Renewable Energy Investments South Africa

NOISE IMPACT STUDY FOR ENVIRONMENTAL IMPACT ASSESSMENT

Establishment of the Happy Valley Wind Energy Facility on Farm 810 near the town of Humansdorp, Eastern Cape

Study done for:

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Title:

Noise Impact Assessment for Environmental Impact Assessment: Establishment of the Happy Valley Wind Energy Facility on Farm 810 near the town of Humansdorp, Eastern Cape.

Client:

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GLOSSARY OF ABBREVIATIONS

DEDEA	Department of Economic Development and Environmental Affairs
DEA	Department of Environmental Affairs
EAP	Environmental Assessment Practitioner
ECA	Environment Conservation Act (Act 78 of 1989)
ECO	Environmental Control Officer
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EMS	Environmental Management System
FEL	Front End Loader
IAPs	Interested and Affected Parties
i.e.	that is
IEM	Integrated Environmental Management
km	kilometres
LHD	Load haul dumper
m	Meters (measurement of distance)
m^2	Square meter
m^3	Cubic meter
mamsl	Meters above mean sea level
MENCO	M^2 Environmental Connections cc
NEMA	National Environmental Management Act, 1998 (Act 107 of 1998)
NCR	Noise Control Regulations (under Section 25 of the ECA)
NGO	Non-government Organisation
PPE	Personal Protective Equipment
PPP	Public Participation Process
SABS	South African Bureau of Standards
SANS	South African National Standards
SHEQ	Safety Health Environment and Quality
TLB	Tip Load Bucket
UTM	Universal Transverse Mercator
WEF	Wind Energy Facility
WHO	World Health Organisation
WTG	Wind Turbine Generator

GLOSSARY OF TERMS

1/3-Octave Band	A filter with a bandwidth of one-third of an octave representing four semitones, or notes on the musical scale. This relationship is applied to both the width of the band, and the centre frequency of the band. See also definition of octave band.
A – Weighting	An internationally standardised frequency weighting that approximates the frequency response of the human ear and gives an objective reading that therefore agrees with the subjective human response to that sound.
Air Absorption	The phenomena of attenuation of sound waves with distance propagated in air, due to dissipative interaction within the gas molecules.
Alternatives	A possible course of action, in place of another, that would meet the same purpose and need (of proposal). Alternatives can refer to any of the following, but are note limited hereto: alternative sites for development, alternative site layouts, alternative designs, alternative processes and materials. In Integrated Environmental Management the so-called "no go" alternative refers to the option of not allowing the development and may also require investigation in certain circumstances.
Ambient	The conditions surrounding an organism or area.
Ambient Noise	The all-encompassing sound at a point being composed of sounds from many sources both near and far. It includes the noise from the noise source under investigation.
Ambient Sound	The all-encompassing sound at a point being composite of sounds from near and far.
Ambient Sound Level	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 a meter was put into operation. In this report the term Background Ambient Sound Level will be used.
Amplitude Modulated Sound	A sound that noticeably fluctuates in loudness over time.
Applicant	Any person who applies for an authorisation to undertake a listed activity or to cause such activity in terms of the relevant environmental legislation.
Assessment	The process of collecting, organising, analysing, interpreting and communicating data that is relevant to some decision.
Audible Frequency Range	Generally assumed to be the range from about 20 Hz to 20,000 Hz, the range of frequencies that our ears perceive as sound.
Background Ambient Sound Level	The level of the ambient sound indicated on a sound level meter in the absence of the sound under investigation (e.g. sound from a particular noise source or sound generated for test purposes). Ambient sound level as per Noise Control Regulations.
C-Weighting	This is an international standard filter, which can be applied to a pressure signal or to a *SPL* or *PWL* spectrum, and which is essentially a pass-band filter in the frequency range of approximately 63 to 4000 Hz. This filter provides a more constant, flatter, frequency response, providing significantly less adjustment than the A-scale filter for frequencies less than 1000 Hz.
dB(A)	Sound Pressure Level in decibel that has been A-weighted, or filtered, to match the response of the human ear.
Decibel (db)	A logarithmic scale for sound corresponding to a multiple of 10 of the threshold of hearing. Decibels for sound levels in air are referenced to an atmospheric pressure of 20 μ Pa.
Diffraction	Modification of the progressive wave distribution due to the presence of obstacles in the field. Reflection and refraction are special cases of diffraction.
Direction of Propagation	The direction of flow of energy associated with a wave.
Disturbing noise	Means a noise level that exceeds the zone sound level or, if no zone sound level has been designated, a noise level that exceeds the ambient sound level

	at the same measuring point by 7 dBA or more.
Environment	The external circumstances, conditions and objects that affect the existence and development of an individual, organism or group; these circumstances include biophysical, social, economic, historical, cultural and political aspects.
Environmental Control Officer	Independent Officer employed by the applicant to ensure the implementation of the Environmental Management Plan (EMP) and manages any further environmental issues that may arise.
Environmental impact	A change resulting from the effect of an activity on the environment, whether desirable or undesirable. Impacts may be the direct consequence of an organisation's activities or may be indirectly caused by them.
Environmental Impact Assessment	An Environmental Impact Assessment (EIA) refers to the process of identifying, predicting and assessing the potential positive and negative social, economic and biophysical impacts of any proposed project, plan, programme or policy that requires authorisation of permission by law and that may significantly affect the environment. The EIA includes an evaluation of alternatives, as well as recommendations for appropriate mitigation measures for minimising or avoiding negative impacts, measures for enhancing the positive aspects of the proposal, and environmental management and monitoring measures.
Environmental issue	A concern felt by one or more parties about some existing, potential or perceived environmental impact.
Equivalent continuous A-weighted sound exposure level ($L_{Aeq,T}$)	The value of the average A-weighted sound pressure level measured continuously within a reference time interval *T*, which have the same mean-square sound pressure as a sound under consideration for which the level varies with time.
Equivalent continuous A-weighted rating level ($L_{Req,T}$)	The Equivalent continuous A-weighted sound exposure level *($L_{Aeq,T}$)* to which various adjustments has been added. More commonly used as ($L_{Req,d}$) over a time interval 06:00 – 22:00 (T=16 hours) and ($L_{Req,n}$) over a time interval of 22:00 – 06:00 (T=8 hours).
Footprint area	Area to be used for the construction of the proposed development, which does not include the total study area.
Frequency	The rate of oscillation of a sound, measured in units of Hertz (Hz) or kiloHertz (kHz). One hundred Hz is a rate of one hundred times per second. The frequency of a sound is the property perceived as pitch: a low-frequency sound (such as a bass note) oscillates at a relatively slow rate, and a high-frequency sound (such as a treble note) oscillates at a relatively high rate.
Green field	A parcel of land not previously developed beyond that of agriculture or forestry use; virgin land. The opposite of Green field is Brown field, which is a site previously developed and used by an enterprise, especially for a manufacturing or processing operation. The term Brown field suggests that an investigation should be made to determine if environmental damage exists.
G-Weighting	An International Standard filter used to represent the infrasonic components of a sound spectrum.
Harmonics	Any of a series of musical tones for which the frequencies are integral multiples of the frequency of a fundamental tone.
Infrasound	Sound with a frequency content below the threshold of hearing, generally held to be about 20 Hz. Infrasonic sound with sufficiently large amplitude can be perceived, and is both heard and felt as vibration. Natural sources of infrasound are waves, thunder and wind.
Integrated Development Plan	A participatory planning process aimed at developing a strategic development plan to guide and inform all planning, budgeting, management and decision-making in a Local Authority, in terms of the requirements of Chapter 5 of the Municipal Systems Act, 2000 (Act 32 of 2000).
Integrated Environmental Management	IEM provides an integrated approach for environmental assessment, management, and decision-making and to promote sustainable development and the equitable use of resources. Principles underlying IEM provide for a democratic, participatory, holistic, sustainable, equitable and accountable

	approach.
Interested and affected parties	Individuals or groups concerned with or affected by an activity and its consequences. These include the authorities, local communities, investors, work force, consumers, environmental interest groups and the general public.
Key issue	An issue raised during the Scoping process that has not received an adequate response and that requires further investigation before it can be resolved.
Listed activities	Development actions that is likely to result in significant environmental impacts as identified by the delegated authority (formerly the Minister of Environmental Affairs and Tourism) in terms of Section 21 of the Environment Conservation Act.
Loudness	The attribute of an auditory sensation that describes the listener's ranking of sound in terms of its audibility.
Magnitude of impact	Magnitude of impact means the combination of the intensity, duration and extent of an impact occurring.
Masking	The raising of a listener's threshold of hearing for a given sound due to the presence of another sound.
Mitigation	To cause to become less harsh or hostile.
Negative impact	A change that reduces the quality of the environment (for example, by reducing species diversity and the reproductive capacity of the ecosystem, by damaging health, or by causing nuisance).
Noise	a. Sound that a listener does not wish to hear (unwanted sounds). b. Sound from sources other than the one emitting the sound it is desired to receive, measure or record. c. A class of sound of an erratic, intermittent or statistically random nature.
Noise Level	The term used in lieu of sound level when the sound concerned is being measured or ranked for its undesirability in the contextual circumstances.
Noise-sensitive development	developments that could be influenced by noise such as: a) districts (see table 2 of SANS 10103:2008) 1. rural districts, 2. suburban districts with little road traffic, 3. urban districts, 4. urban districts with some workshops, with business premises, and with main roads, 5. central business districts, and 6. industrial districts; b) educational, residential, office and health care buildings and their surroundings; c) churches and their surroundings; d) auditoriums and concert halls and their surroundings; e) recreational areas; and f) nature reserves. In this report Noise-sensitive developments is also referred to as a Potential Sensitive Receptor
Octave Band	A filter with a bandwidth of one octave, or twelve semi-tones on the musical scale representing a doubling of frequency.
Positive impact	A change that improves the quality of life of affected people or the quality of the environment.
Property	Any piece of land indicated on a diagram or general plan approved by the Surveyor-General intended for registration as a separate unit in terms of the Deeds Registries Act and includes an erf, a site and a farm portion as well as the buildings erected thereon
Public Participation Process	A process of involving the public in order to identify needs, address concerns, choose options, plan and monitor in terms of a proposed project, programme or development
Reverberant Sound	The sound in an enclosure excluding that is received directly from the source.
Reverberation	The persistence, after emission of a sound has stopped, of a sound field within

	an enclosure.
Significant Impact	An impact can be deemed significant if consultation with the relevant authorities and other interested and affected parties, on the context and intensity of its effects, provides reasonable grounds for mitigating measures to be included in the environmental management report. The onus will be on the applicant to include the relevant authorities and other interested and affected parties in the consultation process. Present and potential future, cumulative and synergistic effects should all be taken into account.
Sound Level	The level of the frequency weighted and time weighted sound pressure as determined by a sound level meter.
Sound Power	Of a source, the total sound energy radiated per unit time.
Sound Pressure Level (SPL)	Of a sound, 20 times the logarithm to the base 10 of the ratio of the RMS sound pressure level to the reference sound pressure level. International values for the reference sound pressure level are 20 micropascals in air and 100 millipascals in water. SPL is reported as L_p in dB (not weighted) or in various other weightings.
Soundscape	Sound or a combination of sounds that forms or arises from an immersive environment. The study of soundscape is the subject of acoustic ecology. The idea of soundscape refers to both the natural acoustic environment, consisting of natural sounds, including animal vocalizations and, for instance, the sounds of weather and other natural elements; and environmental sounds created by humans, through musical composition, sound design, and other ordinary human activities including conversation, work, and sounds of mechanical origin resulting from use of industrial technology. The disruption of these acoustic environments results in noise pollution.
Study area	Refers to the entire study area encompassing all the alternative routes as indicated on the study area map.
Sustainable Development	Development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts: the concept of "needs", in particular the essential needs of the world's poor, to which overriding priority should be given; and the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and the future needs (Brundtland Commission, 1987).
Zone of Potential Influence	The area defined as the radius about an object, or objects beyond which the noise impact will be insignificant.
Zone Sound Level	Means a derived dBA value determined indirectly by means of a series of measurements, calculations or table readings and designated by a local authority for an area. This is similar to the Rating Level as defined in SANS10103.

1 INTRODUCTION

1.1 INTRODUCTION AND PURPOSE

M2 Environmental Connections was commissioned to undertake a specialist study to determine the potential noise impact on the surrounding sound environment due to the establishment of the Happy Valley Wind Energy Facility (WEF) on Farm 810 close to the town of Humansdorp, in the Eastern Cape.

This report describes the potential noise impact that such a facility may have on the surrounding sound environment, highlighting the methods used, potential issues identified, findings and recommendations.

1.2 BRIEF PROJECT DESCRIPTION

Renewable Energy Investments South Africa proposes the development of a wind energy facility and associated infrastructure on Farm 810 (remaining extent and portion 1) near Humansdorp, Eastern Cape.

The area proposed for the WEF is approximately 13 km^2, with the study area investigated being approximately 90 km^2. The facility and associated infrastructure include:

- Up to **15 wind turbines** with associated **Concrete foundations**, although the current layout projects only 13 wind turbines;
- Each wind turbine will consist of a **steel tower**, of up to 105 m high, a **nacelle** (gear box) and three **rotor blades** with a rotor diameter of up to 90 m (i.e. each blade up to 45 m in length);
- Underground electrical distribution **cabling** between the turbines, to be laid underground where practical;
- One on-site **substation** with an associated transformer;
- **Power lines** linking to Eskom's existing substation (Diep River of Melkhout);
- **Internal access roads** to each wind turbine within the facility; and
- Small office/control room/workshop building.

1.3 TERMS OF REFERENCE

SANS 10328:2008 (Edition 2) specifies the methods to assess the noise impacts on the environment due to a proposed activity that might impact on the environment. The standard also stipulates the minimum requirements to be investigated for an EIA. These minimum requirements are:

1. the purpose of the investigation
2. a brief description of the planned development or the changes that are being considered
3. a brief description of the existing environment including, where relevant, the topography, surface conditions and meteorological conditions during measurements
4. the identified noise sources together with their respective sound pressure levels or sound power levels (or both) and, where applicable, the operating cycles, the nature of sound emission, the spectral composition and the directional characteristics
5. the identified noise sources that were not taken into account and the reasons as to why they were not investigated
6. the identified noise-sensitive developments and the noise impact on them
7. where applicable, any assumptions, with references, made with regard to any calculations or determination of source and propagation characteristics
8. an explanation, either by a brief description or by reference, of all measuring and calculation procedures that were followed, as well as any possible adjustments to existing measuring methods that had to be made, together with the results of calculations
9. an explanation, either by description or by reference, of all measuring or calculation methods (or both) that were used to determine existing and predicted rating levels, as well as other relevant information, including a statement of how the data were obtained and applied to determine the rating level for the area in question
10. the location of measuring or calculating points in a sketch or on a map
11. quantification of the noise impact with, where relevant, reference to the literature consulted and the assumptions made
12. alternatives that were considered and the results of those that were investigated
13. a list of all the interested or affected parties that offered any comments with respect to the environmental noise impact investigation
14. a detailed summary of all the comments received from interested or affected parties as well as the procedures and discussions followed to deal with them
15. conclusions that were reached
16. proposed recommendations
17. if remedial measures will provide an acceptable solution which would prevent a significant impact, these remedial measures should be outlined in detail and included in the final record of decision if the approval is obtained from the relevant authority. If the remedial measures deteriorate after time and a follow-up auditing or maintenance programme (or both) is instituted, this programme should be

included in the final recommendations and accepted in the record of decision if the approval is obtained from the relevant authority; and

18. any follow-up investigation which should be conducted at completion of the project as well as at regular intervals after the commissioning of the project so as to ensure that the recommendations of this report will be maintained in the future.

1.4 STUDY AREA

The study area is described in terms of environmental components that may contribute or change the sound character in the area. A site locality map is presented in **Figure 1.1**.

1.4.1 Topography

It is proposed to construct the wind turbines on a ridge of a hill found on Farm 810. The area is hilly to the north, and relatively flat to the south. There are a number of drainage lines in the area, with the Seekoei River and Leeubos River both flowing in a southerly direction towards the Indian Ocean.

1.4.2 Roads and rail roads

The N2 highway passes the proposed wind turbine area to the south with a gravel road crossing the site on the western corner (with the less busy R102 road further south from the N2). There is also a railway line just south of the portion 1, and small dirt road leading to a farming community ("Die Berg") to the east of the portion 1.

1.4.3 Land use

The surrounding land use is rural with agricultural activities, these agricultural activities can be identified from aerial images. As the night-time noise environment is of interest in this document, current land use activities are not expected to impact much on the current noise environment.

1.4.4 Residential areas

The "Die Berg" community could be seen in the most recent topographical maps.

1.4.5 Ground conditions and vegetation

Most of the area is covered with vegetation with trees along the drainage lines. Rocky areas can be found in and around the residential dwellings. The area proposed for the WTGs is on top of a hill in the area which is relative rocky with sparse low growing vegetation.

1.4.6 Existing Background Ambient Sound Levels

Excluding areas within 500 meters from the N2 national road, the study area have a rural character in terms of the background sound levels.

Onsite measurements and the existing soundscape are discussed in more detail in **section 3.2**.

1.5 AVAILABLE INFORMATION

Apart for the Scoping Report (2010) compiled for this proposed project by the author of this report, no other Noise Impact Assessments has been conducted for this area.

1.6 POTENTIAL SENSITIVE RECEPTORS (NOISE SENSITIVE DEVELOPMENTS)

Potentially Sensitive Receptors (PSRs), also known as Noise Sensitive Developments (NSDs) were initially identified using Google Earth®, supported by a site visit to confirm the status of the identified dwellings.

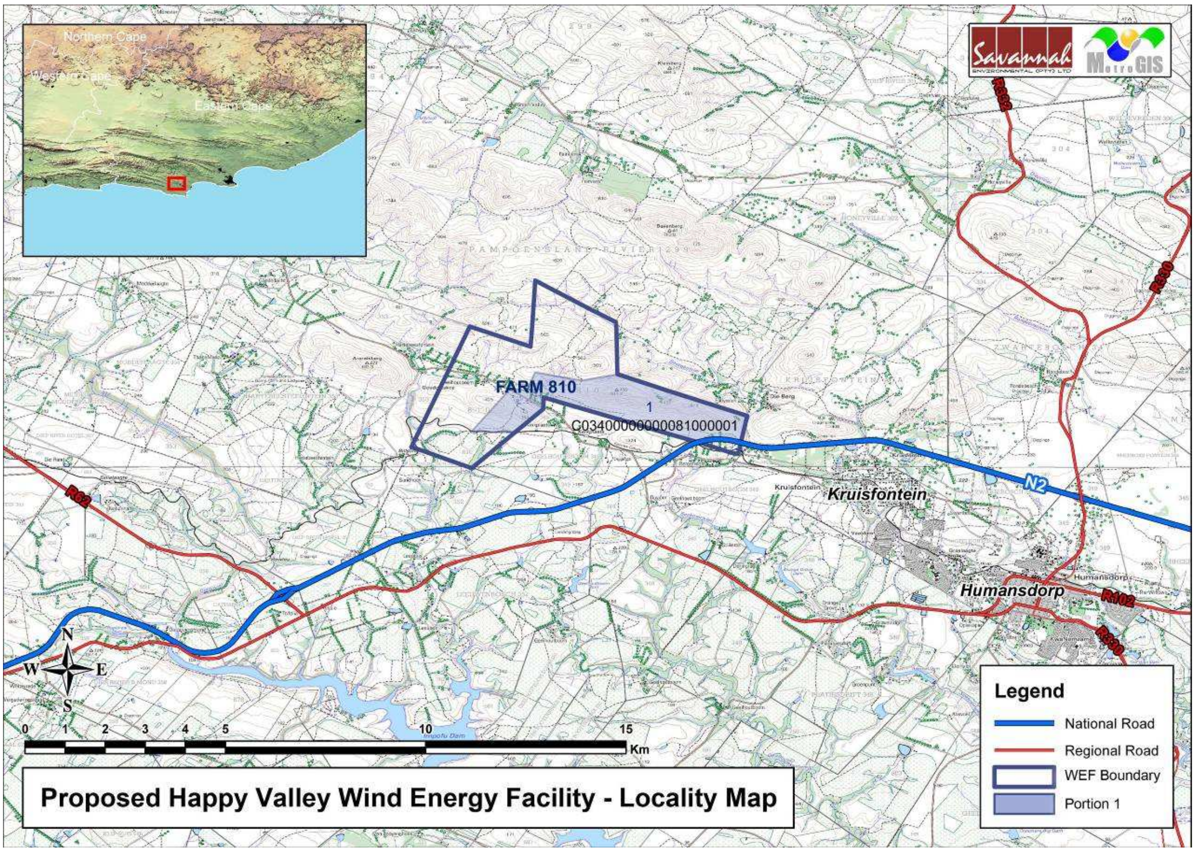

Figure 1.1: Site map indicating area proposed for the WEF

The reason for the site visit, apart from sampling ambient sound levels, is that there could be a number of derelict or abandoned dwellings that could be seen as a sensitive receptor, or small dwellings that could not be identified on the aerial image, or those that were built after the date of the aerial photograph.

Potential receptors in and around the proposed WEF were identified and presented in **Figure 1-2**. The locations of the Potentially Sensitive Receptors are defined in **Table 1.1**. The distances between the PSRs and the closest proposed Wind Turbine Generator (WTG) are defined in **Table 1.1**.

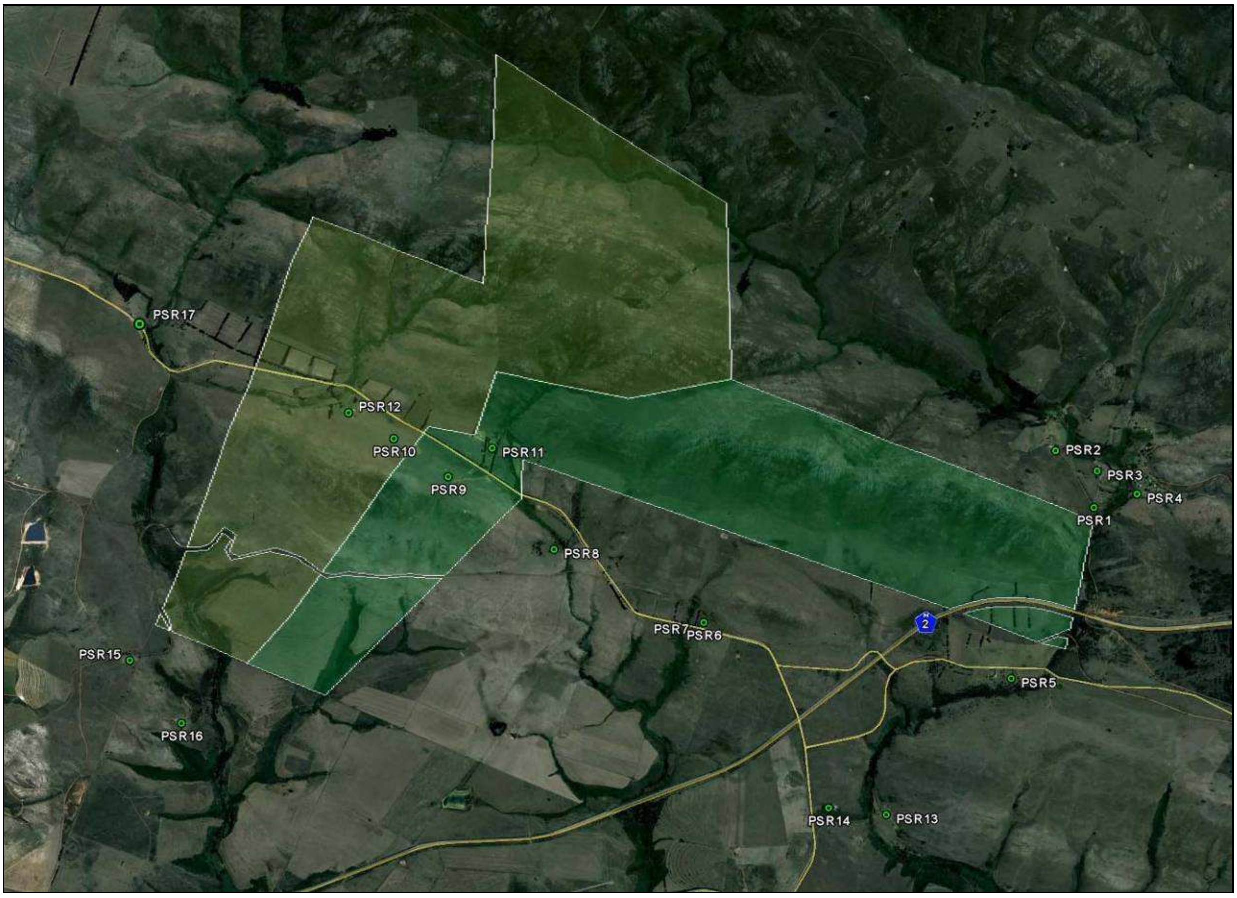

Figure 1-2: Aerial image indicating potentially sensitive receptors (marked as green dots) and boundaries of the proposed WEF.

Table 1.1: Locations of the identified receptors (Datum type: UTM, zone 35H) and SANS Rating Levels

Receptor	Location Longitude	Location Latitude	Closest Turbine	Land Use Type	$L_{Req,D}$ (dBA)	$L_{Req,N}$ (dBA)
PSR01	288016.9	6236853	13 (0.59 km)	Rural	45	35
PSR02	287715.8	6237263	13 (0.63 km)	Rural	45	35
PSR03	288034.1	6237122	13 (0.73 km)	Rural	45	35
PSR04	288333.1	6236960	13 (0.92 km)	Rural	45	35
PSR05	287450.6	6235573	13 (1.10 km)	Rural	45	35
PSR06	285153.3	6235939	8 (1.34 km)	Rural	45	35
PSR07	285114.6	6235844	8 (1.43 km)	Rural	45	35

PSR08	284032.3	6236453	6 (1.02 km)	Rural	45	35
PSR09	283563.4	6237187	6 (1.10 km)	Rural	45	35
PSR10	283244.0	6236970	6 (1.42 km)	Rural	45	35
PSR11	282840.8	6237239	6 (0.72 km)	Rural	45	35
PSR12	282499.6	6237423	6/3 (1.73 km)	Rural	45	35
PSR13	286556.7	6234530	13 (2.33 km)	Rural	45	35
PSR14	286119.4	6234578	11 (2.44 km)	Rural	45	35
PSR15	280889.5	6235556	6 (3.84 km)	Rural	45	35
PSR16	281277.8	6235096	6 (3.79 km)	Rural	45	35
PSR17	280935.4	6238042	1 (2.80 km)	Rural	45	35

2 LEGAL CONTEXT, POLICIES AND GUIDELINES

2.1 THE REPUBLIC OF SOUTH AFRICA CONSTITUTION ACT ("THE CONSTITUTION")

The environmental rights contained in section 24 of the Constitution provide that everyone is entitled to an environment that is not harmful to his or her well-being. In the context of noise, this requires a determination of what level of noise is harmful to well-being. The general approach of the common law is to define an acceptable level of noise as that which the reasonable person can be expected to tolerate in the particular circumstances. The subjectivity of this approach can be problematic which has led to the development of noise standards (see **Section 2.7**).

"Noise pollution" is specifically included in Part B of Schedule 5 of the Constitution, which means that noise pollution control is a local authority competence, provided that the local authority concerned has the capacity to carry out this function.

2.2 THE ENVIRONMENT CONSERVATION ACT

The Environment Conservation Act ("ECA") allows the Minister of Environmental Affairs and Tourism ("now the Ministry of Water and Environmental Affairs") to make regulations regarding noise, among other concerns. See also **section 2.6**.

2.3 THE NATIONAL ENVIRONMENTAL MANAGEMENT ACT

The National Environmental Management Act ("NEMA") defines "pollution" to include any change in the environment, including noise. A duty therefore arises under section 28 of NEMA to take reasonable measures while establishing and operating any facility to prevent noise pollution occurring. NEMA sets out measures which may be regarded as reasonable. They include the following measures:

1. to investigate, assess and evaluate the impact on the environment
2. to inform and educate employees about the environmental risks of their work and the manner in which their tasks must be performed in order to avoid causing significant pollution or degradation of the environment
3. to cease, modify or control any act, activity or process causing the pollution or degradation
4. to contain or prevent the movement of the pollution or degradation
5. to eliminate any source of the pollution or degradation
6. to remedy the effects of the pollution or degradation

2.4 National Environmental Management: Air Quality Act ("AQA")

Section 34 of the National Environmental Management: Air Quality Act (Act 39 of 2004) makes provision for:

(1) the Minister to prescribe essential national noise standards -

(a) for the control of noise, either in general or by specified machinery or activities or in specified places or areas; or

(b) for determining –

(i) a definition of noise

(ii) the maximum levels of noise

(2) When controlling noise the provincial and local spheres of government are bound by any prescribed national standards.

This section of the Act is in force, but no such standards have yet been promulgated. Draft regulations have however, been promulgated for adoption by Local Authorities.

An atmospheric emission licence issued in terms of section 22 may contain conditions in respect of noise. This will however, not be relevant to the facility, as no atmospheric emissions will take place.

2.5 Draft model Air Quality Management By-law for adoption and adaptation by Municipalities

Draft model air quality management by-laws for adoption and adaptation by municipalities was published by the Department of Environmental Affairs in the Government Gazette of 15 July 2009 as General Notice (for comments) 964 of 2009.

Section 18 specifically focuses on Noise Pollution Management, with sub-section 1 stating:

"No person shall make, produce or cause a disturbing noise, or allow it to be made, produced or caused by any person, animal, machine, device or apparatus or any combination thereof."

The draft regulations differ from the current provincial Noise Control Regulations, because it defines a disturbing noise as a noise that is measurable or calculable of which the rating level exceeds the equivalent continuous rating level as defined in SANS 10103:2008.

2.6 Noise Control Regulations

In terms of section 25 of the ECA, the national noise-control regulations (GN R154 in *Government Gazette* No. 13717 dated 10 January 1992) were promulgated. The NCRs were revised under Government Notice Number R. 55 of 14 January 1994 to make it obligatory for all authorities to apply the regulations.

Subsequently, in terms of Schedule 5 of the Constitution of South Africa of 1996, legislative responsibility for administering the noise control regulations was devolved to provincial and local authorities. Provincial Noise Control Regulations exist in the Free State, Western Cape and Gauteng provinces, but the Eastern Cape province have not yet adopted provincial regulations in this regard.

2.7 Noise Standards

Four South African Bureau of Standards (SABS) scientific standards are considered relevant to noise from a Wind Energy Facility. They are:

- SANS 10103:2008. 'The measurement and rating of environmental noise with respect to annoyance and to speech communication'.
- SANS 10210:2004. 'Calculating and predicting road traffic noise'.
- SANS 10328:2008. 'Methods for environmental noise impact assessments'.
- SANS 10357:2004. 'The calculation of sound propagation by the Concave method'.

The relevant standards use the equivalent continuous rating level as a basis for determining what is acceptable. The levels may take single event noise into account, but single event noise by itself does not determine whether noise levels are acceptable for land use purposes. The recommendations that the standards make are likely to inform decisions by authorities, but non-compliance with the standards will not necessarily render an activity unlawful *per se.*

2.8 International Guidelines

While there exist a number of international guidelines and standards that could encompass a document in itself, the three mentioned below were selected as they are used by different countries in the subject of environmental noise management, with the last two documents specifically focussing on the noises associated by wind energy facilities.

2.8.1 Guidelines for Community Noise (WHO, 1999)

The World Health Organization's (WHO) document on the *Guidelines for Community Noise* is the outcome of the WHO- expert task force meeting held in London, United Kingdom, in April 1999. It is based on the document entitled "Community Noise" that was prepared for the World Health Organization and published in 1995 by the Stockholm University and Karolinska Institute.

The scope of WHO's effort to derive guidelines for community noise is to consolidate actual scientific knowledge on the health impacts of community noise and to provide guidance to environmental health authorities and professionals trying to protect people from the harmful effects of noise in non-industrial environments.

Guidance on the health effects of noise exposure of the population has already been given in an early publication of the series of Environmental Health Criteria. The health risk to humans from exposure to environmental noise was evaluated and guidelines values derived. The issue of noise control and health protection was briefly addressed.

The document uses the L_{Aeq} and $L_{A,max}$ noise descriptors to define noise levels.

2.8.2 The Assessment and Rating of Noise from Wind Farms (ETSU, 1997)

This report describes the findings of a Working Group on Wind Turbine Noise, facilitated by the United Kingdom Department of Trade and Industry. It was developed as an Energy Technology Support Unit[1] (ETSU) project. The aim of the project was to provide information and advice to developers and planners on noise from wind turbines. The report represents the consensus view of a number of experts (experienced in assessing and controlling the environmental impact of noise from wind farms). Their findings can be summarised as follows:

1. Absolute noise limits applied at all wind speeds are not suited to wind farms; limits set relative to the background noise (including wind as seen in **Figure 5-2**) are more appropriate
2. $L_{A90,10mins}$ is a much more accurate descriptor when monitoring ambient and turbine noise levels

[1] ETSU was set up in 1974 as an agency by the United Kingdom Atomic Energy Authority to manage research programmes on renewable energy and energy conservation. The majority of projects managed by ETSU were carried out by external organisations in academia and industry. In 1996, ETSU became part of AEA Technology plc which was separated from the UKAEA by privatisation.

3. The effects of other wind turbines in a given area should be added to the effect of any proposed wind energy facility, to calculate the cumulative effect
4. Noise from a wind energy facility should be restricted to no more than 5 dBA above the current ambient noise level at a potential sensitive receptor
5. Wind farms should be limited to within the range of 35dBA to 40dBA (day-time) in a low noise environment. A fixed limit of 43 dBA should be implemented during all night time noise environments. This should increase to 45 dBA (day and night) if the potential receptor has financial investments in the wind energy facility
7. A penalty system should be implemented for wind turbine/s that operates with a tonal characteristic

2.8.3 Noise Guidelines for Wind Farms (MoE, 2008)

This document establishes the sound level limits for land-based wind power generating facilities and describes the information required for noise assessments and submissions under the Environmental Assessment Act and the Environmental Protection Act, Canada.

The document defines:

- Sound Level Limits for different areas (similar to rural and urban areas), defining limits for different wind speeds at 10 m height
- The Noise Assessment Report, including;
  - Information that must be part of the report
  - Full description of noise sources
  - Adjustments, such as due to the wind speed profile (wind shear)
  - The identification and defining of potential sensitive receptors
  - Prediction methods to be used (ISO 9613-2)
  - Cumulative impact assessment requirements
  - It also defines specific model input parameters
  - Methods on how the results must be presented
  - Assessment of Compliance (defining magnitude of noise levels)

The document used the $L_{Aeq,1h}$ noise descriptor to define noise levels.

3 CURRENT ENVIRONMENTAL SOUND CHARACTER

3.1 Measurement Procedure

Ambient (background) noise levels were measured at appropriate times in accordance with the South African National Standard SANS 10103:2008 "***The measurement and rating of environmental noise with respect to land use, health, annoyance and to speech communication***". The standard specifies the acceptable techniques for sound measurements including:

- type of equipment;
- minimum duration of measurement;
- microphone positions;
- calibration procedures and instrument checks; and
- weather conditions.

It should be noted that wind-induced noises are usually seen as unwanted noises, and samples reflecting significant background interference due to wind-induced noises are normally discarded. However, for the purpose of this study, it was opted to include these samples because the typical operating noise of the facility will only be emitted during times when wind-induced noise levels are relevant.

The equipment defined in **Table 3.1** was used for gathering data:

Table 3.1: Equipment used to gather data

Equipment	Model	Serial no	Calibration
SLM	Rion NL-32	01182945	17 June 2010
Microphone*	Rion UC-53A	315479	17 June 2010
Preamplifier	Rion NH-21	28879	17 June 2010
Calibrator	Rion NC-74	34494286	27 January 2011
Wind meter	Kestrel 4000	587391	Calibrated[2]

* Microphone fitted with the appropriate windshield.

3.2 On-site Measurements

Measurements were taken during the day and late evening of 14 August 2010 as well as early mornings 15 and 16 August 2010. The sound level meter was referenced at 1000 Hz directly before and after the measurement was taken. In all cases drift was less than 0.2 dBA.

2 Certificate of Conformity issued by Nielsen-Kellerman Co.

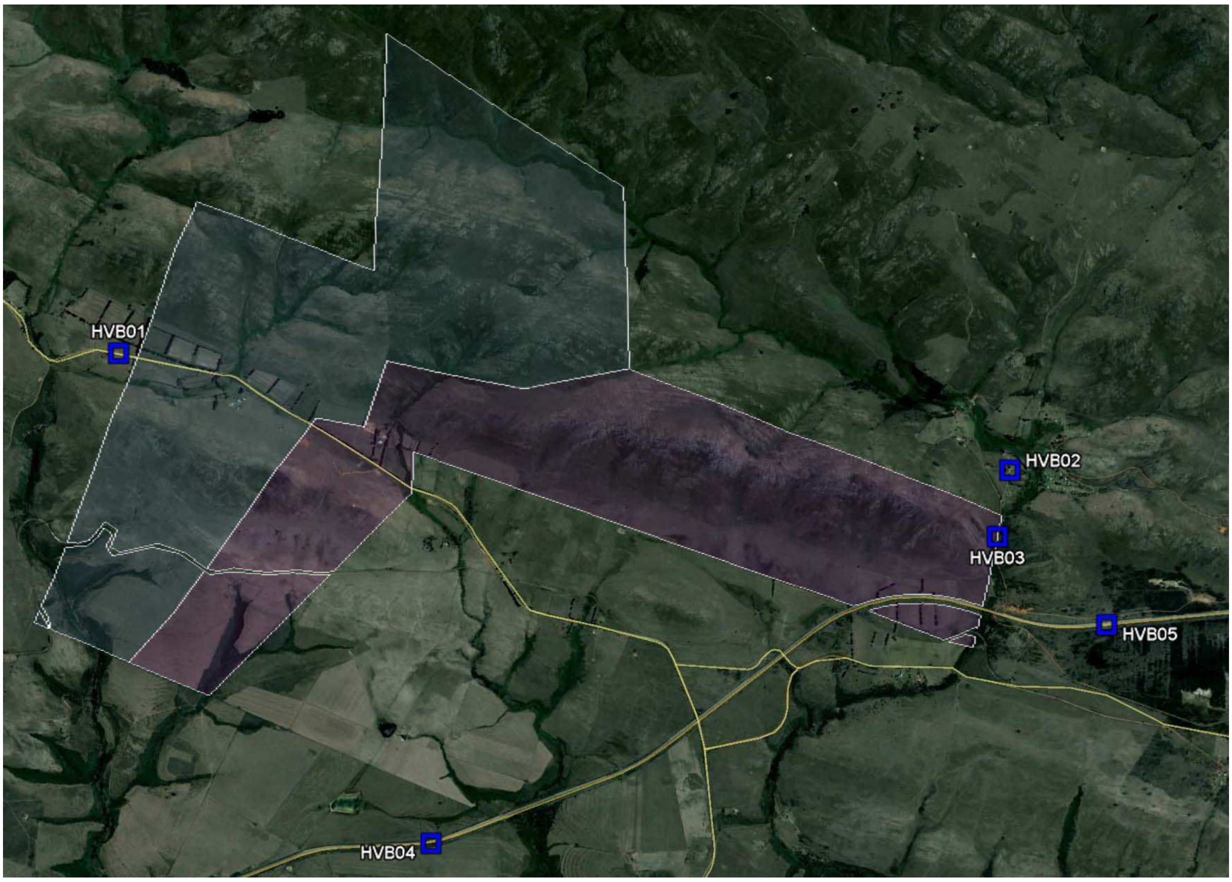

Figure 3-1: Monitoring points selected near the proposed facility (marked as blues squares)

The locations used to measure ambient (background) sound levels are presented in **Figure 3-1**. These points are considered sufficient to determine the ambient (background) sound levels in the area. The results are presented in **Table 3.2** below.

Table 3.2: Results of ambient sound level monitoring (Datum type: Decimal Degrees)

Point name	Location, Latitude	Location, Longitude	$L_{Aeq,T}$ (dBA)	$L_{A, max}$ (dBA)	$L_{A, min}$ (dBA)	L_{A90} (dBA)	Ave. wind speed	Max. wind speed
HVB01 (D)	-33.978053°	24.636507°	53.8	78.3	19.5	23.5	1	2.9
DRBN01(D)	-34.051360°	24.520930°	73.8	94.7	30.1	35.8	3.7	6.3
DRBN01(N)	-34.051360°	24.520930°	66.0	89.5	20.8	23.5	2.1	3.5
HVB02 (D)	-33.985556°	24.705575°	52.2	71.3	40.0	43.3	5.5	11.2
HVB03 (D)	-33.989822°	24.704658°	51.1	59.9	48.3	49.8	1.5	6.7
HVB01 (N)	-33.978053°	24.636507°	23.7	36.3	17.8	19.1	0.4	0.7
HVB01 (N)	-33.978053°	24.636507°	22.1	40.4	17.8	18.8	0.5	0.7
HVB04 (N)	-34.009740°	24.660650°	65.8	90.1	23.9	27.1	2.4	3.2
HVB05 (N)	-33.995525°	24.713147°	66.0	89.5	20.8	23.5	2.1	3.1

Notes:

- SLM fitted at all times with the WS-03 all-weather windshield
- HVB03 is a location on a small stream sheltered by the adjacent hills and trees, and while the wind were audible in the tree tops, the ambient sound environment was dominated by the flowing stream

- The minimum range of the Rion NL 32 Sound Level Meter can be considered as 18 dBA

From the data, it can be observed that the area is generally quiet, with sound levels of 17.8 ($L_{A,min}$) – 18.8 (L_{A90}) dBA at night (windless conditions), that increases as wind speeds increase. Apart from the areas close to the N2 (± 500 distance from road), the area could be considered as rural.

3.3 INFLUENCE OF WIND ON AMBIENT SOUND LEVELS

Unfortunately, current local regulations and standards do not consider changing ambient (background) sound levels due to natural events, such as can be found near coastal or areas where wind-induced noises are prevalent. This is unfortunately unfeasible with wind energy facilities, as these facilities will only operate when the wind is blowing. It is therefore important that the impact of wind-induced noises be considered when determining the noise impact of such as a facility. However, care should be taken when taking this approach due to other factors that complicate noise propagation from wind turbines (see also **section 4.2** as well as **section 6.2**).

Figure 3-2 illustrates this situation where the sound pressure levels associated with wind action increase as wind speeds increase. The sound levels measured (mainly wind impacting on the background ambient sound levels) is also indicated in this figure (in yellow).

The curve developed is based on the noise measurements collected at a number of sites in South Africa. While not site specific, the principle is to fit a curve using the available data that can be used to estimate cautious ambient sound levels during times when wind is blowing. The curve used is also based on a curve developed near the Silverton Wind Farm in Australia.

Figure 3-2 was developed by plotting Sound Pressure Levels ($L_{Aeq,10min}$) versus average wind speed (averaged over the 10 minutes that the measurement was collected), and the estimated curve adjusted downward with 3dBA below the lowest ambient sound levels measured at wind speeds higher than 3 m/s. For the modelling, the appropriate ambient sound levels from this curve will be used. Due to the downward adjustment, the potential full effect of the wind-related ambient noise levels will be reduced (the level used would be at least 3 dBA less than the real ambient sound level).

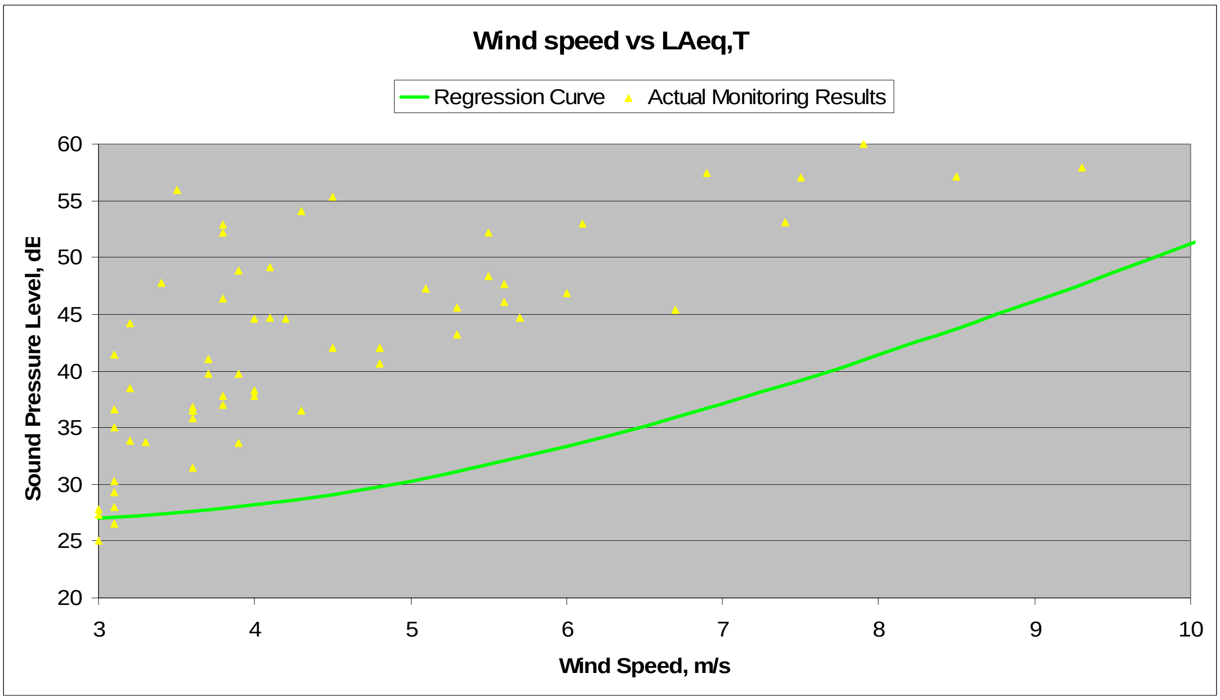

Figure 3-2: Ambient sound levels as wind speed increase

Reasons for a 3dBA penalty used in **Figure 3-2** include the following:

- Uncertainty factors, such as the small inaccuracies/interference that can be incurred during monitoring; This should cover the following points:
    1. Instrument Accuracy and chain of instruments (tripod, cables, Sound Level Meter, Pre-amplifier, Microphone, Calibration – 1 dBA);
    2. Wind shield used to do measurements (2 dBA);
    3. Wind Turbulence and Gustiness making sampling more difficult that would reduce repeatability (2 dBA); and
    4. Wind Shear effects (Refer to **section 5.3.3.1** – 2 dBA).

The RMS value of these uncertainties is approximately 3 dBA.

It should be noted that it is desired that all measurement points be at least 200 m away from any dwelling, and in most cases preferably more than 500 m. In addition the points were selected to be away from structures (buildings, trees, etc.) that could significantly impact the ambient sound levels during periods when wind is blowing. During times when wind is blowing, ambient sound levels are generally higher near dwellings or other structures than at areas away from such structures. There is a number of factors that determine by how much ambient sound levels close to a dwelling might differ from the ambient sound level further away, including:

- Whether there are any wind pumps close to the dwelling;

- Type of trees around dwelling (conifers vs. broad-leaved trees, habitat that it provides to birds, food that it may provide to birds);
- The number, type and distance between the dwelling (measuring point) and trees. This is especially relevant when the trees are directly against the house (where the branches can touch the roof);
- The material used in the construction of the dwelling;
- How well the dwelling was maintained; and
- What type and how many farm animals are in the vicinity of the dwelling.

3.4 EXISTING SOUNDSCAPE

3.4.1 Daytime Ambient Sound Levels

A day ambient sound level map was compiled based on the observed activities, consisting mainly of traffic on the N2 and in a lesser extent, traffic on the R102. Smaller roads were not considered as they do not contribute significantly to the soundscape in the area. The result of the (estimated) ambient sound levels during the day can be found in **Figure 3-3**.

The reader should note that the A-weighted noise levels as illustrated is the "average" or "equivalent" noise level that receptors could experience. While receptors close enough to the road will detect vehicles travelling on the road, they experience that peak noise levels only for a short while. The rest of the time noise levels would return to the ambient sound level. The A-weighted Equivalent noise levels as illustrated are therefore used to "average" the exposure that receptors experience due to traffic in a set time period and is used to define the potential impact that receptors are experiencing.

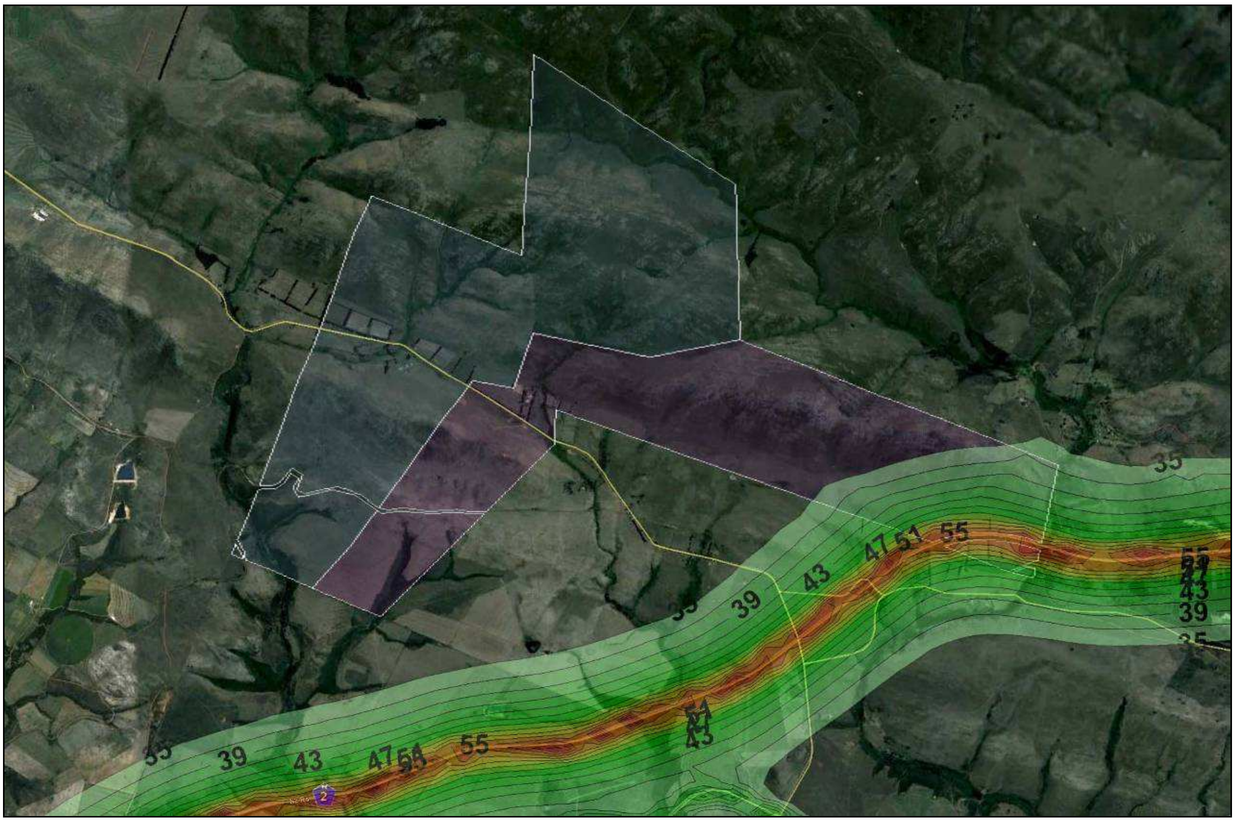

Figure 3-3: Daytime (06:00 – 22:00) ambient sound levels: Contours of constant sound levels

As presented, most of the ambient day-time noise comes from the larger roads in the area.

It should be noted that other noise sources were not added to this ambient sound map. Typical sources during the day would be:

- Dogs barking and farm animals
- Radios or TVs playing in the background
- People speaking
- Other activities, such as farming activities

While some of these noise sources cannot be considered insignificant, the shear task of adding all noise sources makes this task almost impossible. In addition, the more additional noise sources are added, the lower the projected impact of the activity under investigation, due to the increased ambient sound levels. This is however, considered during the impact assessment phase when the probability is estimated, because these types of ambient sounds tend to mask noises during the day. This would be especially relevant for the Kruisfontein community, as while ambient sound levels were not measured in the community, it would be significantly higher than the ambient sound levels assumed in this report.

3.4.2 Night-time Ambient Noise Levels

The site visit and measurements indicated that the N2 national road cannot be excluded as a potential noise source at night.

Based on the site measurements the estimated ambient noise modelling is illustrated in **Figure 3-4**.

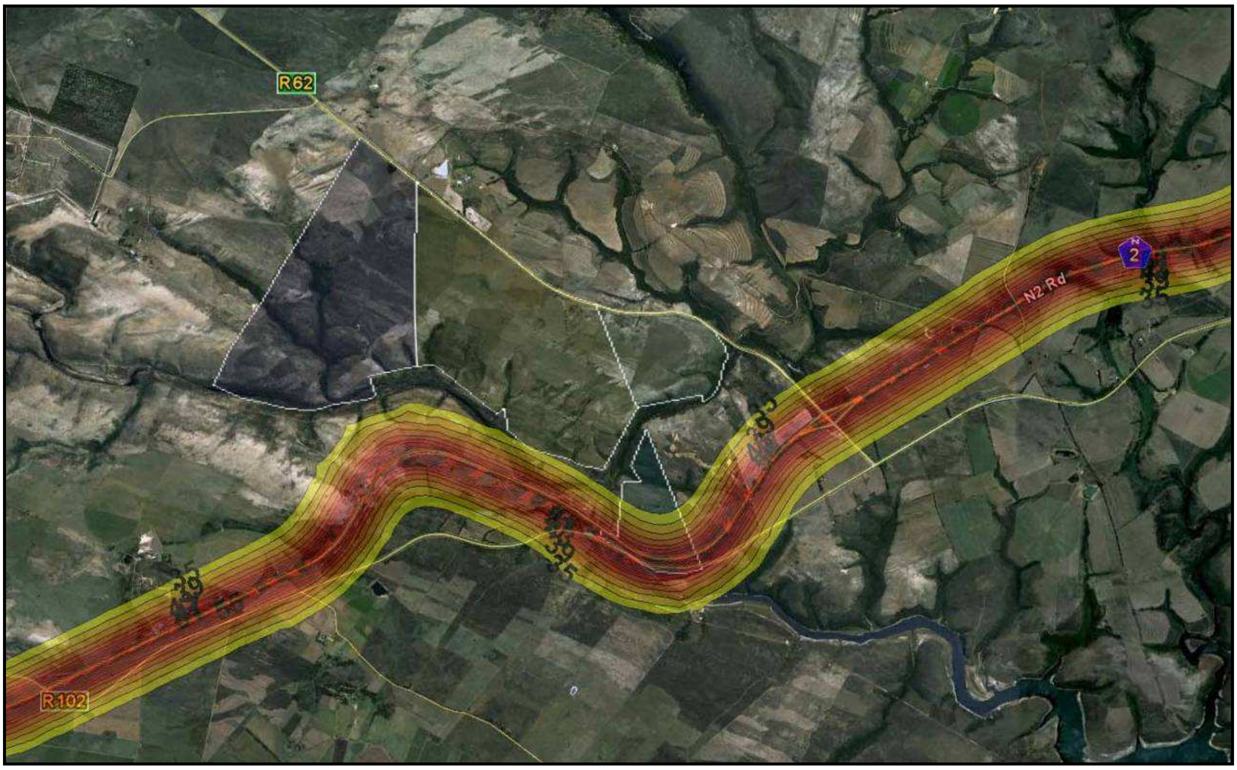

Figure 3-4: Night-time (22:00 – 06:00) ambient sound levels: Contours of constant sound levels

4 POTENTIAL NOISE SOURCES

Increased noise levels are directly linked with the various activities associated with the construction of the facility and related infrastructure, as well as the operational phase of the activity.

4.1 POTENTIAL NOISE SOURCES: CONSTRUCTION PHASE

4.1.1 Construction equipment

Construction activities include:

- Establish internal access roads - the internal road alignment is informed by the positioning of the wind turbines (i.e. **Figure 7-4**);
- Site preparation activities will include clearance of vegetation at the footprint of each turbine. These activities will require the stripping of topsoil which will need to be stockpiled, backfilled and/or spread on site;
- Construct foundations – it is expected that the volume of concrete required for the turbine foundation will be in the order 600 - 700 m^3. Due to the volume of concrete that will be required, an on-site batching plant of approximately 100 m x 100 m, with a high power output capacity could be required to ensure a continuous concreting operation. The source of aggregate is yet undefined;
- Transport of components & equipment to site – all components will be brought to site in sections by means of flatbed trucks. Additionally, components of various specialised construction and lifting equipment are required on site to erect the wind turbines and will need to be transported to site. The typical civil engineering construction equipment will need to be brought to the site for the civil works (e.g. excavators, trucks, graders, compaction equipment, cement trucks, etc.). The components required for the establishment of the overhead power line (including towers and cabling) will be transported to site as required;
- Establishment of laydown & hard standing areas - laydown areas will need to be established at each turbine position for the placement of wind turbine components. Laydown and storage areas will also be required to be established for the civil engineering construction equipment which will be required on site. Hard standing areas will need to be established for operation of the crane. Cranes of the size required to erect turbines are sensitive to differential movement during lifting operations and require a hard standing area, of approximately 25 m x 50 m;
- Erect turbines - a crane will be used to lift the tower sections into place and then the nacelle will be placed onto the top of the assembled tower. The next step will

be to assemble or partially assemble the rotor on the ground; it will then be lifted to the nacelle and bolted in place. A small crane will likely be needed for the assembly of the rotor while the large crane will be needed to put it in place;

- Construct substation - the underground cables carrying the generated power from the individual turbines will join at the substation. The construction of the substation would require a site survey; site clearing and leveling and construction of access road/s (where required); construction of a substation terrace and foundation; assembly, erection and installation of equipment (including transformers); connection of conductors to equipment; and rehabilitation of any disturbed areas and protection of erosion sensitive areas;
- Establishment of ancillary infrastructure - A workshop as well as a contractor's equipment camp may be required. The establishment of these facilities/buildings will require the clearing of vegetation and leveling of the development site and the excavation of foundations prior to construction. A laydown area for building materials and equipment associated with these buildings will also be required;
- Connection of wind turbines to the substation - each wind turbine will be connected to the respective substation via electrical cables, to be lain underground where possible. The installation of these cables will require the excavation of trenches of approximately 1 m deep within which they can then be laid. The underground cables will be planned to follow the internal access roads, where possible;
- New overhead **power lines** to connect to Eskom's existing Skietkuil/Biesiespoort Substation in the area; and
- Site remediation - once construction is completed and once all construction equipment is removed, the site will be rehabilitated where practical and reasonable.

The equipment likely to be required to complete the above tasks will typically include:

- excavator/graders, bulldozer(s), dump trucks(s), vibratory roller, bucket loader, rock breaker(s), drill rig, flat bed truck(s), pile drivers, concrete truck(s), crane(s), fork lift(s) and various 4WD and service vehicles.

Octave sound power levels typical for this equipment are presented in **Appendix A**.

4.1.2 Material supply: Concrete batching plants and use of Borrow Pits

There exist three options for the supply of the concrete to the development site. These options are:

1. The transport of "ready-mix" concrete from the closest centre to the development.

2. The transport of aggregate and cement from the closest centre to the development, with the establishment of a small concrete batching plant close to the activities. This would most likely be a movable plant.
3. The establishment of a small quarrying activity, where aggregate will be mined, crushed and screened and used onsite. Cement will still be transported to the site, where there will be a small movable concrete batching plant.

For the purpose of the EIA, Option 2 was assumed to the preferred option. Aggregate will be sourced from existing commercial borrow pits in the area.

4.1.3 Blasting

Blasting may be required as part of the civil works to clear obstacles or to prepare foundations. However, blasting will not be considered during the EIA phase for the following reasons:

- Blasting is highly regulated, and control of blasting to protect human health, equipment and infrastructure will ensure that any blasts will use the minimum explosives and will occur in a controlled manner. The breaking of obstacles with explosives is also a specialized field and when correct techniques are used, causes significantly less noise than using a rock-breaker.
- People are generally more concerned over ground vibration and air blast levels that might cause building damage than the impact of the noise from the blast. However, these are normally associated with close proximity mining/quarrying.
- Blasts are an infrequent occurrence, with a loud but a relative instantaneous character. Potentially affected parties generally receive sufficient notice (siren) and the knowledge that the duration of the siren noise as well as the blast will be over relative fast results in a higher acceptance of the noise. Note that with the selection of explosives and blasting methods, noise levels from blasting is relatively easy to control.

4.1.4 Traffic

A significant source of noise during the construction phase is additional traffic to and from the site, as well as traffic on the site. This will include trucks transporting equipment, aggregate and cement as well as various components used to develop the wind turbine.

Construction traffic is expected to be generated throughout the entire construction period, however, the volume and type of traffic generated will be dependent upon the construction activities being conducted, which will vary during the construction period. Noise levels due to additional traffic will be estimated using the methods stipulated in SANS 10210:2004 (Calculating and predicting road traffic noise).

4.2 Potential Noise Sources: Operational Phase

Noise emitted by wind turbines can be associated with two types of noise sources. These are aerodynamic sources due to the passage of air over the wind turbine blades and mechanical sources that are associated with components of the power train within the turbine, such as the gearbox and generator and control equipment for yaw, blade pitch, etc. These sources generally have different characteristics and can be considered separately. In addition there are other lesser noise sources, such as the substations themselves, traffic (maintenance) as well as transmission line noise.

4.2.1 Wind Turbine Noise: Aerodynamic sources

Aerodynamic noise is emitted by a wind turbine blade through a number of sources such as:

1. Self noise due to the interaction of the turbulent boundary layer with the blade trailing edge
2. Noise due to inflow turbulence (turbulence in the wind interacting with the blades)
3. Discrete frequency noise due to trailing edge thickness
4. Discrete frequency noise due to laminar boundary layer instabilities (unstable flow close to the surface of the blade)
5. Noise generated by the rotor tips

Noise due to aerodynamic instabilities (mechanisms 3 and 4) can be reduced to insignificant levels by careful design. The other mechanisms are an inescapable consequence of the aerodynamics of the turbine that produces the power and between them they will make up most, if not all, of the aerodynamic noise radiated by the wind turbine. The relative contribution of each source will depend upon the detailed design of the turbine and the wind speed and turbulence at the time.

The mechanisms responsible for tip noise (mechanism 5) are currently under investigation, but it appears that methods for its control through design of the tip shape might be available. Self noise (mechanism 1) is most significant at low wind speeds, whereas noise due to inflow turbulence (mechanism 2) becomes the dominant source at the higher wind speeds. Both mechanisms increase in strength as the wind speed increases, particularly inflow turbulence. The overall result is that at low to moderate wind speeds, the noise from a fixed speed wind turbine increases at a rate of 0.5-1.5 dBA /m/s up to a maximum at wind speeds of 7 -12 m/s (noise generated by the WTG does not increase significantly at wind speeds above 12 m/s).

Therefore, as the wind speed increases, noises created by the wind turbine also increases. At a low wind speed the noise created by the wind turbine is generally (relatively) low, and increases to a maximum at a certain wind speed when it either remains constant, increase very slightly or even drops as illustrated in **Figure 4-1**.

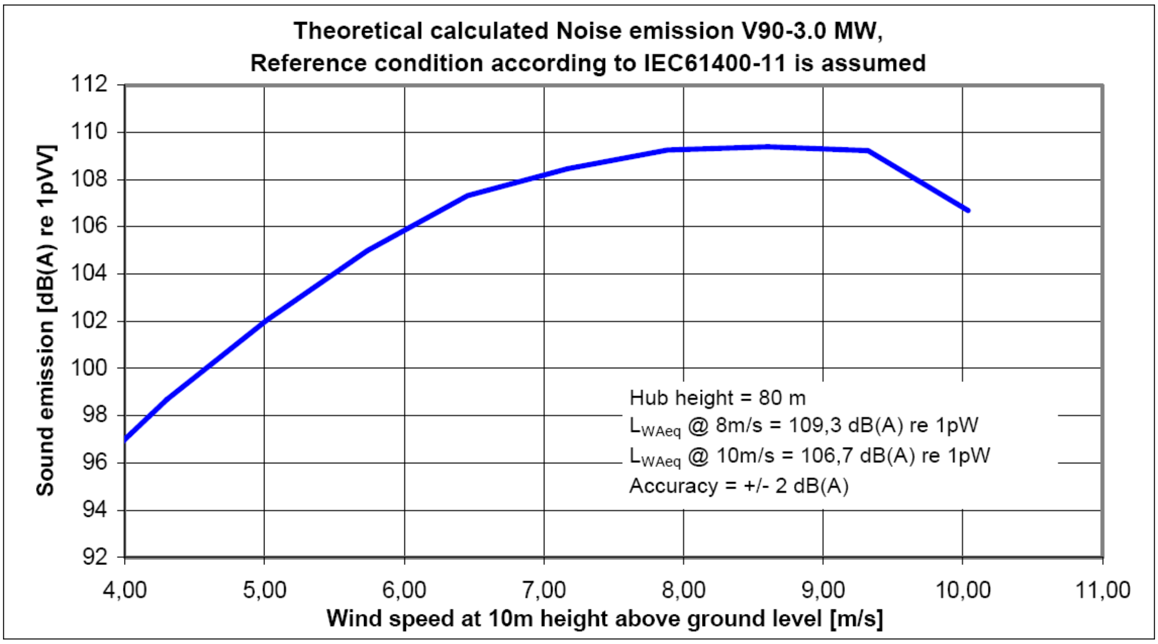

Figure 4-1: Noise Curve Vestas V90 – 3.0 MW, 60Hz (figure for illustration purposes)

Typical noise characteristics can be measured for each type of wind turbine, and minimum/average/maximum curves as seen in **Figure 4-2** can be compiled. The more accurate the data, the more accurate the modelling would be.

The developer highlighted that the Vestas V90 1.8/2.0 MW wind turbine could possibly be considered for use at the facility. The noise characteristics of this turbine were supplied by the developer.

Sound power emissions (in octave sound power levels) for this wind turbine are presented in **Table 7.3**. The propagation model makes use of various frequencies, because these frequencies are affected in different ways as it propagates through air, over barriers and over different ground conditions.

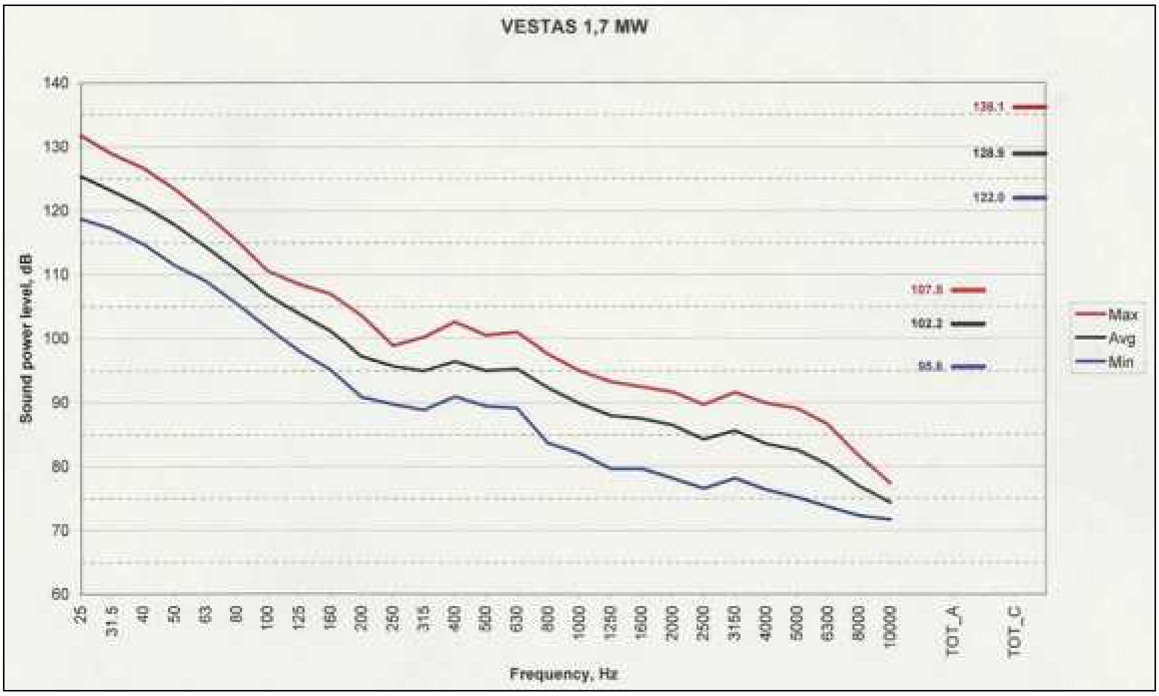

Figure 4-2: Sound power level emission of a Vestas, V66 wind turbine (for illustration purposes only)

4.2.2 Wind Turbine: Mechanical sources

Mechanical noise is generally perceived within the emitted noise from wind turbines as an audible tone(s) that is subjectively more intrusive than a broad band noise of the same sound pressure level. Sources for this noise are generally associated with: the gearbox and the tooth mesh frequencies of the step up stages; generator noise caused by coil flexure of the generator windings that is associated with power regulation and control; generator noise caused by cooling fans; and control equipment noise caused by hydraulic compressors for pitch regulation and yaw control.

Tones are noises with a narrow sound frequency composition (e.g. the whine of an electrical motor). Annoying tones can be created in numerous ways: machinery with rotating parts such as motors, gearboxes, fans and pumps often create tones. An imbalance or repeated impacts may cause vibration that, when transmitted through surfaces into the air, can be heard as tones. Pulsating flows of liquids or gases can also create tones, which may be caused by combustion processes or flow restrictions. The best and most well known example of a tonal noise is the buzz created by a flying mosquito.

Where complaints have been received due to the operation of wind farms, tonal noise from the installed wind turbines appears to have increased the annoyance perceived by the complainants and indeed has been the primary cause for complaint.

However, tones were normally associated with the older models of turbines. All turbine manufacturers have started to ensure that sufficient forethought is given to the design of quieter gearboxes and the means by which these vibration transmission paths may be broken. Through the use of careful gearbox design and/or the use of anti-vibration techniques, it is possible to minimise the transmission of vibration energy into the turbine supporting structure.

The benefits of these design improvements have started to filter through into wind farm developments which are using these modified wind turbines. ***New generation wind turbine generators do not emit any clearly distinguishable tones***.

4.2.3 Transformer noises (Substations)

Also known as magnetostriction, this is when the sheet steel used in the core of the transformer tries to change shape when being magnetised. When the magnetism is taken away, the shape returns, only to try and deform in a different manner when the polarity is changed.

This deformation is not uniform; consequently it varies all over a sheet. With a transformer core being composed of many sheets of steel, these deformations are taking place erratically all over each sheet, and each sheet is behaving erratically with respect to its neighbour. The resultant is the "hum" frequently associated with transformers. While this may be a soothing sound in small home appliances, various complaints are logged in areas where people stay close to these transformers. At a voltage frequency of 50 Hz, these "vibrations" takes place 100 times a second, resulting in a tonal noise at 100Hz. This is normally not an issue if the substation is further than 200 meters from a potentially sensitive receptor.

This is a relative easy noise to mitigate with the use of acoustic shielding and/or placement of the transformer equipment and will not be considered further in the EIA study.

4.2.4 Transmission Line Noise (Corona noise)

Corona noise is caused by the partial breakdown of the insulation properties of air surrounding the conducting wires. It can generate an audible and radio-frequency noise, but generally only occurs in humid conditions as provided by fog or rain. A minimum line potential of 70 kV or higher is generally required to generate corona noise depending on the electrical design. Corona noise does not occur on domestic distribution lines.

Corona noise has two major components: a low frequency tone associated with the frequency of the AC supply (100 Hz for 50 Hz source) and broadband noise. The tonal component of the noise is related to the point along the electric waveform at which the air begins to conduct. This varies with each cycle and consequently the frequency of the emitted tone is subject to great fluctuations. Corona noise can be characterised as broadband 'crackling' or 'buzzing', but fortunately it is generally only a feature during fog or rain.

It will not be further investigated, as corona discharges results in:

- Power losses
- Audible noises
- Electromagnetic interference
- A purple glow
- Ozone production
- Insulation damage

In addition this is associated with high voltage transmission lines, and not the lower voltage distribution lines proposed for construction by the developer.

As such, Electrical Service Providers (such as Eskom) goes to great lengths to design power transmission equipment to minimise the formation of corona discharges. In addition, it is an infrequent occurrence with a relative short duration compared to other operational noises. At the relative low voltages proposed for this project Corona noises would not be an issue.

4.2.5 Low Frequency Noise

4.2.5.1 Background and Information

Low frequency sound is the term used to describe sound energy in the region below ~200Hz. The rumble of thunder and the throb of a diesel engine are both examples of sounds with most of their energy in this low frequency range. Infrasound is often used to describe sound energy in the region below 20Hz.

Almost all noise in the environment has components in this region although they are of such a low level that they are not significant (wind, ocean, thunder). See also **Figure 4-3**, which indicates the sound power levels in the different octave bands from measurements taken at different wind speeds with no other audible noise sources present. Sound that has most of its energy in the 'infrasound' range is only significant if it is at a very high level, far above normal environmental levels.

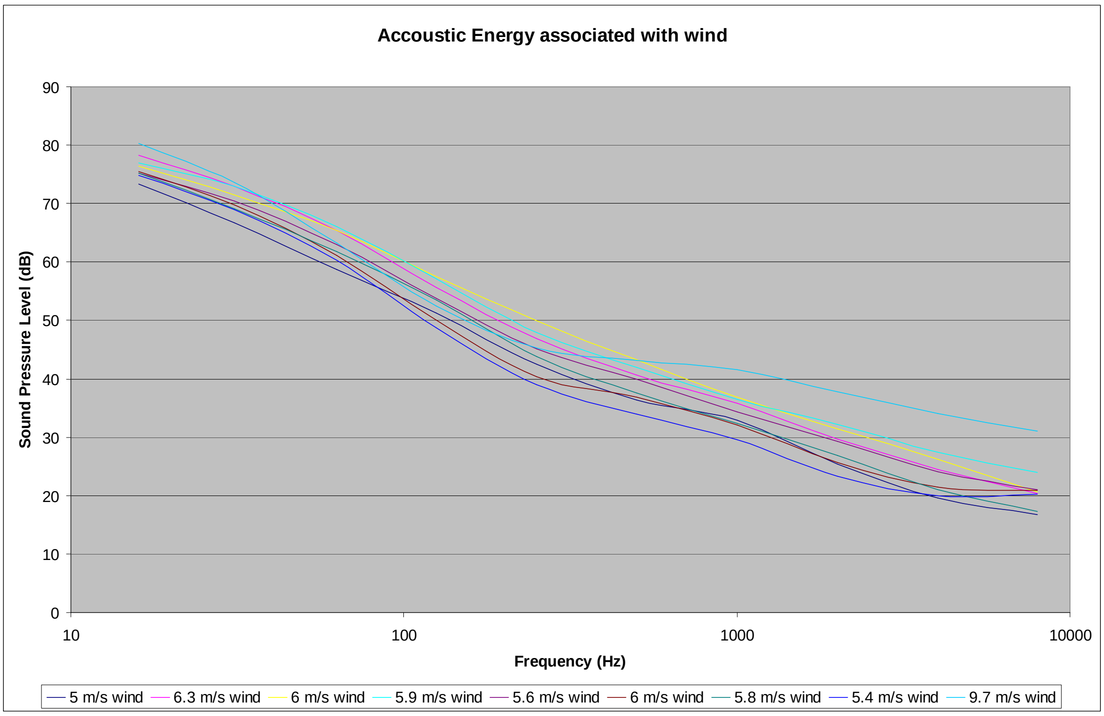

Figure 4-3: Third octave band sound power levels at various wind speeds

4.2.5.2 The generation of Low Frequency Sounds

Due to the low rotational rates of the blades of a WTG as well as the size of these blades, the peak acoustic energy radiated by large wind turbines is in the infrasonic range with a peak in the 8-12 Hz range. For smaller machines, this peak can extend into the low-frequency "audible" (20-200 Hz) range because of higher rotational speeds and multiple blades.

4.2.5.3 Detection of Low Frequency Sounds

The levels of infrasound radiated by the largest wind turbines are very low in comparison to other sources of acoustic energy in this frequency range such as sonic booms, shock waves from explosions, etc. The danger of hearing damage from wind turbine low-frequency emissions is remote to non-existent. However, sounds in a frequency range less than 100Hz can, under the right circumstances, be responsible for annoying nearby residents. Typically, except very near the source, most people outside cannot detect the presence of low-frequency noise from a wind turbine. It should be noted that there are people who are more sensitive to these low frequency sounds.

People can however, under the right set of circumstances, "hear" noise within nearby dwellings if the noise has an impulsive characteristic. Often it is not clear with low-frequency noise if people are hearing or feeling it or some combination of both stimuli.

Due to the impulsive nature of the acoustic low-frequency energy being emitted, there is an interaction between the incident acoustic pulses and the resonances of the homes that serve to amplify the stimuli creating vibrations as well as redistributing the energy higher into the audible frequency region. Thus the annoyance is often connected with the periodic nature of the emitted sounds rather than the frequency of the acoustic energy.

Impulsive noise generation is generally confined to turbines of which the rotors operate downwind of the support tower (downwind machine). In this case, impulses are generated by the interaction of the aerodynamic lift created on the rotor blades and the wake vortices being shed from the tower elements. In the past 20 years, modern wind turbines have nearly exclusively been designed as machines that have their rotors upstream of the tower. Those, except in very rare circumstances, do not generate impulses as nothing is blocking the flow upwind of the rotor. The low-frequency noise generated from an upwind turbine is primarily the result of the interaction of the aerodynamic lift on the blades and the atmospheric turbulence in the wind. Because atmospheric turbulence is a random phenomenon, the radiated low-frequency noise also exhibits a random or non-coherent characteristic. Impulsive noise generated by the tower wake/rotor interaction, on the other hand, tends to be much less random or coherent and therefore much more detectable when it interacts with an intervening resonant structure.

For a healthy young adult, the range of hearing is often quoted as extending from 20Hz to 20,000Hz although the sensitivity of the ear varies significantly with frequency and is most sensitive to sounds with frequencies between around 500Hz and 4,000Hz where the majority of information in speech signals is contained. Above and below this range, the ear becomes decreasingly sensitive and is very insensitive at very low frequencies, meaning that sound levels have to be very high for such sounds to be perceived. Refer also to **Figure 4-4**.

Investigations have, however, shown that the perception and the effects of sounds differ considerably at low frequencies as compared to mid- and high frequencies. The main aspects to these differences are:

- a weakening of pitch sensation as the frequency of the sound decreases below 60 Hz
- perception of sounds as pulsations and fluctuations
- a much more rapid increase of loudness and annoyance with increasing sound level at low frequencies than at mid- or high frequencies
- complaints about the feeling of ear pressure

- annoyance caused by secondary effects like rattling of building elements, e.g. windows and doors or the tinkling of bric-a-brac
- other psycho acoustic effects, e.g. sleep deprivation, a feeling of uneasiness
- reduction in building sound transmission loss at low frequencies compared to mid- or high frequencies

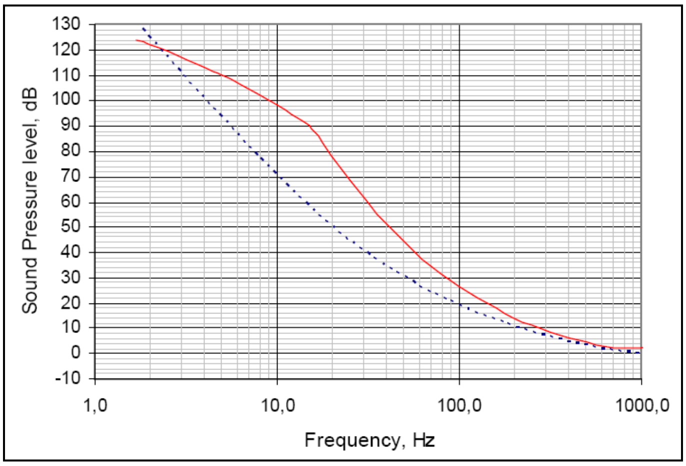

Figure 4-4: The average hearing threshold for humans (pure tones) in a free field (red line). The A-weighting line is the broken line.

4.2.5.4 Measurement, Isolation and Assessment of Low Frequency Sounds

There remains significant debate regarding the noise from WTGs, public response to that noise, as well as the presence or not of low frequency sound and how it affects people. While low frequency sounds can be measured, it is far more difficult to isolate low frequency sounds due to the numerous sources that generate these sounds.

However, from sound power level emission graphs such as **Figure 4-2** and the data contained in **Table 7.3**, it can be seen that a wind turbine has significant potential to generate low frequency sounds with sufficient energy to warrant the need to investigate WTG as a source of low frequency sounds. However, the reader is also referred to **Figure 4-3** and **Figure 4-5** for examples of various sources and associated levels of low frequency sounds. From these two figures it is clear that there is significant acoustic energy in the lower frequencies (less than 100 Hz) in the environment around us.

Of particular note in this regard is the low frequency sounds associated with a 3.6 MW wind turbine at 250 m outdoors (red) and the same turbine at 600 m indoors (green). Note that this should not be seen as a rule for all turbines, as each turbine make, model and size have a specific noise emission characteristic. The larger a wind turbine (especially the blades), the higher the acoustical energy in the lower frequencies and the potential for low frequency sounds should be evaluated for each project and turbine proposed.

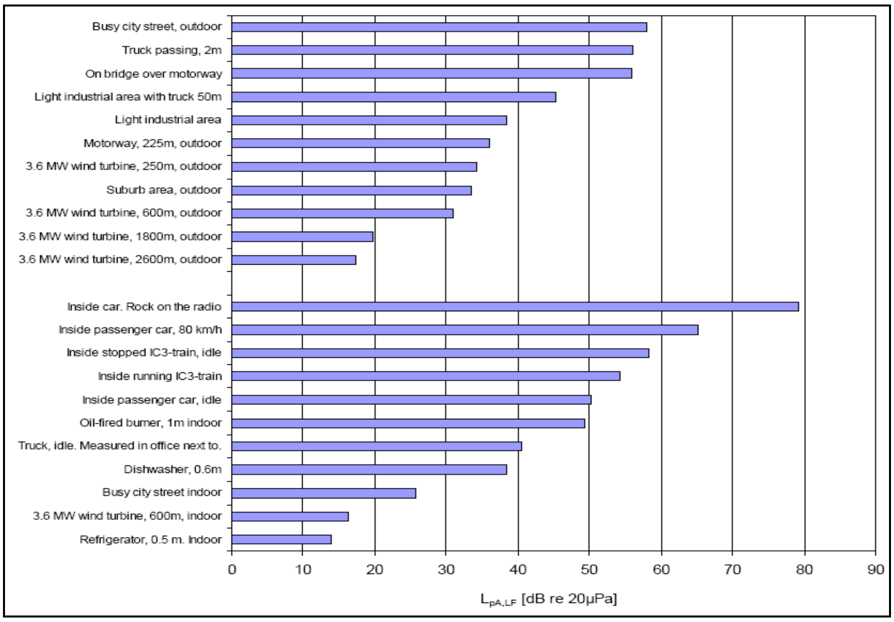

Figure 4-5: Examples on A-weighted low frequency levels $L_{pA,LF}$ from a number of indoor and outdoor sources.

Unfortunately, there isn't a standardised test, nor an assessment procedure available for the assessment of low frequency sounds, neither is there an accepted methodology on how low frequency sounds can be modelled or predicted. This is because low frequency sound can travel large distances, and are present all around us, with a significant component generated by nature itself (ocean, wind, etc.).

SANS 10103:2004 proposes a method to identify whether low frequency noise could be an issue. It proposes that if the difference between the A-frequency weighted and the C-frequency weighted equivalent continuous (L_{Aeq} >> L_{Ceq}) sound pressure levels is greater than 10 dB, a predominant low frequency component **may** be present. However, at all cases existing acoustic energy in low frequencies associated with wind must be considered.

4.2.6 Amplitude modulation

There is one other characteristic of wind turbine sound that increases the sleep disturbance potential above that of other long-term noise sources. The amplitude modulation of the sound emissions from the wind turbines creates a repetitive rise and fall in sound levels synchronised to the blade rotation speed, sometimes referred to as a "swish" or "thump". Many common weather conditions increase the magnitude of amplitude modulation. Unfortunately most of these occur at night.

The threshold for detection of a sound with a modulation frequency of 1 Hz was in an experimental study found to be 1-2 dB below a masking noise (white noise). The masking noise had its energy within the same frequency band as the modulated sound, thus providing optimal possibilities for masking. Modulating characteristics of the sound from a wind turbine therefore makes it more likely to be noticed and less masked by background noise.

Pederson (2003) highlighted a weak correlation between sound pressure level and noise annoyance caused by wind turbines. Residents complaining about wind turbines noise perceived more sound characteristics than noise levels. People were able to distinguish between background ambient sounds and the sounds that the blades made. The noise produced by the blades lead to most complaints. Most of the annoyance was experienced between 16.00 p.m. and midnight. This could be an issue as noise propagation modelling would be reporting an equivalent, or "average" sound pressure level, a parameter that ignores the "character" of the sound.

The graph in **Figure 4-6** shows this effect in the first floor bedroom of a farm home in the U.K. The home is located 930 meters from the nearest turbine (type or details of turbine unknown). The conditions documented by an independent acoustical consultant show the sound level varying over a 9 dBA range from 28 to 37 dBA. The pattern repeats approximately every second often for hours at a time. It is also reported that for many people, especially seniors, children and those with pre-existing medical conditions, this represents a major challenge to restful sleep.

This statement was also confirmed by Delta (2008), stating that sounds from modern large wind turbines are dominated by the aerodynamic noise from the blades rotating in the air. The mid and high frequency aerodynamic noise is modulated by the low blade passage frequency (~1 Hz).

Unfortunately, the mechanism of this noise is not known although various possible reasons have been put forward. Although the prevalence of complaints about amplitude modulation is relatively small, it is not clear whether this is because it does not occur often enough or whether it is because housing is not in the right place to observe it. Furthermore, the fact that the mechanism is unknown means that it is not possible to predict when or whether it will occur.

Even though there are thousands of wind turbine generators in the world, amplitude modulation is one subject receiving the least complaints and due to this very few complaints, little research went into this subject. It is included in this report to highlight all potential risks, albeit extremely low risks such as this (low significance due to very low probability).

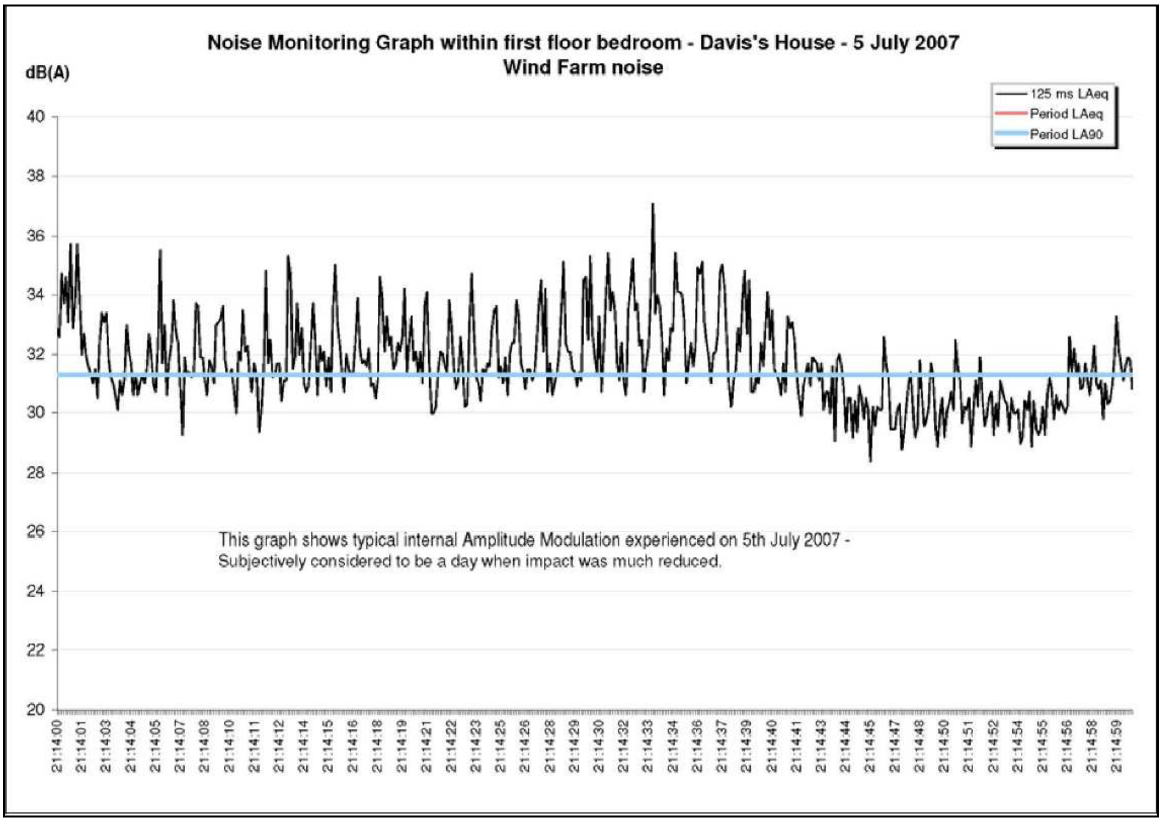

Figure 4-6: Amplitude modulation in a home 930 meters away from a WTG.

5 METHODS: NOISE IMPACT ASSESSMENT AND SIGNIFICANCE

5.1 Noise Impact on Animals

A great deal of research was conducted in the 1960's and 1970's on the effects of aircraft noise on animals. While aircraft noise have a specific characteristic that might not be comparable with industrial noise, the findings should be relevant to most noise sources.

Overall, the research suggests that species differ in their response to:

- Various types of noise
- Durations of noise
- Sources of noise

A general animal behavioural reaction to aircraft noise is the startle response. However, the strength and length of the startle response appears to be dependent on:

- which species is exposed
- whether there is one animal or a group
- whether there have been some previous exposures

Unfortunately, there are numerous other factors in the environment of animals that also influence the effects of noise. These include predators, weather, changing prey/food base and ground-based disturbance, especially anthropogenic. This hinders the ability to define the real impact of noise on animals.

From these and other studies the following can be concluded:

- Animals respond to impulsive (sudden) noises (higher than 90 dBA) by running away. If the noises continue, animals would try to relocate. This is not relevant to wind energy facilities because the turbines do not generate impulsive noises close to these sound levels.
- Animals of most species exhibit adaptation with noise, including aircraft noise and sonic booms (far worse than noises associated with Wind Turbines).
- More sensitive species would relocate to a more quiet area, especially species that depend on hearing to hunt or evade prey, or species that makes use of sound/hearing to locate a suitable mate.
- Noises associated with helicopters, motor- and quad bikes significantly impact on animals.

5.1.1 Domestic Animals

It has been observed that most domestic animals are generally not bothered by noise, excluding most impulsive noises. In the intensity range that a Wind Turbine generates noise, it should not impact on any domestic animal.

5.1.2 Wildlife

Depending on the turbine, some may create significant enough acoustic energy in the low frequency range that might impact on animals that makes use of vibrations to hunt. But in general, most anthropogenic activities have already disturbed sensitive animals that might have been impacted by the noise from a wind turbine.

Noise impacts are therefore very highly species dependent. Studies showed that most animals adapt to noises, and would even return to a site after an initial disturbance, even if the noise is continuous. The more sensitive animals that might be impacted by noise would most likely relocate to a quieter area.

Unfortunately, there are only a few specific studies discussing the potential impacts of noise associated wind turbines on wildlife. It is suspected that noises from wind turbines may mask the sounds of a predator approaching; similarly predators depending on hearing would not be able to locate their prey. However, due to significant background ambient sounds during periods when the wind turbines are operating (wind induced noises), the potential impact from a wind turbine on such animals are questioned.

A noteworthy study was conducted by Stephen Pearce-Higgins *et al* (2009). This survey of breeding birds in non-agricultural British uplands (moors and grassland) included weekly surveys during the breeding season at 12 different wind farm sites, along with comparable nearby landscapes without turbines. Half the wind farms were from the previous generation (way back in the 1990's), with hub heights of 40m and less; the other half had hub heights of 60-70m. Of the twelve species that were observed often enough to provide good data, five seemed relatively unaffected by turbines (including kestrel, lapwing, grouse, skylark, and stonechat), while 7 species were less likely to nest within 500m of turbines, with smaller (i.e., not statistically significant) effects extending to 800m, or roughly half a mile. For six of the species (buzzard, hen harrier, plover, snipe, curlew, and wheatear), numbers were reduced by 39-52%.

The authors note that there is a pressing need for examination of the reasons for the depressed numbers and state: "*we do not know whether our observations of avoidance of turbines reflect a behavioural displacement, the local population consequences of collision* *mortality or reduced productivity, or both. The distinction is important. If there is high mortality of birds breeding close to the turbines associated with collision, then a wind farm may become a population sink if repeatedly colonized by naïve birds. If, however, the birds simply avoid breeding close to the turbines, then displaced birds may settle elsewhere with little cost.*"

They also note that "*species occupying remote semi-natural habitats may be more sensitive to wind farm development than species occupying intensive production landscapes*."

This indicates that the potential significance of a noise impact would depend on the species concerned. Less sensitive species would not be bothered by the noises from the wind turbines, whereas the more sensitive species might relocate. Unfortunately, there is no database of potential sensitive species in South Africa. Taking the precautionary route, it is suggested that construction do not take place within 500 meters from any sensitive species as identified by the Fauna/Avifauna study during the breeding season.

5.2 WHY NOISE CONCERNS COMMUNITIES

Noise can be defined as "unwanted sound", and an audible acoustic energy that adversely affects the physiological and/or psychological well-being of people, or which disturbs or impairs the convenience or peace of any person. One can generalise by saying that sound becomes unwanted when it:

- Hinders speech communication
- Impedes the thinking process
- Interferes with concentration
- Obstructs activities (work, leisure and sleeping)
- Presents a health risk due to hearing damage

However, it is important to remember that whether a given sound is "noise" depends on the listener or hearer. The driver playing loud rock music on their car radio hears only music, but the person in the traffic behind them hears nothing but noise.

Response to noise is unfortunately not an empirical absolute, as it is seen as a multi-faceted psychological concept, including behavioural and evaluative aspects. For instance, in some cases, annoyance is seen as an outcome of disturbances, in other cases it is seen as an indication of the degree of helplessness with respect to the noise source.

Noise does not need to be loud to be considered "disturbing". One can refer to a dripping tap in the quiet of the night, or the irritating "thump-thump" of the music from a neighbouring house at night when one would like to sleep.

Severity of the annoyance depends on factors such as:

- Background sound levels, and the background sound levels the receptor is used to,
- The manner in which the receptor can control the noise (helplessness),
- The time, unpredictability, frequency distribution, duration, and intensity of the noise,
- The physiological state of the receptor,
- The attitude of the receptor about the emitter (noise source).

5.3 IMPACT ASSESSMENT CRITERIA

5.3.1 Overview: The common characteristics

The word "noise" is generally used to convey a negative response or attitude to the sound received by a listener. There are four common characteristics of sound, any or all of which determine listener response and the subsequent definition of the sound as "noise". These characteristics are:

- Intensity
- Loudness
- Annoyance
- Offensiveness

Of the four common characteristics of sound, intensity is the only one which is not subjective and can be quantified. Loudness is a subjective measure of the effect sound has on the human ear. As a quantity it is therefore complicated, but has been defined by experimentation on subjects known to have normal hearing.

The annoyance and offensive characteristics of noise are also subjective. Whether or not a noise causes annoyance mostly depends upon its reception by an individual, the environment in which it is heard, the type of activity and mood of the person and how acclimatised or familiar that person is to the sound.

5.3.2 Noise criteria of concern

The criteria used in this report were drawn from the criteria for the description and assessment of environmental impacts from the EIA Regulations, published by the

Department of Environmental Affairs and Tourism (April 1998) in terms of the NEMA, SANS 10103:2008 as well as guidelines from the World Health Organization.

There are a number of criteria that are of concern for the assessment of noise impacts. These can be summarised in the following manner:

- *Increase in noise levels:* People or communities often react to an increase in the ambient noise level they are used to, which is caused by a new source of noise. With regards to the Noise Control Regulations (promulgated in terms of the ECA), an increase of more than 7 dBA is considered a disturbing noise. See also **Figure 5-1**.
- *Zone Sound Levels:* Previously referred to as the acceptable rating levels, it sets acceptable noise levels for various areas. See also **Table 5.1**.
- *Absolute or total noise levels:* Depending on their activities, people generally are tolerant to noise up to a certain absolute level, e.g. 65 dBA. Anything above this level will be considered unacceptable.

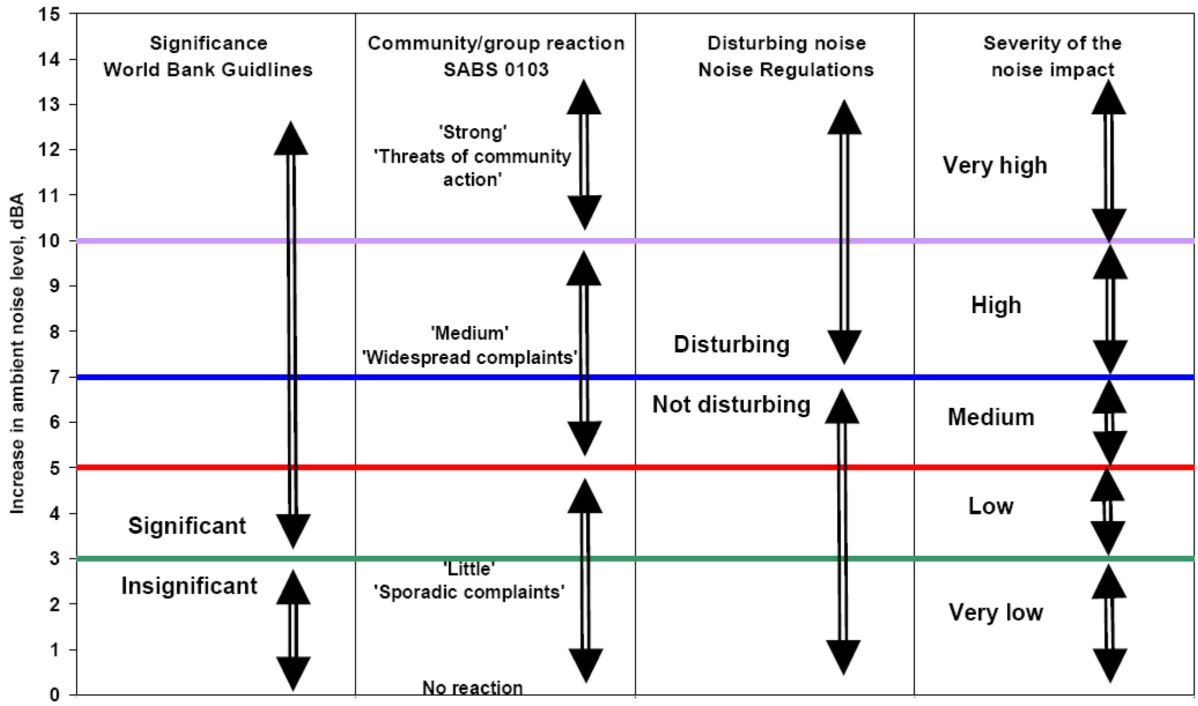

Figure 5-1: Criteria to assess the significance of impacts stemming from noise

In South Africa, the document that addresses the issues concerning environmental noise is SANS 10103:2008 (See also **Table 5.1**). It provides the maximum average background ambient sound levels (referred to as Rating Levels), $L_{Req,d}$ and $L_{Req,n}$, during the day and night respectively to which different types of developments may be exposed. For rural areas the Zone Sound Levels are:

- Day (06:00 to 22:00) - $L_{Req,d}$ = 45 dBA, and

- Night (22:00 to 06:00) - $L_{Req,n}$ = 35 dBA.

For the purpose of this Environmental Noise Impact Assessment the Zone Sound Levels as proposed in SANS 10103:2008 would be adopted to be acceptable to the noise sensitive developments in the area.

SANS 10103:2008 also provides a guideline for estimating community response to an increase in the general ambient noise level caused by an intruding noise. If Δ is the increase in noise level, the following criteria are of relevance:

- **Δ ≤ 3 dBA:** An increase of 3 dBA or less will not cause any response from a community. It should be noted that for a person with average hearing acuity an increase of less than 3 dBA in the general ambient noise level would not be noticeable.
- **3 < Δ ≤ 5 dBA:** An increase of between 3 dBA and 5 dBA will elicit 'little' community response with 'sporadic complaints'. People will just be able to notice a change in the sound character in the area.
- **5 < Δ ≤ 15 dBA:** An increase of between 5 dBA and 15 dBA will elicit a 'medium' community response with 'widespread complaints'. In addition, an increase of 10 dBA is subjectively perceived as a doubling in the loudness of a noise. For an increase of more than 15 dBA the community reaction will be 'strong' with 'threats of community action'.

Table 5.1: Acceptable Zone Sound Levels for noise in districts (SANS 10103)

1	2	3	4	5	6	7
Type of district	**Equivalent continuous rating level ($L_{Req.T}$) for noise** dBA					
	Outdoors			**Indoors, with open windows**		
	Day/night $L_{R,dn}$ [a]	**Daytime** $L_{Req,d}$ [b]	**Night-time** $L_{Req,n}$ [b]	**Day/night** $L_{R,dn}$ [a]	**Daytime** $L_{Req,d}$ [b]	**Night-time** $L_{Req,n}$ [b]
a) Rural districts	45	45	35	35	35	25
b) Suburban districts with little road traffic	50	50	40	40	40	30
c) Urban districts	55	55	45	45	45	35
d) Urban districts with one or more of the following: workshops; business premises; and main roads	60	60	50	50	50	40
e) Central business districts	65	65	55	55	55	45
f) Industrial districts	70	70	60	60	60	50

5.3.3 Determining appropriate Zone Sound Levels

SANS 10103:2008 unfortunately does not cater for instances when background ambient sound levels change due to the impact of external forces. Locations close (up to 500 meters from coastline) to the sea for instance always have an ambient sound level exceeding 35 dBA, and, in cases where the sea is rather turbulent, it can easily exceed 45 dBA. Similarly, noise induced by high winds is not considered in the SANS standard.

Setting noise limits relative to the ambient sound level is relatively straightforward when the prevailing ambient sound level and source level are constant. However, wind turbines emit noise that is related to wind speed, and the environment within which they are heard will probably also be dependent upon the strength of the wind and the noise associated with its effects. It is therefore necessary to derive an ambient sound level that is indicative of the noise environment at the receiving property for different wind speeds so that the turbine noise level at any particular wind speed can be compared with the ambient sound level in the same wind conditions.

Therefore, when assessing the overall noise levels emitted by a Wind Energy Facility, it is necessary to consider the full range of operating wind speeds of the wind turbines. This covers the wind speed range from around 3-5m/s (the turbine cut-in wind speed) up to a wind speed range of 25-35m/s measured at the hub height of a wind turbine. However, the Noise Working Group (1996) proposes that noise limits only be placed up to a wind speed of 12 m/s for the following reasons:

1. Wind speeds are not often measured at wind speeds greater than 12 m/s at 10m height
2. Reliable measurements of background ambient sound levels and turbine noise will be difficult to make in high winds due to the effects of wind noise on the microphone and the fact that one could have to wait several months before such winds were experienced
3. Turbine manufacturers are unlikely to be able to provide information on sound power levels at such high wind speeds for similar reasons
4. If a wind farm meets noise limits at wind speeds lower than 12m/s, it is most unlikely to cause any greater loss of amenity at higher wind speeds. Turbine noise levels increase only slightly as wind speeds increase; however, background ambient sound levels increase significantly with increasing wind speeds due to the force of the wind

Available data indicates that noises from a Wind Turbine is drowned by other noises (wind howling around building, rustling of leaves in trees, rattling noises, etc) above a wind speed of 10 m/s, even if the wind blows in the direction of the receiver.

A cautious ambient sound vs. wind speed regression curve is illustrated in **Figure 5-2**. It should be noted that curves for day time (6:00 – 22:00) and night time (22:00 – 6:00) would be different, but as wind speeds increase, the wind induced noise levels approach the noise emitted by the wind turbine(s).

For the purpose of the EIA, **Figure 5-2** will be considered, the change in sound levels that the receptors may experience together with the zone sound levels as stipulated in SANS 10103:2008. Ambient sound levels associated with specific wind speeds are also defined in **Table 7.3**.

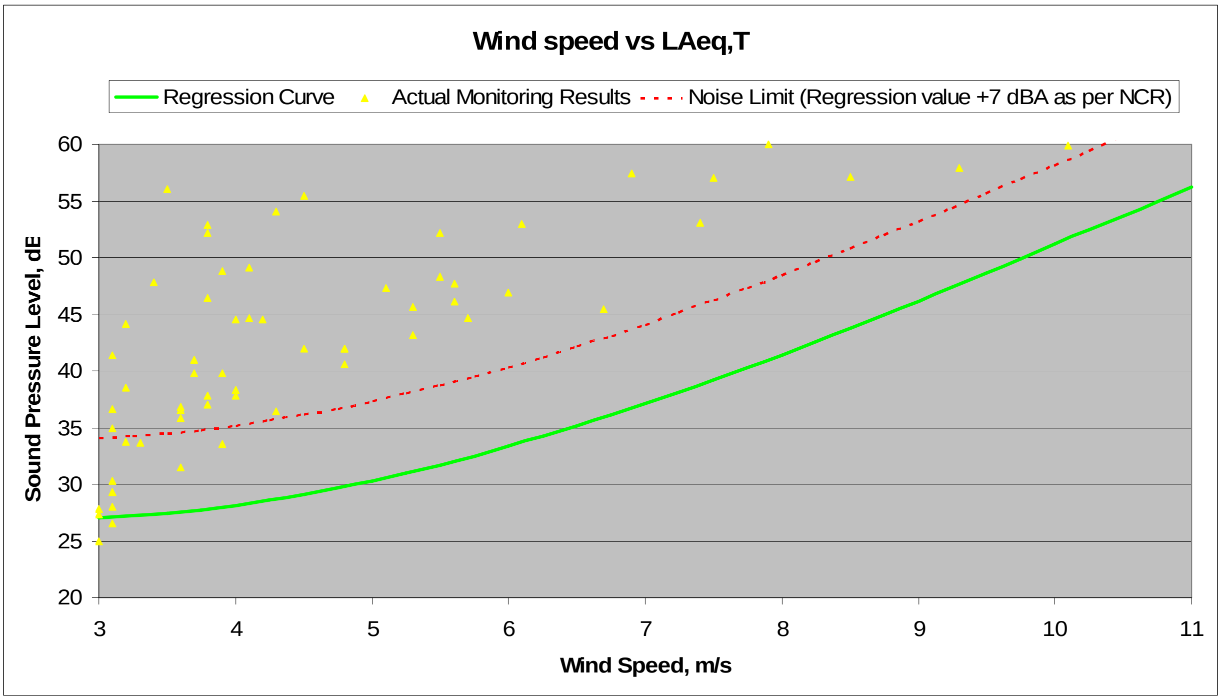

Figure 5-2: Background ambient sound levels associated with increased wind speeds

5.3.3.1 Relationship between wind speed at different levels and noise at ground level

Generally, as the height above ground level increases, wind speed also increases. For acoustical purposes prediction of the wind speed at hub height is based on the wind speed v_{ref} at the reference height (normally 10 meters) for wind speed measurements, extrapolated to a wind speed v_h at hub height, using the widely used formula:

$$v_h = v_{ref} \times \frac{\log\left(h/m\right)}{\log\left(h_{ref}/m\right)}$$

However, depending on topographical layout, this relationship may not be true at all times. Authors such as Van den Berg (2003) indicated that wind speeds at hub height could be significantly higher that expected, at the same time being significantly higher than ground level wind speeds. In these cases, the wind turbines are operational and emitting noise, yet the wind induced ambient sound levels is less than expected (less masking of turbine noise). This is one of the reasons the ambient curve (**Figure 5-2**) is adjusted with -3 dBA, allowing the ambient sound levels to be less at all times than potential "real" ambient sound levels.

This should be considered when evaluating the significance of the impact, especially when the wind turbines are situated on a hill, with the prevailing wind direction being in the direction of potential sensitive receptors living in a valley downwind of the wind energy facility. It is proposed by this author that the precautionary approach be considered, and when there is one or more turbines within 1,000 metres from a downwind receptor(s), that the probability of this impact occurring be elevated with at least one step/factor (e.g. from ***Likely*** to ***Highly Likely***). This is one of the reasons the ambient curve (**Figure 5-2**) is adjusted with -3 dBA, allowing the ambient sound levels to be less at all times than potential "real" ambient sound levels.

5.3.3.2 Other noise sources of significance

In addition, other noise sources that may be present should also be considered. During the day, people are generally bombarded with the sounds from numerous sources considered "normal", such as animal sounds, conversation, amenities and appliances (TV/Radio/CD playing in background, computer(s), freezers/fridges, etc). This excludes activities that may generate additional noise associated with normal work.

At night, sounds that are present are natural sounds from animals, wind as well as other sounds we consider "normal", such as the hum from a variety of appliances (magnetostriction) drawing standby power, freezers and fridges.

Figure 5-3 illustrates the sound levels associated with some equipment or in certain rooms. This is however more for illustrative purposes, as there are many manufacturers with different equipment, each with a different noise emission character.

5.3.4 Determining the Significance of the Noise Impact

The level of detail as depicted in the EIA regulations was fine-tuned by assigning specific values to each impact. In order to establish a coherent framework within which all impacts could be objectively assessed, it was necessary to establish a rating system, which was applied consistently to all the criteria. For such purposes each aspect was assigned a value, ranging from one (1) to five (5), depending on its definition. This assessment is a relative evaluation within the context of all the activities and the other impacts within the framework of the project. An explanation of the impact assessment criteria is defined in **Table 5.2**.

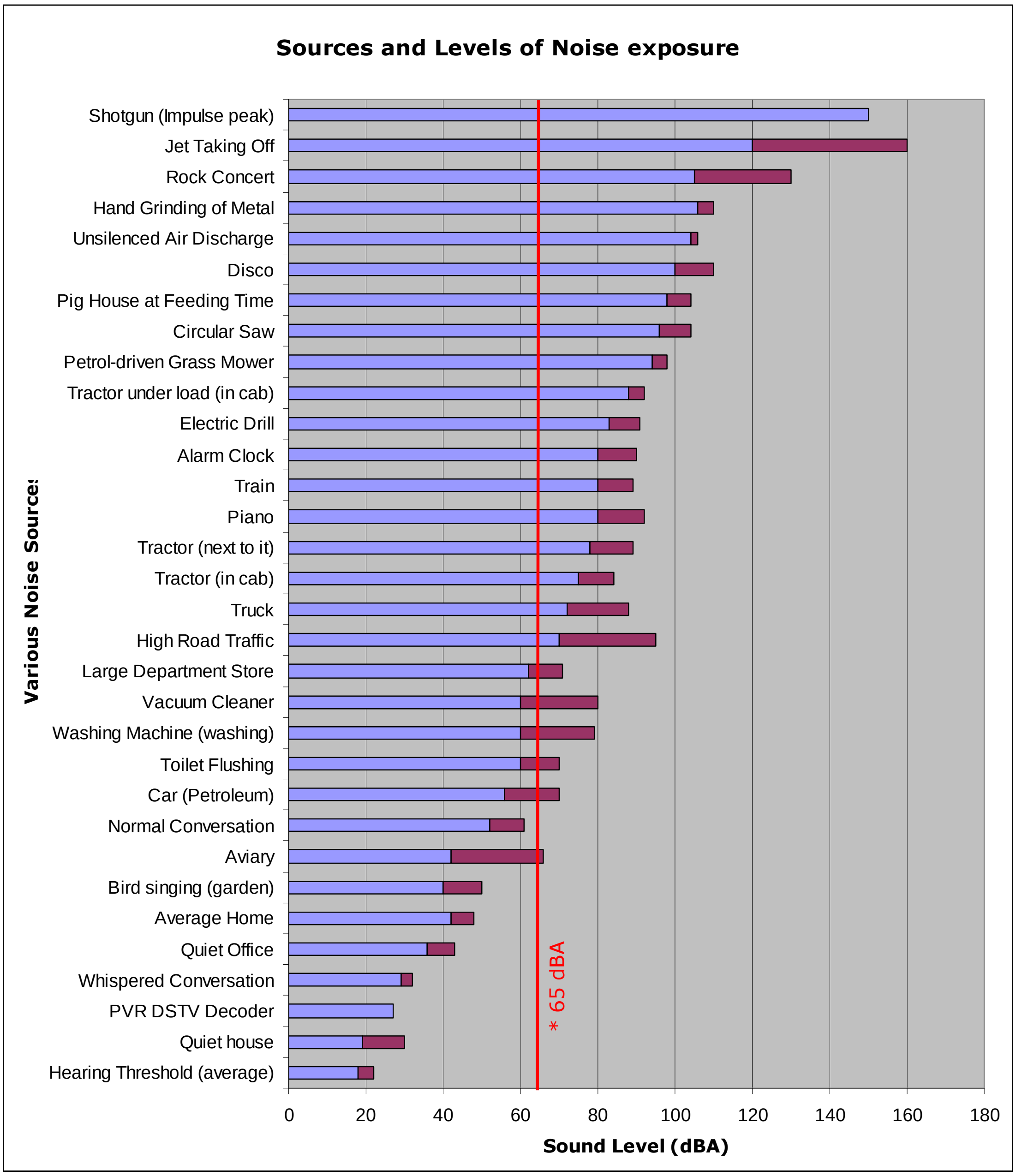

Figure 5-3: Typical Noise Sources and associated Sound Pressure Level

Table 5.2: Impact Assessment Criteria

Duration	
The lifetime of the impact that is measured in relation to the lifetime of the proposed development (construction, operational and closure phases). Will the receptors be subjected to increased noise levels for the lifetime duration of the project, or only infrequently.	
Temporary	The impact will either disappear with mitigation, will be mitigated through a natural process, or will last less than an hour.
Short term	The impact will be applicable less than 24 hours.
Medium term	The impact will last up to a week.
Long term	The impact will last up to a month.
Permanent	Any impacts lasting more than a month. It is considered non-transitory. Mitigation either by man or natural process will not occur in such a way or in such a time span that the impact is transient.
Spatial scale	
Classification of the physical and spatial scale of the impact	
Site	The impacted area extends only as far as the activity, such as footprint occurring within the total site area.
Local	The impact could affect the local area (within 1,000 m from site).
Regional	The impact could affect the area including the neighbouring farms, the transport routes and the adjoining towns.
National	The impact could have an effect that expands throughout the country (South Africa).
International	Where the impact has international ramifications that extend beyond the boundaries of South Africa.
Probability	
This describes the likelihood of the impacts actually occurring, and whether it will impact on an identified receptor. The impact may occur for any length of time during the life cycle of the activity, and not at any given time. The classes are rated as follows:	
Improbable	The possibility of the impact occurring is none, due either to the circumstances, design or experience. The chance of this impact occurring is zero (0 %).
Possible	The possibility of the impact occurring is very low, due either to the circumstances, design or experience. The chances of this impact occurring is defined to be up to 25 %.
Likely	There is a possibility that the impact will occur to the extent that provisions must therefore be made. The chances of this impact occurring is defined to be between 25% and 50 %.
Highly Likely	It is most likely that the impacts will occur at some stage of the development. Plans must be drawn up before carrying out the activity. The chances of this impact occurring is defined to be between 50 % to 75 %.
Definite	The impact will take place regardless of any prevention plans, and only mitigation actions or contingency plans to contain the effect can be relied on. The chance of this impact occurring is defined to be between 75% and 100 %.
Magnitude	
This defines the impact as experienced by any receptor. In this report the receptor is defined as any resident in the area, but excludes faunal species.	
Low	Increase in sound pressure levels between 0 and 3 from the expected wind induced ambient sound level (**Figure 5-2**). The change is just discernable. Total projected noise level is less than the Zone Sound Level in wind-still conditions.
Low Medium	Increase in sound pressure levels between 3 and 5 from the expected wind induced ambient sound level (**Figure 5-2**). The change is easily discernable. Total projected noise level is less than the Zone Sound Level in wind-still conditions.
Medium	Increase in sound pressure levels between 5 and 7 from the expected wind induced ambient sound level (**Figure 5-2** – point above red line). Sporadic complaints. Defined by the National Noise Regulations as being legally 'disturbing'. Any point where the zone sound levels are exceeded during wind still conditions.
High	Increase in sound pressure levels between 7 and 10. Change of 10 dBA is perceived as 'twice as loud', leading to widespread complaints. Any point where noise levels exceed zone sound level during wind still conditions.
Very High	Increase in sound pressure levels higher than 10. Threats of community or group action. Any

	point where noise levels exceed 65 dBA at any receptor.

In order to assess each of these factors for each impact, the following ranking scales as contained in **Table 5.3** will be used.

Table 5.3: Assessment Criteria: Ranking Scales

PROBABILITY		MAGNITUDE	
Description / Meaning	**Score**	**Description / Meaning**	**Score**
Definite/don't know	5	Very high/don't know	10
Highly likely	4	High	8
Likely	3	Medium	6
Possible	2	Low Medium	4
Improbable	1	Low	2
DURATION		**SPATIAL SCALE**	
Description / Meaning	**Score**	**Description / Meaning**	**Score**
Permanent	5	International	5
Long Term	4	National	4
Medium Term	3	Regional	3
Short term	2	Local	2
Temporary	1	Footprint	1

5.3.5 Identifying the Potential Impacts without Mitigation Measures (WOM)

Following the assignment of the necessary weights to the respective aspects, criteria are summed and multiplied by their assigned probabilities, resulting in a value for each impact (prior to the implementation of mitigation measures).

Significance without mitigation is rated on the following scale:

SR < 30	Low (L)	Impacts with little real effect and which should not have an influence on or require modification of the project design or alternative mitigation. No mitigation is required.
30 < **SR** < 60	Medium (M)	Where it could have an influence on the decision unless it is mitigated. An impact or benefit which is sufficiently important to require management. Of moderate significance - could influence the decisions about the project if left unmanaged.
SR > 60	High (H)	Impact is significant, mitigation is critical to reduce impact or risk. Resulting impact could influence the decision depending on the possible mitigation. An impact which could influence the decision about whether or not to proceed with the project.

5.3.6 Identifying the Potential Impacts with Mitigation Measures (WM)

In order to gain a comprehensive understanding of the overall significance of the impact, after implementation of the mitigation measures, it will be necessary to re-evaluate the impact. Significance with mitigation is rated on the following scale:

SR < 30	Low (L)	The impact is mitigated to the point where it is of limited importance.
30 < **SR** < 60	Medium (M)	Notwithstanding the successful implementation of the mitigation measures, to reduce the negative impacts to acceptable levels, the negative impact will remain of significance. However, taken within the overall context of the project, the persistent impact does not constitute a fatal flaw.
SR > 60	High (H)	The impact is of major importance. Mitigation of the impact is not possible on a cost-effective basis. The impact is regarded of high importance and taken within the overall context of the project, is regarded as a fatal flaw. An impact regarded as high significance, after mitigation could render the entire development option or entire project proposal unacceptable.

5.4 EXPRESSION OF THE NOISE IMPACTS

The noise impacts can be expressed in terms of total ambient noise levels as well as the increase in present background ambient sound levels caused by noise emissions from the proposed project.

Predicted ambient sound levels as well as change in ambient sound levels will be presented in appropriate contours of constant sound pressure levels.

For modelling and assessing the potential noise impact the values as proposed in **Table 5.4** will be considered.

Table 5.4: Proposed ambient sound levels and acceptable rating levels

Wind Speed (m/s)	$L_{Aeq,ambient}$ (Figure 5-2) dBA	Night-time Zone Sound Level (SANS 10103:2008) dBA	Proposed Night Rating Level (considering impact of wind) dBA	Maximum Proposed Acceptable Night Rating Level dBA
3	27.04	35	35	40
4	28.15	35	35	40
5	30.30	35	35	40
6	33.33	35	35	40
7	37.09	35	37.1	42.1
8	41.40	35	41.4	46.4

6 METHODS: CALCULATION OF FUTURE NOISE EMISSIONS DUE TO PROPOSED PROJECT

6.1 NOISE EMISSIONS INTO THE SURROUNDING ENVIRONMENT

The noise emissions into the environment from the various sources as defined by the project developer were calculated for the construction and operational phases in detail, using the sound propagation models described by SANS 10357 (Construction and Operation) as well as ISO 9613-2 (Operation).

The following was considered:

- The octave band sound pressure emission levels of processes and equipment (SANS and ISO);
- The distance of the receiver from the noise sources (SANS and ISO);
- The impact of atmospheric absorption (SANS and ISO);
- The meteorological conditions in terms of Pasquill stability (considering refraction effects due to wind direction – SANS only);
- The operational details of the proposed project, such as the location of each Wind Turbine Generator (SANS and ISO);
- Topographical layout (SANS and ISO); and
- Acoustical characteristics of the ground. Soft ground conditions were modelled, as the area where the facility is proposed to be constructed is well vegetated and sufficiently uneven to allow the consideration of soft ground conditions (50% soft for both the SANS and ISO models). This is also the point where the SANS and ISO model differ significantly in the method how attenuation is calculated, with the ISO model largely minimising ground attenuation due to the height of the point source *[the wind turbines in this case]*). The result is that noises originating from noise sources situated very high would be attenuated far less due to ground effects than noises originating closer to the ground surface using the ISO model.

The noise emission into the environment due to additional traffic will be calculated using the sound propagation model described in SANS 10210. Corrections such as the following will be considered:

- Distance of receptor from the road;
- Road construction material;
- Average speeds of travel;
- Types of vehicles used; and
- Ground acoustical conditions.

6.2 FACTORS THAT MUST BE CONSIDERED THAT MIGHT COMPLICATE THE ACCURACY OF NOISE PROPAGATION MODELLING

Reviewing numerous literatures, the following factors were highlighted to complicate noise propagation modelling and prediction when working with wind turbines:

- As previously discussed, a wind turbine can cause a modulation of sound when the blades of the hub rotate, and depend on where the receptor to this sound is located. The threshold for detection of this modulation could be as much as 2 dB below a masking noise (white noise). Modulating sound characteristics from a wind turbine therefore makes it more likely to be noticed and less likely to be masked by background noise (Pederson, 2003). This not considered by predictive models;
- Residents complaining about wind turbine noise perceived the sound characteristics as more annoying than noise levels. People were able to distinguish between background ambient sounds, and the sounds that the blades made. The noise produced by the blades leads to most of the complaints. Most of the annoyance was experienced between 16.00 p.m. and midnight (Pederson, 2003). This could be an issue as noise propagation modelling would be reporting an equivalent, or "average" sound pressure level, a parameter that ignores the "character" of the sound;
- Night time meteorological conditions might be significantly different from the conditions assumed in noise propagation models. This is because of temperature gradients in the atmosphere. On a typical sunny afternoon, air is warmest near the ground and temperature decreases at higher altitudes. This temperature gradient causes sound waves to refract upward (due to the relative higher density of colder air) away from the ground and results in lower noise levels being heard at the listener's position. At night, this temperature gradient will reverse, resulting in cooler temperatures near the ground. This condition, that is often referred to as a temperature inversion, will cause sound to be bent downward towards the ground and results in louder noise levels at a potentially sensitive receptor. Temperature gradients can and will influence sound propagation over long distances and further complicate predictive modelling. The result is that predictive models will under-estimate noise levels;
- The noise emission characteristics of the proposed wind turbines at the height at which the turbine will be installed. Available data for wind turbines show that height above ground level does have an impact on the sound pressure levels at a receptor on ground level. Taller turbines can be heard further than turbines;

- Due to the height of these wind turbines, trees and other structures do not assist with the sound attenuation. It is therefore more difficult to model the effect of ground attenuation. This can result in significant under or over-estimation;
- Apart from the fact that higher turbines are constructed to optimally "harvest" wind energy, higher wind turbines is normally fitted with larger blades. The result is that the sound power levels associated with the wind turbine also increase;
- Wind speeds at hub (nacelle) height could be significantly higher than the wind speeds at ground level (the "van den Berg Effect"). The "real" noise generated by the wind turbine would therefore be significantly higher than expected. In addition, as the wind speed at ground level is less than expected, ambient sound levels at the potentially sensitive receptors will be less, resulting in less "masking" potential from the wind at ground level;
- Down wind effects. Wind alters sound propagation by the mechanism of refraction; that is, wind bends sound waves. These wind gradients, with faster winds at higher elevation and slower winds at lower elevation causes sound waves to be bend downwards as they propagate down wind of the source and to bend upwards when propagating upwind;
- Noise propagation models are only accurate some of the time, for certain conditions. Unfortunately, it is impossible to consider all possible conditions. Therefore, there may be times when noise levels in practice exceed those predicted. If these conditions occur with any regularity, it would impact on closer receptors;
- There is no model that can predict the acceptability of a sound from a source by an individual. While sound pressure level is an important factor, it is certainly not the only one;
- The background sound in an area is important as it directly affects audibility through masking. However, background sound levels summarized (averaged) as an equivalent sound level ignores the random character of the sound. Background sound levels is a variable and typically changes from moment to moment, such as when vehicles pass nearby, birds chirp and the wind gusts. During these instances a noise might be less noticeable, possibly inaudible at times. However, at other times a noise source might be highly detectable;
- Cumulative effects from a number of wind turbines must be considered. A large wind farm (100+ turbines) cannot be treated the same way as a small wind farm (less than 20 turbines). Similarly, the cumulative effects from a number of wind turbines close to potentially sensitive receptors must be considered for the appropriate wind directions and speed;

- There is significant acoustic energy in the lower frequencies in the sounds generated by a wind turbine. With the possible effects of amplitude modulation, it remains an unknown factor;
- The location where the wind farm is to be developed. Areas close to urban development effectively removes these areas for future residential use due to the increased rating levels; and
- Topographical layout should be considered. This is especially important when the turbines are to be installed on a ridge, with potential receptors being situated in a valley downwind from the turbines.

Due to these complicating factors, a precautionary stance should be taken, the approach taken with this assessment.

7 RESULTS AND IMPACT ASSESSMENT

7.1 CONSTRUCTION PHASE IMPACT

Construction activities are highly dependent on the final operational layout. A provisional layout, as provided by the developer, is presented in **Figure 7-4**. As can be seen from this proposal, a number of different activities might take place close to a potentially sensitive receptor, each with a specific potential impact. The activities have been defined in detail in **section 4.1**.

7.1.1 Description of Construction Activities Modelled

The following construction activities are assumed to take place simultaneously with the existing activities observed during the site visit (see **Figure 7-1**).

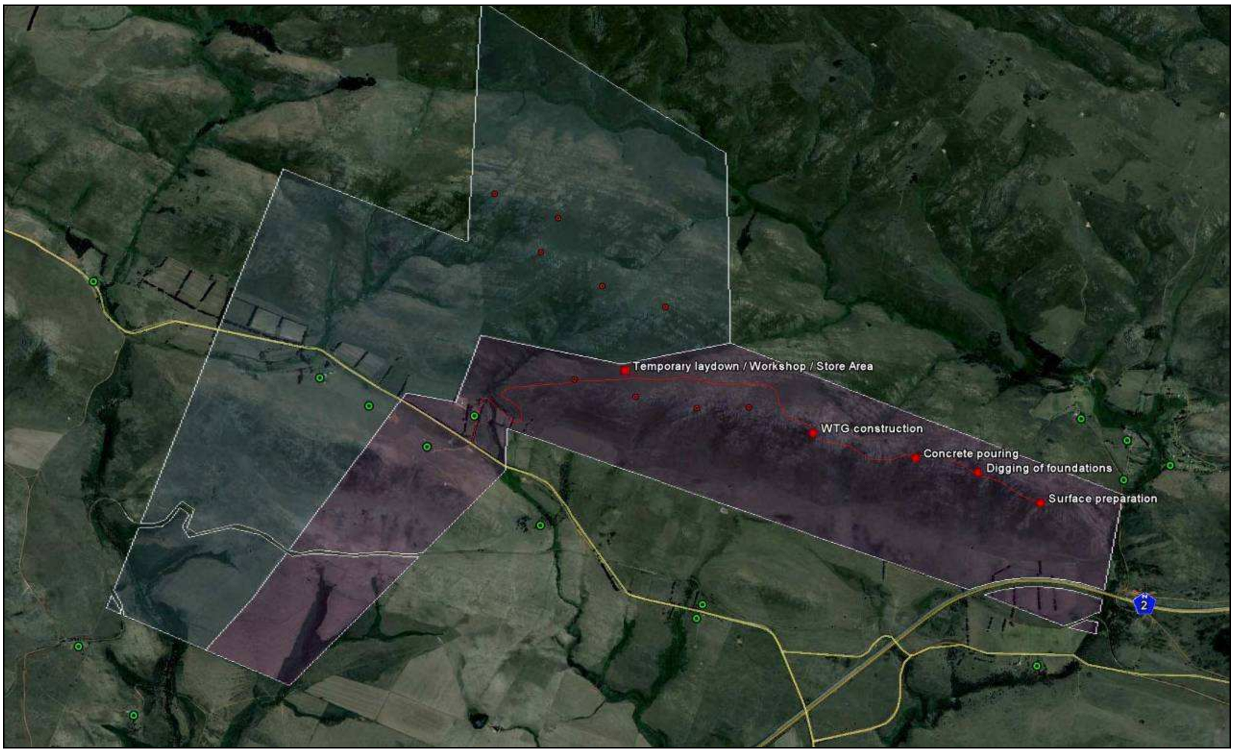

Figure 7-1: Illustration of locations of various construction activities that could take place simultaneously

Construction activities are selected at the locations of turbines 10 (*turbine construction*), 11 (*pouring of concrete*), 12 (*digging of foundations*) and 13 (*surface preparation*), with the temporary laydown/workshop/storage area assumed at the area where the sub-station is proposed.

This would represent the worst case scenario with five activities taking place simultaneously. For the purpose of the EIA the activities that are most likely to create the most noise are:

- General work at the workshop area. This would be activities such as equipment maintenance, off-loading and material handling. All vehicles will travel to this site where most equipment and material will be off-loaded (general noise, crane). Material, such as aggregate and building sand, will be taken directly to the construction area (foundation establishment). Activities will be taking place for 16 hours during the 16 hour day time period.
- Surface preparation prior to civil work. This could be the removal of topsoil and levelling with compaction, or the preparation of an access road (bulldozer/grader). Activities will be taking place for 8 hours during the 16 hour day time period.
- Preparation of foundation area (sub-surface removal until secure base is reached – excavator, compaction, and general noise). Activities will be taking place for 10 hours during the 16 hour day time period.
- Pouring and compaction of foundation concrete (general noise, electric generator/compressor, concrete vibration, mobile concrete plant, TLB). As foundations must be poured in one go, the activity is projected to take place over the full 16 hour day time period.
- Erecting of the wind turbine generator (general noise, electric generator/compressor and a crane). Activities will be taking place for 16 hours during the 16 hour day time period.
- Traffic on the site (trucks transporting material, aggregate/concrete, work crews) moving from the workshop/store area to the various activity sites. All vehicles to travel at less than 60 km/h, with a maximum of 5 trucks and vehicles per hour to be modelled travelling to the areas where work is taking place (red line).

The following equipment is presumed to be on site:

- 1x Bulldozer
- 1x Grader
- 1x Front-end loader and/or 1x Excavator
- 2x Electric Generator/Air Compressor and vibrators
- 1x TLB
- 1x Mobile Concrete Batching Plant/Truck
- 2x Cranes
- 2x Load haul dumpers

- 5x light delivery vehicles/people carriers (travelling onsite)

There will be a number of smaller equipment, but the addition of the general noise source (at each point) covers most of these noise sources. All equipment would be operating under full load (generate the most noise). Atmospheric conditions would be ideal for sound propagation.

Note that this scenario is selected to present the worse case scenario, with all equipment operating under full load, and with the construction activities selected/positioned to be near to a closest potentially sensitive receptor (Die Berg community). The various sound power levels of the equipment used (in the octave bands) can be found in **Appendix A**.

7.1.2 Results: Construction Phase

The scenario as defined in the previous section (**section 7.1**) was modelled with the output presented in **Figure 7-2** and **Figure 7-3**. Modelled noise levels are defined in **Table 7.1** with the impact tables presented in **Table 7.2**.

Only the calculated day time ambient noise levels are presented, as construction activities that might impact on sensitive receptors should be limited to the 06:00 – 22:00 time period. The worst case scenario is presented with the entire activities take place simultaneously during wind-still conditions, in good sound propagation conditions (20°C and 80% humidity).

Even though construction activities are projected to take place only during day time, it might be required at times that construction activities take place during the night (particularly for a large project). Below is a list (and reasons) of construction activities that might occur during night time:

- Concrete pouring: Large portions of concrete do require pouring and vibrating to be completed once started, and work is sometimes required until the early hours of the morning to ensure a well established concrete foundation. However the work force working at night for this work will be considerably smaller than during the day.
- Working late due to time constraints: Weather plays an important role in time management in construction. A spell of bad weather can cause a construction project to fall behind its completion date. Therefore it is hard to judge beforehand if a construction team would be required to work late at night.

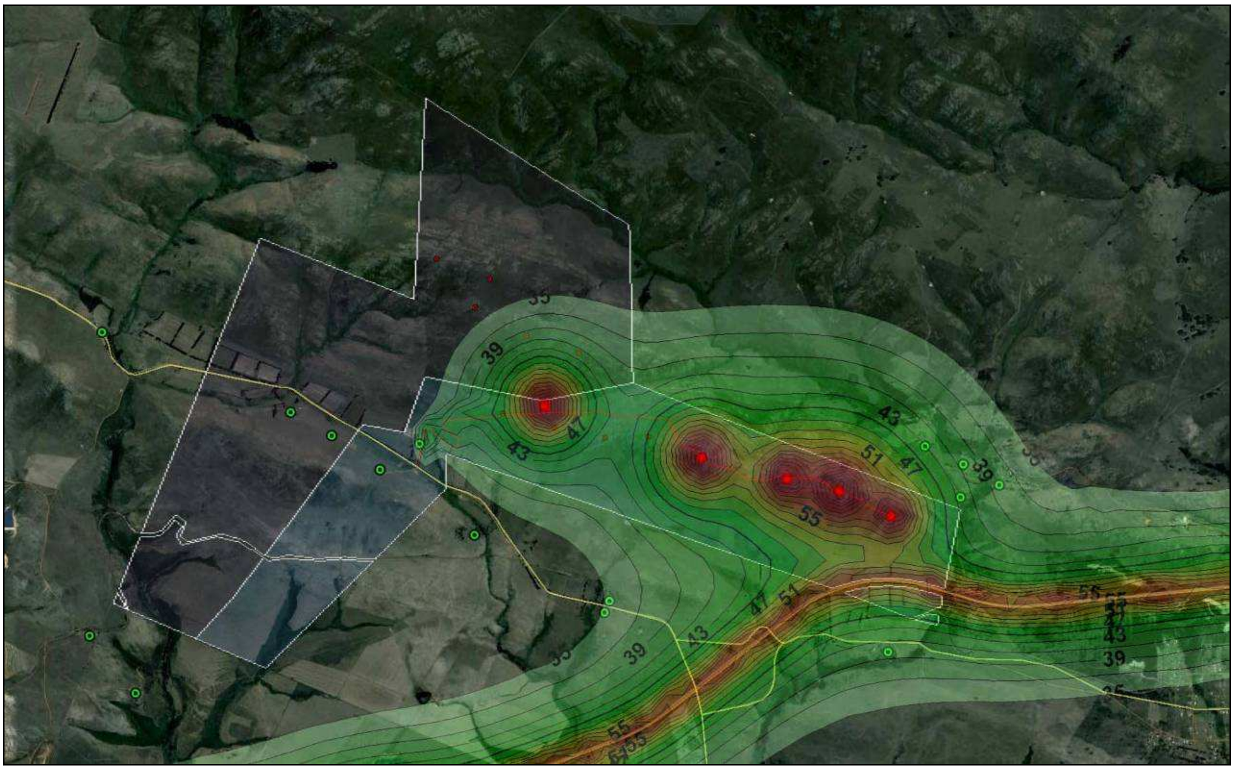

Figure 7-2: Construction noise: Projected total contours of constant noise levels

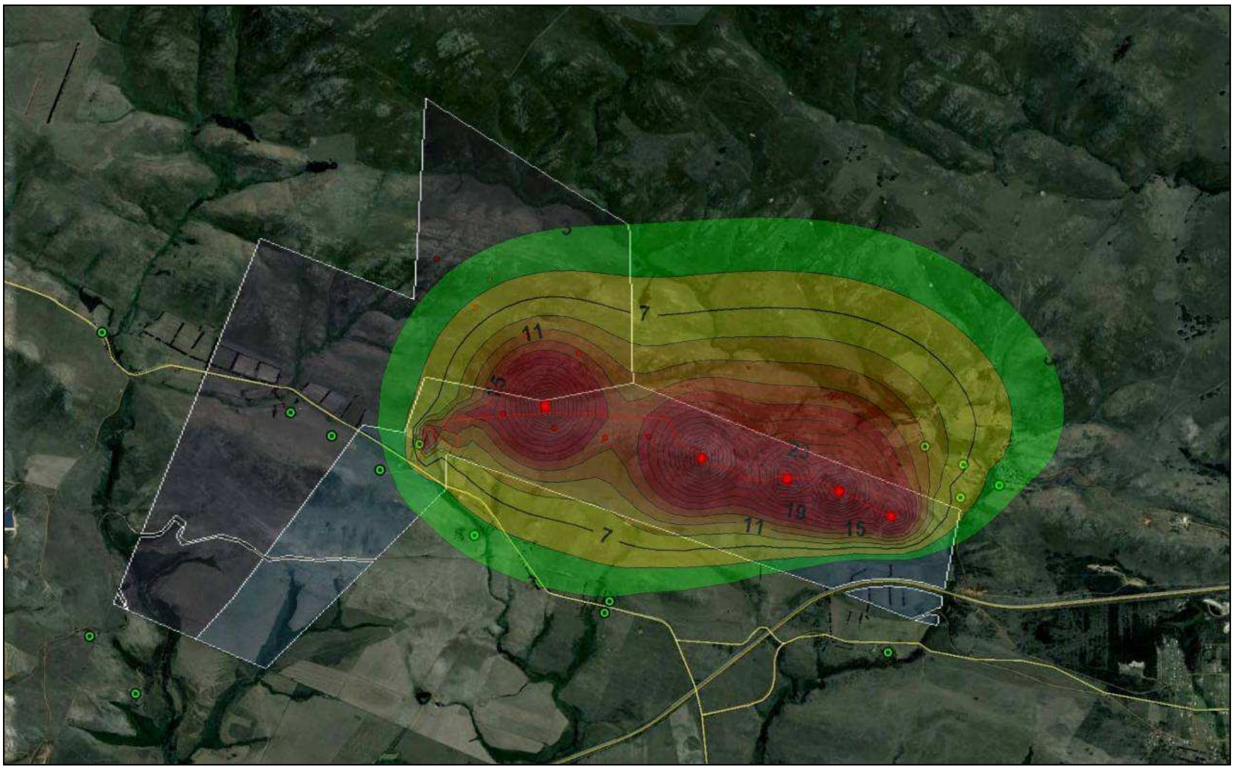

Figure 7-3: Construction noise: Projected change in ambient sound levels: Contours of constant noise levels

Table 7.1: Construction: Defining noise impact on Receptors (dBA) (Datum type: Universal Transverse Mercator, zone 34 - South)

Receptor	Estimated Ambient Sound Level	Day Ambient Noise Level[3]	Change in Noise Levels	Defining Significance of Noise Impact (See Table 5.2 and Table 5.3)				
				Magnitude	Duration	Extent	Probability	Significance
PSR01	36.1	42.3	6.1	2	4	3	2	**18**
PSR02	32.0	42.9	10.9	8	4	3	2	**30**
PSR03	33.0	40.2	7.3	6	4	3	2	**26**
PSR04	34.1	38.1	4.1	4	4	3	1	**11**
PSR05	38.1	39.8	1.7	2	4	3	1	**9**
PSR06	32.5	35.3	2.8	2	4	3	1	**9**
PSR07	32.9	35.1	2.2	2	4	3	1	**9**
PSR08	28.7	32.7	4.0	4	4	3	1	**11**
PSR09	28.3	39.7	11.5	8	4	3	2	**30**
PSR10	28.3	30.9	2.7	2	4	3	1	**9**
PSR11	28.2	29.9	1.6	2	4	3	1	**9**
PSR12	28.2	29.2	1.0	2	4	3	1	**9**
PSR13	32.6	33.5	0.9	2	4	3	1	**9**
PSR14	35.9	36.3	0.4	2	4	3	1	**9**
PSR15	28.6	28.9	0.4	2	4	3	1	**9**
PSR16	30.0	30.2	0.3	2	4	3	1	**9**
PSR17	28.2	28.6	0.4	2	4	3	1	**9**

7.1.3 Impact Assessment: Construction Phase

The impact assessment for the various construction activities that may impact on the surrounding environment is presented in the **Table 7.2**.

Table 7.2: Impact Assessment: Construction Activities without Mitigation

Nature:	Numerous simultaneous construction activities that could impact on PSRs
Acceptable Rating Level	Rural district with little road traffic: 45 dBA outside during day (refer **Table 5.1**). Use $L_{Req,D}$ of 45 dBA for rural areas.
Extent ($\Delta L_{Aeq,D}$>7dBA)	**Regional** – Change in ambient sound levels would extend further than 1,000 meters from activity **(3).**
Duration	**Long term** – Noisy activities in the vicinity of the receptor could last up to a month **(4).**
Magnitude	See **Table 7.1** Ambient noise levels < Zone Sound Level *$\Delta L_{Aeq,D}$>7dBA (mainly due to low ambient sound levels adopted)* **Low to high (2 – 8).**
Probability	Total projected ambient noise levels relatively low. Change in ambient sound levels high due to low ambient noise levels assumed. Normal daily activities would likely mask all construction related noises. **Improbable (1)** – **Possible (2).**
Significance	**Low (30)** *Worse case for PSR09 (traffic past house) and PSR03 (construction activity).*

[3] Ambient sound level was calculated using the SANS methods discussed in this report.

Status	Negative.
Reversibility	High.
Irreplaceable loss of resources?	Not relevant.
Comments	-
Can impacts be mitigated?	Yes, though mitigation not required.
Mitigation:	*Refer section 8.1.*
Cumulative impacts:	This impact is cumulative with existing ambient background noises as well as other noisy activities conducted in the same area.
Residual Impacts:	This impact will only disappear once construction activities cease.

Table 7.2 defines the significance of noise impacts during construction as low for all potentially sensitive receptors.

While mitigation is not required, the implementation of mitigation measures could result in a reduction of both the projected sound pressure levels and the probabilities that increased noises would impact on PSRs.

7.2 Operational Phase Impact

7.2.1 Description of Operational Activities Modelled

Typical day time activities would include:

- The operation of the various Wind Turbines,
- Maintenance activities (relative insignificant noise source).

However, the day time period (working day) was not considered for the EIA because noise generated during the day by the WEF is generally masked by other noises from a variety of sources surrounding potential sensitive receptors. The reader is also referred to **Figure 5-3**.

However, times when a quiet environment is desired (at night for sleeping, weekends etc.) noise levels are more critical. The time period investigated therefore would be the quiet period, normally associated with the 22:00 – 06:00 timeslot. Maintenance activities would therefore not be considered, concentrating on the ambient sound levels created due to the operation of the various Wind Turbine Generators (WTGs) at night.

The developer indicated that the RePower MM82, RePower MM92 or RePower 3.XM wind turbine is considered for the WEF. Unfortunately the 3rd octave sound power levels for this turbine was not available with the compilation of the report, but based on available data of the MM82 and MM92, the Vestas V90 2.0 MW turbine (operating in mode 0), for which 3rd octave sound power levels are available were used. While the 3rd octave spectrum characteristics does differ, the total sound power levels are sufficiently close to provide an indication of the potential noise impacts and risks. The 3rd octave sound power levels Vestas V90 2.0 MW turbine (operating in mode 0) is presented in **Table 7.3**.

Table 7.3: Sound Power Emission Levels for the Vestas V90 2.0 MW: Mode 0 with wind speed at 10 m

Wind Speed at 10 m (m/s)	Wind speed at 2 m (m/s) (m = 0.05)	$L_{Aeq,ambient}$ (Figure 5-2) dBA 2 m height	31.5 (dB)	63 (dB)	125 (dB)	250 (dB)	500 (dB)	1000 (dB)	2000 (dB)	4000 (dB)	L_{WA} (dBA)
5*	3.5	27.2	109.0	105.9	100.7	97.2	94.8	94.1	91.7	89.7	99.2
6*	4.2	31.6	112.3	108.8	104.4	100.5	97.9	97.5	94.6	93.1	102.4
7*	4.8	32.6	113.6	110.5	106.0	101.6	99.3	98.7	96.0	93.8	103.6
8*	5.5	34.7	114.4	111.4	106.9	102.2	99.5	98.7	96.3	94.2	103.9

* Source: WINDTEST (2006) for a Vestas V90 2.0MW wind turbine with hub height of 105 m above ground with 90 m rotor diameter. Turbine operating in Mode 0.

A wind rose for Cape St. Francis (2004 – 2010) indicates that the prevailing wind direction is normally west (±29%) and west south-west (±13%). Of less significance is other wind directions in the eastern (±12%) and east north-east (±9%) directions. Modelling will therefore be done for a western wind blowing at 5 m/s, using both the Concawe and ISO models. Modelling is only conducted at the 5 m/s wind speed as numerous studies have confirmed that the risk of a noise impact is the highest at a low wind speed.

Potential impacts due to low frequency sounds will also be considered. For this purpose the sound power level at both the 16 and 31.5 Hz frequency band will also be estimated and used to calculate the C-Weighted Noise Levels. However, as previously highlighted, as wind speeds increase, wind induced noise levels also increases, and the associated ambient sound levels due to wind will be considered at all times. However, existing acoustic energy in the low frequency range will also be considered (refer **Figure 4-3**).

It should be noted that SANS 10357:2004 does not provide methods to estimate sound propagation below 63 Hz. While this report does calculate the sound power levels at lower frequency bands (to allow the calculation of the C-weighted Sound Power Levels to estimate the potential/probability for low frequency noises), the reader should realise that this is for information purposes only. In terms of accuracy, the sound power level at these frequency bands is estimated at ±5-15 dBA (due to the unknown adjustment factor for meteorological effects at that octave band frequency).

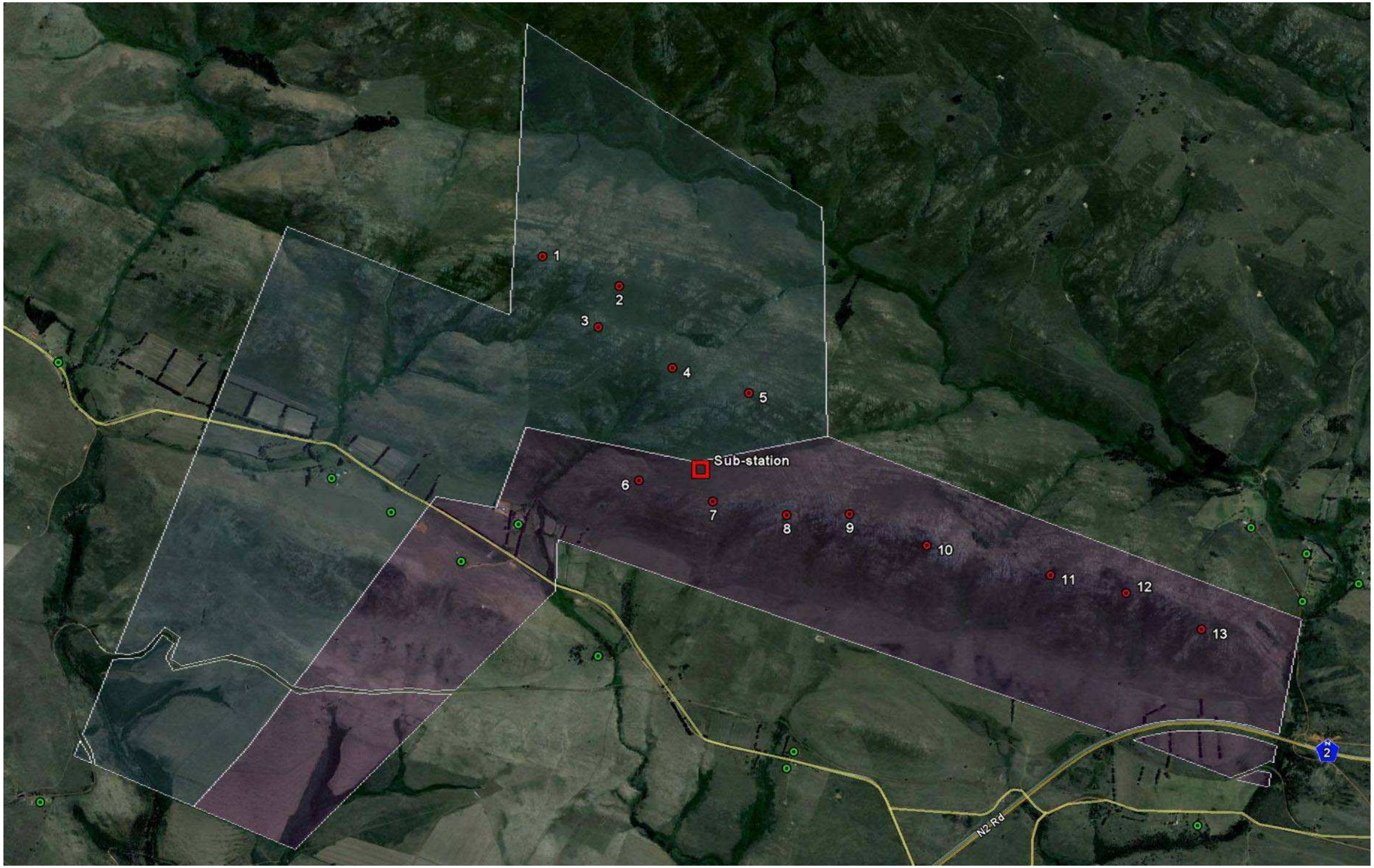

Figure 7-4: Layout of WEF as modelled with turbines numbered (turbines marked as a red circle)

7.2.2 Results: Operational Phase

Projected Noise Levels in the area due to the operation of the Wind Energy Facility are illustrated in the following figures.

Figure 7-5 illustrates the total projected sound pressure levels (as modelled with the Concawe model) with a western wind blowing at 5 m/s. Wind induced noise levels are still relatively low, projected at approximately 27.2 dBA, with **Table 7.4** defining the $L_{Aeq,N(projected)}$, $\Delta L_{Aeq,N}$ and estimated $L_{C,N}$ at the various potentially sensitive receptors. The change in ambient sound levels illustrated in **Figure 7-6**.

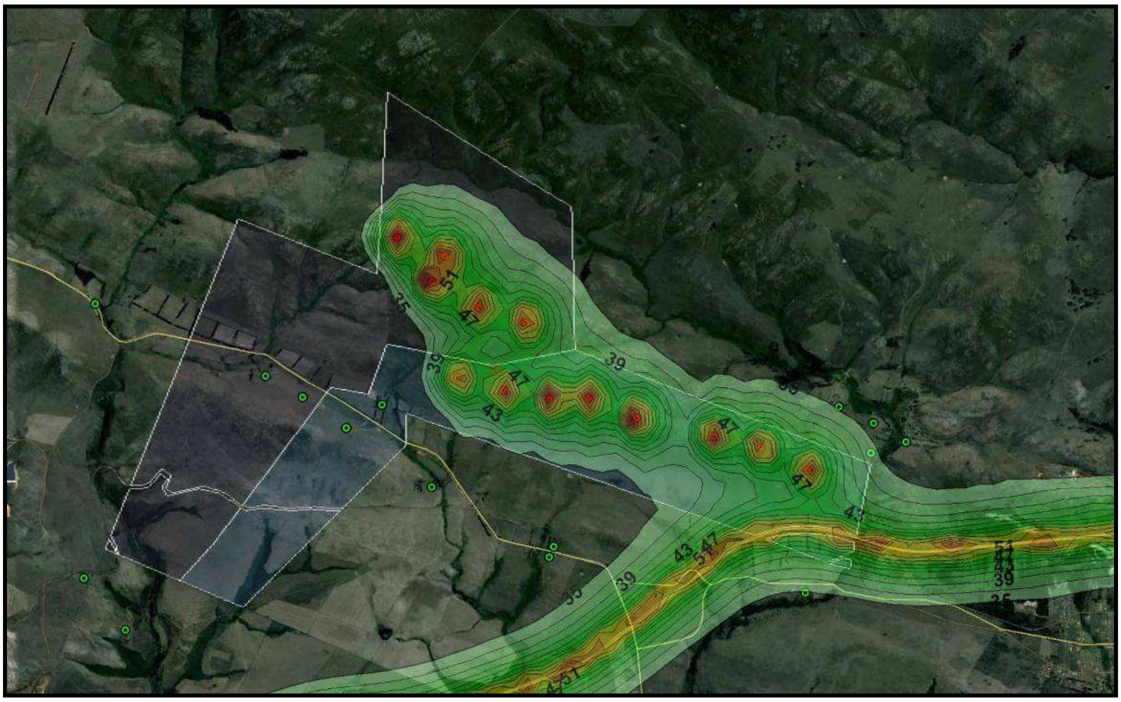

Figure 7-5: Total Projected Sound Levels (Concawe model) from facility; Contours of constant sound levels with a western wind blowing at 5 m/s (WTGs marked as red dots, PSRs as green dots)

Table 7.5 illustrates the total projected sound pressure levels (as modelled with the ISO model). The ISO model does not consider refraction effects due to wind speed and direction, resulting in a model that only models likely downwind conditions.

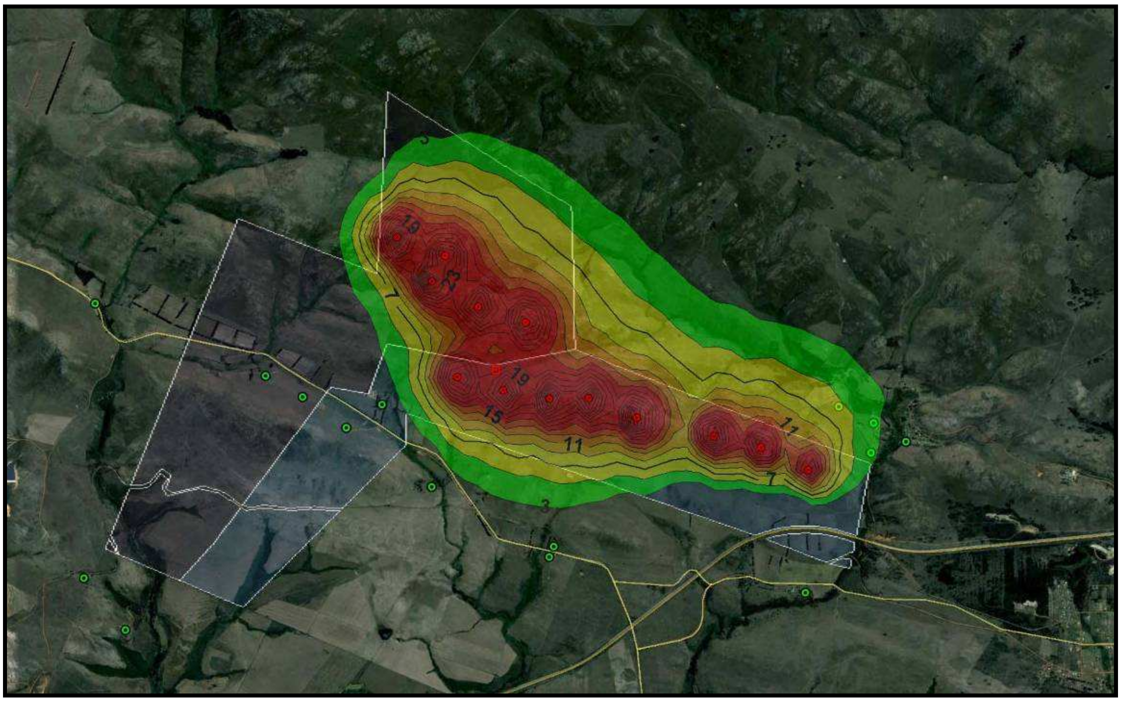

Figure 7-6: Change in ambient sound levels (Concawe model), contours of constant noise levels with a Western wind blowing at 5 m/s (turbines marked as red dots, PSRs as green dots)

Table 7.4: Sound Pressure Levels and change in ambient sound levels at relevant PSRs for a Western wind at 5 m/s (Concawe model)

PSR	Estimated ambient sound levels (dBA)	Modelled Ambient Noise Level due to WEF (dBA)	Change Ambient Sound Levels due to WEF (dBA)	Estimated C-weighted Sound Pressure Level (dBC)	Magnitude	Duration	Extent	Probability	Significance of noise Impact (see Table 5.2 and Table 5.3)
PSR01	32.7	36.5	3.8	54.8	6	5	2	3	**39**
PSR02	29.3	35.0	5.7	54.8	6	5	2	3	**39**
PSR03	30.1	34.1	4.0	53.1	2	5	2	3	**27**
PSR04	30.9	32.9	2.1	50.6	2	5	2	3	**27**
PSR05	34.2	34.7	0.5	48.5	2	5	2	2	**18**
PSR06	29.6	30.8	1.2	48.9	2	5	2	2	**18**
PSR07	29.9	30.9	1.0	48.2	2	5	2	2	**18**
PSR08	27.5	28.9	1.4	48.9	2	5	2	2	**18**
PSR09	27.3	29.1	1.8	50.4	2	5	2	2	**18**
PSR10	27.3	28.3	0.9	46.8	2	5	2	2	**18**
PSR11	27.3	28.1	0.8	45.0	2	5	2	2	**18**
PSR12	27.3	28.0	0.7	43.3	2	5	2	2	**18**
PSR13	29.6	30.0	0.4	42.1	2	5	2	2	**18**
PSR14	32.3	32.5	0.2	42.1	2	5	2	2	**18**
PSR15	27.4	28.1	0.6	33.1	2	5	2	2	**18**
PSR16	28.1	28.6	0.6	33.4	2	5	2	2	**18**
PSR17	27.3	28.0	0.7	36.1	2	5	2	2	**18**

Table 7.5: Sound Pressure Levels and change in ambient sound levels at relevant PSRs with a 5 m/s wind (as calculated with the ISO model)

PSR	Estimated ambient sound levels (dBA)	Modelled Ambient Noise Level due to WEF (dBA)	Change Ambient Sound Levels due to WEF (dBA)	Estimated C-weighted Sound Pressure Level (dBC)	Magnitude	Duration	Extent	Probability	Significance of noise Impact (see Table 5.2, Table 5.3 and Table 7.6)
PSR01	32.7	34.6	1.9	47.4	2	5	2	3	**27**
PSR02	29.3	33.0	3.7	47.9	4	5	2	3	**33**
PSR03	30.1	32.4	2.3	46.3	2	5	2	3	**27**
PSR04	30.9	32.1	1.2	44.6	2	5	2	3	**27**
PSR05	34.2	34.7	0.5	44.2	2	5	2	2	**18**
PSR06	29.6	31.3	1.8	46.0	2	5	2	2	**18**
PSR07	29.9	31.3	1.5	45.5	2	5	2	2	**18**
PSR08	27.5	30.8	3.3	46.9	4	5	2	2	**22**
PSR09	27.3	32.1	4.7	48.3	4	5	2	2	**22**
PSR10	27.3	30.0	2.7	45.9	2	5	2	2	**18**
PSR11	27.3	29.3	2.0	44.8	2	5	2	2	**18**
PSR12	27.3	28.8	1.5	43.7	2	5	2	2	**18**
PSR13	29.6	30.0	0.4	40.9	2	5	2	2	**18**
PSR14	32.3	32.5	0.2	41.1	2	5	2	2	**18**
PSR15	27.4	27.6	0.2	36.6	2	5	2	2	**18**
PSR16	28.1	28.2	0.2	36.8	2	5	2	2	**18**
PSR17	27.3	27.6	0.3	38.8	2	5	2	2	**18**

7.2.3 Impact Assessment: Operational Phase without mitigation

This Environmental Noise Impact Assessment focuses on the impacts on the surrounding sound environment during times when a quiet environment is highly desirable. Noise limits are therefore appropriate for the most noise-sensitive activity, such as sleeping, or areas used for relaxation or other activities (places of worship, school, etc).

Appropriate Zone Sound Levels is therefore important, yet it has been indicated that the SANS recommended Night Rating Level ($L_{Req,N}$) might be inappropriate due to the increased ambient sounds relating to wind action, especially when the wind speeds increase to above 8 m/s.

A more appropriate method to determine the potential impact would be to make use of both the total projected noise levels as well as the change in ambient sound levels that receptors may experience. Using the $\Delta L_{Aeq,N}$ of 3 dBA (or higher), it can be seen that it is possible that a number of PSRs could detect the change in ambient sound levels when the facility would be operational.

Using the model parameters as outlined, the following can be concluded:

- There is a low risk that the projected ambient noise level could exceed the acceptable night time rating levels (when wind speeds are less than 6 m/s, else wind induced noise levels start to play a significant role). However, there is a likely probability that the closest residents of "Die Berg" community may experience noise levels exceeding the Zone Sound Levels.
- Changes in ambient sound levels are projected to be low excluding the closest residents of the "Die Berg" community. These changes in ambient noise levels are less than 7 dBA, and it is therefore unlikely that the increases in noise levels will represent a "disturbing noise".
- The operation of the wind turbines will slightly add to the acoustical energy in the low frequencies. However there is already significant acoustical energy in the low frequencies due to the wind induced noise. The risk of low-frequency noise impacting on PSRs is considered low.
- It should be noted that the probability are estimated to be between 10 – 20% (probable) for this impact to occur, but due to the complex topography the probability has been raised to a likely as recommended in **section 5.3.3.1**.

Table 7.6: Impact Assessment: Operational phase without mitigation

Nature:	*Numerous turbines operating simultaneously during a period when a quiet environment is desirable.*
Acceptable Rating Level	Rural district with little road traffic: 35 dBA outside during night (refer **Table 5.1**). Use $L_{Req,N}$ of 35 dBA
Extent ($\Delta L_{Aeq,N}$>7dBA)	**Local** – Impact will extend less than 1,000 meters from activity. **(2).**
Duration	**Permanent** – Facility will operate for a number of years **(5)**
Magnitude	Refer **Table 7.4** and **Table 7.5** (Turbine 13) **Low (2) – medium (6)**
Probability	**Improbable (1) - Likely (3)**
Significance	**39 (Medium)** for closest receptors from "Die Berg" community
Status	Negative
Reversibility	High
Irreplaceable loss of resources?	*Not relevant*
Comments	-
Can impacts be mitigated?	Yes. A list of mitigation options is still presented that could further reduce the potential impact on the potentially sensitive receptors.
Mitigation:	*Refer* ***section 8.2.***
Cumulative impacts:	This impact is cumulative with existing ambient background noises.
Residual Impacts:	This impact will only disappear once the operation of the facility stops, or the sensitive receptor no longer exists.

8 MITIGATION OPTIONS

8.1 CONSTRUCTION PHASE

The significance of noise during the construction phase is low, yet mitigation measures are included in this report to allow the developer to further reduce the noise levels. Mitigation options included both management measures as well as technical changes.

Management options to reduce the noise impact during the construction phase include:

- Route construction traffic as far as practical possible from potentially sensitive receptors;
- Ensure a good working relationship between the developer and all potentially sensitive receptors. Communication channels should be established to ensure prior notice to the sensitive receptor if work is to take place close to them. Information that should be provided to the potential sensitive receptor(s) include:
  - Proposed working times
  - how long the activity is anticipated to take place;
  - what is being done, or why the activity is taking place;
  - contact details of a responsible person where any complaints can be lodged should there be an issue of concern.
- When working near (within 500 meters – potential construction of access roads and trenches) to a potential sensitive receptor(s), limit the number of simultaneous activities to the minimum;
- When working near to potentially sensitive receptors, coordinate the working time with periods when the receptors are not at home where possible. An example would be to work within the 08h00 to 14h00 time-slot to minimize the significance of the impact because:
  - Potential receptors are most likely at school or at work, minimizing the probability of an impact happening;
  - Normal daily activities will generate other noises that would most likely mask construction noises, minimizing the probability of an impact happening.

Technical solutions to reduce the noise impact during the construction phase include:

- Using the smallest/quietest equipment for the particular purpose. For modelling purposes the noise emission characteristics of large earth-moving equipment (typically of mining operations) were used, that would most likely over-estimate the noise levels. The use of smaller equipment therefore would have a significantly lower noise impact;
- Ensuring that equipment is well-maintained and fitted with the correct and appropriate noise abatement measures.

8.2 OPERATIONAL PHASE

The significance of the noise impact is considered medium and the developer should consider the following to ensure that the potential noise impact risk is minimised.

Mitigation measures that should be considered before the development of this wind energy facility would include:

- The developer can consider larger wind turbines which would require less wind turbines for the same power generation potential, but increase the buffer zone appropriately (***modelling would be required to define the recommended buffer zone***);
- The developer and consider to use smaller and/or quieter wind turbines, especially turbine 13;
- The developer can consider relocating turbine 13 slightly further from "Die Berg" community;
- Developing the same number of wind turbines over a larger area;
- Ensuring a larger setback around the potentially sensitive receptors (Die Berg community) taking cognisance of prevailing wind directions;
- A combination of the above options.

Mitigation measures that would reduce a potential noise impact after the implementation of the facility includes (if a noise complaint is registered):

- Operating all, or selected wind turbines in a different mode. For the purpose of the Impact Assessment (with mitigation) the Vestas V90 2.0MW turbine operating in mode 0 was used. The Vestas as well as most other manufacturers allow the turbines to be operated in a different mode. This allows the wind turbine generator to operate more silently, albeit with a slight reduction of electrical power generation capability.

- Problematic wind turbines could also be disabled, or the rotational speeds significantly decreased during periods when a quieter environment is desired (and complaints registered).

In addition:

1. Good public relations are essential. At all stages surrounding receptors should be educated with respect to the sound generated by wind turbines. The information presented to stakeholders should be factual and should not set unrealistic expectations. It is counterproductive to suggest that the wind turbines will be inaudible, or to use vague terms like "quiet". Modern wind turbines produce a sound due to the aerodynamic interaction of the wind with the turbine blades, audible as a "swoosh", which can be heard at some distance from the turbines. The magnitude of the sound will depend on a multitude of variables and will vary from day to day and from place to place with environmental and operational conditions. Audibility is distinct from the sound level, because it depends on the relationship between the sound level from the wind turbines and the ambient background sound level.
2. Community involvement needs to continue throughout the project. Annoyance is a complicated psychological phenomenon; as with many industrial operations, expressed annoyance with sound can reflect an overall annoyance with the project, rather than a rational reaction to the sound itself. Wind projects offer a benefit to the environment and the energy supply for the greater population, and offer economic benefits to the land owners leasing installation sites to the wind farm. A positive community attitude throughout the greater area should be fostered, particularly with those residents near the wind farm, to ensure they do not feel that advantage have been taken of them.
3. The developer must implement a line of communication (i.e. a help line where complaints could be lodged. All potential sensitive receptors should be made aware of these contact numbers. The Wind Energy Facility should maintain a commitment to the local community and respond to concerns in an expedient fashion. Sporadic and legitimate noise complaints could develop. For example, sudden and sharp increases in sound levels could result from mechanical malfunctions or perforations or slits in the blades. Problems of this nature can be corrected quickly, and it is in the developer's interest to do so.

9 ENVIRONMENTAL MANAGEMENT PLAN

9.1 CONSTRUCTION PHASE

Projected noise levels during construction of the Wind Energy Facility were modelled using the methods as proposed by SANS 10357:2004. The resulting future noise projections indicated that the construction activities, as modelled for the worst case scenario, would not comply with the Noise Control Regulations (GN R154), but would comply with the acceptable day rating levels as per the SANS 10103:2008 guidelines.

Various construction activities would be taking place during the development of the facility and may pose a noise risk to them. The significance of this noise impact was defined to be of a low significance. However, mitigation measures were still proposed that could reduce the potential noise impacts, risks and the probability of any complaints being registered.

The following measures are recommended to define the performance of the developer in mitigating the projected impacts and reducing the significance of the noise impact.

OBJECTIVE	**Control noise pollution stemming from construction activities**
Project Component(s)	Construction of infrastructure, including but not limited to: turbine system (foundation, tower, nacelle and rotor), substation(s), access roads and electrical power cabling.
Potential Impact	• Increased noise levels at potentially sensitive receptors • Potentially changing the acceptable land use capability
Activity/Risk source	Any construction activities taking place within 500 meters from potentially sensitive receptors (PSR)
Mitigation Target/Objective	• Ensure equivalent A-weighted noise levels below 45 dBA at potentially sensitive receptors. • Ensure that maximum noise levels at potentially sensitive receptors be less than 65 dBA. • Prevent the generation of disturbing or nuisance noises • Ensure acceptable noise levels at surrounding stakeholders and potentially sensitive receptors. • Ensuring compliance with the Noise Control Regulations

Mitigation: Action/Control	**Responsibility**	**Timeframe**
Establish a line of communication and notify all stakeholders and PSRs of the means of registering any issues, complaints or comments.	- Environmental Control Officer	All phases of project

Notify potentially sensitive receptors about work to take place at least 2 days before the activity in the vicinity (within 500 meters) of the PSR is to start. Following information to be presented in writing: - Description of Activity to take place - Estimated duration of activity - Working hours - Contact details of responsible party	- Contractor - Environmental Control Officer	At least 2 days, but not more than 5 days before activity is to commence
Ensure that all equipment are maintained and fitted with the required noise abatement equipment.	- Environmental Control Officer	Weekly inspection
Measure the peak noise levels of equipment used when operational and keep database of noise levels	- Acoustical Consultant / Approved Noise Inspection Authority	Start of project Twice annually
When any noise complaints are received, noise monitoring should be conducted at the complainant, followed by feedback regarding noise levels measured	- Acoustical Consultant / Approved Noise Inspection Authority	Within 7 days after complaint was registered
The construction crew must abide by the local by-laws regarding noise.	- Contractor - Environmental Control Officer	Duration of construction phase
Where possible construction work should be undertaken during normal working hours (06H00 – 22H00), from Monday to Saturday; If agreements can be reached (in writing) with the all the surrounding (within a 1,000 distance) potentially sensitive receptors, these working hours can be extended.	- Contractor	As required

Performance indicator	• **Equivalent A-weighted noise levels below 45 dBA at potentially sensitive receptors (8 hours).** • **Ensure that maximum noise levels at potentially sensitive receptors are less than 65 dBA.** • **No noise complaints are registered**
Monitoring	Noise monitoring to be conducted downwind from all noisy activities or at PSRs when work is taking place within 1,000 meters from a potentially sensitive receptor. Monitoring to take place every time that a noise complaint is registered.

9.2 OPERATIONAL PHASE

Projected noise levels during operation of the Wind Energy Facility were modelled using the methodology as proposed by both SANS 10357:2004 and ISO 9613-2.

The resulting future noise projections indicated that the operation of the facility would comply with the Noise Control Regulations (GN R154) but not with the SANS 10103:2008 proposed guidelines during periods when the wind speeds are less than 6 m/s and the wind blows in a westerly direction (winds from the south-western quarter). While the projected significance of noise impacts is low for most

PSRs, the significance of a noise impact could be medium for the closest residents of "Die Berg" community.

Mitigation measures are however proposed to ensure that the potential noise impacts and risks be optimally minimized.

The following measures are recommended to define the performance of the developer in mitigating the projected impacts and reducing the significance of the noise impact.

OBJECTIVE	**Control noise pollution stemming from operation of WEF**
Project Component(s)	Operational Phase
Potential Impact	• Increased noise levels at potentially sensitive receptors • Changing ambient sound levels could change the acceptable land use capability • Disturbing character of sound
Activity/Risk source	Simultaneous operation of a number of Wind Turbines
Mitigation Target/Objective	• Ensure that the change in ambient sound levels as experienced by Potentially Sensitive Receptors is less than 5 dBA. • Prevent the generation of nuisance noises • Ensure acceptable noise levels at surrounding stakeholders and potentially sensitive receptors.

Mitigation: Action/Control	**Responsibility**	**Timeframe**
Defining the ambient sound levels in 10 minute bins over a period of 14 days before the operational phase starts inside and outside of the dwellings of at PSR01 and PSR03. 10 minute sampling bins should be co-ordinated with 10 m wind speed.	- Acoustical Consultant	Before operational phase commence
Design and implement a noise monitoring programme	- Acoustical Consultant	Before operational phase commence
Add additional noise monitoring points at any complainants that registered a noise complaint relating to the operation of the WEF	- Acoustical Consultant / Approved Noise Inspection Authority	With quarterly monitoring

Performance indicator	**Ensure that the change in ambient sound levels as experienced by Potentially Sensitive Receptors is less than 7 dBA**
Monitoring	Quarterly noise monitoring by an Acoustic Consultant or Approved Noise Inspection Authority for the first year of operation. Monitoring should take place over a 24 hour period in 10 minute bins, with the results co-ordinated with the 10 m wind speed. Noise monitoring programme to be developed and implemented at the start of operation.

10 CONCLUSIONS

This report is an Environmental Noise Impact Assessment of the predicted noise environment for the proposed Happy Valley Wind Energy Facility west of Humansdorp, making use of predictive models to identify issues of concern. With the input data as used, this assessment indicated that the proposed project will have an impact of ***low significance*** on specific receptors in the area during the construction phase, and a potential noise impact of ***medium significance*** during the operational phase on the closest residents in "Die Berg" community. Mitigation measures are proposed to allow a further potential to reduce noise impacts as well as noise risks.

With its potential for environmental and economic advantages, wind power generation have significant potential to become a large industry in South Africa. However, when wind farms are near to potential sensitive receptors, consideration must be given to ensuring a compatible co-existence. The potential sensitive receptors should not be adversely affected and yet, at the same time the wind farms need to reach an optimal scale in terms of layout and number of units.

Wind turbines produce sound, primarily due to mechanical operations and aerodynamics effects at the blades. Modern wind turbine manufacturers have virtually eliminated the noise impact caused by mechanical sources and instituted measures to reduce the aerodynamic effects. But, as with many other activities, the wind turbines emit sound power levels at a level that can impact on areas at some distance away. When potentially sensitive receptors are nearby, care must be taken to ensure that the operations at the wind farm do not cause unduly annoyance or otherwise interfere with the quality of life of the receptors.

It should be noted that this does not suggest that the sound from the wind turbines should not be audible under all circumstances - this is an unrealistic expectation that is not required or expected from any other agricultural, commercial, industrial or transportation related noise source – but rather that the sound due to the wind turbines should be at a reasonable level in relation to the ambient sound levels.

11 RECOMMENDATIONS

The potential noise impact that the proposed facility could have on the surrounding environment (specifically "Die Berg" community) could be of a medium significance during the important operational phase. It is recommended that the developer consider the various mitigation options proposed in this document to further minimize noise impacts and risks during the operational phase.

Should the layout (or type of wind turbines used) change significantly, it is recommended that the new layout be remodelled/reviewed in terms of the potential noise impact by an independent acoustics specialist.

It is recommended that the ambient sound environment be defined over a longer period as per the environmental management plan (section 8.2).

In addition quarterly monitoring noise monitoring should be conducted an acoustic consultant for the first year of operation. This monitoring is to take place over a period of 24 hours in 10 minute bins, with the resulting data co-ordinated with wind speeds as measured at a 10 meter height. These samples should be collected when the Wind Turbines are operational. Quarterly monitoring is recommended at PSR01 and PSR03 for the first year, as well as any other receptors that have complained to the developer regarding noise originating from the facility.

Annual feedback regarding noise monitoring should be presented to all stakeholders and other Interested and Affected parties in the area. Noise monitoring must be continued as long as noise complaints are registered.

This report should also be made available to all potential sensitive receptors in the area, or the contents explained to them to ensure that they understand all the potential risks that the development of a wind energy facility may have on them and their families.

While the potential noise impact was determined to be insignificant, the implementation of the proposed mitigation measures could further reduce the potential noise impact as well as potential noise risks to the absolute minimum.

12 THE AUTHOR

The author of this report, M. de Jager (B. Ing (Chem), UP) graduated in 1998 from the University of Pretoria. He has been interested in acoustics as from school days, doing projects mainly related to loudspeaker enclosure design. Interest in the matter brought him into the field of Environmental Noise Measurement, Prediction and Control. As from 2007 he has been involved with the following projects:

- Full Noise Impact Studies for a number of Wind Energy Facilities, including: Cookhouse, Amakhala Emoyeni, Dassiesfontein/Klipheuwel, Rheboksfontein, AB, Dorper, Suurplaat, Gouda, Riverbank, Deep River, West Coast, West Coast One, Karoo, Velddrift and Saldanha.
- Full Noise Impact Studies for a number of mining projects, including: Skychrome (Pty) Ltd (A Ferro-chrome mine), Mooinooi Chrome Mine (WCM), Buffelsfontein East and West (WCM), Elandsdrift (Sylvania), Jagdlust Chrome Mine (ECM), Apollo Brick (Pty) Ltd (Clay mine and brick manufacturer), Arthur Taylor Expansion project (X-Strata Coal SA), Klipfontein Colliery (Coal mine), Landau Expansion project (Coal mine), Modelling for Tweefontein Colliery Expansion.

The author is an independent consultant to the project, the developer as well as Savannah Environmental (Pty) Ltd. He,

- o does not and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the Environmental Impact Assessment Regulations
- o have and will not have no vested interest in the proposed activity proceeding
- o have no and will not engage in conflicting interests in the undertaking of the activity
- o undertake to disclose all material information collected, calculated and/or findings, whether favourable to the developer or not
- o will ensure that all information containing all relevant facts be included in this report.

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APPENDIX A

TYPICAL SOUND POWER LEVELS, VARIOUS TYPES OF EQUIPMENT

Table B.1: Sound power level in various octave bands

Frequency	63	125	250	500	1000	2000	4000
A-Weight Factor	-26.22	-16.19	-8.67	-3.25	0	1.2	0.96
Equipment / Process	**Sound power level, dB re1 pW, in octave band, Hz**						
Crusher	121.1	122.3	120.1	120	117.3	112.5	106.3
Mobile Crusher/Screen (Rock)	114.2	109.5	106.2	106	104.1	102.2	101
Crushing/Screening (Coal, small)	100.5	96.9	97.3	99.2	98.4	98.8	94.3
CAT D10 Bulldozer	118.3	115.2	111	109.1	107.5	103	97
CAT D11 Bulldozer	121.22	112.2	111.4	110.9	110.4	101.45	93.67
Front End Loader	105	117	113	114	111	107	101
Road Truck average	90	101	102	105	105	104	99
Drilling Machine	107.2	109.4	109.2	106.1	104.7	101.2	99.8
CAT Water Dozer	112.9	114.5	111.45	109.7	108.35	107.2	104
Excavator	110	112	118	105	106	99	95
Terex 30 ton haul dumper	102.4	105.3	108.9	108.8	108.2	105.1	99.2
Hitachi EX1200 Excavator	113.2	116	119.7	112.5	109.8	108.4	105.4
Cement truck (with cement)	104	107	106	108	107	105	102
Operational Hitachi Grader	107.7	107.9	106.8	106.2	104.2	101.1	97.2
Grader	100	111	108	108	106	104	98
Haul truck	107.9	113.2	116.9	114.4	110.6	106.8	100.2
Road Transport Reversing/Idling	108.2	104.6	101.2	99.7	105.4	100.7	98.7
Vesta V66, max	125.1	113.6	106.3	106.2	100.4	96.4	95.3
Vesta V66, ave	120.1	109.4	100.9	100.5	95.3	91.3	88.8
Vesta V66, min	114.4	104	94.84	94.8	87.5	83.3	80.7
Nordex N90 2.5MW at 4m/s	110.42	104.49	101.37	96.35	91.6	89.3	85.54
Nordex N90 2.5MW at 7m/s	117.92	111.99	108.87	103.85	99.1	96.8	93.04
Vestas V90 2.0 MW at 5m/s	105.9	100.7	97.2	94.8	94.1	91.7	89.7
Vestas V90 2.0 MW at 7m/s	111.4	106.9	102.2	99.5	98.7	96.3	94.2
RePower MM92 at 7.5m/s	109.3	107.4	105.6	101.9	96.7	89.8	83.1
General noise	100	100	103	105	105	100	100
CAT Rock Breaker	119.1	118.2	115.2	115.7	114.9	115.7	110.4
Crane	89	98	101	103	102	102	98
Portable Diesel Generator	96.7	99.5	101.2	97.4	91.3	89.6	81.1

End of report.