BTE RENEWABLES

ENVIRONMENTAL ACOUSTIC IMPACT ASSESSMENT

ESIZAYO WIND ENERGY FACILITY EXPANSION

06 APRIL 2022

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REPORT (VERSION 01)

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WSP
BUILDING C, KNIGHTSBRIDGE
33 SLOANE STREET
BRYANSTON, 2191
SOUTH AFRICA

T: +27 11 361 1380
F: +086 606 7121
WSP.COM

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Checked by	B. Keiser			
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GLOSSARY OF TERMS

Sound	Sound is small fluctuations in air pressure, measured in Newtons per square meter (N/m^2) or Pascals (Pa) that are transmitted as vibrational energy via a medium (air) from the source to the receiver. The human ear is a pressure transducer, which converts these small fluctuations in air pressure into electrical signals, which the brain then interprets as sound.
Noise	Noise is generally defined as unwanted sound.
Sound or noise level	A sound or noise level is a sound measurement that is expressed in decibels (dB or dB(A)).
dB or dB(A)	The human ear is a sensitive instrument that can detect fluctuations in air pressure over a wide range of amplitudes. This limits the usefulness of sound quantities in absolute terms. For this reason, a sound measurement is expressed as ten times the logarithm of the ratio of the sound measurement to a reference value, 20 micro (millionth) Pa. This process converts a scale of constant increases to a scale of constant ratios and considerably simplifies the handling of sound measurement quantities. The attached 'A' indicates that the sound measurement has been A-weighted.
dB(Z)	Historically sound levels were read off a hand-held meter and the noise levels were noted in dB, after the development of different weighting curves sound levels were noted as Z-weighting or dB(Z) to reduce the confusion with different type of weighting applied noise levels. dB(Z) refers to linear noise levels.
A-weighting	The human ear is not equally sensitive to sound of all frequencies, i.e. it is less sensitive to low pitched (or 'bass') than high pitched (or 'treble') sounds. In order to compensate when making sound measurements, the measured value is passed through a filter that simulates the human hearing characteristic. Internationally this is an accepted procedure when working with measurements that relate to human responses to sound/noise.
Ambient sound level	Ambient noise will be defined as the totally encompassing sound in a given situation at a given time, and is usually composed of sound from many sources, both near and far.
Annoyance	General negative reaction of the community or person to a condition creating displeasure or interference with specific activities**.**
Sound pressure	Sound pressure is the force of sound exerted on a surface area perpendicular to the direction of the sound and is measured in N/m^2 or Pa. The human ear perceives sound pressure as loudness and can also be expressed as the number of air pressure fluctuations that a noise source creates.
Sound pressure level	The sound pressure level is a relative quantity as it is a ratio between the actual sound pressure and a fixed reference pressure. The reference pressure is usually the threshold of hearing, namely 20 microPascals (μPa).
Sound power	Sound power is the rate of sound energy transferred from a noise source per unit of time in Joules per second (J/s) or Watts (W).
Sound power level	The sound power level is a relative quantity as it relates the sound power of a source to the threshold of human hearing (10^{-12} W). Sound power levels are expressed in dB(A), as they are referenced to sound detected by the human ear (A-weighted).
Noise nuisance	Noise nuisance means any sound which disturbs or impairs or may disturb or impair the convenience or peace of any person.
Octave bands	The octave bands refer to the frequency groups that make a sound. The sound is generally divided in to nine groups (octave bands) ranging from 32 Hertz (Hz) to 8,000 Hz. The lower frequency ranges of a sound have a vibrating character where the higher frequency of sound has the character of high-pitched sound. In viewing the total octave bands scale from 32 Hz to 8000 Hz the character of the sound can be described.

ACRONYMS AND ABBREVIATIONS

AIA	Acoustic Impact Assessment
BA	Basic Assessment
BTE	BTE Renewables
CadnaA	Computer Aided Noise Abatement
dB	Decibel
dB(A)	A-weighted sound measurement
dB(C)	C-weighted sound measurement
dB(Z)	Z-weighted sound measurement
EHS	Environmental, Health and Safety
ha	Hectare
Hz	Hertz
IFC	International Finance Corporation
L_{A90}	Noise level exceeded for 90% of the measurement period
L_{Aeq}	Equivalent continuous sound pressure level
$L_{R,dn}$	Equivalent continuous day/night rating level
$L_{Req,d}$	Equivalent continuous rating level for day-time
$L_{Req,n}$	Equivalent continuous rating level for night-time
$L_{Req,T}$	Typical noise rating levels
m/s	Meters per second
MW	Megawatt
NEMA	National Environmental Management Act 107 of 1998
NEMAQA	The National Environmental Management: Air Quality Act 39 of 2004
PWL	Sound Power Level
SACNASP	South African Council for Natural Scientific Professions
SANS	South African National Standards
WEF	Wind Energy Facility
WHO	World Health Organisation
WSP	WSP Group Africa (Pty) Ltd

EXECUTIVE SUMMARY

BTE Renewables (BTE) is proposing an expansion to the already authorised Esizayo Wind Energy Facility (WEF) in the Western Cape Province through the inclusion of new land parcels to the northeast of the site. Such land parcels include Portion 2 of Farm Aanstoot Farm 72, Portion 1 of Farm Leeuwenfontein 71 and Remainder of Farm Leeuwenfontein 71. A total additional area of 5,850 ha is proposed, with the addition of up to 23 new wind turbines.

WSP Group Africa (Pty) Ltd (WSP) has been appointed to undertake the Basic Assessment (BA) for the proposed expansion project. Wind turbines have the potential to generate noise and as such a specialist Environmental Acoustic Impact Assessment (AIA) is required as part of the BA process for the WEF. This report presents the findings of the Screening-Level Environmental AIA performed.

The International Finance Corporation (IFC) Environmental Health and Safety (EHS) guidelines for Wind Energy were followed for this assessment, which is primarily based on the ETSU-R-97 report. Such guidance stipulates that a preliminary modelling exercise is executed using a simple model which assumes hemispherical propagation of noise from each turbine to determine potential impact on receptors within a 2 km radius of the turbines. If L_{A90} noise levels at all sensitive receptors are below 35 dB(A) at a wind speed of 10 m/s (at a height of 10 m) during day and night times, this would be sufficient to assess the noise impact of the proposed facility. If L_{A90} levels at any receptor location are above 35 dB(A) then a more detailed acoustic study will need to be carried out.

Two sensitive receptors (farmhouses) were identified within 2 km of the site, namely FH A (west of the site, with T10 being the nearest turbine (1,520 m away)) and FH B (east of the site, with T8 being the nearest turbine (1,005 m away)). Based on WSP's preliminary model (following the IFC methodology), the following was determined:

- Results indicate that predicted L_{A90} noise levels during both day and night are below the 35 dB(A) threshold, as stipulated in the IFC EHS guidance, at the FH A receptor. As such, no adverse impacts are anticipated and meeting this condition offers sufficient protection of amenity at this receptor.
- At FH B, however, L_{A90} noise levels are predicted to be slightly above this 35 dB(A) threshold, indicating that noise from the turbines could create a nuisance or impact at this location. It is therefore recommended that the location of the turbines in close proximity of FH B (T8 and T9) be reconsidered. Such an approach will limit impacts on this receptor and avoid the need for additional, in-depth studies. Alternatively, a more detailed acoustic study will need to be undertaken.

The resultant environmental acoustic risks for sensitive receptor FH A were ranked "low", while for sensitive receptor FH B, risks were ranked "low to medium". Acoustic impacts of WEFs are very site-specific and the impacts are directly assessed using predicted L_{A90} levels at nearby receptors. The different wind energy developments in the region (as identified in **Section 7.2**) are located in different areas with their own set of receptor locations. If the impacts on the receptors at the Esizayo site are low, then the impact from the other WEFs on these receptors will be significantly lower based on distance from the source.

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1 INTRODUCTION

BTE Renewables (BTE) is proposing an expansion to the already authorised Esizayo Wind Energy Facility (WEF) through the inclusion of new land parcels to the northeast of the site. Such land parcels include Portion 2 of Farm Aanstoot Farm 72, Portion 1 of Farm Leeuwenfontein 71 and Remainder of Farm Leeuwenfontein 71. A total additional area of 5,850 ha is proposed, with the addition of up to 23 new wind turbines.

WSP Group Africa (Pty) Ltd has been appointed to undertake the Basic Assessment (BA) for the proposed Project. Wind turbines have the potential to generate noise and as such a specialist Environmental Acoustic Impact Assessment (AIA) is required as part of the BA process. This report presents the findings of the Screening-Level Environmental AIA performed. It is noted that noise impacts are anticipated from the wind turbines, however, noise from the powerlines will be negligible and as such impacts for these have not been assessed.

1.1 TERMS OF REFERENCE

The terms of reference, designed to best meet the project requirements are summarised below:

- Execution of a preliminary modelling exercise using a simple model which assumes hemispherical propagation of noise from each turbine to determine potential impact on receptors within a 2 km radius of the turbines;
- If L_{A90} noise levels at all sensitive receptors are below 35 dB(A) at a wind speed of 10 m/s at a height of 10 m during day and night times, this would be sufficient to assess the noise impact of the proposed facility. If L_{A90} levels at any receptor location are above 35 dB(A) then a more detailed acoustic study will need to be carried out; and
- Presentation of modelled results in the form of an Environmental AIA report (this report)

1.2 DECLARATION OF INDEPENDENCE

Kirsten Collett is an air quality and acoustic consultant with a Master of Science (Atmospheric Sciences) degree obtained from the University of the Witwatersrand. She is currently employed by WSP and has worked on environmental acoustic impact assessments, monitoring and modelling for a variety of clients over the past nine years. She has provided acoustic consulting support to various client industries including petrochemical, mining and production industries among others. She is also a registered Professional Natural Scientist (Pr. Nat. Sci.) with the South African Council for Natural Scientific Professions (SACNASP). Please see **Appendix A** for a short CV detailing project experience.

I hereby declare that I am fully aware of my responsibilities in terms of the National Environmental Management Act: Environmental Impact Assessment Regulations of 2014 and that I have no financial or other interest in the undertaking of the proposed activity other than the imbursement of consultant's fees.

Name:	Kirsten Collett
Company:	WSP Group Africa (Pty) Ltd
Contact Details:	+27 11 361 1372
	Kirsten.Collett@wsp.com
Signature:	

2 BACKGROUND

2.1 LOCALITY

The proposed Esizayo expansion project is located immediately northeast of the previously authorised Esizayo WEF, located 30 km northwest of Laingsburg in the Western Cape Province (**Figure 1**). The expansion area extends across three farms, namely Portion 2 of Farm Aanstoot Farm 72, Portion 1 of Farm Leeuwenfontein 71 and Remainder of Farm Leeuwenfontein 71. The facility falls within the Laingsburg Local Municipality under the jurisdiction of the Central Karoo District Municipality.

The site is considered highly suitable for a wind energy project due to the following:

- Climatic conditions;
- Relief and aspect;
- Land availability; and
- Access to the National Grid through Eskom's Komsburg Substation located approximately 2 km from the site.

2.2 TOPOGRAPHY

The topography of the Esizayo expansion site is relatively flat comprising open areas and mountainous slopes. The elevation of the Esizayo site ranges from 860 m to 1,260 m (**Figure 2**). There are several natural gullies and watercourses, which drain the site in the direction of the slope, however, these are ephemeral in nature, and seldom have water present in the channels.

Since topography has an influence on the propagation and channelling of noise, terrain data was included in the acoustic model in order to account for such influences.

2.3 SENSITIVE RECEPTORS

Sensitive receptors are identified as areas that may be impacted negatively due to noise associated with the proposed WEF. Examples of receptors include, but are not limited to, schools, shopping centres, hospitals, office blocks and residential areas. Being such a remotely located site, dominant receptors in the area surrounding the site include small farmsteads and farmhouses. Within a 2 km radius of the site, only two specific sensitive receptors (farmhouses) were identified in this study, with details presented in **Figure 3** and **Table 1**. It is noted that FH A represents the farmhouse receptor (FH 5) used in the original acoustic assessment for the already authorised Esizayo WEF.

Table 1: Sensitive receptors surrounding the project site

ID	Description	Latitude (°S)	Longitude (°E)	Nearest Turbine	Distance from Nearest Turbine (m)	Direction from Nearest Turbine
FH A	Farmhouse	32.973131	20.600913	T10	1,520	West
FH B	Farmhouse	32.955828	20.667622	T8	1,005	Southeast

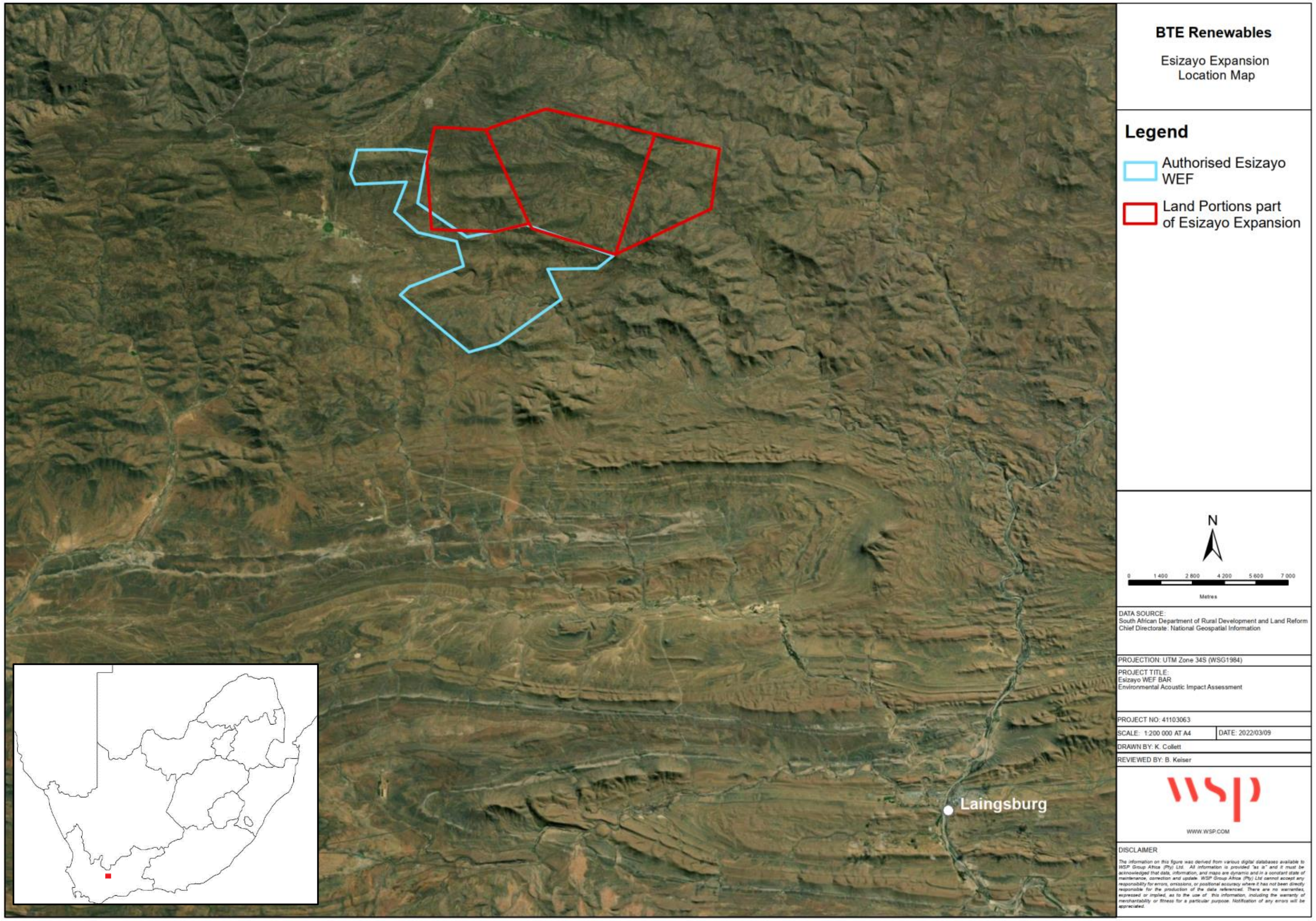

Figure 1: Location of the project site

Figure 2: **Map indicating the surrounding terrain and the location of the proposed wind turbines**

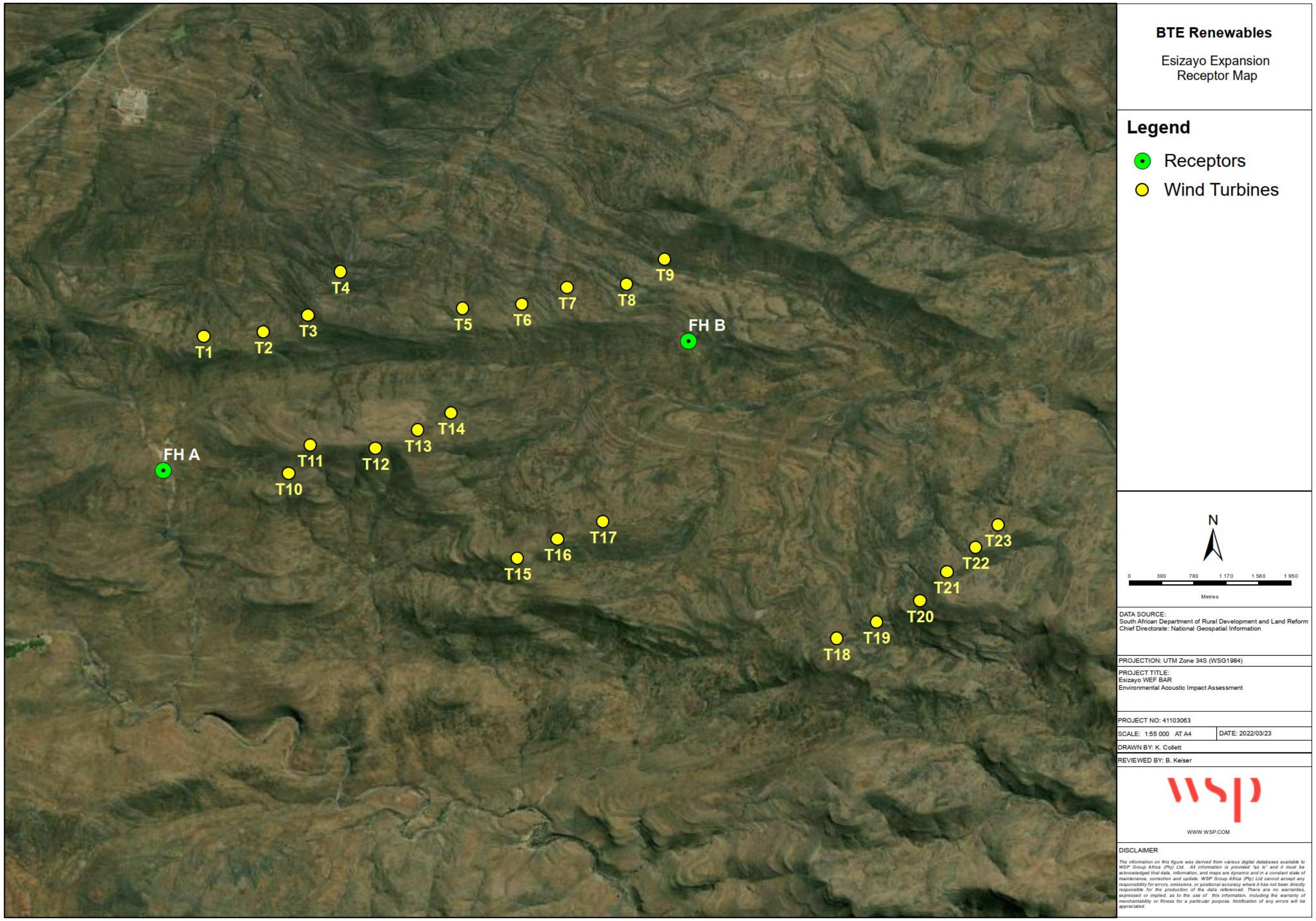

Figure 3: Location of sensitive receptors

2.4 PROJECT DESCRIPTION

2.4.1 WIND ENERGY POWER GENERATION PROCESS

Wind power is the conversion of wind energy into a useful form of energy, such as electricity, using modern and highly reliable wind turbines. Wind power is non-dispatchable, meaning that for economic operation, all of the available output must be taken when it is available.

The main components of a modern utility-scale wind turbine are illustrated in **Figure 4**. When the wind blows around the blades, the shape of the blades creates aerodynamic lift and drag. These forces are used to generate torque, which causes the blades to spin the rotor on its axis, creating mechanical power that is converted into electricity in a generator housed in the nacelle (Council of Canadian Academics, 2015).

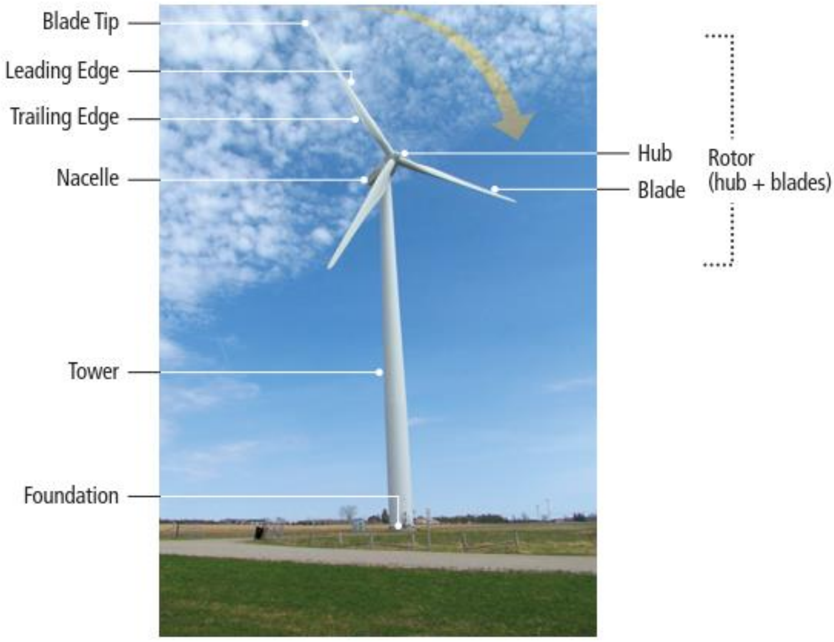

Figure 4: Components of a typical wind turbine (Council of Canadian Academics, 2015)

The electricity generated by the wind turbines is passed through a step-up transformer and then transmitted via either underground or overhead cables to a central substation, which connects the WEF to a high voltage network. Wind turbines are designed to operate automatically with minimal maintenance for approximately 20-25 years.

2.4.2 PROJECT INFRASTRUCTURE

The details of the Esizayo WEF expansion are outlined in **Table 2**. The locations of the wind turbines in relation to both the topography and nearby sensitive receptors are presented in **Figure 2** and **Figure 3**, respectively.

Table 2: Details of the proposed WEF and associated infrastructure

Generation capacity	Up to 200 MW
Number of turbines	Up to 23
Generation capacity per turbine	Up to 10 MW
Total area of the site	5,850 ha

Area occupied by each turbine	Each turbine with a foundation of up to 25 m in diameter and up to 4 m in depth. Compacted hard standing areas of up to 4.5 ha each.
Turbine hub height	Up to 150 m
Rotor diameter	Up to 200 m
Sound Power Level (at 10 m/s)	106.0 dB(A)

2.4.3 PHASES OF DEVELOPMENT

CONSTRUCTION PHASE

The main activities associated with the construction phase of the WEF will include the following:

- **Establishment of an access road to the site** – The site is already easily accessible via the tarred R354 national road, however, the regional gravel road connecting the site to the R354 will need to be upgraded.
- **Establishment of internal roads** – Internal road access will be constructed onsite. These roads will be up to 9 m in width. The length of the internal road network is approximately 30 km.
- **Site preparation** – Site preparation includes the clearance of vegetation and any bulk earthworks (including blasting if required) within the footprint of each construction area that may be required in terms of the facility design.
- **Transport of components and equipment to site** – All construction material (i.e. masts, blades and associated infrastructure), machinery and equipment (i.e. graders, excavators, trucks, cement mixers etc.) will be transported to site utilising the national, regional and local road network.
- **Establishment of a laydown area on site** – Construction materials, machinery and equipment will be kept at relevant laydown and/or storage areas. A 1.1 ha laydown and storage area has been proposed for this project, with an additional 40,000 m^2 for concrete towers if required. The laydown area will limit potential environmental impacts associated with the construction phase by limiting the extent of the activities to one designated area. The location of the laydown area is not currently known and will be decided upon once the project has been identified as a preferred bidder.
- **Construction of foundations** – Concrete foundations will be constructed at each turbine location. Foundation holes will be mechanically excavated to a depth of 4 m, depending on the local geology. Concrete will be batched on site.
- **Construction of the turbine** – Large mobile lifting cranes (wheeled and tracked) will be brought onto site to lift each of the tower parts into place.
- **Power evacuation to the grid** – Power will be exported to the grid via the onsite substation on the authorised Esizayo WEF.

2.4.4 OPERATIONAL PHASE

The proposed wind facility is anticipated to have a minimum life of 20 years. The facility will operate seven days a week. While the project is considered to be self-sufficient, maintenance and monitoring activities will be required.

2.4.5 DECOMMISSIONING PHASE

Following the initial 20-year operational period of the wind facility, the continued economic viability will be investigated. In the event that the facility is still deemed viable the life of the facility will be extended. The facility will only be decommissioned once it is no longer economically viable. In the event that a decision is made to completely decommission the facility all the components will be disassembled, reused and recycled or disposed. The site would be returned to its current use i.e. agricultural (grazing).

2.5 WIND TURBINES AND NOISE

Noise from wind turbines can be classified into two categories, namely mechanical noise generated from the turbine's mechanical components and aerodynamic noise, produced by flow of air over the turbine blades.

2.5.1 MECHANICAL NOISE

The mechanical noise generated by a wind turbine is predominantly tonal (dominated by a narrow range of frequencies), but may also be broadband in character, displaying a wide range of frequencies (Council of Canadian Academics, 2015). Such noise is produced by the physical movement of the following components:

- Gearbox;
- Generator;
- Yaw drives;
- Cooling fans; and
- Auxiliary equipment.

Over time, appropriate design and manufacturing have reduced the mechanical noise produced from wind turbines. As such, the aerodynamic noise from the blades has become the dominant source of noise for modern turbines, however, low frequency tones associated with mechanical sources are audible for some turbines (Hau, 2006; Manwell *et al*., 2009; Oerlemans, 2011).

2.5.2 AERODYNAMIC NOISE

Aerodynamic noise is typically broadband in nature and is generated by the interaction between air flow and different parts of the turbine blades. These interactions depend on the speed and turbulence of the wind; the shape of the blade; the angle between the blade and relative wind velocity flowing over the blade; and the distance from the hub. The noise levels produced are relative to the velocity of the air flow, with higher rotor speeds resulting in higher noise levels. Specifically, parts of the blade closer to the tips move faster than those closer to the hub, resulting in faster relative air velocities and create higher aerodynamic noise levels. As such, most of the aerodynamic noise is produced near (but not at) the blade tips. This is partly why turbines with longer blades have a higher sound power level (Oerlemans, 2011).

Aerodynamic noise from wind turbines also has a strong directional component, projecting primarily downward, upward, or even perpendicular depending on the dominant mechanism (Oerlemans, 2011). As such, noise levels measured at a particular location can vary depending on the direction, speed and turbulence of the prevailing wind. Furthermore, as the rotor turns, the orientation of each blade changes in relation to a stationary receiver. As such, the noise levels at the receiver will vary as the blades rotate, resulting in periodic regular changes in noise levels over time (Renewable UK, 2013).

As wind speed increases, the aerodynamic noise of the turbines also increases. At low speeds the noise created is generally low and increases to a maximum at a certain speed (around 10 m/s) where it either remains constant or can even slightly decrease.

2.5.3 LOW FREQUENCY NOISE AND INFRASOUND

In addition to the noise discussed above, wind turbines also produce some steady, deep, low frequency sounds (between 1 – 100 Hz), particularly under turbulent wind conditions. Sound waves below 20 Hz are called infrasound. These infrasound levels are only audible at very high sound pressure levels. Older wind turbines that had downwind rotors created noticeable amounts of infrasound. Levels produced by modern-day, up-wind style turbines are below the hearing threshold for most people (Jakobsen, 2005).

The human ear is substantially less sensitive to sound at very low or very high frequencies. For most people, a very low pitch sound (20 Hz) must have a sound pressure level of 70 dB to be audible. Levels of infrasound near modern commercial wind turbines are far below this level and are generally not perceptible to people (Leventhall, 2006).

Low frequency sound, like all other sound, decreases as it travels away from the source. Siting wind turbines further away from sensitive receptors will therefore decrease the risk of infrasound. It is, however, important to note that in flat terrain, low frequency sound can travel more effectively than high frequency sound. Most environmental sound measurements and noise regulations are based on the A-weighed decibel scale (dB(A)), which under-weights low frequency sounds in order to mimic the human ear. Thus, noise limits based on the dB(A) levels do not fully regulate infrasound. The dB(C) scale offers an alternative of measuring sound that provides more weight to lower frequencies (Jakobsen, 2005; Bolin *et al.*, 2011).

SANS 10103 proposes a methodology to identify whether low frequency noise could be an issue. The method suggests that if the difference between L_{Aeq} and L_{Ceq} is greater than 10 dB, then a predominant low frequency component may be present. However, in all cases the existing acoustic energy in low frequencies associated with wind must be considered.

2.5.4 SUBSTATION AND TRANSFORMER NOISE

In addition to the noise from wind turbines, wind farms require a substation and transformers, which produce a characteristic "hum" or "crackle" noise. Utility companies have experience with building and siting such sources to minimise their impact. Substation-related noise is relatively easy to mitigate should this be required, based on the use of acoustic shielding and careful planning regarding placement away from sensitive receptors. As such, noise associated with this source is not considered in this assessment.

2.6 EXISTING NOISE CLIMATE

The existing noise climate in the area surrounding the proposed wind energy project is typically rural with limited anthropogenic influences. Current sources of noise include livestock, farm equipment, birds, insects and motor vehicles travelling along nearby roads.

3 ACOUSTIC FUNDAMENTALS

3.1 PRINCIPLES

Sound is defined as any pressure variation (in air, water or other medium) that the human ear can detect. Noise is defined as “unwanted sound”. Noise can lead to health impacts and can negatively affect people’s quality of life. Hearing impairment is typically defined as a decrease in the threshold of hearing. Severe hearing deficits may be accompanied by tinnitus (ringing in the ears). Noise-induced hearing impairment occurs predominantly in the higher frequency range of 3,000 to 6,000 Hertz (Hz), with the largest effect at 4,000 Hz. With increasing L_{Aeq} and increasing exposure time, noise-induced hearing impairment occurs even at frequencies as low as 2,000 Hz. However, hearing impairment is not expected to occur at L_{Aeq} levels of 75 dB(A) or below, even for prolonged occupational noise exposure.

Speech intelligibility is adversely affected by noise. Most of the acoustical energy of speech is in the frequency range of 100 to 6,000 Hz, with the most important cue-bearing energy being between 300 and 3,000 Hz. Speech interference is basically a masking process in which simultaneous interfering noise renders speech incapable of being understood. Environmental noise may also mask other acoustical signals that are important for daily life such as doorbells, telephone signals, alarm clocks, music, fire alarms and other warning signals.

Sleep disturbance is a major effect of environmental noise. It may cause primary effects during sleep and secondary effects that can be assessed the day after night-time noise exposure. Uninterrupted sleep is a prerequisite for good physiological and mental functioning and the primary effects of sleep disturbance are: (a) difficulty in falling asleep; and (b) awakenings and alterations of sleep stages or depth. The difference between the sound levels of a noise event and background sound levels, rather than the absolute noise level, may determine the reaction probability.

The annoyance due to a given noise source is subjective from person to person, and is also dependent upon many non-acoustic factors such as the prominence of the source, its importance to the listener’s economy (wellbeing), and his or her personal opinion of the source. Increased exposure to noise can have negative effects on individuals, both physiological (influence on communication, productivity and even impaired hearing) and psychological effects (stress, frustration and disturbed sleep). As such, noise impacts need to be understood to mean one or a combination of negative physical, physiological or psychological responses experienced by individuals, whether consciously or unconsciously, caused by exposure to noise.

More technically, noise impacts are defined as the capacity of noise to induce annoyance depending upon its physical characteristics, including the sound pressure level, spectral characteristics and variations of these properties with time. During day-time, individuals may be annoyed at L_{Aeq} levels below 55 dB(A), while very few individuals are moderately annoyed at L_{Aeq} levels below 50 dB(A). Sound levels during the evening and night should be 5 to 10 dB(A) lower than during the day (World Health Organisation, 1999).

Table 3: Typical noise levels

Sound Pressure Level (dB(A))	Typical Source	Subjective Evaluation
130	threshold of pain	intolerable
120 110	heavy rock concert grinding on steel	extremely noisy
100 90	loud car horn at 3 m construction site with pneumatic hammering	very noisy
80 70	kerbside of busy street loud radio or television	loud
60 50	department store general office	moderate to quiet
40 30	inside private office inside bedroom	quiet to very quiet
20	unoccupied recording studio	almost silent

3.2 NOISE PROPAGATION

Sound is a pressure wave that diminishes with distance from source. Depending on the nature of the noise source, sound propagates at different rates. The three most common categories of noise are point sources (specified single point of noise generation), line sources (multiple linear noise generating points, such as a road) and area sources (specified single area of noise generation). The most important factors affecting noise propagation are:

- The type of source (point, line or area);
- Obstacles such as barriers and buildings;
- Distance from source;
- Atmospheric absorption;
- Ground absorption; and
- Reflections.

Research has shown that doubling the distance from a noise source results in a proportional decline in noise level. Sound propagation in air can be compared to ripples on a pond. The ripples spread out uniformly in all directions, decreasing in amplitude as they move further from the source. An acoustically hard site exists where sound travels away from the source over a generally flat, hard surface such as water, concrete, or hard-packed soil. These are examples of reflective ground, where the ground cover provides little or no attenuation. The standard attenuation rate for hard site conditions is 6 dB(A) per doubling of distance for point sources. Thus, if you are at a position one meter from the source and move one meter further away from the source, the sound pressure level will drop by 6 dB(A), moving to 4 meters, the drop will be a further 6 dB(A), and so on. When ground cover or normal unpacked earth (i.e. a soft site) exists between the source and receptor, the ground becomes absorptive to sound energy. Absorptive ground results in an additional noise reduction of approximately 1.5 dB(A) per doubling of distance.

This methodology is only applicable when there are no reflecting or screening objects in the sound path. When an obstacle is in the sound path, part of the sound may be reflected and part absorbed and the remainder may be transmitted through the object. How much sound is reflected, absorbed and/or transmitted depends on many factors, including the properties of the object. When receptor locations are not in the line of sight of the noise source, there may be up to 20 dB(A) attenuation for broadband noise, with a further 10 to 15 dB(A) attenuation when inside the average residence and the windows are open.

3.3 CHARACTERISTICS OF NOISE

The human ear simultaneously receives sound (normal un-weighted sound or Z-weighting dB(Z)) at many frequencies (octave bands) at different amplitudes. The ear then adjusts its sensitivity based on the amplitude of the sound observed. This focuses the sound and makes it audible by adjusting the amplitude of the low, middle and high frequencies. To measure how a person experiences sound, an electronic weighting adjusted to the Z-weighted sound was developed, including three different weighting curves, namely:

- **A-weighting -** This measurement is often noted as dB(A) and this weighting curve attempts to make the noise level meter respond closely to the characteristics of a human ear. It adjusts the frequencies at low and high frequencies. Various national and international standards relate to measurements recorded in the A-weighting of sound pressure levels;
- **B-weighting** - is similar to A-weighting but with less attenuation. The B-weighting is very seldom, if ever, used. The B-weighting follows the C-weighted trend;
- **C-weighting -** is intended to represent how the ear perceives sound at high decibel levels. C-weighted measurements are reported as dB(C); and
- **Z-weighting -** this refers to linear, un-weighted noise levels.

The weighting is employed by arithmetically adding a table of values (**Table 4**), listed by octave bands, to the measured linear sound pressure levels for each specific octave band. The resulting octave band measurements are logarithmically added to provide a single weighted value describing the sound, based on the applied weighting curve (**Figure 5**). Thus, if the A-weighted curve was applied to the sound, the noise level is noted as dB(A).

Table 4: Frequency weighting table for the different weighting curves

Frequency (Hz)	32 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1k Hz	2k Hz	4k Hz	8k Hz
A-weighting	-39.4	-26.2	-16.1	-8.6	-3.2	0	1.2	1	1.1
B-weighting	-17.1	-9.3	-4.2	-1.3	-0.3	0	-0.1	-0.7	-2.9
C-weighting	-3	-0.8	-0.2	0	0	0	-0.2	-0.8	-3
Z-weighting	0	0	0	0	0	0	0	0	0

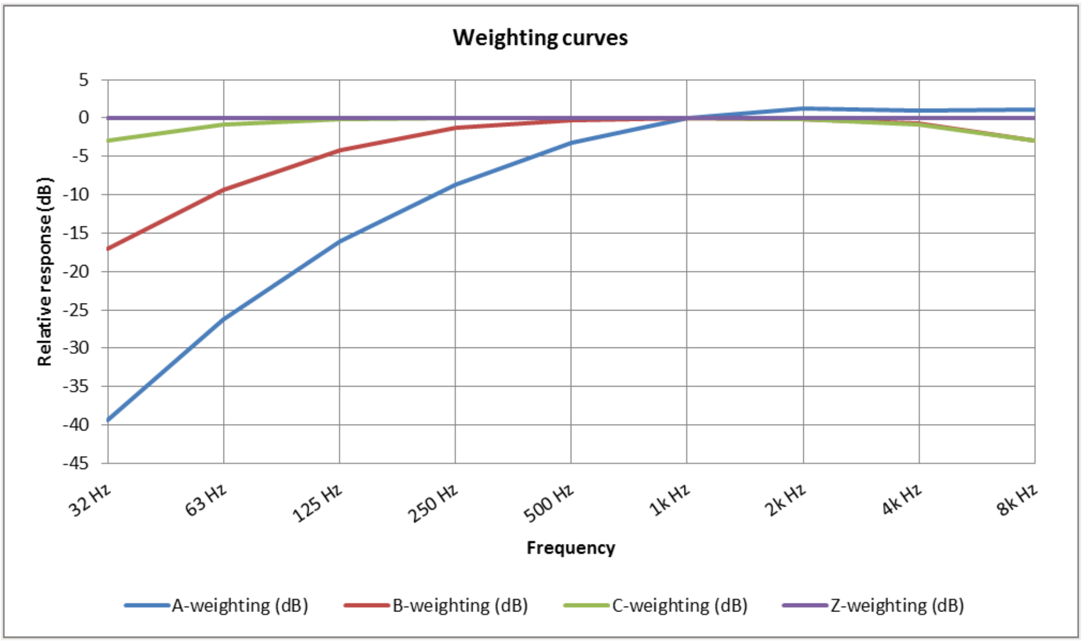

Figure 5: Weighting curves

4 LEGISLATIVE FRAMEWORK

4.1 SOUTH AFRICAN LEGISLATION

4.1.1 SOUTH AFRICAN NOISE CONTROL REGULATIONS

In South Africa, environmental noise control has been in place for three decades, beginning in the 1980s with codes of practice issued by the South African National Standards (formerly the South African Bureau of Standards, SABS) to address noise pollution in various sectors of the country. Under the previous generation of environmental legislation, specifically the Environmental Conservation Act 73 of 1989 (ECA), provisions were made to control noise from a National level in the form of the Noise Control Regulations (GNR 154 of January 1992). In later years, the ECA was replaced by the National Environmental Management Act 107 of 1998 (NEMA) as amended. The National Environmental Management: Air Quality Act 39 of 2004 (NEMAQA) was published in line with NEMA and contains noise control provisions under Section 34:

> *"(1) The minister may prescribe essential national standards –*
>
> *(a) for the control of noise, either in general or by specific machinery or activities or in specified places or areas; or*
>
> *(b) for determining –*
>
> *(i) a definition of noise; and*
>
> *(ii) the maximum levels of noise.*
>
> *(2) When controlling noise, the provincial and local spheres of government are bound by any prescribed national standards."*

Under NEMAQA, the Noise Control Regulations were updated and are to be applied to all provinces in South Africa. The Noise Control Regulations give all the responsibilities of enforcement to the Local Provincial Authority, where location specific by-laws can be created and applied to the locations with approval of Provincial Government. Where province-specific regulations have not been promulgated, acoustic impact assessments must follow the Noise Control Regulations. These regulations define the following:

- **Ambient Sound Level:** the reading on an integrating impulse sound level meter taken at a measuring point in the absence of any alleged disturbing noise at the end of a total period of at least 10 minutes, after such meter had been put into operation;
- **Zone Sound Level**: a derived dB(A) value determined indirectly by means of a series of measurements, calculations or table readings and designated by a local authority for an area; and
- **Disturbing Noise**: a noise level which exceeds the zone sound level or, if no zone sound level has been designated, a noise level which exceeds the ambient sound level at the same measuring point by 7 dB(A) or more.

With the above definitions in mind, regulation 4 of the Noise Control Regulations stipulate that no person shall make, produce or cause a disturbing noise, or allow it to be made, produced or caused by any person, machine, device or apparatus or any combination thereof.

Furthermore, NEMAQA prescribes that the Minister must publish maximum allowable noise levels for different districts and National noise standards. These have not yet been accomplished and as a result all monitoring and assessments are done in accordance with the SANS 10103:2008 and 10328:2008 as discussed in the sections that follow.

4.1.2 SOUTH AFRICAN NATIONAL STANDARDS (SANS)

The SANS 10328:2008 (*Methods for Environmental Noise Impact Assessments*) presently inform Environmental AIAs in South Africa. This standard defines that the purpose of an Environmental AIA is to determine and quantify the acoustical impact of, or on, a proposed development. It also stipulates the methods used to assess impacts as well as the minimum requirements to be investigated and included in the Environmental AIA report as part of the EIA. These minimum requirements include:

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 considered 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.

The SANS 10103:2008 document (*The measurement and rating of environmental noise with respect to speech communication*) provides methods and guidelines to assess working and living environments with respect to acoustic comfort as well as respect to possible annoyance by noise. As applicable to this assessment, SANS 10103 provides guideline typical rating levels for noise in different districts. These rating levels are presented in **Table 5**.

Table 5: Typical rating levels for noise in districts (adapted from SANS 10103:2008)

Type of District	Classification	Equivalent Continuous Rating level for Noise ($L_{Req,T}$) (dB(A))	
		Outdoors	
		Daytime ($L_{Req,d}$)	Night-time ($L_{Req,n}$)
a) Rural	A	45	35
b) Suburban (with little road traffic)	B	50	40
c) Urban	C	55	45
d) Urban (with one or more of the following: workshops, business premises and main roads)	D	60	50
e) Central Business Districts	E	65	55
f) Industrial District	F	70	60

As stipulated in SANS 10103:2008, noise can pose as an annoyance to a community if the increase in average noise levels exceeds the ambient noise by a certain degree. These specified increases together with the relevant estimated community responses are presented in **Table 6**.

Table 6: Categories of community/group response (adapted from SANS 10103:2008)

Excess ($\Delta L_{Req,T}$)[a] dB(A)	Estimated Community or Group Response	
	Category	Description
0 – 10	Little	Sporadic Complaints
5 – 15	Medium	Widespread Complaints
10 – 20	Strong	Threats of community/group action
>15	Very Strong	Vigorous community/group action

Overlapping ranges for the excess values are given because a spread in the community reaction might be anticipated.
[a] $\Delta L_{Req,T}$ should be calculated from the appropriate of the following:
1) $L_{Req,T}$ = $L_{Req,T}$ of ambient noise under investigation MINUS $L_{Req,T}$ of the residual noise (determined in the absence of the specific noise under investigation);
2) $L_{Req,T}$ = $L_{Req,T}$ of ambient noise under investigation MINUS the maximum rating level of the ambient noise given in Table 1 of the code;
3) $L_{Req,T}$ = $L_{Req,T}$ of ambient noise under investigation MINUS the typical rating level for the applicable district as determined from Table 2 of the code; or
4) $L_{Req,T}$ = Expected increase in $L_{Req,T}$ of ambient noise in the area because of the proposed development under investigation.

4.1.3 WESTERN CAPE NOISE CONTROL REGULATIONS

The Esizayo WEF expansion is located within the Western Cape Province. The control of noise in the Western Cape is governed under section 25 of the ECA as The Western Cape Noise Control Regulations (PN 200 of 2013). The regulations define the following:

— **Ambient Noise:** the all-encompassing sound in a given situation at a given time, measured as the reading on an integrated impulse sound level meter for a total period of at least 10 minutes;

— **Disturbing Noise:** a noise, excluding the unamplified human voice, which-

(a) exceeds the rating level by 7 dB(A);

(b) exceeds the residual noise level where the residual noise level is higher than the rating level;

(c) exceeds the residual noise level by 3 dB(A) where the residual noise level is lower than the rating level; or

(d) in the case of a low-frequency noise, exceeds the level specified in Annex B of SANS 10103;

- **Noise Sensitive Activity:** any activity that could be negatively impacted by noise, including residential, healthcare, educational or religious activities;
- **Rating Level:** the applicable outdoor equivalent continuous rating level as indicated in SANS 10103;
- **Residual Noise:** the all-encompassing sound in a given situation at a given time, measured as the reading on an integrated impulse sound level meter for a total period of at least 10 minutes, excluding noise alleged to be causing a noise nuisance or disturbing noise; and
- **Sound Level:** the equivalent continuous rating level as defined in SANS 10103, considering impulse, tone and night-time corrections.

With the above definitions in mind, Section 2 of the regulations prohibits anyone from causing a disturbing noise. While under section 4: (1) the local authority or any other authority responsible for considering an application for a building plan approval, business licence approval, planning approval or environmental authorisation, may instruct the applicant to conduct and submit, as part of the application:

a) a noise impact assessment in accordance with SANS 10328 to establish whether the noise impact rating of the proposed land use or activity exceeds the appropriate rating level for a particular district as indicated in SANS 10103; or

b) where the noise level measurements cannot be determined, an assessment, to the satisfaction of the local authority, of the noise level of the proposed land use or activity.

(2) a) A person may not construct, erect, upgrade, change the use of or expand any building that will house a noise-sensitive activity in a predominantly commercial or industrial area, unless he or she insulates the building sufficiently against external noise so that the sound levels inside the building will not exceed the appropriate maximum rating levels for indoor ambient noise specified in SANS 10103;

b) The owner of a building referred to in paragraph (a) must inform prospective tenants or buyers in writing of the extent to which the insulation measures contemplated in that paragraph will mitigate noise impact during the normal use of the building.

c) Paragraph (a) does not apply when the use of the building is not changed.

(3) Where the results of an assessment undertaken in terms of sub-regulation (1) indicate that the applicable noise rating levels referred to in that sub-regulation will likely be exceeded, or will not be exceeded but will likely exceed the existing residual noise levels by 5 dB(A) or more:

a) the applicant must provide a noise management plan, clearly specifying appropriate mitigation measures to the satisfaction of the local authority, before the application is decided; and

b) implementation of those mitigation measures may be imposed as a condition of approval of the application.

(4) Where an applicant has not implemented the noise management plan as contemplated in sub-regulation (3), the local authority may instruct the applicant in writing to:

a) cease any activity that does not comply with that plan; or

b) reduce the noise levels to an acceptable level to the satisfaction of the local authority.

4.2 INTERNATIONAL GUIDELINES

4.2.1 WORLD HEALTH ORGANISATION GUIDELINES FOR COMMUNITY NOISE

The World Health Organisation (WHO) together with the Organisation for Economic Co-operation and Development (OECD) are the main international bodies that have collected data and developed assessments on the effects of exposure to environmental noise. This has provided the following summary of thresholds for noise nuisance in terms of the outdoor day-time equivalent continuous A-weighted sound pressure level (L_{Aeq}) in residential districts:

— At 55 - 60 dB(A) noise creates annoyance;
— At 60 - 65 dB(A) annoyance increases considerably; and
— Above 65 dB(A) constrained behaviour patterns, symptomatic of serious damage caused by noise

The WHO therefore recommends a maximum outdoor day-time (07:00 – 22:00) L_{Aeq} of 55 dB(A) in residential areas and schools in order to prevent significant interference with normal activities. It further recommends a maximum night-time (22:00 – 07:00) L_{Aeq} of 45 dB(A) outside dwellings. No distinction is made as to whether the noise originates from road traffic, from industry, or any other noise source.

The WHO guideline for industrial noise is set at 70 dB(A) over a period of 24 hours. Anything above this level would cause hearing impairment, however, a peak noise level of 110 dB(A) is allowable on a fast response measurement.

4.2.2 INTERNATIONAL FINANCE CORPORATION GUIDELINES

From the International Finance Corporation (IFC) Environmental, Health and Safety (EHS) Guidelines, the impacts of noise beyond the property boundary of a facility are addressed in section 1.7 (IFC, 2007). The noise guidelines stipulated by the IFC are grouped into two categories, namely "Residential; institutional; educational" and "Industrial; commercial" (**Table 7**). Such guidelines are in-line with the WHO guidelines as discussed above and are as such applicable to this assessment. Noise impacts should not exceed these levels or result in a maximum increase in background noise levels of 3 dB(A) at the nearest off site receptor location.

Table 7: IFC Environmental Noise Level Guidelines

Receptor	One-hour L_{Aeq} (dBA) Daytime (07:00 – 22:00)	One-hour L_{Aeq} (dBA) Night-time (22:00 – 07:00)
Residential; institutional; educational	55	45
Industrial; commercial	70	70

The guideline also states that highly intrusive noise, such as noise from aircraft flyovers and passing trains should not be included when establishing background noise levels.

4.2.3 THE ASSESSMENT AND RATING OF NOISE FROM WIND FARMS (ETSU)

The ETSU-R-97 report describes the framework for the measurement of noise associated with wind farms and provides indicative noise levels that offer a reasonable degree of protection to communities surrounding wind farm developments, without placing unreasonable restrictions on the wind farm developers. The assessment was developed by a Working Group on Wind Turbine Noise, facilitated by the United Kingdom Department of Trade and Industry. The key findings identified in the assessment include:

— Absolute noise limits applied at all wind speeds are not suited to wind farms. Limits set relative to background noise are more appropriate;
— The L_{A90} descriptor is much more accurate when monitoring and assessing wind turbine noise;
— Limits should be set on noise over a range of wind speeds up to 12 m/s when measured at 10 m height;
— The effects of other WEFs in a specific area should be added to the effect of the proposed WEF in order to determine the cumulative effect;
— Increases in noise levels as a result of a WEF should be restricted to 5 dB(A) above the current ambient noise level at a specified receptor location;
— Noise from wind farms should be limited to a range between 35 and 40 dB(A) (daytime) in a low noise environment. A fixed limit of 43 dB(A) should be implemented during night-time. This should increase to 45 dB(A) (day and night) if the potential receptors have financial investments in the facility; and

- For turbines spaced further apart, if noise is limited to an L_{A90} of 35 dB(A) at wind speeds up to 10 m/s at 10 m height, then this condition alone offers sufficient protection of amenity and background noise surveys would not be necessary.

5 METHODOLOGY

The IFC EHS guidelines for Wind Energy were followed for this assessment, which is primarily based on the ETSU-R-97 report. Such guidance stipulates that a preliminary modelling exercise should be carried out using a simple model which assumes hemispherical propagation of noise from each turbine to determine potential impact on receptors within a 2 km radius of the turbines.

The CadnaA (Computer Aided Noise Abatement) acoustic model was used to calculate noise levels at specific receivers (sensitive receptors). The CadnaA software provides an integrated environment for noise predictions under varying scenarios and calculates the cumulative effects of various sources. The model uses ground elevations in the calculation of the noise levels in a grid and uses standard meteorological parameters that have an effect on the propagation of noise. CadnaA has been utilised in many countries across the globe for the modelling of environmental noise and town planning. It is comprehensive software for three-dimensional calculations, presentation, assessment and prediction of environmental noise emitted from industrial plants, parking lots, roads, railway schemes or entire towns and urbanized areas.

The IFC EHS guidance then indicates that if the model results indicate L_{A90} noise levels at all sensitive receptors are below 35 dB(A) at a wind speed of 10 m/s (at a height of 10 m) during day and night times, this would be sufficient to assess the noise impact of the proposed facility. If L_{A90} levels at any receptor location are above 35 dB(A) then a more detailed acoustic study will need to be carried out.

6 ASSUMPTIONS AND LIMITATIONS

In this Environmental AIA, various assumptions were made and limitations experienced that may impact on the results obtained. These include:

- The turbine specifications provided are assumed to be representative of what will be installed in reality;
- The turbine locations provided are assumed to be an accurate representation of where these will be located in reality; and
- Identification of sensitive receptors is based on a desktop assessment and it is assumed that all key receptors have been included.

7 RESULTS

7.1 OPERATIONAL PHASE

Table 8 presents the predicted noise levels from 23 turbines (with a hub height of 150 m and sound power level of 106.0 dB(A)). The model was run taking the surrounding terrain into account. Results indicate that predicted L_{A90} noise levels during both day and night are below the 35 dB(A) threshold, as stipulated in the IFC EHS guidance, at the FH A receptor. As such, no adverse impacts are anticipated and meeting this condition offers sufficient protection of amenity at this receptor. At FH B, however, L_{A90} noise levels are predicted to be slightly above this 35 dB(A) threshold, indicating that noise from the turbines could create a nuisance or impact at this location. It is therefore recommended that the location of the turbines in close proximity of FH B be reconsidered. Such an approach will limit impacts on this receptor and avoid the need for additional, in-depth studies. Alternatively, a more detailed acoustic study will need to be undertaken.

Table 8: Predicted noise levels at sensitive receptors

ID	Predicted L_{Aeq} noise level	Predicted L_{A90} noise level	L_{A90} below 35 dB(A)
FH A	33.6	31.6	Yes
FH B	37.9	35.9	No

Note: L_{A90} calculation based on guidance from the ETSU-R-97 report

7.2 CUMULATIVE ASSESSMENT

The Esizayo WEF expansion is located adjacent to several other proposed/authorised WEFs, namely:

- Gunsfontein
- Mainstream - Sutherland
- Mainstream – Sutherland II
- Mainstream – Rietrug
- Komsberg East
- Komsberg West
- G7 – Roggeveld
- G7 – Roggeveld II
- ACED – Karusa
- ACED – Great Karoo
- ACED – Soetwater
- BTE - Esizayo
- BTE – Maralla West
- BTE – Maralla East

Based on location, the only immediate adjacent site to the Esizayo expansion site is the Esizayo site itself. With the introduction of the Esizayo expansion facility, the cumulative impact is projected to remain low. It must be noted that such a cumulative assessment is based on the overall rating level from the other sites and specific turbine locations for other projects have not been considered in this acoustic model and resultant assessment.

8 ASSESSMENT OF IMPACTS

The purpose of this environmental AIA is to identify the potential impacts and associated risks posed by the operation of the proposed Esizayo WEF expansion on the noise climate of the area. The outcomes of the impact assessment will provide a basis to identify the key risk drivers and make informed decisions on the way forward in order to ensure that these risks do not result in unacceptable social or environmental risk.

All impacts of the operation of the proposed project were evaluated using a risk matrix, which is a semi-quantitative risk assessment methodology. This system derives an environmental impact level on the basis of the extent, duration, potential intensity and probability of potentially significant impacts. The overall risk level is determined using professional judgement based on a clear understanding of the nature of the impact, potential mitigatory measures that can be implemented and changes in risk profile as a result of implementation of these mitigatory measures. A full description of the risk rating methodology is presented in **Appendix B**. Key localised acoustic impacts associated with the project include:

- Operational phase impacts of noise on sensitive receptor FH A; and
- Operational phase impacts of noise on sensitive receptor FH B.

Outcomes of the AIA are contained within **Table 9** outlining the impact of each parameter and the resulting risk level. The resultant environmental acoustic risks for sensitive receptor FH A were ranked "low", while for sensitive receptor FH B, risks were ranked "low to medium". Acoustic impacts of WEFs are very site-specific and the impacts are directly assessed using predicted L_{A90} levels at nearby receptors. The different wind energy developments in the region (as identified in **Section 7.2**) are located in different areas with their own set of receptor locations. If the impacts on the receptors at the Esizayo site are low, then the impact from the other WEFs on these receptors will be significantly lower based on distance from the source.

Table 9: Impact assessment of risks associated with the operation of the Esizayo WEF expansion

Description	Without Mitigation						With Mitigation					
	Extent	Duration	Potential Intensity	Probability	Significance	**Risk Level**	Extent	Duration	Potential Intensity	Probability	Significance	**Risk Level**
Operational phase impacts of noise on sensitive receptor FH A	1	3	1	0.1	0.5	**Low**	1	3	1	0.1	0.5	**Low**
Operational phase impacts of noise on sensitive receptor FH B	1	3	4	0.75	6.0	**Medium**	1	3	2	0.5	3.0	**Low**

9 MITIGATION AND MANAGEMENT MEASURES

The significance of the environmental acoustic impact of the operation of the WEF is considered to be low at the FH A receptor and as such no mitigation is proposed at this location. Noise levels at the FH B receptor are, however, elevated and re-location of the nearby turbines should be considered or mitigation measures should be employed, namely (IFC, 2015):

- Operating turbines in reduced noise mode should any complaints be received;
- Building walls/appropriate noise barriers around potentially affected buildings;
- Limiting turbine operations above the wind speed at which turbine noise becomes unacceptable in the project-specific circumstances;
- Ensuring a larger setback distance from potentially sensitive receptor locations; and
- Consideration of installing larger capacity wind turbines, limiting the number of turbines to be installed but having the same power generation potential.

10 CONCLUSIONS

WSP has been appointed to undertake the BA for the for the proposed Esizayo expansion project. Wind turbines have the potential to generate noise and as such a specialist Environmental AIA is required as part of the BA process for the WEF.

Based on the IFC EHS Guidelines for Wind Energy a preliminary modelling exercise was executed using a simple model which assumes hemispherical propagation of noise from each turbine to determine potential impact on receptors within a 2 km radius of the turbines. If L_{A90} noise levels at all sensitive receptors are below 35 dB(A) at a wind speed of 10 m/s (at a height of 10 m) during day and night times, this would be sufficient to assess the noise impact of the proposed facility. If L_{A90} levels at any receptor location are above 35 dB(A) then a more detailed acoustic study will need to be carried out.

Two sensitive receptors (farmhouses) were identified within 2 km of the site, namely FH A (west of the site, with T10 being the nearest turbine (1,520 m away)) and FH B (east of the site, with T8 being the nearest turbine (1,005 m away)). Based on WSP's preliminary model (following the IFC methodology), the following was determined:

— Results indicate that predicted L_{A90} noise levels during the day and night are below the 35 dB(A) threshold, as stipulated in the IFC EHS guidance, at the FH A receptor. As such, no adverse impacts are anticipated and meeting this condition offers sufficient protection of amenity at this receptor.
— At FH B, however, L_{A90} noise levels are predicted to be slightly above this 35 dB(A) threshold, indicating that noise from the turbines could create a nuisance or impact at this location. It is therefore recommended that the location of the turbines in close proximity of FH B be reconsidered. Such an approach will limit impacts on this receptor and avoid the need for additional, in-depth studies. Alternatively, a more detailed acoustic study will need to be undertaken.

The resultant environmental acoustic risks for sensitive receptor FH A were ranked "low", while for sensitive receptor FH B, risks were ranked "low to medium". Acoustic impacts of WEFs are very site-specific and the impacts are directly assessed using predicted L_{A90} levels at nearby receptors. The different wind energy developments in the region (as identified in **Section 7.2**) are located in different areas with their own set of receptor locations. If the impacts on the receptors at the Esizayo site are low, then the impact from the other WEFs on these receptors will be significantly lower based on distance from the source.

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APPENDIX

A CURRICULUM VITAE

KIRSTEN COLLETT, M.Sc. (Pr.Sci.Nat)

PRINCIPAL CONSULTANT (AIR QUALITY AND ACOUSTICS), ENVIRONMENT & ENERGY

Years with the firm

10

Years of experience

12

Professional qualification

Pri.Sci.Nat

Areas of expertise

Air Quality Impact Assessments

Air Quality Management

Ambient Air Quality and Acoustic Monitoring

Environmental Acoustic Assessments

CAREER SUMMARY

Kirsten is a Senior Air Quality and Acoustic Consultant with a Master of Science (Atmospheric Sciences) degree obtained from the University of the Witwatersrand. She is currently employed at the Johannesburg branch of WSP Environmental and has worked on various air quality and acoustic impact assessments; air quality management plans; air quality and acoustic monitoring projects; and air quality and acoustic modelling projects for a variety of clients over the past ten years. She has provided consulting support to various client industries including petrochemical, mining, metallurgical, manufacturing and local government bodies among others. She is also a registered Professional Natural Scientist (Pr.Nat.Sci.) with the South African Council for Natural Scientific Professions (SACNASP).

EDUCATION

Master of Science, Atmospheric Sciences, University of Witwatersrand, Johannesburg, South Africa	2009
Bachelor of Science (Honours) Geography and Environmental Studies, University of the Witwatersrand, Johannesburg, South Africa	2006
Bachelor of Science, Geography and Environmental Studies, University of Witwatersrand, Johannesburg, South Africa	2005

ADDITIONAL TRAINING

Business-focussed Project Management	2013
Snake Awareness Training	2016

PROFESSIONAL MEMBERSHIPS

South African Council for Natural Scientific Professions	SACNASP
National Association for Clean Air	NACA

PROFESSIONAL EXPERIENCE

Air Quality

- AQIA for a Proposed Cement Grinding Processing Facility, Umbogintwini, KwaZulu-Natal (2021): WSP was appointed to conduct an AQIA in the form of an Atmospheric Impact Report as part of an Atmospheric Emission Licence (AEL) application for a proposed cement grinding processing facility. The assessment consisted of the compilation of a comprehensive emissions inventory to account for emissions from the facility as well as dispersion modelling using the AERMOD dispersion model to assess the impacts of emissions on any surrounding receptors. Client: Platinum Cement Industries.
- Atmospheric Emission Licence (AEL) Audit, Annual Reporting and NAEIS submission for a Foundry, Isando, Gauteng (2021): Project Manager and Lead Consultant. WSP was appointed to undertake an audit of the facility's current AEL to assess the accuracy of what was represented in the AEL as well as to evaluate compliance with the conditions stipulated in the AEL. Additionally the scope of work included compilation of their Annual Report as well as reporting of emissions onto the National Atmospheric Emissions Inventory System (NAEIS). Kirsten was responsible for conducting the audit, compiling the audit report and annual report and submitting all information onto NAEIS. Client: Weir Minerals.
- AQIA for a Revised Production Rate for a Chemical Producer, Cape Town (2020): Project Manager and Lead Consultant. WSP was appointed to conduct an AQIA

in the form of an Atmospheric Impact Report as part of an Atmospheric Emission Licence (AEL) amendment application for a production rate change at the facility. The assessment consisted of the compilation of a comprehensive emissions inventory to account for emissions from the facility as well as dispersion modelling using the AERMOD dispersion model to assess the impacts of emissions on any surrounding receptors. Client: Protea Chemicals.

- AQIA for a Proposed Independent Power Project, Qatar (2020): Project Manager and Lead Consultant. WSP was contracted to undertake a screening-level air quality impact assessment to determine the suitability of the proposed stack heights in dispersing emission away from sensitive receptors. The project included a baseline assessment, emissions inventory, dispersion modelling using SCREEN3 and comparison of the predicted concentrations against the Qatar ambient air quality standards. Client: WSP Middle East.
- AQIA for a Proposed Expansion to an Iron Ore Loading Port, Saldanha (2019): Project Manager and Lead Consultant. WSP was contracted to undertake an air quality impact assessment to determine the impacts of a proposed increase in iron ore storage and handling capacity at the Saldanha Port. The project included a baseline assessment, compilation of a comprehensive emissions inventory and dispersion modelling using the CALPUFF dispersion model to assess the impacts of emissions on the surrounding communities. Client: Transnet Port Terminals Saldanha Bay.
- Isibonelo Colliery Air Quality Management Plan, Mpumalanga, South Africa (2019-2020): Project Manager and Lead Consultant. Anglo American Coal SA requested the compilation of an Air Quality Management Plan (AQMP) for the Isibonelo Colliery in the Mpumalanga province. The AQMP was aimed at improving air quality at the colliery through the identification of main sources of emissions and recommendations to reduce emissions from these sources. Kirsten was responsible for the compilation of the AQMP which was performed through a baseline assessment of activities at the colliery; identification of key emission sources; compilation of a detailed site specific emissions inventory; determination of the impact of emissions from the colliery on surrounding communities using the AERMOD dispersion modelling software; review of current management and mitigation techniques at the colliery; and development of strategies to minimise any impacts of emissions from the colliery going forward. Client: Anglo American Coal SA.
- Atmospheric Emission Licence (AEL) Audit for a Manganese Multipurpose Terminal, Saldanha (2019): Lead Consultant. WSP was contracted to undertake an audit of the current provisional AEL (PAEL) for the terminal and assist with conversion of the PAEL to a final AEL. The project included a site visit and audit, Client and Authority liaison and assistance with submission of the AEL on the South African Atmospheric Emission Licencing and Inventory Portal (SAAELIP). Client: Transnet Port Terminals Saldanha Bay.
- Air Quality Impact Assessment (AQIA) for a Proposed Waste to Energy Facility, Kuwait (2017-2018): Lead Consultant. WSP was contracted to undertake an air quality impact assessment to determine the impacts of a proposed waste to energy facility in Kuwait. The project included assessment of baseline monitoring data (conducted by a local partner), a baseline assessment, emissions inventory, dispersion modelling using CALPUFF and comparison of the predicted concentrations against the Kuwait and International ambient air quality guidelines/standards. A preliminary screening assessment was undertaken using SCREEN3 to determine the monitoring locations for the baseline monitoring campaign. Client: WSP Middle East.
- Dust Fallout and Particulate Matter Monitoring for nine Collieries, Mpumalanga, South Africa (2016-present): Project Manager. WSP was appointed to manage Anglo American Coal SA's air quality monitoring requirements at nine of their collieries. The contract includes dust fallout monitoring at all nine collieries, while

continuous particulate matter (PM_{10} and $PM_{2.5}$) monitoring is conducted at seven collieries using mobile custom-designed solar system trailers. Kirsten is responsible for project management and quality control for the project. Client: Anglo American Coal SA.

Acoustics

- Environmental Acoustic Impact Assessment for a Proposed Manganese Mine, Kanye, Botswana (2021): Project Manager and Lead Consultant. WSP was appointed to undertake an environmental acoustic impact assessment for a proposed manganese mine in Botswana. Kirsten was responsible for conducting the assessment which included a baseline assessment; development of a comprehensive acoustic inventory; and determination of the impact of the proposed project on the surrounding sensitive receptors using the Computer Aided Noise Abatement (CadnaA) acoustic modelling software. Client: Loci Environmental.
- Environmental Acoustic Impact Assessment for the expansion to a refuse transfer station, Cape Town, South Africa (2020): Project Manager and Lead Consultant. WSP was appointed to undertake an environmental acoustic impact assessment for the proposed expansion to the Athlone Refuse Transfer Station in the city of Cape Town. Kirsten was responsible for conducting the assessment which included baseline acoustic monitoring; development of a comprehensive acoustic inventory; and determination of the impact of the proposed project on the surrounding sensitive receptors using the Computer Aided Noise Abatement (CadnaA) acoustic modelling software. Client: Resource Management Services.
- Environmental Acoustic Impact Assessment for the expansion to a tailings storage facility, North West Province, South Africa (2017-2020): Project Manager and Lead Consultant. WSP was appointed to undertake an environmental acoustic impact assessment for the proposed extension of the Kareerand Tailings Storage Facility. Kirsten was responsible for conducting the assessment which included baseline acoustic monitoring; development of a comprehensive acoustic inventory for both the construction and operational phases of the project; and determination of the impact of the proposed project on the surrounding sensitive receptors using the Computer Aided Noise Abatement (CadnaA) acoustic modelling software. Client: AngloGold Ashanti.
- Environmental Acoustic Impact Assessment for three wind energy facilities, Northern and Western Cape, South Africa (2016-2019): Project Manager and Lead Consultant. WSP was appointed to undertake an environmental acoustic impact assessment for three proposed wind energy facilities located between Sutherland and Matjiesfontein in the Northern and Western Cape provinces. Kirsten was responsible for conducting the assessments which included baseline acoustic monitoring; development of a comprehensive acoustic inventory for both the construction and operational phases of the project; and determination of the impact of the proposed wind energy facilities on the surrounding sensitive receptors (farm houses) using the Computer Aided Noise Abatement (CadnaA) acoustic modelling software. Client: BioTherm Energy.
- Environmental Acoustic Impact Assessment for the proposed rehabilitation of the Sekoma-Morwamosu road section, Botswana (2017): Project Manager and Lead Consultant. WSP was appointed to undertake an environmental acoustic impact assessment for the proposed rehabilitation of a section of road within the southern part of Botswana. Kirsten was responsible for conducting the assessment. Current operational noise levels in the vicinity of the road section where determined using an acoustic modelling platform, with current (2017) traffic count data as input. The acoustic impacts of the proposed rehabilitation were determined using attenuation-over-distance calculations (construction phase) and acoustic modelling (operational phase). Changes in noise levels at specific receptor locations were then assessed for each phase and the resultant community responses were evaluated. Client: Loci Environmental.

APPENDIX

B

IMPACT ASSESSMENT METHODOLOGY

APPENDIX

The impacts were assessed using the risk matrix defined in tables that follow.

Impact Assessment Parameters – Extent

Extent Descriptors	Definitions	Rating
Site	The impact footprint remains within the cadastral boundary of the site.	1
Local	The impact footprint extends beyond the cadastral boundary of the site, to include the immediately adjacent and surrounding areas.	2
Regional	The impact footprint includes the greater surrounding area within which the site is located.	3
National	The scale / extent of the impact is applicable to Botswana.	4
Global	The extent / scale of the impact is global.	5

Impact Assessment Parameters – Duration

Duration Descriptors	Definitions	Rating
Construction Period Only	The impact endures for only as long as the Construction period of the proposed activity. This implies the impact is fully reversible.	1
Short Term	The impact continues to manifest for a period of between 3 – 10 years. The impact is reversible.	2
Medium Term	The impact continues to manifest for a period of 10 – 30 years. The impact is reversible with relevant and applicable mitigation and management actions.	3
Long Term	The impact continues for a period in excess of 30 years. However, the impact is still reversible with relevant and applicable mitigation and management actions.	4
Permanent	The impact will continue indefinitely and is irreversible.	5

Impact Assessment Parameters – Potential Intensity

Descriptors: Potential Negative Consequence	Rating	Score
Human health – morbidity / mortality. Loss of species.	High	16
Reduced faunal populations, loss of livelihoods, individual economic loss.	Moderate-high	8
Reduction in environmental quality – air, soil, water. Loss of habitat, loss of heritage, amenity.	Moderate	4
Nuisance.	Moderate-low	2
Negative change – with no other consequences.	Low	1

APPENDIX

Impact Assessment Parameters – Probability

Likelihood / Probability Descriptors	Definitions	Rating
Improbable	The possibility of the impact occurring is negligible and only under exceptional circumstances.	0.1
Unlikely	The possibility of the impact occurring is low with less than 10% chance of occurring. The impact has not occurred before.	0.2
Probable	The impact has a 10 – 40% chance of occurring. Only likely to happen once every three or more years.	0.5
Highly Probable	It is most likely that the impact will occur. A 41 – 75% chance of occurring.	0.75
Definite	More than 75% chance of occurring. The impact occurs regularly.	1

From the tables above, the significance of the impacts is then calculated using the following equation:

(Extent + Duration + Potential Intensity) x Probability = Significance

The significance level of the risks, as weighted by the above equation, identifies the risk rating that each impact triggers and the associated authorisation implications as outlined in the table below:

Impact Assessment Parameters – Significance

Descriptors	Definitions	Rating
Low	The project can be authorised with a low risk of environmental degradation.	**> 5**
Medium	The project can be authorised but with conditions and routine inspections.	**5 – 8**
High	The project can be authorised but with strict conditions and high levels of compliance and enforcement in respect of the impact in question.	**9 – 15**
Fatally Flawed	The project cannot be authorised.	**>15**