50.44"	32°58'20.63"	1190		20°30'37.28"	32°45'58.37"	940
20°27'23.56"	33°04'38.07"	1211		20°24'00.40"	32°59'35.37"	1280		20°30'37.67"	32°47'08.43"	930
20°27'42.27"	33°04'52.59"	1210		20°24'11.92"	33°01'09.07"	1309		20°30'16.42"	32°48'01.50"	1026
20°28'06.39"	33°04'55.28"	1182		20°24'25.27"	32°58'16.83"	1210		20°30'18.08"	32°46'16.71"	998
20°26'12.35"	33°03'50.84"	1203		20°24'24.81"	33°01'01.27"	1300		20°30'30.19"	32°49'30.59"	1120
20°26'23.02"	33°03'41.61"	1230		20°24'33.36"	32°57'59.95"	1308		20°29'33.58"	32°48'06.46"	1010
20°26'31.96"	33°03'31.15"	1216		20°24'33.87"	32°57'47.06"	1320		20°30'21.79"	32°47'49.92"	989
20°27'16.77"	33°03'36.50"	1180		20°24'35.10"	32°57'21.60"	1369		20°30'14.51"	32°46'29.04"	990
20°30'05.02"	33°05'08.34"	1205		20°24'37.58"	32°57'34.56"	1320		20°32'33.58"	32°50'59.29"	1058
20°30'29.33"	33°05'02.09"	1219		20°24'42.25"	32°57'10.20"	1345		20°30'42.55"	32°49'08.53"	1060
20°30'38.06"	33°04'37.14"	1211		20°24'57.51"	32°55'29.35"	1420		20°30'36.72"	32°49'19.68"	1110
20°30'43.65"	33°04'50.27"	1258		20°24'59.69"	32°55'51.45"	1378		20°29'34.59"	32°47'53.21"	1030
20°31'30.21"	33°04'31.37"	1228		20°25'19.74"	33°01'12.67"	1220		20°32'41.00"	32°50'08.37"	1076
20°31'27.45"	33°03'35.42"	1226		20°25'23.79"	32°55'32.32"	1400		20°30'39.56"	32°49'47.42"	1110
20°31'19.84"	33°03'19.55"	1250		20°25'33.17"	33°01'04.80"	1210		20°32'35.96"	32°50'46.60"	1062
20°31'30.90"	33°03'02.63"	1220		20°25'44.10"	32°59'03.38"	1280		20°30'44.22"	32°50'01.99"	1128
20°31'38.99"	33°02'51.75"	1240		20°26'03.36"	32°56'43.86"	1340		20°30'40.19"	32°50'14.05"	1110
20°31'50.02"	33°02'42.32"	1210		20°26'17.05"	32°56'23.90"	1390		20°29'21.94"	32°48'13.97"	983
20°31'45.25"	33°02'25.62"	1210		20°26'43.07"	32°55'44.03"	1405		20°30'28.72"	32°50'36.44"	1187
20°31'41.31"	33°02'13.06"	1238		20°26'46.09"	32°56'11.32"	1410		20°30'30.87"	32°50'50.87"	1147
20°31'53.12"	33°02'04.89"	1250		20°27'06.33"	32°55'54.69"	1416		20°30'18.28"	32°51'13.52"	1200
20°32'03.71"	33°01'55.61"	1260		20°27'24.88"	32°59'06.20"	1290		20°30'23.77"	32°51'02.14"	1176
20°32'17.02"	33°01'49.29"	1290		20°27'50.99"	32°58'55.95"	1363		20°32'38.21"	32°50'20.89"	1070
20°32'25.08"	33°01'38.36"	1320		20°28'03.52"	32°58'48.59"	1386		20°32'40.22"	32°50'34.94"	1091
20°32'20.27"	33°01'21.93"	1320		20°28'24.33"	32°59'27.91"	1308		20°28'35.49"	32°49'52.89"	1020
20°32'19.90"	33°01'09.03"	1330		20°28'24.15"	32°59'49.80"	1288		20°28'39.78"	32°50'17.15"	1113
20°32'31.75"	33°01'00.93"	1318		20°28'39.12"	32°58'36.92"	1427		20°28'40.92"	32°50'40.74"	1040
20°31'58.05"	33°00'40.83"	1328		20°28'54.42"	32°58'01.90"	1510		20°28'45.91"	32°50'53.34"	1040
20°32'08.84"	33°00'31.66"	1316		20°29'05.61"	32°58'50.45"	1409		20°28'45.03"	32°51'06.00"	1058
20°31'11.16"	32°59'46.78"	1351		20°29'06.72"	32°57'54.29"	1478		20°28'30.52"	32°49'28.62"	980
20°30'45.54"	32°59'46.97"	1380		20°29'11.42"	32°58'17.90"	1455		20°29'39.51"	32°47'39.85"	980
20°30'20.05"	32°59'45.72"	1369		20°29'32.94"	32°57'53.95"	1409		20°25'45.28"	32°54'17.49"	1160
20°29'46.43"	32°59'42.49"	1350		20°30'20.44"	32°57'48.80"	1380		20°25'54.12"	32°54'07.72"	1160
20°30'08.70"	33°00'14.48"	1288		20°30'41.46"	32°58'10.73"	1394		20°25'56.55"	32°53'55.13"	1204
20°30'01.91"	33°00'26.02"	1297		20°30'54.18"	32°58'03.59"	1369		20°26'00.52"	32°53'43.07"	1239
20°29'55.99"	33°00'38.00"	1260		20°31'44.49"	32°57'55.13"	1355		20°25'59.73"	32°53'29.83"	1230
20°29'50.86"	33°00'50.12"	1260		20°31'56.28"	32°57'46.89"	1400		20°26'15.92"	32°52'41.15"	1140
20°29'53.20"	33°01'02.82"	1246		20°32'08.84"	32°57'39.50"	1366		20°26'18.04"	32°52'28.99"	1135
20°29'57.14"	33°01'15.29"	1221		20°24'24.73"	32°59'41.10"	1270		20°26'08.04"	32°51'44.25"	1051
20°30'04.93"	33°01'37.92"	1200		20°24'29.38"	32°59'28.86"	1280		20°26'09.70"	32°51'31.34"	1077
20°30'11.58"	33°02'15.16"	1170		20°24'41.92"	32°59'21.55"	1270		20°26'11.71"	32°51'18.42"	1110
20°30'11.14"	33°02'33.92"	1147		20°24'53.56"	32°59'11.12"	1266		20°26'20.20"	32°51'08.49"	1114

Rietkloof				Brandvalley				Karreebosch		
Longitude	Latitude	Elevation [m]		Longitude	Latitude	Elevation [m]		Longitude	Latitude	Elevation [m]
20°29'01.92"	33°02'22.86"	1156		20°25'17.86"	32°59'04.74"	1286		20°26'26.39"	32°50'57.28"	1081
20°28'23.90"	33°01'15.40"	1280		20°28'30.60"	32°58'47.67"	1420		20°26'52.78"	32°49'30.37"	940
20°28'29.59"	33°01'03.43"	1231		20°28'46.68"	32°58'13.03"	1453		20°26'59.04"	32°49'19.29"	950
20°28'23.60"	33°00'44.44"	1280		20°28'51.75"	32°58'29.66"	1450		20°27'03.74"	32°49'04.99"	943
20°28'32.36"	33°00'33.88"	1260		20°24'36.81"	33°00'53.24"	1243		20°27'00.48"	32°48'50.66"	960
20°29'00.01"	33°02'42.77"	1120		20°23'48.07"	32°59'42.92"	1282		20°27'03.92"	32°48'38.36"	979
20°33'02.47"	33°03'28.28"	1205		20°24'06.86"	32°59'23.72"	1240		20°27'12.12"	32°48'28.27"	966
20°33'05.59"	33°03'15.57"	1199		20°25'19.90"	32°58'21.05"	1270		20°30'57.15"	32°49'02.99"	1028
20°33'01.45"	33°03'01.41"	1209		20°28'21.75"	32°58'17.34"	1394		20°30'15.51"	32°49'36.06"	1081
20°32'59.88"	33°02'48.54"	1204		20°29'27.48"	32°58'07.75"	1423		20°32'42.30"	32°49'55.32"	1010
20°33'03.34"	33°02'35.90"	1215		20°28'50.03"	32°59'24.72"	1336		20°25'37.40"	32°54'27.75"	1145
20°27'57.12"	33°00'36.62"	1242		20°28'36.43"	32°59'06.60"	1370		20°26'17.47"	32°52'09.33"	1080
20°32'19.70"	33°00'21.35"	1290		20°25'44.81"	33°00'55.98"	1184		20°26'48.20"	32°49'42.23"	937
20°31'28.69"	33°04'54.31"	1184						20°27'11.87"	32°48'13.14"	1000
20°28'27.72"	33°01'27.87"	1226						20°28'34.86"	32°50'05.16"	1086
								20°30'33.63"	32°50'24.87"	1147
								20°26'10.75"	32°52'54.62"	1150
								20°28'49.93"	32°49'43.05"	972
								20°28'45.93"	32°51'19.95"	1053
								20°26'00.02"	32°53'11.41"	1210

Witberg				Esizayo				Roggeveld		
Longitude	Latitude	Elevation [m]		Longitude	Latitude	Elevation [m]		Longitude	Latitude	Elevation [m]
20°28'08.82"	33°16'59.07"	1442.7		20°33'40.64"	32°57'30.35"	1380		20°29'48.80"	32°56'31.84"	1392
20°28'09.84"	33°17'07.88"	1450		20°35'09.27"	32°57'22.54"	1335		20°29'59.40"	32°56'24.35"	1423
20°27'58.98"	33°17'09.71"	1450		20°33'59.92"	32°57'25.55"	1370		20°30'12.40"	32°56'18.53"	1410
20°27'48.42"	33°17'11.90"	1437.6		20°38'07.36"	33°01'29.88"	1200		20°30'19.68"	32°56'08.68"	1383
20°27'29.38"	33°17'22.74"	1412.8		20°37'22.97"	33°01'44.37"	1201		20°30'26.37"	32°55'58.45"	1370
20°27'16.41"	33°17'24.43"	1410		20°38'24.73"	33°01'23.44"	1180		20°30'20.28"	32°55'44.74"	1401
20°27'02.33"	33°17'21.48"	1400		20°34'50.00"	32°57'24.09"	1333		20°30'25.43"	32°55'34.16"	1420
20°26'49.53"	33°17'19.94"	1381.7		20°38'28.65"	33°01'07.22"	1140		20°30'30.49"	32°55'23.53"	1418
20°26'51.87"	33°17'30.93"	1400		20°38'47.93"	33°01'05.65"	1120		20°30'34.79"	32°55'12.02"	1387
20°26'39.57"	33°17'31.76"	1380.9		20°38'52.28"	32°59'00.64"	1218		20°30'49.65"	32°55'24.78"	1375
20°27'07.29"	33°17'36.05"	1380		20°35'28.53"	32°57'22.60"	1294		20°31'00.62"	32°55'17.37"	1350
20°26'28.02"	33°17'32.85"	1352.2		20°36'31.06"	33°01'13.36"	1222		20°31'08.87"	32°55'08.31"	1310
20°26'15.98"	33°17'45.06"	1346.2		20°37'48.06"	33°01'36.33"	1190		20°30'31.77"	32°54'58.90"	1328
20°26'31.76"	33°18'00.94"	1340		20°34'28.82"	32°57'22.40"	1328		20°30'33.25"	32°54'45.24"	1340
20°26'18.51"	33°17'58.18"	1353.5		20°38'34.92"	32°59'07.08"	1205		20°30'47.32"	32°54'40.94"	1340
20°26'05.34"	33°17'55.46"	1370		20°36'17.80"	33°00'21.36"	1170		20°30'59.89"	32°54'34.73"	1320
20°25'51.44"	33°17'57.28"	1343.1		20°35'08.37"	33°00'34.12"	1199		20°31'07.55"	32°54'25.18"	1320
20°27'28.41"	33°16'59.33"	1378.8		20°36'54.18"	33°01'16.68"	1199		20°31'20.88"	32°54'19.25"	1301
20°27'14.18"	33°17'00.46"	1387.1		20°38'07.45"	33°01'08.78"	1139		20°31'29.89"	32°54'10.58"	1291
20°26'59.96"	33°17'00.88"	1369.3		20°39'15.22"	32°59'47.79"	1120		20°31'30.66"	32°53'56.88"	1260
20°22'22.34"	33°17'49.96"	1230		20°35'41.12"	33°00'37.48"	1180		20°31'35.77"	32°53'45.18"	1230

Witberg				Esizayo				Roggeveld		
Longitude	Latitude	Elevation [m]		Longitude	Latitude	Elevation [m]		Longitude	Latitude	Elevation [m]
20°21'59.66"	33°17'54.29"	1220		20°38'32.57"	33°00'50.99"	1077		20°31'41.21"	32°53'34.61"	1194
20°21'45.50"	33°17'54.78"	1220		20°35'58.51"	33°00'26.17"	1160		20°31'47.35"	32°53'24.44"	1200
20°21'31.88"	33°17'54.92"	1220		20°37'46.52"	33°00'03.77"	1100		20°31'55.36"	32°53'15.25"	1230
20°28'23.16"	33°17'04.97"	1424.4		20°37'03.75"	33°01'31.32"	1190		20°32'04.80"	32°53'06.84"	1218
20°25'38.42"	33°17'59.93"	1320.1		20°38'09.70"	32°59'49.23"	1120		20°32'14.43"	32°52'57.72"	1173
20°26'44.72"	33°17'59.29"	1340		20°39'11.54"	32°59'02.32"	1200		20°32'23.56"	32°52'49.13"	1180
				20°38'21.34"	32°59'29.78"	1128		20°32'29.26"	32°52'38.65"	1188
				20°37'05.80"	33°01'03.72"	1145		20°32'48.91"	32°52'22.79"	1230
				20°38'32.85"	32°59'42.80"	1119		20°32'57.06"	32°52'13.58"	1205
				20°39'48.11"	32°59'12.16"	1180		20°32'36.70"	32°52'27.87"	1240
				20°36'45.10"	32°59'08.38"	1165		20°30'05.26"	32°54'21.85"	1304
				20°40'51.63"	32°59'26.94"	1174		20°29'51.83"	32°54'06.01"	1298
				20°35'08.94"	32°58'32.35"	1196		20°30'03.85"	32°54'00.56"	1313
				20°38'15.65"	32°59'07.03"	1179		20°30'10.80"	32°53'50.33"	1286
				20°37'19.56"	32°59'58.82"	1105		20°30'13.89"	32°53'38.86"	1270
				20°35'05.32"	32°57'42.00"	1251		20°30'21.01"	32°53'26.18"	1270
				20°37'21.71"	32°59'06.87"	1158		20°30'25.68"	32°53'15.42"	1261
				20°36'35.18"	33°00'14.92"	1120		20°30'24.66"	32°53'04.04"	1236
				20°35'40.16"	32°57'06.40"	1197		20°30'18.27"	32°52'44.60"	1270
				20°35'24.40"	32°58'22.66"	1210		20°32'25.36"	32°51'34.69"	1100
				20°36'56.46"	32°59'53.88"	1111		20°32'28.27"	32°51'23.15"	1089
				20°35'07.17"	32°57'58.25"	1221		20°32'33.48"	32°51'12.61"	1087
				20°35'21.92"	33°00'22.80"	1161		20°30'34.11"	32°52'41.54"	1240
				20°36'40.63"	33°01'28.00"	1160		20°30'05.02"	32°52'46.81"	1230
				20°39'40.12"	33°00'25.20"	1060		20°29'29.70"	32°56'43.50"	1410
				20°39'28.85"	32°59'08.86"	1182		20°29'30.70"	32°56'58.59"	1419
				20°37'21.56"	32°59'42.59"	1118				
				20°36'58.31"	33°00'11.74"	1104				
				20°34'53.49"	32°58'42.04"	1171				
				20°38'11.37"	33°00'52.55"	1083				
				20°36'27.28"	33°00'57.11"	1142				
				20°35'34.50"	32°56'40.40"	1141				
				20°34'46.05"	32°57'45.19"	1246				
				20°35'31.94"	32°58'58.40"	1160				

Soetwater				Karusa		
Longitude	Latitude	Elevation [m		Longitude	Latitude	Elevation [m
20°42'02.34	32°44'33.40	1420		20°37'51.20	32°46'50.73	1310
20°41'15.97	32°44'03.45	1395		20°37'43.61	32°46'58.09	1310
20°40'51.47	32°43'54.06	1408		20°38'45.89	32°47'29.63	1315
20°40'28.05	32°43'46.64	1410		20°38'38.17	32°47'36.42	1340
20°40'25.19	32°43'55.65	1394		20°38'30.19	32°47'42.67	1333
20°40'10.60	32°43'58.52	1390		20°38'13.19	32°47'44.41	1309
20°40'05.60	32°44'06.40	1390		20°37'58.00	32°47'49.47	1231
20°39'54.17	32°44'10.83	1384		20°37'43.41	32°47'52.40	1241
20°39'38.74	32°44'12.97	1370		20°37'29.87	32°47'55.90	1260
20°39'23.12	32°44'14.92	1347		20°37'18.09	32°48'00.65	1256
20°39'05.72	32°44'15.58	1360		20°37'09.37	32°48'17.43	1250
20°38'58.76	32°44'30.92	1316		20°37'05.78	32°48'29.30	1250
20°38'53.65	32°44'38.90	1310		20°37'03.39	32°48'38.68	1263
20°38'44.38	32°44'44.99	1320		20°37'01.31	32°48'48.00	1286
20°38'34.41	32°44'50.65	1320		20°37'05.58	32°49'00.08	1280
20°38'24.65	32°44'56.35	1310		20°37'08.81	32°49'11.83	1238
20°38'13.37	32°45'12.42	1293		20°37'05.55	32°49'39.38	1212
20°37'59.92	32°45'15.87	1290		20°37'01.28	32°49'47.88	1244
20°37'43.52	32°45'17.59	1320		20°36'57.13	32°49'56.41	1270
20°37'32.83	32°45'22.59	1314		20°36'54.97	32°50'05.91	1260
20°37'36.62	32°45'34.30	1308		20°36'49.90	32°50'14.04	1260
20°37'40.40	32°45'46.10	1330		20°36'46.66	32°50'23.60	1264
20°44'16.41	32°46'12.27	1364		20°36'30.49	32°50'48.94	1240
20°43'52.03	32°46'28.21	1308		20°36'18.84	32°50'53.80	1206
20°42'34.39	32°47'23.36	1150		20°36'03.62	32°51'32.40	1226
20°41'47.31	32°47'53.19	1189		20°35'52.88	32°51'37.49	1246
20°41'50.47	32°48'08.06	1213		20°35'42.80	32°51'43.27	1227
20°41'40.83	32°48'13.55	1237		20°37'48.68	32°52'51.08	1230
20°41'54.15	32°44'39.15	1379		20°38'12.30	32°52'52.82	1211
20°38'48.16	32°44'16.36	1360		20°38'31.47	32°52'50.99	1210
20°38'21.03	32°45'05.39	1300		20°38'38.54	32°52'43.53	1213
20°37'50.74	32°46'02.55	1275		20°38'41.70	32°52'33.65	1180
20°43'50.02	32°45'45.80	1370		20°38'45.44	32°52'24.46	1160
20°43'37.55	32°45'51.04	1370		20°38'47.29	32°52'14.22	1150
20°44'18.42	32°46'02.09	1390		20°37'32.90	32°46'24.23	1301
20°43'56.76	32°46'06.28	1366		20°37'34.92	32°46'36.21	1304
20°42'26.69	32°47'33.01	1212		20°38'00.19	32°47'11.17	1339
20°42'19.71	32°47'39.68	1243		20°37'58.80	32°47'21.36	1347
20°42'11.23	32°47'45.05	1248		20°39'43.02	32°47'33.21	1285
20°41'58.19	32°47'48.04	1208		20°39'36.53	32°47'40.47	1326
20°41'33.74	32°48'20.42	1250		20°39'29.70	32°47'47.63	1333
20°41'21.77	32°48'22.99	1267		20°39'12.94	32°47'45.63	1321

Soetwater				Karusa		
Longitude	Latitude	Elevation [m		Longitude	Latitude	Elevation [m
20°41'15.33	32°48'30.06	1270		20°37'09.81	32°48'06.67	1240