Appendix C

SPECIALIST STUDIES

Appendix C1

AVIFAUNA IMPACT ASSESMENT

ADDENDUM TO THE AVIFAUNAL IMPACT ASSESSMENT CONDUCTED FOR THE PROPOSED BEAUFORT WEST WIND ENERGY FACILTY (WEF) NEAR BEAUFORT WEST,

WESTERN CAPE PROVINCE

APPLICATION FOR AMENDMENT OF ENVIRONMENTAL AUTHORISATION

Addendum report compiled by:

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EXECUTIVE SUMMARY

The purpose of this addendum report is to revisit the avifaunal impact assessments for the proposed Beaufort West Wind Energy Facility (WEF) near Beaufort West in the Western Cape (Avisense 2011; Avisense 2016; Van Rooyen *et al*. 2016), based on the proposed amendment to the environmental authorisation in June 2019.

The proposed changes are as follows:

Aspect	Authorised	Proposed amendment
Hub height	Up to 150m	Up to 200m
Rotor diameter	Up to 150m	Up to 200m
Number of turbines	70	Up to 70

Given the potential changes to the turbine specifications, a re-assessment of the potential turbine collision impact was carried out in light of the proposed amendment, in order to establish if the original pre-mitigation assessment by Avisense (2011; 2016) should be revised, and if the original mitigation measures need to be revised.

It is concluded that the proposed increase in the turbine dimensions require the original pre-mitigation impact significance rating of **"medium-high"** for the risk of mortality due to turbine collisions, to be changed to **"high",** if the current authorised layout remains unchanged. However, should the number of turbines reduce significantly, it will result in the original pre-mitigation collision rating remaining unchanged, or even reducing, depending on the extent of the reduction in the number of turbines.

The proposed amendment would be advantageous from a bird impact perspective if the number of turbines is reduced as a result of the amendment. Should the turbine dimensions increase as proposed, and the number of turbines remain unchanged at 70, it would increase the risk of collisions and it would then be a disadvantage from the bird impact perspective.

It is further concluded that the original mitigation measures listed in the Bird Specialist Study (Avisense 2011; 2016) remain applicable and need not be revised in view of the proposed changes to the turbine dimensions.

1 Background

The purpose of this addendum report is to revisit the avifaunal impact assessments for the proposed Beaufort West Wind Energy Facility (WEF) near Beaufort West in the Western Cape (Avisense 2011; Avisense 2016; Van Rooyen *et al*. 2016), based on the proposed amendment to the environmental authorisation in June 2019. The proposed changes are provided in **Table 1** below.

Table 1: Proposed turbine dimensions amendments

Aspect	Authorised	Proposed amendment
Hub height	Up to 150m	Up to 200m
Rotor diameter	Up to 150m	Up to 200m
Number of turbines	70	Up to 70

2 Terms of reference

Due to these proposed changes in **Table 1**, and in accordance with the National Environmental Management Act, 1988 (No. 107 of 1998) (NEMA), a re-assessment of potential impacts on the associated avifauna is required to be undertaken before an Amendment to Environmental Authorisation can be granted for the revised WEF development. **The impact which is specifically relevant in this instance is the risk of priority species mortality due to collisions with the turbines.**

The Terms of Reference (ToR) for this addendum report are as follows:

- Assess the impacts related to the proposed change from the authorised turbine specifications (if any);
- Assess advantages or disadvantages of the proposed change in turbine specifications (comparative assessment between the authorised hub height and rotor diameter, versus the proposed specifications); and
- Identify additional or changes to the mitigation measures required to avoid, manage or mitigate the impacts associated with the proposed turbine specifications (if any).

3 The findings of the original bird impact assessment reports

The original Bird Specialist Study (Avisense 2011; 2016) identified risks (**Table 2**) of bird collisions with the wind turbines.

Key species which Avisense (2011: 2016) identified in the original Bird Specialist Study as being most at risk is Blue Crane *Anthropoides paradisea*, Ludwig's Bustard *Neotis ludwigii*, Kori Bustard *Ardeotis kori* and Martial Eagle *Polemaetus bellicosus*. Van Rooyen *et al*. (2016) identified Secretary bird *Sagittarius serpentarius*, Greater Kestrel *Falco rupicoloides*, Lesser Kestrel *Falco naumanni* and Ludwig's Bustard as being most at risk of collisions, based on four (4) seasons' monitoring.

Table 2: Original bird collision risk

Environmental parameter	Impact	Rating prior to mitigation	Rating post mitigation
Avifauna	Priority species mortality due to collision with the turbines	Medium - high	Low

4 The relevance of turbine numbers and dimensions in avifaunal mortality risk

Most of the studies to date found turbine dimensions to play a relatively unimportant role in the magnitude of the collision risk relative to other factors such as topography, turbine location, morphology, behaviour and a species' inherent ability to avoid the turbines, and may only be relevant in combination with other factors, particularly wind strength and topography (see Howell 1997, Barrios & Rodriguez 2004; Barclay *et al.* 2007, Krijgsveld *et al.* 2009, Smallwood 2013; Everaert 2014). Three (3) studies found a correlation between hub height and mortality (De Lucas *et al.* 2008; Loss *et al.* 2013 and Thaxter *et al*. 2017).

The summary below provides a list of published findings on the topic:

- Howell *et al.* 1997 states on p.9: "*The evidence to date from the Altamont Pass does not support the hypothesis that the larger rotor swept area (RSA) of the KVS–33 turbines contributes proportionally to avian mortality, i.e. larger area results in more mortalities. On the contrary, the ratio of K-56 turbines to KVS-33 turbines rather than RSA was approximately 3.4:1 which as consistent with the 4.1:1 mortality ratio. It appears that the mortality occurred on a per-turbine basis i.e. each turbine simply presented an obstacle*."
- Barrios & Rodriguez 2004 states on p. 80: "*Most deaths and risk situations occurred in two rows at PESUR with little space between consecutive turbines. This windwall configuration (Orloff & Flannery 1992) might force birds that cross at the blade level to take a risk greater than in less closely spaced settings. However, little or no risk was recorded for five turbine rows at PESUR having exactly the same windwall spatial arrangement of turbines. Therefore, we conclude that physical structures had little effect on bird mortality unless in combination with other factors*."
- Barclay *et al.* 2007 states on p. 384: "*Our analysis of the data available from North America indicates that this has had different consequences for the fatality rates of birds and bats at wind energy facilities. It might be expected that as rotor swept area increased, more animals would be killed per turbine, but our analyses indicate that this is not the case. Rotor-swept area was not a significant factor in our analyses. In addition, there is no evidence that taller turbines are associated with increased bird fatalities. The per turbine fatality rate for birds was constant with tower height*."
- De Lucas *et al.* 2008 states on p. 1702: "*All else being equal, more lift is required by a griffon vulture over a taller turbine at a higher elevation and we found that such turbines killed more vultures compared to shorter turbines at lower elevations.*"
- Krijgsveld *et al.* 2009 states on p. 365: "*The results reported in this paper indicate that collision risk of birds with larger multi-MW wind turbines is similar to that with smaller earlier-generation turbines, and much lower than expected based on the large rotor surface and high altitude-range of modern turbine. Clearly, more studies of collision victims are needed before we can confidently predict the relationship between size and configuration of wind turbines and the risk for birds to collide with a turbine.*"
- Smallwood *et al*. 2013 states on p.26 – 27 (see also Fig 9 on p.30): "*Red-tailed hawk (Buteo jamaicensis) and all raptor fatality rates correlated inversely with increasing wind-turbine size (Figs. 9A, B). Thousands of additional MW of capacity were planned or under construction in 2012, meaning that the annual toll on birds and bats will increase. However, the expected increase of raptor fatalities could be offset by reductions of raptor fatalities as older wind projects are repowered to new, larger wind turbines, especially if the opportunity is taken to carefully site the new wind turbines (Smallwood and Karas 2009, Smallwood et al. 2009)*."
- Loss *et al.* 2014 states on p. 208: "*The projected trend for a continued increase in turbine size coupled with our finding of greater bird collision mortality at taller turbines suggests that precaution must be taken to reduce adverse impacts to wildlife populations when making decisions about the type of wind turbines to install."*

- Everaert, 2014 states on p. 228: "*Combined with the mortality rates of several wind farms in the Netherlands (in similar European lowland conditions near wetlands or other areas with water), no significant relationship could be found between the number of collision fatalities and the rotor swept area of the turbines (Fig. 4). In contrast to more common landscapes, Hötker (2006) also found no significant relationship between mortality rate and the size of wind turbines near wetlands and mountain ridges*."
- In the most recent paper on the subject by Thaxter *et al*. (2017), the authors conducted a systematic literature review of recorded collisions between birds and wind turbines within developed countries. They related collision rate to species-level traits and turbine characteristics to quantify the potential vulnerability of 9 538 bird species globally. For birds, larger turbine capacity (megawatts) increased collision rates; however, deploying a smaller number of large turbines with greater energy output reduced total collision risk per unit energy output. In other words, although there was a positive relationship between wind turbine capacity and collision rate per turbine, the strength of this relationship was insufficient to offset the reduced number of turbines required per unit energy generation with larger turbines. *Therefore, to minimize bird collisions, wind farm electricity generation capacity should be met through deploying fewer, large turbines, rather than many, smaller ones*.

The authorised rotor diameter of 150m for the Beaufort West WEF translates into a rotor swept area of approximately 17 671m² per turbine. An increase of the rotor diameter to 200m will result in a rotor swept area of approximately 31 415m². This amounts to an increase of 77.7% in the rotor swept area per turbine.

5 Re-assessment of collision mortality impact

Given the proposed changes to the turbine specifications, a re-assessment of the potential collision impact was carried out for the proposed amendment, in order to establish if the original pre-mitigation significance rating proposed by Avisense (2011; 2016) should be revised. The increase of 77.7% in rotor swept area per turbine is significant, and unless the number of turbines is reduced, it will result in an increase in the overall collision risk. However, should the number of turbines reduce significantly, it will result in the collision rating remaining unchanged, or even reducing, depending on the extent of the reduction in the number of turbines (see also section 6 below).

Given the significant proposed increase in rotor swept area, it is concluded that the original pre-mitigation impact significance rating of **"medium - high"** for potential collision mortality will not be valid anymore, should the proposed change in the turbine dimensions be applied to the current layout of 70 turbines. In that case, a collision risk rating of "**high**" would be more appropriate (see **Table 3** below).

Table 3: Revised ratings table

(A) Mortality
Nature: Operational activities would result in a **negative direct** impact on the avifauna of the REF site.
Impact Magnitude – **Medium-High**
• **Extent**: The extent of the impact could be **regional**. Within a landscape, a permanent migration of individuals from a source population to a sink situation, e.g, where birds continually get killed and replaced may lead to a stabilization of the overall demographic system. • **Duration**: The duration would be **long-term** as the ecology of the area would be affected at least until the project stops operating. • **Intensity**: Numbers of individuals of threatened species may be killed in collision incidents, so change will be **Medium-High**.
Likelihood – There is a **high** likelihood that birds will be killed.
IMPACT SIGNIFICANCE (PRE-MITIGATION) – HIGH
Degree of Confidence: The degree of confidence is **Medium**.

6 Revised mitigation measures

An assessment was undertaken by Avisense (2011; 2016) to determine if the mitigation measures originally proposed for the Beaufort West WEF would need to be revisited in order to keep the residual impacts rating "**low**" in terms of the following two (2) factors:

- The proposed increase in the rotor diameter will result in an increased risk of collisions for priority species (see Section 5 above).
- The "Best Practice Guidelines for Avian Monitoring and Impact Mitigation at Proposed Wind Energy Development Sites in Southern Africa", (Jenkins *et al*. 2011) revised in 2015, requires that either all, or part of the pre-construction monitoring is repeated if there is a time period of three years or more between the data collection and the construction of the wind farm. This re-assessment is necessary in order to take cognisance of any changes in the environment which may affect the risk to avifauna, and to incorporate the latest available knowledge into the assessment of the risks. In order to give effect to this requirement, nest searches were repeated in June 2019 to ensure current information on the breeding status of priority species at the proposed Beaufort West WEF is recorded.

No additional priority species nests were recorded during the nest searches in June 2019, which could be impacted by the proposed WEF.

It is concluded that the original mitigation measures listed in the Bird Specialist Study (Avisense 2011; 2016) remains valid and do not need be revised in view of the proposed changes to the turbine dimensions.

7 Conclusions

Given the potential changes to the turbine specifications, a re-assessment of the potential turbine collision impact was carried out in light of the proposed amendment, in order to establish if the original pre-mitigation assessment by Avisense (2011; 2016) should be revised, and if the original mitigation measures need to be revised.

It is concluded that the proposed increase in the turbine dimensions require the original pre-mitigation impact significance rating of **"medium-high"** for the risk of mortality due to turbine collisions, to be changed to **"high",** <u>if the current authorised layout remains unchanged</u>. However, should the number of turbines reduce significantly, it will result in the original pre-mitigation collision rating remaining unchanged, or even reducing, depending on the extent of the reduction in the number of turbines.

The proposed amendment would be advantageous from a bird impact perspective if the number of turbines is reduced as a result of the amendment. Should the turbine dimensions increase as proposed, and the number of turbines remain unchanged at 70, it would increase the risk of collisions and it would then be a disadvantage from the bird impact perspective.

It is further concluded that the original mitigation measures listed in the Bird Specialist Study (Avisense 2011; 2016) remain applicable and therefore do not need to be revised in view of the proposed changes to the turbine dimensions.

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Appendix C2

BAT IMPACT ASSESEMENT

BAT IMPACT ASSESSMENT: AMENDMENT

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BEAUFORT WEST WIND ENERGY FACILITY, WESTERN CAPE

DECLARATION OF INDEPENDENCE

In terms of the National Environmental Management Act of 1998, I, Stephanie C Dippenaar, owner of Stephanie Dippenaar Consulting, operating as a sole proprietor, do hereby declare that I have no conflicts of interest related to the work of this Second Amendment of the Bat Impact Assessment Report: Beaufort West Wind Energy Facility, Western Cape. I have no personal or financial connections to the relevant property owners, developers, planners, financiers or consultants of the development.

Stephanie C Dippenaar

Signed at Stellenbosch on 31 July 2019

BAT IMPACT ASSESSMENT AMENDMENT: BEAUFORT WEST WEF

1. PROJECT DESCRIPTION

South Africa Mainstream Renewable Power Developments (Pty) Ltd (Mainstream) received Environmental Authorisation (EA) from the Department of Environmental Affairs (DEA) for development of the Beaufort West Wind Energy Facility, located near the town of Beaufort West in the Western Cape Province in March 2012. Subsequent amendments were issued by DEA which involved the following changes:

- Splitting the wind component of the authorised 360MW to 590MW Beaufort West Renewable Energy Facility into the 140MW Trakas Wind Farm and the 140MW Beaufort West Wind Farm;
- Reduction in the total number of wind turbines to 70;
- Reduction in the total area of the project and the number of farms affected;
- Amendment of the turbine layouts;
- Amendment of the authorised specifications of the hub height of up to 120m and the blade length of up to 60m to be a 150m hub height and a 150m rotor diameter (75m blade length).

Mainstream is currently submitting an amendment application to the DEA to again modify turbine specifications. Stephanie Dippenaar Consulting has been contracted by South Africa Mainstream Renewable Power to undertake an assessment of the project amendments (Table 1) with regards to the potential impacts to bats.

Table 1: Aspects of the proposed amendment

Aspect to be amended	Previously assessed	Proposed amendment
Hub height	Up to 150 m	Up to 200 m
Rotor diameter	Up to 150 m	Up to 200 m

Beaufort West WEF will have a total capacity of 140MW, but the exact turbine specifications that will be deployed are not known yet. With the proposed larger turbine model associated with the amendment, less turbines will be constructed to reach the overall export capacity of 140 MW. A number of turbines could therefore be removed from the layout during final design and micro-siting.

The main negative impact of turbines on bats is the encroachment of air space where bats forage or commute. Table 2 and Figure 1 indicate the increase in the volume of the total sweep area, if turbine sweep is calculated as a sphere. For example, should 40 turbines be installed, with a hub height of 200 m and a rotor diameter of 200 m, there will be a 35,45% increase in sweep area. The lowest point of the sweep of the turbine blades is also indicated, as this could have an impact on bat mortality, see Section 4.1.

Table 2: Changes in area of collision

Aspect to be amended	Previously assessed (70)	Proposed amendment (40)	Difference between Authorised specifications and Amendment
Total volume of the sweep of the turbine blades, if calculated as a sphere where the hub height is 200m and the rotor diameter is 200m	0.1236966 km^3	0.1968673 km^3	0.0731708 km^3 more airspace is occupied (35,45% increase)
Lowest point of the sweep of the turbine blades, from ground level	75 m	100 m	25 m higher from ground level

2. TERMS OF REFERENCE

The purpose and scope of this report is to assess whether the proposed amendments to the EA will alter the impacts identified in the original bat impact assessment performed by Animalia Consultants (Pty) Ltd, namely Fifth and Final Progress Report of a 12-month Long-Term Bat Monitoring Study (September 2016) and the subsequent mitigation recommendations from an amendment letter compiled by Animalia Consultants (Pty) Ltd dated 8 February 2016. Animalia is no longer conducting bat assessments and thus a different Specialist, that did not undertake the preconstruction monitoring study, was appointed.

Amendments or additions to the mitigation measures in the existing Environmental Management Programme (EMPr) will be identified in this report in order to prevent, manage and mitigate impacts of the proposed turbine changes (if found to be necessary). The cumulative impacts (of wind energy developments within a 20 km radius of the WEF) identified in the original bat impact assessment will be reviewed considering the current developments and updated if necessary.

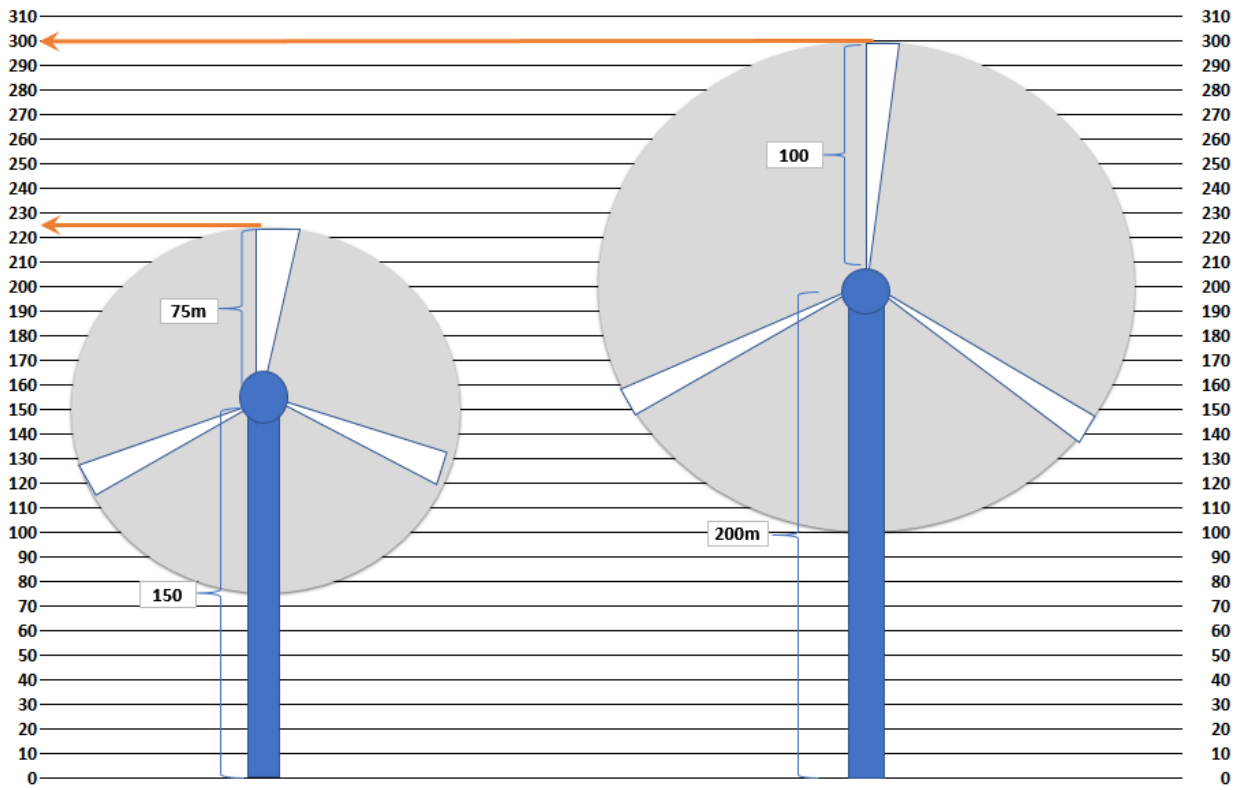

Figure 1: Changes in specifications of turbine dimension

3. METHODS

The current scientific literature was reviewed to gain insight into the relationship of turbine size on bat mortalities to aid in the assessment of the impacts of greater turbine hub height and rotor diameter. The literature was also reviewed for effective mitigation measures for the relevant impacts.

The original bat impact assessment report was reviewed with critical assessment of bat species richness and activity levels on site, the sensitivity map, impact assessment, cumulative impact assessment and recommended mitigation measures considering the proposed project amendments.

4. RESULTS

4.1 Literature review

The proposed increased turbine dimensions result in a larger rotor swept area and greater overall height per turbine. The impact relevant to this amendment is the change in risk of direct collision of bats in flight with moving turbine blades. Two studies by Barclay *et al.* (2007) and Georgiakakis *et al*. (2012) reported a positive exponential relationship of bat mortalities with turbine tower height, with no effect of the size of rotor sweep area (blade diameter). Whereas Rydell *et al*. (2010) found significant positive effects of tower height and rotor swept area with bat mortality. Studies by Johnson *et al*. (2003) and Fiedler *et al.* (2007) corroborated findings of increased mortalities with increased turbine dimensions. However, Thompson *et al*. (2017) performed a synthesis and review of mortality data from 218 North American studies representing 100 wind farms and did not find a significant relationship between increased turbine height and increased bat mortality. It is important to note that turbine specifications in the above-mentioned studies (hub height range of 44 m to 98 m and maximum rotor diameter of 180 m) are smaller than the maximum dimensions applied for in this amendment and, the wind farms consisted of much fewer turbines. Rydell *et al*. (2010) found the bat mortality rate to be independent of the size of the wind farm (number of turbines) however, the survey covered a maximum of 18 turbines which is substantially fewer than the proposed 70 turbines for Beaufort West WEF.

Thaxter and co-workers (2017) undertook the first global quantitative assessment from published literature of the effects of wind farms on bat and bird mortality. They detected a strong positive association between turbine capacity (MW) and collisions per turbine for both bats and birds. Per wind farm energy output, a large number of small turbines resulted in higher predicted mortality rates than fewer larger turbines. The modelled mortality rate was highest when 1000 0.01MW turbines were used, thereafter the mortality rate decreased exponentially up to 1.2 MW turbines. The mortality for bats then increased again from 14 bats with 1.2 MW turbines, to 24 bats with 2.5 MW turbines. Thus, increasing the turbine dimensions with a reduction in total number of turbines would reduce mortality up to a point (1.2 MW turbines), thereafter mortality would increase with an increase in turbine dimensions.

The other consideration is that a greater turbine hub height increases the height of the lower blade tip from the ground, and may shift the species-specific risks towards open air foraging and high-flying species, such as the Molossidae family (Free-tailed bats), while reducing the risk for species flying closer to ground level (Willig *et al.,* 2018). Willig and co-workers (2018) investigated the vertical distribution of bat activity within the European Alps. They demonstrated a clear trend of decreased activity with increased height, most activity was recorded below 50 m height. Mathews *et al.* (2016) found greater species richness and activity levels at ground level than at heights between 30 and 80 m. Wind farm fatalities of clutter-edge foraging species, that do not typically occupy open air spaces high above the ground, have been found in South Africa (Aronson *et al.,* 2013; MacEwan, 2016). Additionally, the Bat Specialist/Consultant has observed the trend of higher activity and species richness at lower monitoring systems, usually situated around 10 m, in most preconstruction bat monitoring studies conducted across South Africa. Therefore, it seems that the proportion of bat species at risk may decrease with increased hub height, but open-air high-flying species would have an increased mortality risk.

4.2 Review of the Final Progress Report of 12-month Long-Term Bat Monitoring Study

4.2.1 Species richness and activity trends

Acoustic monitoring was conducted during bat monitoring at 80 m height for a period of 12 months (16 April 2015 – 18 April 2016) on the meteorological mast on site without system failures (Animalia, 2016). The height at which monitoring took place is an important consideration for the proposed amendment to assess the relevance of the trends in species richness and activity levels detected at 80 m height, relative to the proposed amended turbine specifications. The height at which monitoring took place is 20 m below the lowest reach of this proposed amendment turbine sweep area, but if the specifications of the monitoring systems, namely SM2BAT, used at Beaufort West WEF are taken into account, at least some data would have been recorded within the sweep of the turbine blades. This data will be verified during the first half of the post construction monitoring.

As expected, higher activity levels were detected at the 10 m recording height than 80 m height; however, the species richness was the same for both recording heights. *Tadarida aegyptiaca* (Eqyptian free-tail bat) was the most abundant species on site and at the 80 m monitoring height (Animalia, 2016). This is a high-flying species with a high risk of collision with turbine blades (Sowler *et al*., 2017). Lower bat activity was detected over the winter months with a steady increase from September 2015 to April 2016. The peak activity periods were identified as late September to early January over the time of 20:00 – 03:00, and mid-January to mid-March over the time of 19:00 – 04:00. Section 5 (Initial mitigation measures and details) of the final bat monitoring report (Animalia, 2016) suggests mitigations for the higher activity periods and higher risk species. Considering the increased airspace that would be occupied by the larger turbines evaluated in this amendment, and thus the high mortality risk to the dominant species (*Tadarida aegyptiaca*) detected on site, mitigation conditions need to be carefully re-evaluated during the first few months after the onset of the wind farm. If deemed necessary, Table 3 should be adapted to a turbine specific mitigation strategy.

4.2.2 Sensitivity map

The sensitivity map identified areas of moderate and high bat sensitivity and designated buffers of **50 m** and **200 m**, respectively (Animalia 2016). Siting of turbines, and other construction activities, in these buffers should be avoided. Buffer zones therefore stay the same as recommended during the bat monitoring report, but for **this amendment, all components, including the turbine blade tips, must be excluded from entering the buffer areas.**

The Applicant must ensure that turbines are placed at an appropriate distance away from bat sensitivity areas, based on the finalized turbine dimensions. The turbine layout should be approved by a bat specialist upon finalisation of turbine specifications.

4.2.3 Impact assessment

Of the impacts identified in the EIA, only bat mortalities due to direct blade impact or barotrauma during foraging activities (Section 6 of the EIA report), are relevant to this amendment. The impact was identified as very high negative (score of -76) without mitigation, and reduced to low negative (score of -26) with the following mitigations (Animalia, 2016):

- **Adhere to the bat sensitivity map (avoid development in the demarcated sensitivity areas and their buffers);**
- **All turbines must be curtailed below cut in speed and not allow for freewheeling from the start of operation. Bat activity is markedly higher over low wind speed periods. Preventing freewheeling should not affect energy production significantly and will be a significant bat conservation mitigation measure.**
- **Implement an operational bat monitoring study immediately after construction of turbines and apply mitigation measures outlined by the Bat Specialist during the operational monitoring study.**

In order to avoid mitigation from the onset of the wind farm, the following recommended mitigation measures should be added to the above:

- **A maximum number of 40 turbines, with a hub height of 200 m and a rotor diameter of 200 m, is proposed with the provided total output of 140 MW. If more than 40 turbines with these specifications are installed, the curtailment programme as indicated in the bat monitoring report (Animalia, 2016) is to be applied from the onset of the wind development, see Table 3. This curtailment then needs to be refined by a bat specialist during the operational phase. Should smaller turbines be deployed, more turbines may be installed, but with the agreement of a bat specialist.**
- **To account for the lack of data within the sweep of the amended turbine specifications, the appropriate turbines, as indicated by the post-construction bat specialist, should be installed with bat monitoring equipment at height and bat monitoring should start at the onset of turbines.**
- **An operational bat monitoring study should already be in place at the start of the wind farm operation and should be implemented immediately after construction of turbines. Mitigation measures outlined by the Bat Specialist during the operational monitoring study should be applied with due diligence.**

Table 3: Wind turbine mitigation schedule taken from the final progress report of the 12-month long bat monitoring study (Animalia, 2016).

	Terms of mitigation implementation
Spring/Summer peak activity (times to implement curtailment/ mitigation)	Late September to early January 20:00 – 03:00
Environmental conditions in which to implement curtailment/ mitigation	Below 9m/s wind speed at 120m above ground level, and above 15°C temperature at 120m above ground level
Summer/Autumn peak activity (times to implement curtailment/ mitigation)	Mid-January to mid-March 19:00 – 04:00
Environmental conditions in which to implement curtailment/ mitigation	Below 8.5m/s wind speed at 120m above ground level, and above 18°C temperature at 120m above ground level

Considering the greater turbine dimensions proposed in this amendment application, the negative impact would remain very high without mitigation and reduced to low with the proposed mitigation. Ratings would remain as in the final EIA report on condition of the application of the mitigation recommendations from the final EIA report, the above listed added mitigation measures and sensitivity buffers recommended in section 4.2.2 of this report.

4.2.4 Cumulative impact assessment

The pertinent threat to bats, from the cumulative impact of several wind energy facilities operating within a single general area, is mortality from turbine blade collision and barotrauma. There is potential for significant loss of locally active bats and migratory bats that will essentially reduce the effective population size and may cause population crashes.

According to the DEA's Renewable Energy EIA Application Database for SA (First quarter 2019), there are currently two authorised wind farms within a 20 km radius of the Beaufort West WEF, namely:

- Trakas WEF (Applicant - Mainstream Renewables)
- The proposed wind and solar facility on Farm Lombaardskraal, Farm 330, Beaufort West (EAP – Savannah Environmental Consultants)

Additionally, there are several solar energy facilities authorised in the greater area:

- 300MW PV solar energy facility on the Farm Streenrotsfontein near Beaufort West, Western Cape (Applicant - BioTherm Energy)
- Beaufort West Solar Power Plant Sites 2 and 3, Western Cape Province (EAP – CSIR)

- Beaufort West Photovoltaic Park on Portion 9 of the Farm 161 Kuilspoort in Western Cape Province (Applicant - EAB Astrum Energy)
- 10MW Roma Energy Leeu Gamka Solar Plant On Portion 40 Of The Farm Kruidfontein No 33, Western Cape Province (Applicant - Roma Energy Leeu Gamka)
- The Leeu Gamka Solar Power Plant, Near Beaufort West And Leeu Gamka, Beaufort West Local Municipality, Western Cape Province (Applicant - Through Fare General Trading)

Although solar power installations do not typically contribute directly to bat mortalities, they do result in habitat destruction that may interrupt foraging behaviours.

Currently, there are no guidelines or recommendations of how to mitigate for the cumulative impact of wind farms within a greater area. This amendment assessment assumes all neighbouring facilities will implement appropriate mitigation measures informed by their preconstruction EIA studies, and that the mitigation measures proposed in this report are adhered to.

5. CONCLUSION

After review of relevant scientific literature and the long-term preconstruction monitoring report, the requested amendments to the turbine dimensions proposed for the Beaufort West wind energy facility would continue to have an overall negative impact to bats as identified during the bat monitoring study conducted in 2016 (Animalia 2016). The mortality risk may be decreased for the lower flying species detected on site as the lower blade tip height increases with larger turbine dimensions. However, there is a higher risk of mortality for high flying species (that is also the most abundant species on site) as the rotor swept area and higher blade tip height are increased with larger turbine dimensions. To account for this higher risk, added mitigation measures are recommended together with the original mitigation measures of the final bat monitoring study (section 4.2.3 of this report).

The overall negative impact for direct blade impact or barotrauma during foraging activities was identified as very high negative (score of -76) without mitigation, and reduced to low negative (score of -26) with mitigations (Animalia, 2016). These impact scores will stay the same if all sensitivity and buffer zones are avoided (Section 4.2.2) and if all mitigation measures are applied as described in Section 4.2.3:

To reduce bat mortality risk, a three-pronged consideration must be used when selecting the appropriate turbine technology for the wind farm:

- Turbine dimensions with a greater hub height (to increase lower blade tip height and reduce collision risk with lower flying species)
- Turbine dimensions with the smallest rotor diameter (to decreased total tip height and reduce collision risk with high flying species)
- Least number of turbines required to generate the total megawatt output of the facility

An operational monitoring study must be implemented immediately upon construction of the wind farm and already be in place when turbines are starting to operate. All applicable mitigation measures should be incorporated in the EMPr and mitigation measures recommended by the Bat Specialist during the operational monitoring study must be implemented immediately and in real time.

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Appendix C3

NOISE IMPACT ASSESEMENT

South Africa Mainstream Renewable Power Developments (Pty) Ltd

ENVIRONMENTAL NOISE IMPACT ASSESSMENT

for the

Proposed Beaufort West Wind Energy Facility South of Beaufort West, Western Cape Province

Study done for:

MAINSTREAM RENEWABLE POWER

Prepared by:

EAR Enviro Acoustic Research

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EXECUTIVE SUMMARY

INTRODUCTION AND PURPOSE

This report is an Environmental Noise Impact Assessment of the predicted noise environment due to the development of the proposed Beaufort West WEF south of Beaufort West, Western Cape Province. The report considers the ambient sound levels previously measured in similar areas, the author's expertise, as well as a output of sound propagation model (making use of the worst-case scenario in terms of the precautionary approach) to identify potential issues of concern.

PROJECT DESCRIPTION

Mainstream has received authorisation to develop the Beaufort West WEF and associated infrastructure. An amendment to the turbine specifications is being proposed and therefore it is proposed that project would comprise of the following:

- Up to 70 wind turbines;
- Each turbine will have a hub height of between up to 200 m and a rotor diameter of up to 200m (changed from 150m hub height and rotor diameter, this forms part of the proposed amendment process);
- One or more substations;
- A number of internal access roads;
- Upgrading existing access roads;
- Administration and warehouse buildings; and
- A temporary contractor's camp.

BASELINE ASSESSMENT

Ambient (background) noise levels were previously measured in the vicinity of the area for a number of renewable wind projects. This data was plotted against wind speeds, with the data analysed with the best curve fitted through this data. This data would be relevant to this area, as the project focus area have a similar developmental status.

These measurements illustrate the rural character of the area during periods with light or no winds, with mainly natural sounds defining the acoustic character. The area would be considered a **Rural Noise District** in terms of the SANS 10103:2008 Rating Level. The data also clearly indicate that the ambient sound levels will increase as wind speeds increase.

NOISE IMPACT DETERMINATION AND FINDINGS

The potential noise impact of operational activities is of a low significance on surrounding receptors staying in the area. The addition of the Trakas WEF will cumulatively increase the ambient sound levels in the area but the significance of the cumulative noise impact will be **low**. The Rietpoort Game Reserve area will be well outside the acoustic zone of influence from the wind turbines and noise impact will be insignificant.

The potential noise impact must again be evaluated should the layout be changed where any wind turbines are located closer than 1,000 m from a confirmed NSD (where the structure is used for residential purposes) or if the developer decides to use a different wind turbine that has a sound power emission level higher than the Acciona WTG used in this report (sound power emission level exceeding 113 dBA re 1 pW).

NEED AND DESIRABILITY OF PROJECT

The proposed renewable power generation activities (worst-case evaluated) will raise the ambient sound levels at the closest identified structures. Subject that the structures identified at NSD 01 and 05 are not used for residential purposes, the sound levels are not expected to be disturbing.

The project however, will greatly assist in the provision of energy, which will allow further economic growth and development in South Africa and locally. The project will generate short and long-term employment and other business opportunities and promote renewable energy in South Africa and locally. People in the area that are not directly affected by increased noises will have a positive perception of the project and will see the need and desirability of the project.

With its promise for environmental and economic advantages, wind power generation has 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, 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 aerodynamic 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 undue annoyance or otherwise interfere with the quality of life of the receptors.

MANAGEMENT AND MITIGATION OF NOISE IMPACT

The significance of noise during the operational phase is low and additional mitigation measures are not required.

It should be noted that the noise impact is based on sound power emission levels of the Acciona AW125 3000 wind turbine (sound power emission level of 108.4 dBA re 1 pW at 7 m/s) for the Beaufort West WEF. If the developer selects to use a different wind turbine with a significantly higher sound power emission level, the significance of the noise impact may rise and the noise impact should be re-evaluated.

RECOMMENDATIONS AND CONCLUSIONS

The addition of the Trakas WEF will cumulatively increase the ambient sound levels in the area but the significance of the cumulative noise impact will be **low**. The mitigation identified and proposed will ensure that the cumulative impacts remain low.

The potential noise impact must again be evaluated should the layout be changed where any wind turbines are located closer than 1,000 m from a confirmed NSD or if the developer decides to use a different wind turbine that has a sound power emission level higher than the Acciona WTG used in this report (sound power emission level exceeding 113 dBA re 1 pW).

The potential noise impact of operational activities is of a low significance on surrounding receptors staying in the area. The addition of the Trakas WEF will cumulatively increase the ambient sound levels in the area but the significance of the cumulative noise impact will be **low**.

Considering the requirements of a Part 2 Amendment, the following can be concluded:

- The proposed change in turbine specifications will not result in a noise impact that is significantly different from the potential noise impact from the authorized wind turbine specifications;
- The proposed change in turbine specifications will not introduce any new advantages or disadvantages in terms of acoustics;
- This noise impact assessment provides clear and more specific mitigation measures to ensure that the projected noise impact will be managed to a low level

at all the identified structures that may be used for residential purposes. This assessment did consider the worst-case scenario.

Considering the **low** significance of the noise impacts (after mitigation, inclusive of cumulative impacts), it is the opinion of the author that the proposed amendment to the hub height and rotor diameter (from 150m to 200m) of the Beaufort West WEF be authorised.

CONTENTS OF THE SPECIALIST REPORT – CHECKLISTS

Contents of this report in terms of Regulation GNR 982 of 2014, Appendix 6	Cross-reference in this report
(a) details of— the specialist who prepared the report; and the expertise of that specialist to compile a specialist report including a curriculum vitae;	**Section 1**
(b) a declaration that the specialist is independent in a form as may be specified by the competent authority;	**Section 2** *(also separate document to this report)*
(c) an indication of the scope of, and the purpose for which, the report was prepared;	**Section 3.1**
(d) the date and season of the site investigation and the relevance of the season to the outcome of the assessment;	**Section 5**
(e) a description of the methodology adopted in preparing the report or carrying out the specialised process;	**Section 3.6**
(f) the specific identified sensitivity of the site related to the activity and its associated structures and infrastructure;	**Sections 3.3**, **3.4** and **5**
(g) an identification of any areas to be avoided, including buffers;	Not relevant and required.
(h) a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Buffers not required.
(i) a description of any assumptions made and any uncertainties or gaps in knowledge;	**Section 9**
(j) a description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives on the environment;	**Sections 10** and **11**
(k) any mitigation measures for inclusion in the EMPr;	**Sections 12.2.1**
(l) any conditions for inclusion in the environmental authorisation;	**Sections 12.2.2**
(m) any monitoring requirements for inclusion in the EMPr or environmental authorisation;	**Section 14.1**
(n) a reasoned opinion— i. as to whether the proposed activity or portions thereof should be authorised; and ii. if the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr or Environmental Authorization, and where applicable, the closure plan;	i. **Section 15** ii. **Sections 12.2.1** and **Sections 12.2.2**
(o) a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	No comments received (**Section 3.5**)
(p) any other information requested by the competent authority	Nothing requested

Contents of this report in terms of Regulation GNR 982 of 2014, Appendix 3 - Environmental Impact Assessment Process	**Cross-reference in this report**
Describe any policies or legislation relevant to your field that the applicant will need to comply with.	**Sections 4.2**
Comment on need/desirability of the proposal in terms your field and in terms of the proposal's location.	**Section 11.4**
Determine the-- (i) nature, significance, consequence, extent, duration and probability of the impacts occurring to inform identified preferred alternatives; and (ii) degree to which these impacts- (aa) can be reversed; (bb) may cause irreplaceable loss of resources, and (cc) can be avoided, managed or mitigated;	**Sections 7, 8, 10** and **11**
Determine what the most ideal location within the site for the activity is in terms of your field.	**Section 11.4**
Identify suitable measures to avoid, manage or mitigate identified impacts.	(i) **planning, design and pre-construction**; Review report, slight change to wind turbine specifications (iii) **construction**; Review report, slight change to wind turbine specifications (iv) **operation;** Section 11.1 and 12.1 (v) **decommissioning, closure & rehabilitation**. Section 11.2
Identify residual risks that need to be managed and monitored.	There will be no residual risks after closure.
Include a concluding statement indicating a preferred alternative in terms of your field.	No alternative available.

This report should be sited as:

De Jager, M. (2019): "*Environmental Noise Impact Assessment for the Proposed Beaufort West Wind Energy Facility South of Beaufort West, Western Cape Province*". Enviro-Acoustic Research CC, Pretoria

Client:

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SSAMRP-BWWEF/ENIA/201907-Rev 0

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Date:

July 2019

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GLOSSARY OF ABBREVIATIONS

ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
EARES	Enviro Acoustic Research cc
ECA	Environment Conservation Act
EIA	Environmental Impact Assessment
ENIA	Environmental Noise Impact Assessment

ENM	Environmental Noise Monitoring
ENPAT	Environmental Potential Atlas for South Africa
EPs	Equator Principles
EPFIs	Equator Principles Financial Institutions
FEL	Front-end Loader
GN	Government Notice
IEC	International Electrotechnical Commission
IFC	International Finance Corporation
ISO	International Organization for Standardization
LFN	Low Frequency Noise
METI	Ministry of Economy, Trade, and Industry
NASA	National Aeronautical and Space Administration
NCR	Noise Control Regulations
NSD	Noise-sensitive Development
PWL	Sound Power Level
SABS	South African Bureau of Standards
SANS	South African National Standards
SPL	Sound Power Level
TOR	Terms of Reference
UTM	Universal Transverse Mercator
WEF	Wind Energy Facility
WHO	World Health Organization
WTG	Wind Turbine Generator

GLOSSARY OF UNITS

dB	Decibel (expression of the relative loudness of the un-weighted sound level in air)
dBA	Decibel (expression of the relative loudness of the A-weighted sound level in air)
Hz	Hertz (measurement of frequency)
kg/m^2	Surface density (measurement of surface density)
km	kilometre (measurement of distance)
m	Meter (measurement of distance)
m^2	Square meter (measurement of area)
m^3	Cubic meter (measurement of volume)
mamsl	Meters above mean sea level

m/s	Meter per second (measurement for velocity)
°C	Degrees Celsius (measurement of temperature)
µPa	Micro pascal (measurement of pressure – in air in this document)

1 THE AUTHOR

The Author started his career in the mining industry as a bursar Learner Official (JCI, Randfontein), working in the mining industry, doing various mining-related courses (Mining [stoping and development], Rock Mechanics, Surveying, Sampling, Safety and Health [Ventilation, noise, illumination etc.] and Metallurgy. He did work in both underground (Coal, Gold and Platinum) as well as opencast (Coal) for 4 years, the last two during which he studied Mining Engineering. He used to be a holder of a temporary blasting certificate during the period he mined at JCI: Cook 2 shaft. He changed course from Mining Engineering to Chemical Engineering after the second year of his studies at the University of Pretoria.

After graduation he worked as a Water Pollution Control Officer at the Department of Water Affairs and Forestry for two years (first year seconded from the Consulting Engineering firm Wates, Meiring and Barnard), where duties included the perusal (evaluation, commenting and recommendation) of various regulatory required documents (such as EMPR's, Water Licence Applications and EIA's), auditing of licence conditions as well as the compilation of Technical Documents.

Since leaving the Department of Water Affairs, Morné has been in private consulting for the last 20 years, managing various projects for the mining and industrial sector, private developers, business, other environmental consulting firms as well as the Department of Water Affairs. During that period he has been involved in various projects, either as specialist, consultant, trainer or project manager, successfully completing a number of these projects. During that period he gradually moved towards environmental acoustics, focusing on this field exclusively since 2007.

He has been interested in acoustics as from school days, doing projects mainly related to loudspeaker design. Interest in the matter brought him into the field of Environmental Noise Measurement, Prediction and Control as well as blasting impacts.

Since 2007 he has completed more than 300 Environmental Noise Impact Assessments and Noise Monitoring Reports as well as various acoustic consulting services, including amongst others:

Wind Energy Facilities	*Full Environmental Noise Impact Assessments for - Bannf (Vidigenix), iNCa Gouda (Aurecon SA), Isivunguvungu (Aurecon), De Aar (Aurecon), Kokerboom 1 (Aurecon), Kokerboom 2 (Aurecon), Kokerboom 3 (Aurecon), Kangnas (Aurecon), Plateau East*

	and West (Aurecon), Wolf (Aurecon), Outeniqwa (Aurecon), Umsinde Emoyeni (ARCUS) , Komsberg (ARCUS), Karee (ARCUS), Kolkies (ARCUS), San Kraal (ARCUS), Phezukomoya (ARCUS), Canyon Springs (Canyon Springs), Perdekraal (ERM), Scarlet Ibis (CESNET), Albany (CESNET), Sutherland (CSIR), Kap Vley (CSIR), Kuruman (CSIR), Rietrug (CSIR), Sutherland 2 (CSIR), Perdekraal (ERM), Teekloof (Mainstream), Eskom Aberdene (SE), Dorper (SE), Spreeukloof (SE), Loperberg (SE), Penhoek Pass (SE), Amakhala Emoyeni (SE), Zen (Savannah Environmental – SE), Goereesoe (SE), Springfontein (SE), Garob (SE), Project Blue (SE), ESKOM Kleinzee (SE), Namas (SE), Zonnequa (SE), Walker Bay (SE), Oyster Bay (SE), Hidden Valley (SE), Deep River (SE), Tsitsikamma (SE), AB (SE), West Coast One (SE), Hopefield II (SE), Namakwa Sands (SE), VentuSA Gouda (SE), Dorper (SE), Klipheuwel (SE), INCA Swellendam (SE), Cookhouse (SE), Iziduli (SE), Msenge (SE), Cookhouse II (SE), Rheboksfontein (SE), Suurplaat (SE), Karoo Renewables (SE), Koningaas (SE), Spitskop (SE), Castle (SE), Khai Ma (SE), Poortjies (SE), Korana (SE), IE Moorreesburg (SE), Gunstfontein (SE), Boulders (SE), Vredenburg (Terramanzi), Loeriesfontein (SiVEST), Rhenosterberg (SiVEST), Noupoort (SiVEST), Prieska (SiVEST), Dwarsrug (SiVEST), Graskoppies (SiVEST), Philco (SiVEST), Hartebeest Leegte (SiVEST), Ithemba (SiVEST), !Xha Boom (SiVEST), Spitskop West (Terramanzi), Haga Haga (Terramanzi), Vredenburg (Terramanzi), Msenge Emoyeni (Windlab)
Mining and Industry	*Full Environmental Noise Impact Assessments for – Delft Sand (AGES), BECSA – Middelburg (Golder Associates), Kromkrans Colliery (Geovicon Environmental), SASOL Borrow Pits Project (JMA Consulting), Lesego Platinum (AGES), Tweefontein Colliery (Cleanstream Environmental), Evraz Vametco Mine and Plant (JMA), Goedehoop Colliery (Geovicon), Hacra Project (Prescali Environmental), Der Brochen Platinum Project (J9 Environment), Brandbach Sand (AGES), Verkeerdepan Extension (CleanStream Environmental), Dwaalboom Limestone (AGES), Jagdlust Chrome (MENCO), WPB Coal (MENCO), Landau Expansion (CleanStream Environmental), Otjikoto Gold (AurexGold), Klipfontein Colliery (MENCO), Imbabala Coal (MENCO), ATCOM East Expansion (Jones and Wagner), IPP Waterberg Power Station (SE), Kangra Coal (ERM), Schoongesicht (CleanStream Environmental), EastPlats (CleanStream Environmental), Chapudi Coal (Jacana Environmental), Generaal Coal (JE), Mopane Coal (JE), Glencore Boshoek Chrome (JMA), Langpan Chrome (PE), Vlakpoort Chrome (PE), Sekoko Coal (SE), Frankford Power (REMIG), Strahrae Coal (Ferret Mining), Transalloys Power Station (Savannah), Pan Palladum Smelter, Iron and PGM Complex (Prescali Environmental), Fumani Gold (AGES), Leiden Coal (EIMS), Colenso Coal and Power Station (SiVEST/EcoPartners), Klippoortjie Coal (Gudani), Rietspruit Crushers (MENCO), Assen Iron (Tshikovha), Transalloys (SE), ESKOM Ankerlig (SE), Nooitgedacht Titano Project (EcoPartners), Algoa Oil Well (EIMS), Spitskop Chrome (EMAssistance), Vlakfontein South (Gudani), Leandra Coal (Jacana), Grazvalley and Zoetveld (Prescali), Tjate Chrome (Prescali), Langpan Chromite (Prescali), Vereeniging Recycling (Pro Roof), Meyerton Recycling (Pro Roof), Hammanskraal Billeting Plant 1 and 2 (Unica), Development of Altona Furnace, Limpopo Province (Prescali Environmental), Haakdoorndrift Opencast at Amandelbult Platinum (Aurecon), Landau Dragline relocation (Aurecon), Stuart Coal Opencast (CleanStream Environmental), Tetra4 Gas Field Development (EIMS), Kao Diamonds – Tiping Village Relocation (EIMS), Kao Diamonds – West Valley Tailings Deposit (EIMS), Upington Special Economic Zone (EOH), Arcellor Mittal CCGT Project near Saldanha (ERM), Malawi Sugar Mill Project (ERM), Proposed Mooifontein Colliery (Geovicon Environmental), Goedehoop North Residue Deposit Expansion (Geovicon Environmental), Mutsho 600MW Coal-Fired Power Plant (Jacana Environmentals), Tshivhaso Coal-Fired Power Plant (Savannah Environmental), Doornhoek Fluorspar Project (Exigo), Royal Sheba Project (Cabanga Environmental), Rietkol Silica (Jacana), Gruisfontein Colliery (Jacana), Lehlabili Colliery (Jaco-K Consulting), Bloemendal Colliery (Enviro-Insight), Rondevly Colliery (REC), Welgedacht Colliery (REC), Kalabasfontein Extension (EIMS)*
Road and Railway	*K220 Road Extension (Urbansmart), Boskop Road (MTO), Sekoko Mining (AGES), Davel-Swaziland-Richards Bay Rail Link (Aurecon), Moloto Transport Corridor Status Quo Report and Pre-Feasibility (SiVEST), Postmasburg Housing Development (SE), Tshwane Rapid Transport Project, Phase 1 and 2 (NRM Consulting/City of Tshwane), Transnet Apies-river Bridge Upgrade (Transnet), Gautrain Due-diligence (SiVest), N2 Piet Retief (SANRAL), Atterbury Extension, CoT (Bokomoso Environmental), Riverfarm*

	Development (Terramanzi)
Airport	*Oudtshoorn Noise Monitoring (AGES), Sandton Heliport (Alpine Aviation), Tete Airport Scoping (Aurecon)*
Noise monitoring and Audit Reports	*Peerboom Colliery (EcoPartners), Thabametsi (Digby Wells), Doxa Deo (Doxa Deo), Harties Dredging (Rand Water), Xstrata Coal – Witbank Regional (Xstrata), Sephaku Delmas (AGES), Amakhala Emoyeni WEF (Windlab Developments), Oyster Bay WEF (Renewable Energy Systems), Tsitsikamma WEF Ambient Sound Level study (Cennergi and SE), Hopefield WEF (Umoya), Wesley WEF (Innowind), Ncora WEF (Innowind), Boschmanspoort (Jones and Wagner), Nqamakwe WEF (Innowind), Hopefield WEF Noise Analysis (Umoya), Dassiesfontein WEF Noise Analysis (BioTherm), Transnet Noise Analysis (Aurecon), Jeffries Bay Wind Farm (Globeleq), Sephaku Aganang (Exigo), Sephaku Delmas (Exigo), Beira Audit (BP/GPT), Nacala Audit (BP/GPT), NATREF (Nemai), Rappa Resources (Rayten), Measurement Report for Sephaku Delmas (Ages), Measurement Report for Sephaku Aganang (Ages), Bank of Botswana measurements (Linnspace), Skukuza Noise Measurements (Concor), Development noise measurement protocol for Mamba Cement (Exigo), Measurement Report for Mamba Cement (Exigo), Measurement Report for Nokeng Fluorspar (Exigo), Tsitsikamma Community Wind Farm Pre-operation sound measurements (Cennergi), Waainek WEF Operational Noise Measurements (Innowind), Sedibeng Brewery Noise Measurements (MENCO), Tsitsikamma Community Wind Farm Operational noise measurements (Cennergi), Noupoort Wind Farm Operational noise measurements (Mainstream), Twisdraai Colliery (Lefatshe Minerals), SASOL Prospecting (Lefatshe Minerals)*
Small Noise Impact Assessments	*TCTA AMD Project Baseline (AECOM), NATREF (Nemai Consulting), Christian Life Church (UrbanSmart), Kosmosdale (UrbanSmart), Louwlardia K220 (UrbanSmart), Richards Bay Port Expansion (AECOM), Babalegi Steel Recycling (AGES), Safika Slag Milling Plant (AGES), Arcelor Mittal WEF (Aurecon), RVM Hydroplant (Aurecon), Grootvlei PS Oil Storage (SiVEST), Rhenosterberg WEF, (SiVEST), Concerto Estate (BPTrust), Ekuseni Youth Centre (MENCO), Kranskop Industrial Park (Cape South Developments), Pretoria Central Mosque (Noman Shaikh), Soshanguve Development (Maluleke Investments), Seshego-D Waste Disposal (Enviroxcellence), Zambesi Safari Equipment (Owner), Noise Annoyance Assessment due to the Operation of the Gautrain (Thornhill and Lakeside Residential Estate), Upington Solar (SE), Ilangalethu Solar (SE), Pofadder Solar (SE), Flagging Trees WEF (SE), Uyekraal WEF (SE), Ruuki Power Station (SE), Richards Bay Port Expansion 2 (AECOM), Babalegi Steel Recycling (AGES), Safika Ladium (AGES), Safika Cement Isando (AGES), RareCo (SE), Struisbaai WEF (SE), Perdekraal WEF (ERM), Kotula Tsatsi Energy (SE), Olievenhoutbosch Township (Nali), , HDMS Project (AECOM), Quarry extensions near Ermelo (Rietspruit Crushers), Proposed uMzimkhulu Landfill in KZN (nZingwe Consultancy), Linksfield Residential Development (Bokomoso Environmental), Rooihuiskraal Ext. Residential Development, CoT (Plandev Town Planners), Floating Power Plant and LNG Import Facility, Richards Bay (ERM), Floating Power Plant project, Saldanha (ERM), Vopak Growth 4 project (ERM), Elandspoort Ext 3 Residential Development (Gibb Engineering), Tiegerpoort Wedding Venue (Henwood Environmental)*
Project reviews and amendment reports	*Loperberg (Savannah), Dorper (Savannah), Penhoek Pass (Savannah), Oyster Bay (RES), Tsitsikamma Community Wind Farm Noise Simulation project (Cennergi), Amakhala Emoyeni (Windlab), Spreeukloof (Savannah), Spinning Head (SE), Kangra Coal (ERM), West Coast One (Moyeng Energy), Rheboksfontein (Moyeng Energy), De Aar WEF (Holland), Quarterly Measurement Reports – Dangote Delmas (Exigo), Quarterly Measurement Reports – Dangote Lichtenburg (Exigo), Quarterly Measurement Reports – Mamba Cement (Exigo), Quarterly Measurement Reports – Dangote Delmas (Exigo) Quarterly Measurement Reports – Nokeng Fluorspar (Exigo), Proton Energy Limited Nigeria (ERM), Hartebeest WEF Update (Moorreesburg) (Savannah Environmental), Modderfontein WEF Opinion (Terramanzi), IPD Vredenburg WEF (IPD Power Vredenburg), etc.*

2 DECLARATION OF INDEPENDENCE

I, Morné de Jager declare that:

- I act as the independent environmental practitioner in this application
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting environmental impact assessments, including knowledge of the National Environmental Management Act (107 of 1998), the Environmental Impact Assessment Regulations of 2010, and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, regulations and all other applicable legislation;
- I will take into account, to the extent possible, the matters listed in regulation 8 of the regulations when preparing the application and any report relating to the application;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- I will ensure that information containing all relevant facts in respect of the application is distributed or made available to interested and affected parties and the public and that participation by interested and affected parties is facilitated in such a manner that all interested and affected parties will be provided with a reasonable opportunity to participate and to provide comments on documents that are produced to support the application;
- I will ensure that the comments of all interested and affected parties are considered and recorded in reports that are submitted to the competent authority in respect of the application, provided that comments that are made by interested and affected parties in respect of a final report that will be submitted to the competent authority may be attached to the report without further amendment to the report;
- I will keep a register of all interested and affected parties that participated in a public participation process; and
- I will provide the competent authority with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not
- all the particulars furnished by me in this form are true and correct;
- will perform all other obligations as expected from an environmental assessment practitioner in terms of the Regulations; and
- I realise that a false declaration is an offence in terms of regulation 71 and is punishable in terms of section 24F of the Act.

Disclosure of Vested Interest

- I do not have and will not have any vested interest (either business, financial, personal or other) in the proposed activity proceeding other than remuneration for work performed in terms of the Environmental Impact Assessment Regulations, 2010.

____
Signature of the environmental practitioner:

Enviro-Acoustic Research cc
Name of company:

____
Date:

3 INTRODUCTION

3.1 INTRODUCTION AND PURPOSE

South Africa Mainstream Renewable Power Developments (Pty) Ltd (hereafter referred to as Mainstream) was issued with an Environmental Authorisation (EA) for the proposed development of a Wind and Photovoltaic (PV) Energy Facility, near Beaufort West in the Western Cape Province on 20 March 2012 (DEA Reference 12/12/20/1784). An Amendment of the EA was issued on 23 March 2015 (DEA Reference 12/12/20/1784/AM1). Thereafter an Amendment to extent the validity period of the EA was issued on 25 January 2017 (DEA Reference 12/12/20/1784/AM5).

Following a Part 2 Amendment process, Mainstream was issued with an Environmental Authorisation (EA) on 13 February 2017 for a 140MW wind farm (DEA Reference 12/12/20/1784/1). The EA dated 13 February 2017 replaced the original EA and all subsequent amendments. The amendment process and associated specialist studies considered the impacts of turbines with hub heights of 150m and with rotor diameters of 150m. The amendment being applied for is to increase the assessed and authorised turbine dimensions to have hub heights of up to 200m and rotor diameters of up to 200m.

Enviro-Acoustic Research CC was contracted by SiVEST SA (Pty) Ltd (on behalf of Mainstream) to conduct an Environmental Noise Impact Assessment (ENIA) to determine the potential noise impact on the surrounding environment due to the proposed changes in the wind turbine specifications.

This report briefly describes potential ambient sound levels in the area, potential worst-case noise rating levels and the potential noise impact that the facility, may have on the surrounding sound environment, highlighting the methods used, potential issues identified, findings and recommendations. This report did not investigate vibrations and only briefly considers blasting.

This study considered local regulations and both local and international guidelines, using the terms of reference (ToR) as proposed by SANS 10328:2008 to allow for a comprehensive Noise Report.

3.2 BRIEF PROJECT DESCRIPTION

Mainstream received an EA to develop the Beaufort West WEF and associated infrastructure approximately 63 km south of the town of Beaufort West in the Western Cape Province (refer to **Figure 3-1**).

The wind energy market is fast changing and adapting to new technologies as well as site specific constraints. Optimizing the technical specifications can add value through, for example, minimizing environmental impact and maximizing energy yield. As such the developer has been evaluating several turbine models, however the selection will only be finalized at a later stage once the most optimal wind turbine are identified (factors such as meteorological data, price and financing options, guarantees and maintenance costs, etc. must be considered).

Because of the availability of more optimal or efficient wind turbines, the Mainstream is considering changing the wind turbine specifications. As the specifications of the final selection are not yet defined, this review will evaluate a potential worst-case scenario, considering a wind turbine with a sound power emission level of 108.4 dBA. To ensure that the selected model is in line with the worst-case scenario and to ensure compliance to the EA, Mainstream wishes to apply for an amendment to the EA for an authorised hub height and rotor diameter of 200 m each.

Other infrastructure associated with the proposed WEF may include:

- A contractor's camp;
- A laydown area next to the locations of the proposed wind turbines;
- Foundations to support the wind turbines;
- Cabling between the turbines, to be laid underground where practical, which will connect to one or more on-site substations;
- Existing roads will be used as far as possible. However, where required, internal access roads will be constructed between the turbines; and
- Site offices and a workshop area for maintenance and storage purposes.

3.3 STUDY AREA

The proposed WEF will be located in the Central Karoo District Municipality, approximately 63 km south from Beaufort West. The study area is further described in terms of environmental components that may contribute to or change the sound character in the area.

3.3.1 Topography

The area is described as "extremely irregular plains" by the Environmental Potential Atlas for South Africa (ENPAT[1]). Due to the height of the wind turbines, as well as the position where they may developed (on top of the hills and ridges) it is unlikely that topographical features will limit the propagation of sound from the wind turbines.

3.3.2 Roads and rail roads

The N12 national road transects project area. While traffic volumes may be high at times during the day, this road carries little traffic at night. While night-time traffic may change the ambient sound levels at times, this will not be considered.

3.3.3 Land use

Land use is mostly wilderness (including eco-tourism) with some agricultural activities (game and sheep farming). Existing land use activities are not expected to impact on the ambient sound levels.

3.3.4 Residential areas

Excluding potentially noise-sensitive developments identified in **Section 3.3.7**, there are no formal residential areas, communities or towns close to the facility.

3.3.5 Other industrial and commercial processes

There are no other noise sources of significant importance in the area.

3.3.6 Ground conditions and vegetation

Most of the area falls within the Nama Karoo biome with the vegetation typical of the Karroid Broken Veld. Considering a worse-case scenario, 50% hard ground conditions were used for modelling purposes due to the more sparse vegetation associated with the karoo vegetation. It should be noted that this factor is only relevant for air-borne waves being reflected from the ground surface, with certain frequencies slightly absorbed by the vegetation.

3.3.7 Existing Ambient Sound Levels

The area has a rural developmental character, with night-time sound levels typical of a rural area. With this being a desktop assessment, the site was not visited and will consider ambient sound level measurements collected in similar, quiet rural areas. This constitutes

[1] Van Riet, W. Claassen, P. van Rensburg, J. van Viegen & L. du Plessis, "*Environmental Potential Atlas for South Africa"*, Pretoria, 1998.

more than 30,000 10-minute measurements, divided into day- and night-time periods. This is discussed in more detail in **Section 5**.

3.4 POTENTIAL NOISE-SENSITIVE RECEPTORS (DEVELOPMENTS) AND NO-GO AREAS

Potentially sensitive receptors, also known as noise-sensitive developments (NSDs), located within or close to the WEF were identified using Google Earth® (green dots, see **Figure 3-2**). NSDs 01 and 05 were included in this assessment, even though the land owner confirmed that these structures are old goat sheds mainly used for shade.

3.5 COMMENTS REGARDS TO NOISE RECEIVED DURING THIS PROJECT

A comment was observed in the "Addendum to the Environmental Noise Impact Study into the Propose Amendments to the Establishment of a Wind Farm at Beaufort West in the Western Cape" (2015, Jongens).

A query was received from the owner of the Rietpoort Game Reserve, located to the west of the closest wind turbines (just further than 2,000m) of the Beaufort West WEF. The owner was concerned about the potential impact of noise from the WEF on his clients and his game.

This addendum specifically focused in the potential noise impact on the Rietpoort Game Reserve. This addendum determined that the noise impact will be insignificant.

This will again be assessed in this study.

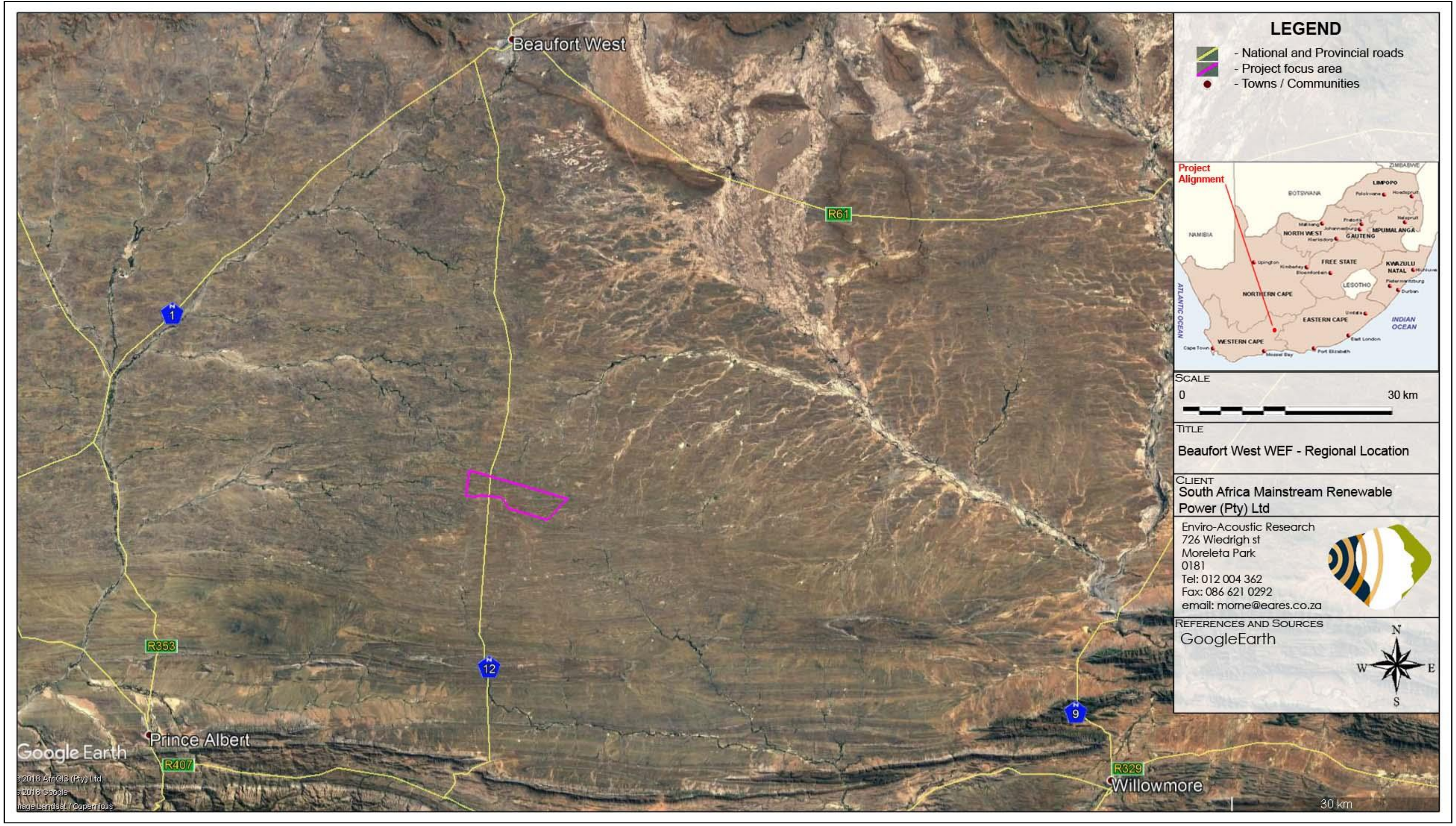

Figure 3-1: Locality map indicating project focus area involved in the Beaufort West WEF

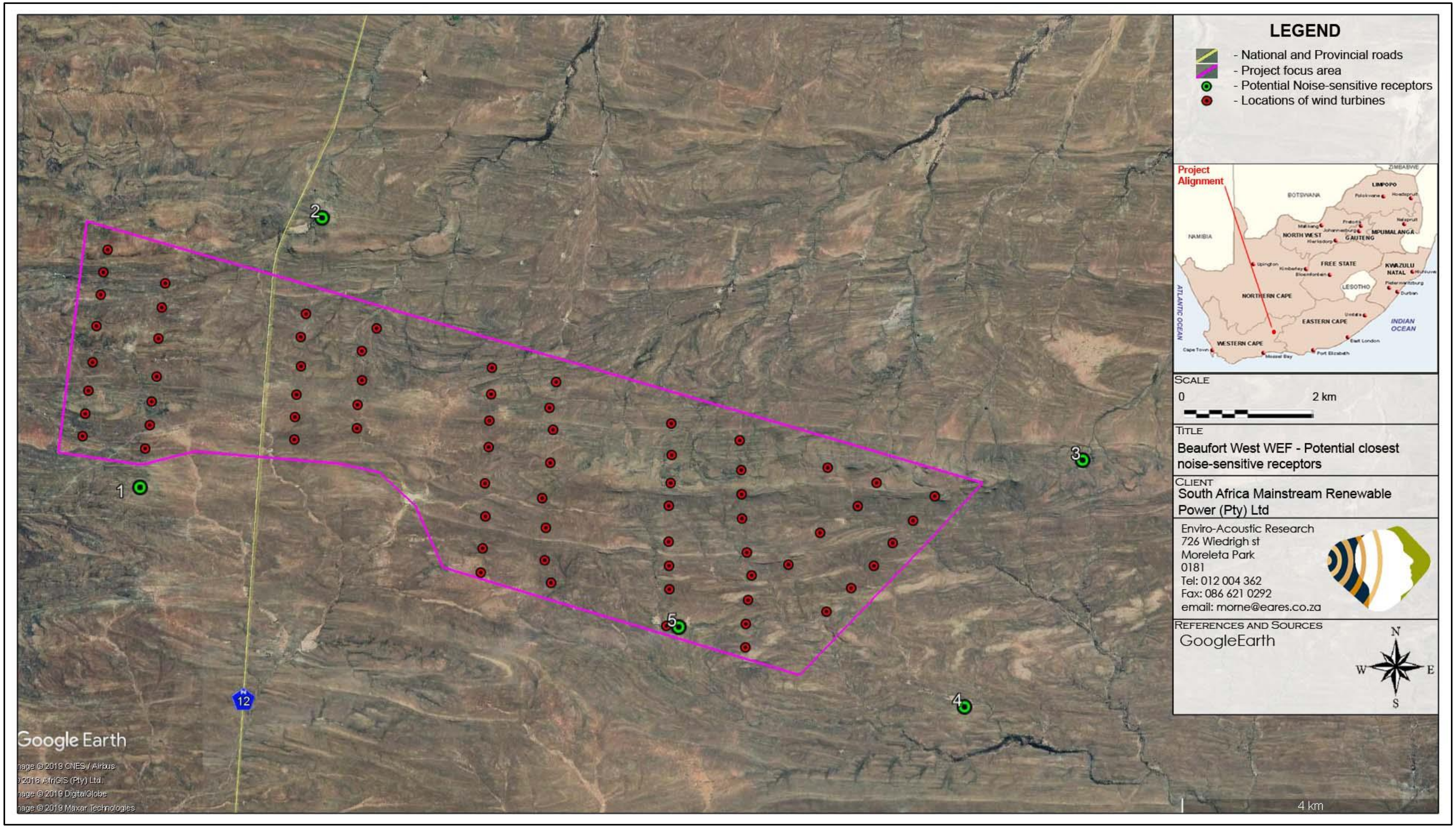

Figure 3-2: Aerial image indicating potentially noise-sensitive developments (green dots)

3.6 TERMS OF REFERENCE (TOR)

A noise impact assessment must be completed for the following reasons:

- It was identified as an environmental theme needing further investigation i.t.o. the National Screening Tool as per the procedures of Government Gazette 42451 of 10 May 2019 (draft);
- It may require a change in land use as highlighted in SANS 10328:2008, section 5.3;
- If a noise sensitive development is to be established within 1,000 m from an industry (SANS 10328:2008 [5.4 (g)]) *or visa versa* (SANS 10328:2008 [5.4 (h)]);
- If a wind farm (wind turbines - SANS 10328:2008 [5.4 (i)]) or a source of low-frequency noise (such as cooling or ventilation fans - SANS 10328:2008 [5.4 (l)]) is to be established within 2,000 m from a potential noise sensitive development *or visa versa*;
- It is a controlled activity in terms of the NEMA regulations and a ENIA is required, because:
    - It may cause a disturbing noise that is prohibited in terms of section 18(1) of the Government Notice 579 of 2010; and
- It is generally required by the local or district authority as part of the environmental authorization or planning approval in terms of Regulation 2(d) of GN R154 of 1992.

In addition, Appendix 6 of GN 982 of December 2014 (Gov. Gaz. 38282), issued in terms of the National Environmental Management Act, No. 107 of 1998 also defines minimum information requirements for specialist reports. As this application forms part of a Part 2 Amendment, the following issues must be investigated, assessed and discussed:

- The potential impacts relating to the proposed change in turbine specifications;
- The potential advantages or disadvantages of the proposed change in turbine specifications (a comparative assessment between the authorized (150 m hub height and rotor diameter) and the proposed specification;
- Identify additional or changes to the mitigation measures required to avoid, manage or mitigate the impacts associated with the proposed change in turbine specifications.

This will be covered in the Concluding remarks of this report (**section 15**).

In South Africa the document that addresses the issues specifically concerning environmental noise is SANS 10103:2008. It has recently been thoroughly revised and brought in line with the guidelines of the World Health Organisation (WHO). It provides the maximum average ambient noise levels during the day and night to which different types of developments indoors may be exposed.

In addition, SANS 10328:2008 (Edition 3) specifies the methodology to assess the potential noise impacts on the environment due to a proposed activity that might impact on the environment. This standard also stipulates the minimum requirements to be investigated for EIA purposes. These minimum requirements are:

a) the purpose of the investigation (see **section 3.1**);
b) a brief description of the planned development or the changes that are being considered (see **section 3.2**);
c) a brief description of the existing environment including, where relevant, the topography, surface conditions and meteorological conditions during measurements (see **section 3.3 and 5**);
d) 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 (see section **6** and **8**);
e) the identified noise sources that were not taken into account and the reasons as to why they were not investigated (see **section 3.2**, **9** and **10**);
f) the identified noise-sensitive developments and the noise impact on them (see **section 3.4**, **10** and **11**);
g) where applicable, any assumptions, with references, made with regard to any calculations or determination of source and propagation characteristics (see **section 9**);
h) 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 (see **section 5**, **6**, **8** and **9**);
i) 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 (see **section 5**, **9** and **10**);

j) the location of measuring or calculating points in a sketch or on a map (see **section 5** and **10**);
k) quantification of the noise impact with, where relevant, reference to the literature consulted and the assumptions made (see **section 10**);
l) alternatives that were considered and the results of those that were investigated (see **section 11.4**);
m) a list of all the interested or affected parties that offered any comments with respect to the environmental noise impact investigation (see **section 3.5**);
n) 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 (see **section 3.5**);
o) conclusions that were reached (see **section 15**);
p) proposed recommendations (see **section 15**);
q) 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 (see **sections 12** and **15**); and
r) 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 (see **section 15**).

4 LEGAL CONTEXT, POLICIES AND GUIDELINES

4.1 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 under the particular circumstances. The subjectivity of this approach can be problematic, which has led to the development of noise standards (see **Section 4.5**).

"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.

4.2 THE ENVIRONMENT CONSERVATION ACT (ACT 73 OF 1989)

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 4.2.1**.

4.2.1 Noise Control Regulations (GN R154 of 1992)

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. The Provincial regulations will be relevant for the Western Cape Province.

4.2.2 Western Cape Provincial Noise Control Regulations: PN 200 of 2013

The control of noise in the Western Cape is legislated in the form of the Noise Control Regulations in terms of Section 25 of the Environment Conservation Act No. 73 of 1989, applicable to the Province of the Western Cape as Provincial Notice 200 of 20 June 2013.

The regulations define:
"**ambient noise**" means the all-encompassing sound in a given situation at a given time, measured as the reading on an integrated impulse sound level meter for a total period of at least 10 minutes".

"**disturbing noise**" means a noise, excluding the unamplified human voice, which—
(a) exceeds the rating level by 7 dBA;
(b) exceeds the residual noise level where the residual noise level is higher than the rating level;
(c) exceeds the residual noise level by 3 dBA where the residual noise level is lower than the rating level; or
(d) in the case of a low-frequency noise, exceeds the level specified in Annex B of SANS 10103;

''noise sensitive activity'' means any activity that could be negatively impacted by noise, including residential, healthcare, educational or religious activities;

''low-frequency noise'' means sound which contains sound energy at frequencies predominantly below 100 Hz;

''rating level'' means the applicable outdoor equivalent continuous rating level indicated in Table 2 of SANS 10103;

''residual noise'' means the all-encompassing sound in a given situation at a given time, measured as the reading on an integrated impulse sound level meter for a total period of at least 10 minutes, excluding noise alleged to be causing a noise nuisance or disturbing noise;

"sound level'' means the equivalent continuous rating level as defined in SANS 10103, taking into account impulse, tone and night-time corrections;

These Regulations prohibits anyone from causing a disturbing noise (Clause 2) and uses the $L_{Aeq,impulse}$ descriptor to define ambient sound and noise levels.

Also, in terms of regulation 4:
(1) The local authority, or any other authority responsible for considering an application for a building plan approval, business license 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 subregulation (1) indicate that the applicable noise rating levels referred to in that subregulation will likely be exceeded, or will not be exceeded but will likely exceed the existing residual noise levels by 5 dBA 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 subregulation (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.

4.3 The National Environmental Management Act (Act 107 of 1998)

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; and
6. to remedy the effects of the pollution or degradation.

In addition, Appendix 6 of GN R 982 of 2014, issued in terms of this Act, has general requirements for EAPs and specialists. It also defines minimum information requirements for specialist reports. Draft procedures was published on 10 May 2019 in Government Gazette No 42451, highlighting proposed procedures to be followed for the assessment and minimum criteria for the reporting of identified environmental themes in terms of Section 24(5)(a) and (h) of this Act (when applying for Environmental Authorization).

4.4 National Environmental Management: Air Quality Act (Act 39 of 2004)

Section 34 of the National Environmental Management: Air Quality Act (Act 39 of2004) 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 has been promulgated, but no such standards have yet been issued. 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 terms of noise. This, however, is not relevant to the project as no atmospheric emissions will take place.

4.5 NOISE STANDARDS

There are a few South African scientific standards (SABS) relevant to noise from mines, industry and roads. 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';
- SANS 10181:2003. 'The Measurement of Noise Emitted by Road Vehicles when Stationary'; and
- SANS 10205:2003. 'The Measurement of Noise Emitted by Motor Vehicles in Motion'.

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. With regards to SANS 10103:2008, the recommendations are likely to inform decisions by authorities, but non-compliance with the standard will not necessarily render an activity unlawful *per se.*

4.6 INTERNATIONAL GUIDELINES

While a number of international guidelines and standards exist, those selected below are used by numerous countries for environmental noise management.

4.6.1 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_{AMax} noise descriptors to define noise levels. It should be noted that a follow-up document focusing on Night-time Noise Guidelines for Europe (WHO, 2009).

4.6.2 Night Noise Guidelines for Europe (WHO, 2009)

Refining previous Community Noise Guidelines issued in 1999, and incorporating more recent research, the World Health Organization has released a comprehensive report on the health effects of night time noise, along with new (non-mandatory) guidelines for use in Europe. Rather than a maximum of 30 dB inside at night (which equals 45-50 dB max outside), the WHO now recommends a maximum year-round outside night-time noise average of 40 db to avoid sleep disturbance and its related health effects. The report notes that only below 30 dB (outside annual average) are "*no significant biological effects observed*," and that between 30 and 40 dB, several effects are observed, with the chronically ill and children being more susceptible; however, "*even in the worst cases the effects seem modest*." Elsewhere, the report states more definitively, "*There is no sufficient evidence that the biological effects observed at the level below 40 dB (night, outside) are harmful to health*." At levels over 40 dB, "*Adverse health effects are observed*" and "*many people have to adapt their lives to cope with the noise at night. Vulnerable groups are more severely affected*."

The 184-page report offers a comprehensive overview of research into the various effects of noise on sleep quality and health (including the health effects of non-waking sleep arousal), and is recommended reading for anyone working with noise issues. The use of an outdoor noise standard is in part designed to acknowledge that people do prefer to leave windows open when sleeping, though the year-long average may be difficult to obtain (it would require longer-term sound monitoring than is usually budgeted for by either industry or neighbourhood groups).

While recommending the use of the average level, the report notes that some instantaneous effects occur in relation to specific maximum noise levels, but that the health effects of these "cannot be easily established."

4.6.3 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 [2] (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 are more appropriate
2. $L_{A90,10mins}$ is a much more accurate descriptor when monitoring ambient and turbine noise levels
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 NSD. Ambient noise levels is measured onsite in terms of the $L_{A90,10min}$ descriptor for a period sufficiently long enough for a set period
5. Wind farms should be limited to within the range of 35 dBA to 40 dBA (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 NSD has financial investments in the wind energy facility
6. A penalty system should be implemented for wind turbine/s that operates with a tonal characteristic

This is likely the guideline used in the most international countries to estimate the potential noise impact stemming from the operation of a Wind Energy Facility. It also recommends an improved methodology (compared to a fixed upper noise level) on

[2] 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 organizations in academia and industry. In 1996, ETSU became part of AEA Technology plc which was separated from the UKAEA by privatisation.

determining ambient sound levels in periods of higher wind speeds, critical for the development of a wind energy facility. Because of its international importance, the methodologies used in the ETSU R97 document will be considered.

The document uses the $L_{Aeq,f}$ and L_{A90} descriptors to define noise levels using the "Fast"-time weighting.

4.6.4 The UK Institute of Acoustics Good Practice Guide

The Good Practice Guide (GPG) was published by the UK Institute of Acoustics (IOA) in May 2013 and has been endorsed by the UK Government as current industry good practice. The guide presents current good practice in the assessment of wind turbine developments to the ETSU-R-97 methodology, at the various stages of the assessment process.

During the development of the GPG, a detailed study was undertaken of wind farm noise propagation and prediction methods used in a number of countries. The outcome of this research resulted in the GPG recommending a modified version of the ISO 9613-2[3] method in calculating the levels of wind turbine noise at receptor locations (immission levels).

The ISO 9613-2 method predicts noise levels at the receptor by taking the octave-band sound power level spectrum of the source, and applying a number of attenuation factors that determine the resulting sound pressure level. These factors are:

- Geometric divergence - the level of attenuation due to geometric divergence is based upon the distance from source to receptor.
- Atmospheric Absorption – frequencies are attenuated as it travels through the air, with higher frequencies being absorbed more readily. This does depend on the temperature and relative humidity of the air itself. The GPG recommends a temperature of 10°C and 70% relative humidity to represent a…"reasonably low level of air absorption".
- Directivity Factor - the directivity factor is used to account for a source which radiates sound in a non-uniform pattern (i.e. non-spherical). Wind turbine sound power levels are measured in a downwind direction, therefore providing worst-case predictions.

[3] ISO 9613-2:1996 Acoustics -- Attenuation of sound during propagation outdoors - Part 2: General method of calculation.

- Ground Effect - the propagation of noise from a source is affected by the presence of the ground. The ground conditions are described in ISO 9613 through the variation of the ground type. This variable can be set between 0, which represents non porous (reflective surfaces such as water, ice, concrete etc.) and 1, which represents 'soft' ground, such as that covered by trees or other vegetation. The GPG recommends the use of 0.5, along with a receptor height of 4 m results in realistic predictions of noise from wind turbines in most cases.
- Barrier Attenuation - Any barrier between the source and receiver will reduce predicted noise immission levels with the GPG states that barrier attenuation should be limited to no more than 2 dB, and is only applicable where there is no line of sight between the tip of the turbine and the receptor.
- Propagation Through Foliage and Local Structures - ISO 9613 allows for adjustment of noise levels based upon the propagation path travelling through, or close to, vegetation or other nearby structures (such as other houses). Use of this factor is not recommended for use in the prediction of wind turbine noise and has therefore not been considered, as per GPG guidance.
- Additional Parameters - whilst not part of the standard ISO 9613-2 model, the GPG states that an additional 3 dB should be added to noise immission levels at properties located across a valley or with heavily concave ground between the property and the wind turbine(s).

The GPG states that the turbine sound power levels should be stated and these should include an appropriate allowance for measurement uncertainty. If the data provided contains no allowance for measurement uncertainty, or uncertainties are not provided, an additional 2 dB should be included. Declared Apparent Sound Power Levels (L_{wd}) as defined in IEC 61400-14[4], may be used as presented with no additional allowances.

ISO 9613-2 provides a prediction of noise levels likely to occur under worst-case conditions; those favourable to the propagation of sound, i.e. down-wind or under a moderate, ground-based temperature inversion as often occurs at night (often referred to as stable atmospheric conditions).

[4] IEC 61400-14 Wind turbines – Part 14: Declaration of apparent sound power level and tonality values.

4.6.5 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, refer also **Table 4-1**[5]
- 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)

Table 4-1: Summary of Sound Level Limits for Wind Farms (MoE)

Wind speed (m/s) at 10 m height	4	5	6	7	8	9	10
Wind Turbine Sound Level Limits, Class 3 Area, dBA	40	40	40	43	45	49	51
Wind Turbine Sound Level Limits, Class 1 & 2 Areas, dBA	45	45	45	45	45	49	51

The document used the $L_{Aeq,1hr}$ noise descriptor to define noise levels. It is not clear whether the instrument must be set to the "Fast" or "Impulse" time weighing setting, but, as the "Fast" setting is used in most international countries it is assumed that the instrument will be set to the "Fast" setting.

It should be noted that these Sound Level Limits are included for the reader to illustrate the criteria used internationally. Due to the lack of local regulations specifically relevant to wind energy facilities this criteria will also be considered during the determination of the significance of the noise impact.

[5]The measurement of wind induced background sound level is not required to establish the applicable limit. The wind induced background sound level reference curve was determined by correlating the A-weighted ninetieth percentile sound level (L90) with the average wind speed measured at a particularly quiet site. The applicable Leq sound level limits at higher wind speeds are given by adding 7 dB to the wind induced background L90 sound level reference values

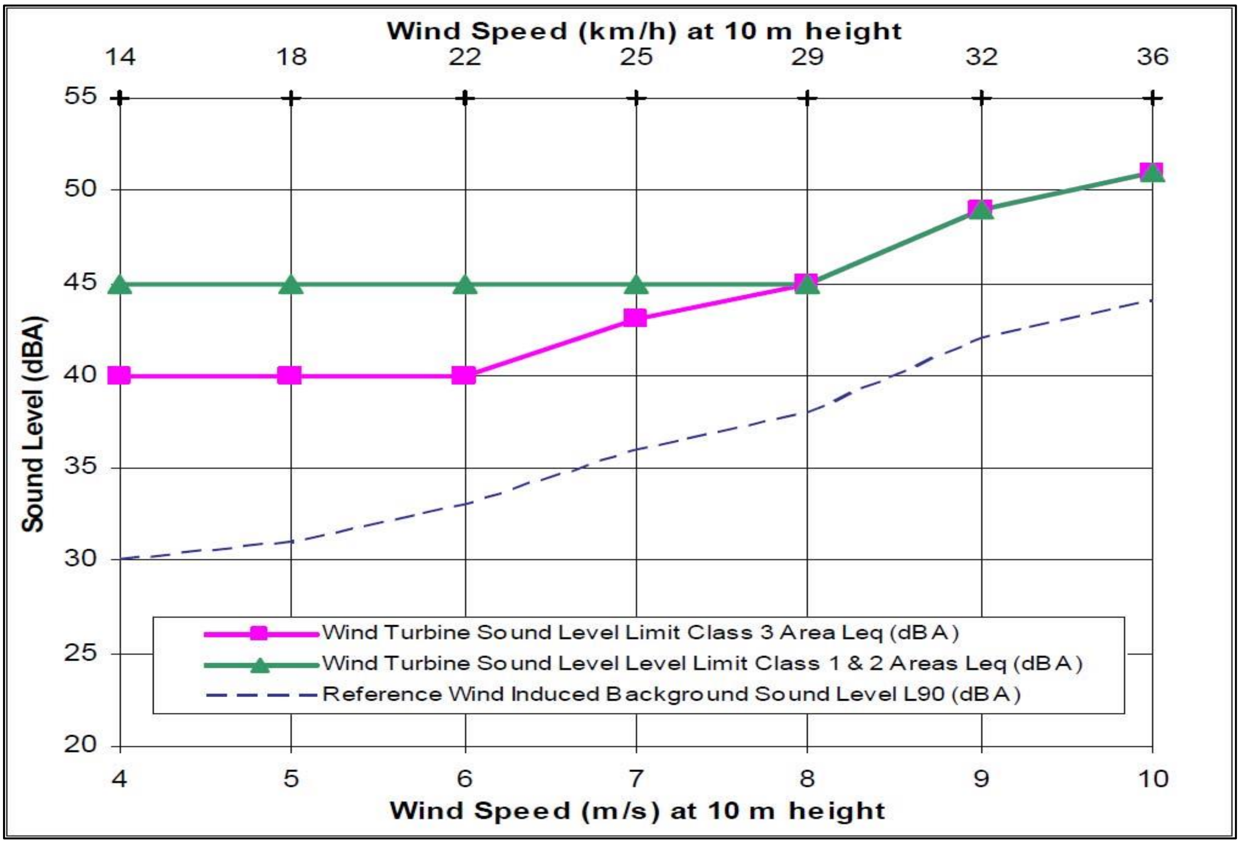

Figure 4-1: Summary of Sound Level Limits for Wind Turbines (MoE Canada)

4.6.6 Equator Principles

The **Equator Principles** (EPs) are a voluntary set of standards for determining, assessing and managing social and environmental risk in project financing. Equator Principles Financial Institutions (EPFIs) commit to not providing loans to projects where the borrower will not or is unable to comply with their respective social and environmental policies and procedures that implement the EPs.

The Equator Principles were developed by private sector banks and were launched in June 2003. Revision III of the EPs has been in place since June 2013. The participating banks chose to model the Equator Principles on the environmental standards of the World Bank (1999) and the social policies of the International Finance Corporation (IFC). Eighty-three financial institutions (2016) have adopted the Equator Principles, which have become the de facto standard for banks and investors on how to assess major development projects around the world.

The environmental standards of the World Bank have been integrated into the social policies of the IFC since April 2007 as the International Finance Corporation Environmental, Health and Safety (EHS) Guidelines.

4.6.7 IFC: General EHS Guidelines – Environmental Noise Management

These guidelines are applicable to noise created beyond the property boundaries of a development that conforms to the Equator Principle.

It states that noise prevention and mitigation measures should be applied where predicted or measured noise impacts from a project facility or operations exceed the applicable noise level guideline at the most sensitive point of reception. The preferred method for controlling noise from stationary sources is to implement noise control measures at source.

It goes as far as to proposed methods for the prevention and control of noise emissions, including:

- Selecting equipment with lower sound power levels;
- Installing silencers for fans;
- Installing suitable mufflers on engine exhausts and compressor components;
- Installing acoustic enclosures for equipment casing radiating noise;
- Improving the acoustic performance of constructed buildings, apply sound insulation;
- Installing acoustic barriers without gaps and with a continuous minimum surface density of 10 kg/m^2 in order to minimize the transmission of sound through the barrier. Barriers should be located as close to the source or to the receptor location to be effective;
- Installing vibration isolation for mechanical equipment;
- Limiting the hours of operation for specific pieces of equipment or operations, especially mobile sources operating through community areas ;
- Re-locating noise sources to less sensitive areas to take advantage of distance and shielding;
- Placement of permanent facilities away from community areas if possible;
- Taking advantage of the natural topography as a noise buffer during facility design;
- Reducing project traffic routing through community areas wherever possible;
- Planning flight routes, timing and altitude for aircraft (airplane and helicopter) flying over community areas; and
- Developing a mechanism to record and respond to complaints.

It sets noise level guidelines (see **Table 4-2**) as well as highlighting the certain monitoring requirements pre- and post-development. It adds another criterion in that the existing background ambient noise level should not rise by more than 3 dBA. This criterion will effectively sterilize large areas of any development. It is, therefore, the considered opinion that this criterion was introduced to address cases where the existing ambient noise level is already at, or in excess of the recommended limits.

Table 4-2: IFC Table .7.1 - Noise Level Guidelines

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

The document uses the $L_{Aeq,1\ hr}$ noise descriptors to define noise levels. It does not determine the detection period, but refers to the IEC standards, which requires the fast detector setting on the Sound Level Meter during measurements for Europe.

4.6.8 National and International Guidelines - Appropriate limits for game parks and wilderness

The United States National Park Services identifies that "intrusive" un-natural sounds are of concern for the National Park Services (United States[6]) as many visitors go to parks to enjoy the soundscape (interpreted as natural soundscape). Naturally quiet places will not mean (as per interpretation of the author and available information) that the noise levels in the area will be low but rather that the soundscape contributors are of a natural origin (faunal communication, wind, water etc.).

These natural events could include the dawn chorus when songbirds start to sing at the start of a new day or frogs croaking after a rainfall event. Although game park visitors, receptors in "natural" areas and hospitality industries may not seek intrusive un-natural sounds, the operation of the game park/hospitality industry or receptors dwelling itself is source of anthropogenic noise (vehicles, game park electrical and mechanical infrastructure etc.). National Parks do though implement their own guidelines/rules regarding noise created by park visitors.

[6] National Park Services, "Soundscape Preservation and Noise Management", 2000, p. 1.

Natural sounds can contribute a meaningful magnitude[7] to the ambient soundscape depending on season, time, faunal species, habitat and habitat fragmentation etc. Although the magnitude may be loud, natural sounds may contain harmonics[8] and other pleasant sounds that visitors seek when going to parks or wilderness areas.

Certain International states have tried implementing laws regarding external environmental "un-natural" noise sources into areas with natural sounds. In USA there exists numerous state and local laws to encourage industries near parks to keep within limits set out by the local authorities[9]. The United States National Park Service's efforts include attempts to reduce the flights over the Grand Canyon due to the introduction of non-natural impulsive noise events at the park.

4.6.9 European Parliament Directive 200/14/EC

Directive 2000/14/EC relating to the noise emission in the environment by equipment for use outdoors was adopted by the European Parliament and the Council and first published in May 2000. The Directive was applied from January 3rd, 2002. The directive placed sound power limits on equipment to be used outdoors in a suburban or urban setting. Failure to comply with these regulations may result in products being prohibited from being placed on the EU market. Equipment list is vast and includes machinery such as compaction machineries, dozers, dumpers excavators etc. Manufacturers as a result started to consider noise emission levels from their products to ensure that their equipment will continue to have a market in most countries.

[7] Environ. We Int. Sci. Tech, "Ambient noise levels due to dawn chorus at different habitats in Delhi", 2001, p. 134.
[8] Panatcha Anusasananan, Suksan Suwanarat, Nipon Thangprasert, "Acoustic Characteristics of Zebra Dove in Thailand", p. 4.
[9] E.g. State of Oregon's Environmental Standards for Wilderness Areas

5 CURRENT ENVIRONMENTAL SOUND CHARACTER

5.1 EFFECT OF SEASON ON SOUND LEVELS

Natural sounds are a part of the environmental noise surrounding humans. In rural areas the sounds from insects and birds would dominate the ambient sound character, with noises such as wind flowing through vegetation increasing as wind speed increase. Work by Fégeant (2002) stressed the importance of wind speed and turbulence causing variations in the level of vegetation generated noise. In addition, factors such as the season (e.g. dry or no leaves versus green leaves), the type of vegetation (e.g. grass, conifers, deciduous), the vegetation density and the total vegetation surface all determine both the sound level as well as spectral characteristics.

Ambient sound levels are significantly affected by the area where the sound measurement location is situated. When the sound measurement location is situated within an urban area, close to industrial plants or areas with a constant sound source (ocean, rivers, etc.), seasons and even increased wind speeds have an insignificant to massive impact on ambient sound levels.

Sound levels in undeveloped rural areas (away from occupied dwellings) however are impacted by changes in season for a number of complex reasons. The two main reasons are:

- Faunal communication during the warmer spring and summer months as various species communicate in an effort to find mates; and
- Seasonal changes in weather patterns, mainly wind (also see **section 5.2**).

For environmental noise, weather plays an important role; the greater the separation distance, the greater the influence of the weather conditions; so, from day to day, a road 1,000 m away can sound very loud or can be completely inaudible.

Other, environmental factors that impact on sound propagation includes wind, temperature and humidity, as discussed in the following sections.

5.1.1 Effect of wind on sound propagation

Wind alters sound propagation by the mechanism of refraction; that is, wind bends sound waves. Wind nearer to the ground moves more slowly than wind at higher altitudes, due to surface characteristics such as hills, trees, and man-made structures that interfere with the wind. This wind gradient, with faster wind at higher elevation and slower wind at lower elevation, causes sound waves to bend downward when they are traveling to a location downwind of the source and to bend upward when traveling toward a location upwind of the source. Waves bending downward means that a listener standing downwind of the source will hear louder noise levels than the listener standing upwind of the source. This phenomenon can significantly impact sound propagation over long distances and when wind speeds are high.

Over short distances, wind direction has a small impact on sound propagation as long as wind velocities are reasonably slow, i.e. less than 3 – 5 m/s.

5.1.2 Effect of temperature on sound propagation

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, away from the ground and results in lower noise levels being heard at a measurement location. In the evening, this temperature gradient will reverse, resulting in cooler temperatures near the ground. This condition, often referred to is a temperature inversion will cause sound to bend downward toward the ground and results in louder noise levels at the listener position. Like wind gradients, temperature gradients can influence sound propagation over long distances and further complicate measurements.

Generally sound propagate better at lower temperatures (down to 10^{o}C), and with everything being equal, a decrease in temperature from 32^{o}C to 10^{o}C would decrease the sound level at a listener 600 m away by 3 dB (at 1,000 Hz).

5.1.3 Effect of humidity on sound propagation

The effect of humidity on sound propagation is quite complex, but effectively relates how increased humidity changes the density of air. Lower density translates into faster sound wave travel, so sound waves travel faster at high humidity. With everything being equal, an increase in humidity from 20% to 80% would increase the sound level at a listener 600 m away by 3 dB (at 1,000 Hz).

5.2 EFFECT OF WIND SPEEDS ON VEGETATION AND SOUND LEVELS

Wind speed is a determining factor for sound levels at most rural locations. With no wind, there is little vegetation movement that could generate noises, however, as wind speeds increase, the rustling of leaves increases which subsequently can increase sound levels. This directly depends on the type of vegetation in a certain area. The impact of increased wind speeds on sound levels depends on the vegetation type (deciduous versus connivers), the density of vegetation in an area, seasonal changes (in winter deciduous trees are bare) as well as the height of this vegetation. This excludes the effect of faunal communication as vegetation may create suitable habitats and food sources.

5.3 INFLUENCE OF WIND ON NOISE LIMITS

Current local regulations and standards do not consider changing ambient (background) sound levels due to natural events such as can be found near the coast or areas where wind-induced noises are prevalent. This is unfeasible with wind energy facilities as these facilities will only operate when the wind is blowing. It is therefore important that the contribution of wind-induced noises be considered when determining the potential noise impact from such as a facility. Care should be taken when taking this approach due to other factors that complicate noise propagation from wind turbines.

While the total ambient sound levels are of importance, the spectral characteristics also determine the likelihood that someone will hear external noises that may or may not be similar in spectral characteristics to that of the vegetation that created the noise. Bolin (2006) did investigate spectral characteristics and determined that annoyance might occur at levels where noise generated by wind turbine noise exceeds natural ambient sounds with 3 dB or more.

Low frequency noises can also be associated with some wind turbines. Separating the potential low frequency noise from wind turbines from that generated by natural sources as well as other anthropogenic sources can and will be a challenge.

There are a number of factors that determine how ambient sound levels close to a dwelling (or the low-frequency noise levels inside the house) might differ from the ambient sound levels further away (or even at another dwelling in the area), including:

- Type of activities taking place in the vicinity of the dwelling;
- Equipment being used near the dwelling, especially equipment such as water pumps, compressors and air conditioners;
- Whether there are any windmills (*"windpompe"*) close to the dwelling as well as their general maintenance condition;
- 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);

- Distance to large infrastructural developments, including roads, railroads and even large diameter pipelines;
- Distances to other noise sources, whether anthropogenic or natural (such as the ocean or running water);
- The material used in the construction of the dwelling;
- The design of the building, including layout and number of openings;
- How well the dwelling is maintained; and
- The type and how many farm animals are in the vicinity of the dwelling.

5.4 POTENTIAL EXISTING AMBIENT SOUND LEVELS

Because wind induced noises are a significant source of noise during periods when wind turbines operate, it cannot be excluded. It however, complicates ambient sound measurements, as a few singular measurements will provide insufficient data to allow any confidence in the subsequent information obtained.

Ambient (background) noise levels were previously measured in the vicinity of the area for various projects, including Komsberg, Aberdene, Amakhala Emoyeni, Cookhouse, Kolkies etc. WEF projects. Wind speed data (at 10m) were available for a number of these projects, providing more than 30,000 measurements though accurate wind speed data was not available for all these measurements.

This sound level data was sorted into 15,000 measurements for the daytime and 7,000 measurements for the night-time period. This data was plotted against wind speeds, with the data analysed with the best curve fitted through this data.

While the ambient sound levels discussed in this report was measured over the last 10 years, the data will still be relevant as the area did not experience any developmental changes.

The analysed data is illustrated in **Figure 5-1** (for the day-time period) and **Figure 5-2** for the night-time period. While the area may be quiet (typical for an undeveloped rural area), wind turbines will only operate during windy periods, with most wind turbines only starting to operate at a wind speed exceeding 3 m/s.

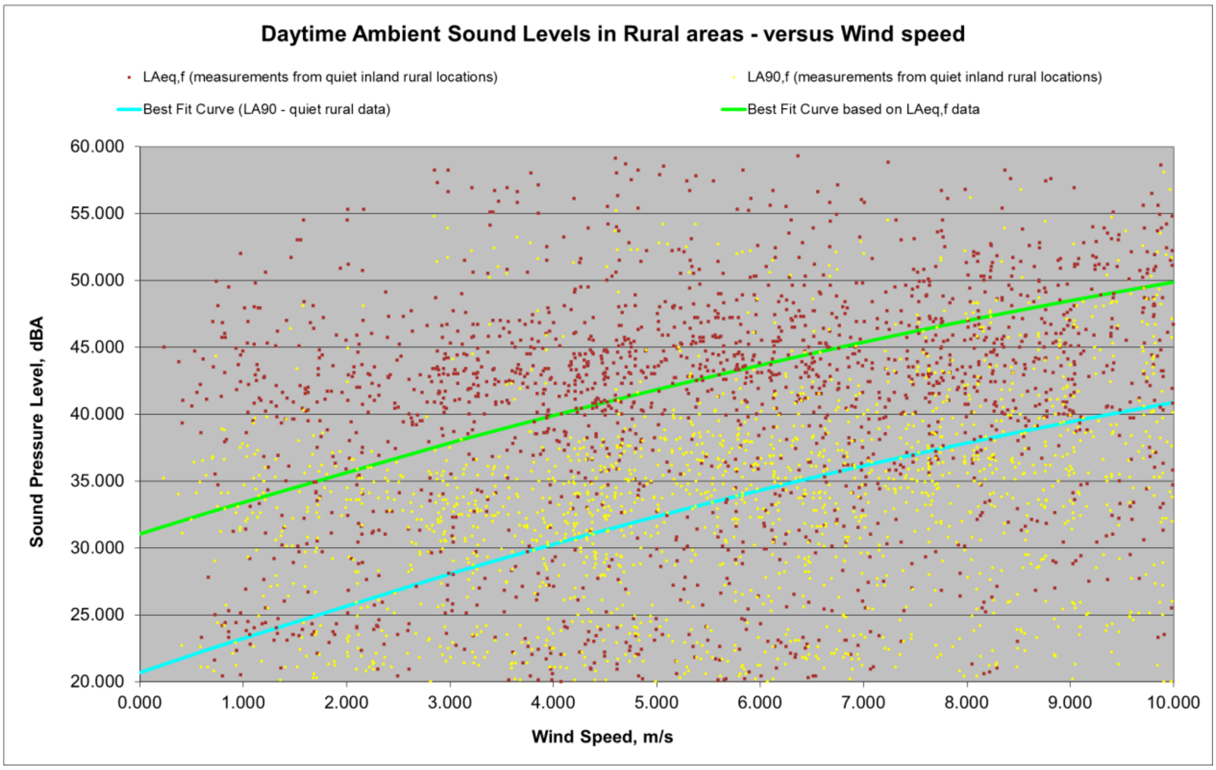

Figure 5-1: Summary of onsite daytime sound levels compared to long-term sound levels measured in other rural areas

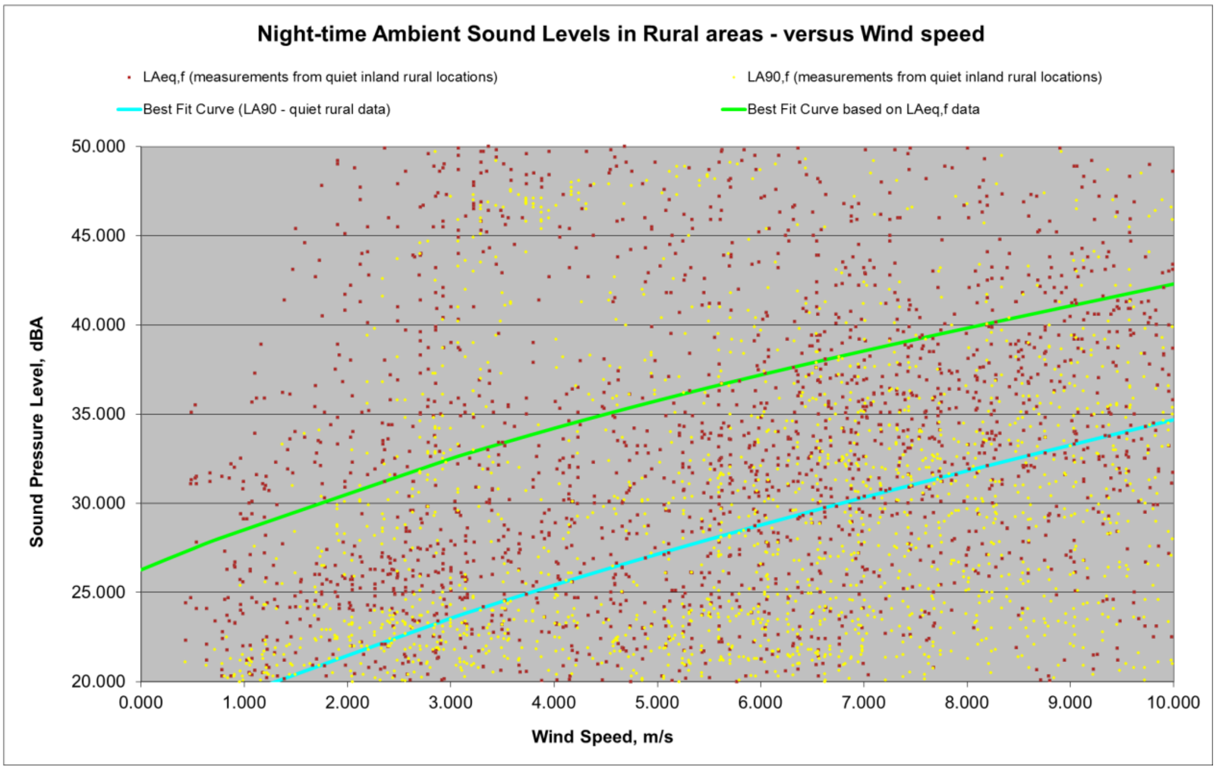

Figure 5-2: Summary of onsite night-time sound levels compared to long-term sound levels measured in other rural areas

6 POTENTIAL NOISE SOURCES

Increased noise levels are directly linked with the various activities associated with the construction of the WEF and related infrastructure, as well as the operational phase of the WEF. The most significant stage relating to noise is generally the operational phase, and not the construction phase. This normally is due to the relatively short duration of construction activities and the fact that most construction activities are limited to the daylight period.

Potential NSD in addition is also more sensitive to intrusion noises during the night-time period, as this is the critical period when people require rest and sleep. Due to a more stable atmosphere, lower night-time temperatures as well as a higher relative humidity, noises generally travel further at night. As such this assessment will only consider the night-time operational phase.

6.1 POTENTIAL NOISE SOURCES: OPERATIONAL PHASE

The proposed development would be designed to have an operational life of up to 25 years, although the producer agreement with the state may only be 20 years. During operation of the development, most of the site will continue with the existing land-use (agricultural). The only development related activities on-site will be routine servicing and unscheduled maintenance. The noise impact from maintenance activities is insignificant, with the main noise source being the wind turbine blades and the nacelle (components inside).

Noise emitted by wind turbines can be divided in 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.

6.1.1 Wind Turbine Noise: Aerodynamic sources[10]

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

[10] *Renewable Energy Research Laboratory, 2006; ETSU R97: 1996*

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); and
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 6-1**. The sound power emissions (in octave sound power levels) as used in this report are presented in **Table 10-1**.

The developer is considering the use of a number of different wind turbines, but the decision will be made at a later stage. To allow the evaluation of the potential noise impact, this assessment will use the sound power emission levels of the Acciona AW125 3000 wind turbine, with the noise emission levels illustrated (refer to **Figure 6-1**).

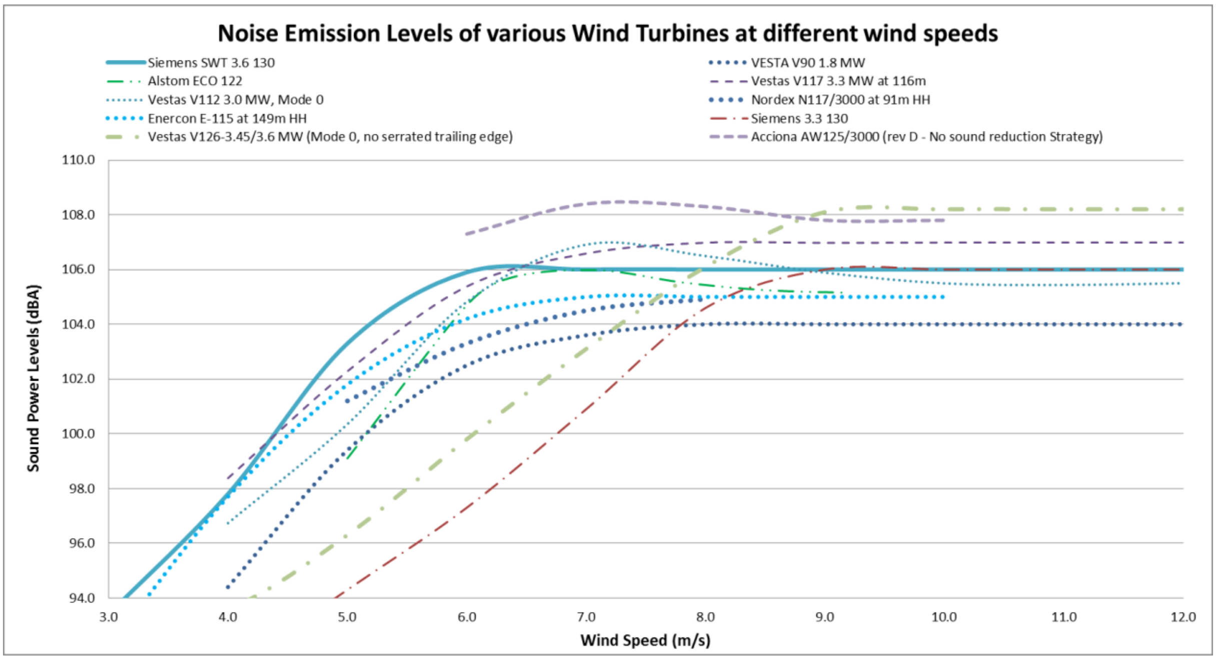

Figure 6-1: Noise Emissions Curve of a number of different wind turbines (figure for illustration purposes only)

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 providing a higher accuracy than models that only use the total sound power level. The octave sound power levels for various wind turbines are presented on **Figure 6-2**.

6.1.1.1 Control Strategies to manage Noise Emissions during operation

Wind turbine manufacturers provide their equipment with control mechanisms to allow for a certain noise reduction during operation that can include:

- A reduction of rotational speed, and/or
- the increase of the pitch angle and/or reduction of nominal generator torque to reduce the angle of attack.

These mechanisms are used in various ways to allow the reduction of noise levels from the wind turbines, although this also results in a reduction of power generation.

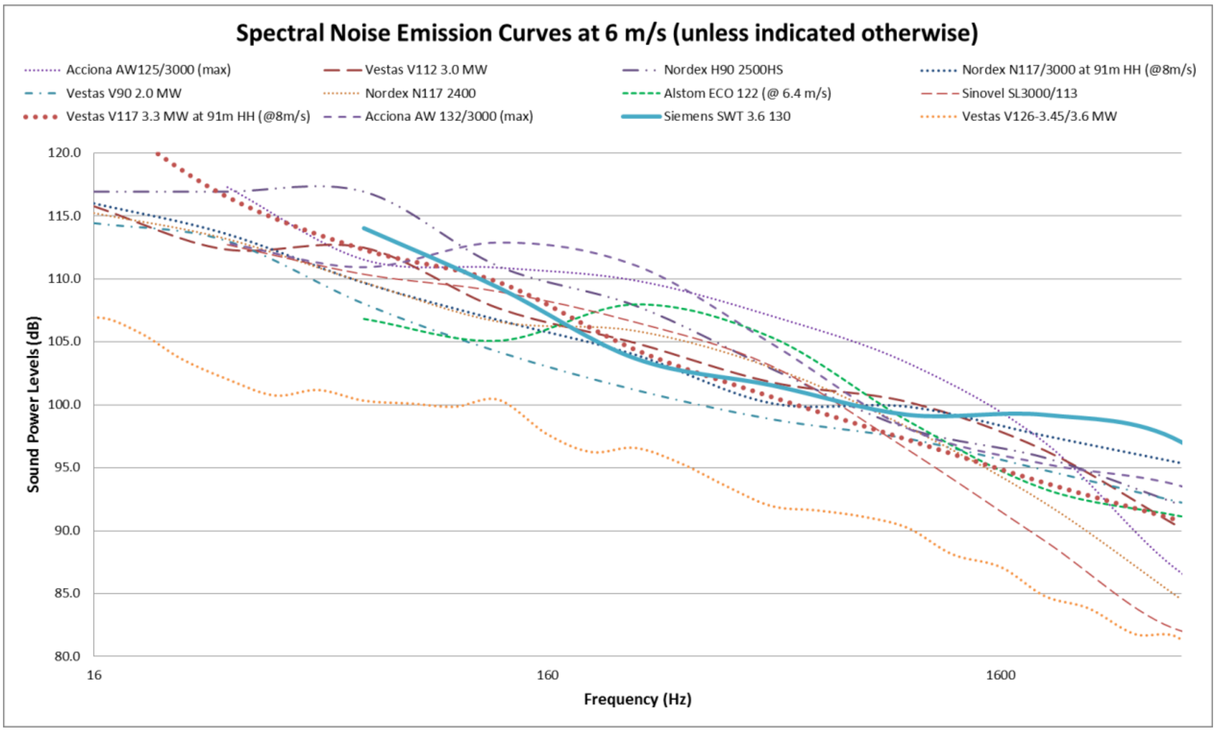

Figure 6-2: Octave sound power emissions of various wind turbines

6.1.2 Wind Turbine: Mechanical sources[11]

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.

[11]*Renewable Energy Research Laboratory, 2006; ETSU R97: 1996; Audiology Today, 2010; HGC Engineering, 2007*

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 should not emit any clearly distinguishable tones***.

6.1.3 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 100 Hz. This is normally not an issue if the substation is further than 200 meters from a potentially sensitive receptor.

This is a relatively 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.

6.1.4 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; and
- 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) go 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.

6.1.5 Low Frequency Noise[12]

6.1.5.1 Background and Information

Low frequency noise (LFN) is the term used to describe sound energy in the region below ~200 Hz. 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 20 Hz.

[12]*Renewable Energy Research Laboratory, 2006; DELTA, 2008; DEFRA, 2003; HGC Engineering, 2006; Whitford, Jacques, 2008; Noise-con, 2008; Minnesota DoH, 2009; Kamperman, 2008, Van den Berg, 2004; Bolin, 2011; Thorne, 2010; Ambrose, 2011;* Møller, 2010; O'Neal, 2011

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 6-3**, which indicates the sound power levels in the different octave bands from measurements taken at different wind speeds with no other audible noise sources. 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.

LFN from wind turbines has in the last few years become more prominent, with various studies and articles covering this subject.

6.1.5.2 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, significant acoustic energy is radiated by large wind turbines in the infrasonic range.

6.1.5.3 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 non-existent. However, sounds in a frequency range less than 100 Hz can, under the right circumstances, be responsible for annoying nearby residents. However, except very near the source, most people outside cannot detect the presence of low-frequency noise from a wind turbine, and low-frequency noise from natural events (especially wind related) already exist all over and as illustrated in **Figure 6-3**.

It should be noted that a number of studies highlighted that these sounds are below the threshold of perception (BWEA, 2005), although this should be clarified. Most acousticians would agree that the low frequency sounds are inaudible to most people, yet, there are a number of studies that highlight that it can be more perceptible to people inside their houses as well as people that are more sensitive to low frequency sounds.

Thorne (2011) notes that;
"*Low frequency sound and infrasound are normal characteristics of a wind farm as they are the normal characteristics of wind, as such. The difference is that "normal" wind is laminar or smooth in effect whereas wind farm sound is non-laminar and presents a pulsing nature*."

Residents studied by Thorne often report that the LFN is noticeably worse in their homes than it is outside[13].

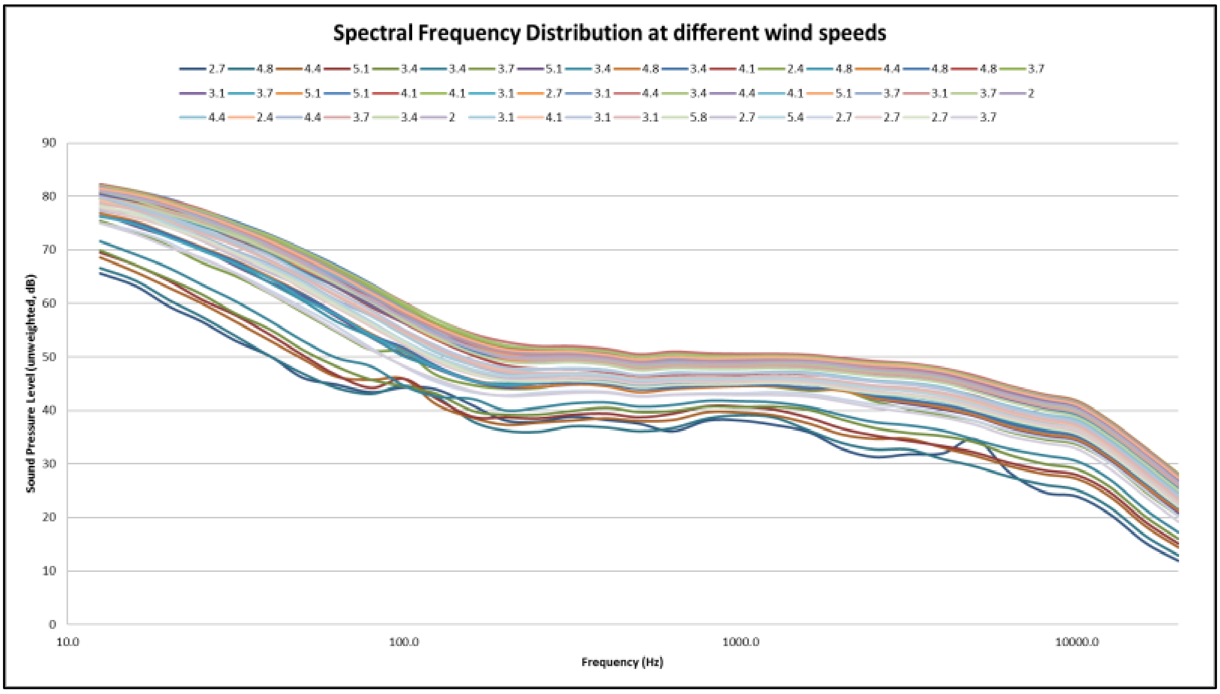

Figure 6-3: Third octave band sound power levels at various wind speeds at a location where wind induced noises dominate

6.1.5.4 Measurement, Isolation and Assessment of LFN[14]

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

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 proposes a method to identify whether LFN could be an issue from an operating facility. It proposes that if the difference between the measured A-frequency weighted and the C-frequency weighted equivalent continuous ($L_{Aeq}>>L_{Ceq}$) sound pressure levels is greater than 10 dB, a predominant LFN component **may** be present.

[13] *Hubbard, 1990; Thorne, 2010; Ambrose, 2011*
[14] Hessler, 2011; James,

However, in all cases existing acoustic energy in low frequencies associated with wind must be considered.

6.1.5.5 Summary: Low Frequency Noise[15]

LFN is always present around us as it is produced by both man and nature. While problems have been associated with older downwind wind turbines in the 1980s, this has been considered by the wind industry in the design of modern upwind turbines. LFN however has been very controversial in the last few years with the anti-wind fraternity claiming measurable impacts, with governments and wind-energy supporter studies indicating no link between LFN and any health impacts. This study notes the various claims and as such follows a more precautious approach.

6.1.6 Amplitude modulation[16]

Although considered rare, 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 (AM) 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".

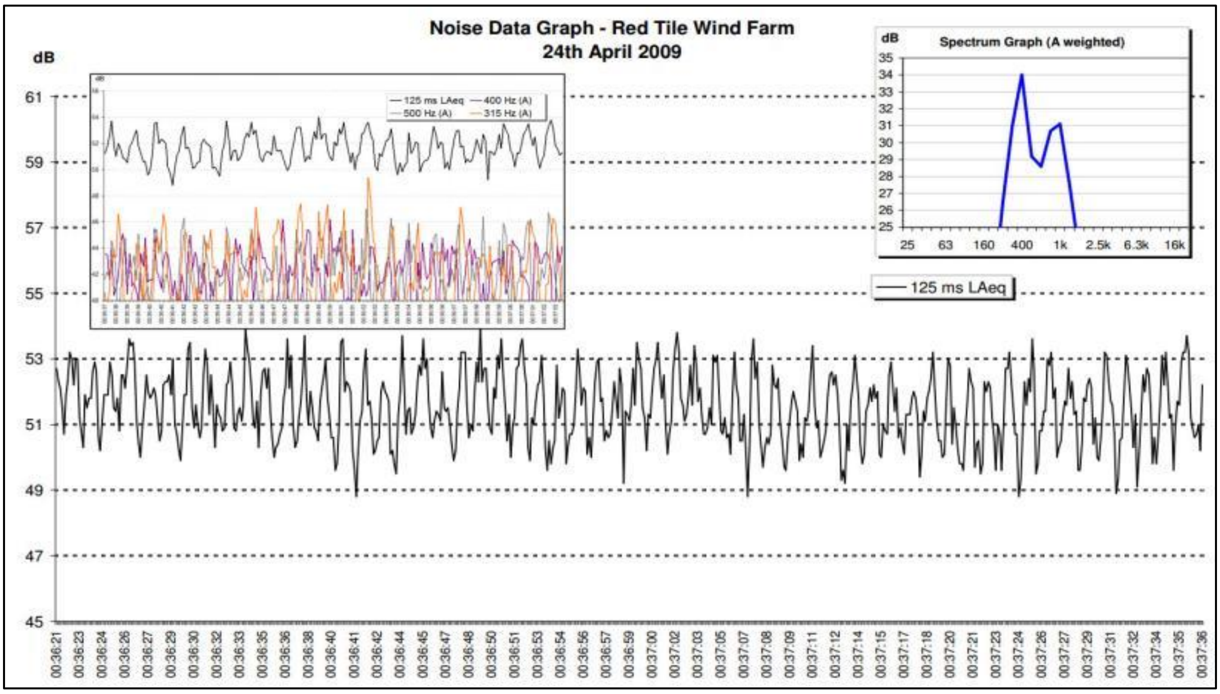

Figure 6-4: Example time-sound series graph illustrating AM as measured by Stigwood[17] (*et al*) (2013)

[15] *BWEA, 2005*

[16] *Renewable Energy Research Laboratory, 2006; Audiology Today, 2010; HGC Engineering, 2007; Whitford, 2008; Noise-con, 2008; DEFRA, 2007; Bowdler, 2008; Smith (2012); Stigwood (2013); Tachibana (2013)*

[17] Stigwood (*et al*) (2013): "*Audible amplitude modulation – results of field measurements and investigations compared to psycho-acoustical assessments and theoretical research*"; Paper presented at the 5th International Conference on Wind Turbine Noise, Denver 28 – 30 August 2013

Pedersen (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 the blades made. The noise produced by the blades lead to most complaints. Most of the annoyance was experienced between 16:00 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 word map (**Figure 6-5**) below categorises some of the many terms used by affected residents to describe AM, including physical likeness of the sound and musical terms describing the character of AM.

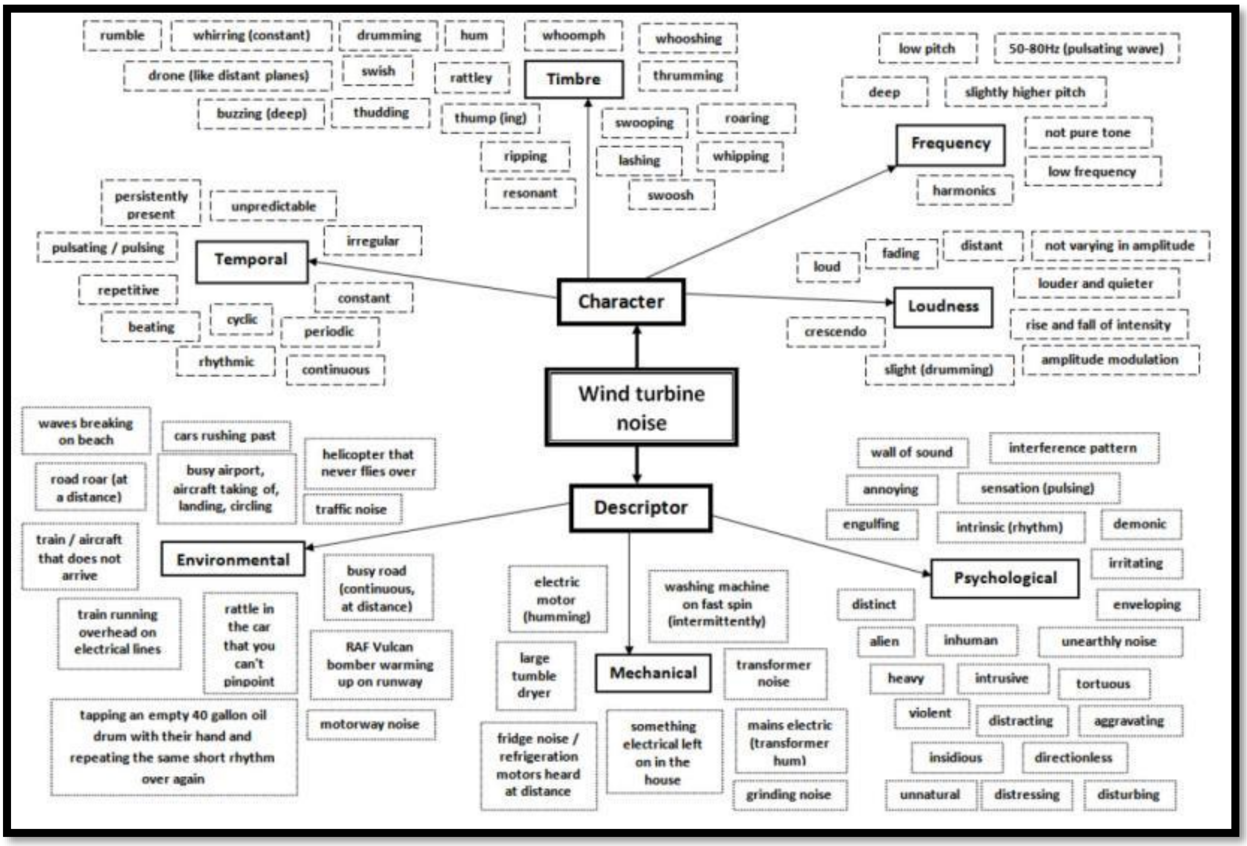

Figure 6-5: Word map of terms used to describe the sound of AM (source: Stigwood (*et al*) (2013))

The mechanism of amplitude modulated noises 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.

Bowdler (2008) concludes that there are probably two distinct mechanisms in operation to create AM. The first is swish which is a function of the observers position relative to one turbine. The second is thump which is due to turbine blades passing through uneven air velocities as they rotate. In the second case the uneven air may be due to interaction of other turbines, excessive wind shear or topography. These two mechanisms are entirely separate though it is possible that they interact.

Stigwood (*et al*) (2013) also measured amplitude modulation at distances up to 1000 meters from the closest wind turbines at a number of wind farms in the United Kingdom and have summarized that:

- AM is more common than previously reported.
- AM should be measured during evening (after sunset), night time or early morning periods.
- Meteorological effects, such as atmospheric stability, which lead to downward refraction resulting from changes in the sound speed gradient alter the character and level of AM measured.
- AM is generated by all wind turbines including single turbines.
- Propagation conditions, mostly affected by meteorology and the occurrence of localised heightened noise zones determine locations that will be affected.
- Findings confirm that AM occurrence is frequent (at the eleven wind farms investigated) and can readily be identified in the field by measuring under suitable conditions and using appropriate equipment and settings.
- Audible features of AM including frequency content and periodicity vary both within and between wind farms.
- Noise character can differ considerably within a short time period. The constant change in AM character increases attention and cognitive appraisal and reappraisal, inhibiting acclimatisation to the sound.

That AM can be a risk and significantly increase the annoyance with wind energy facilities cannot be disputed. It has been reported with a number of recent studies confirming this significant noise characteristic. However, even though there is thousands of wind turbine generators in the world, amplitude modulation are still one subject receiving the least complaints and due to this very few complaints, little research went into this subject. Studies as recently as 2012 (Smith, 2012) highlight the need for additional studies and data collection.

However, because of these unknown factors (low frequency noises and AM), this noise study adopts a precautious stance and will consider the worst-case scenario.

6.1.7 Summary Conclusions on Wind Turbine Noise

Wind turbines do generate sound in both the inaudible and audible frequency range. However, the manner how this sound is perceived by people would differ between people and communities, as well as the surrounding environmental conditions in which they live. There are some studies[18] that show correlations between noise annoyance and a dislike to the facility, with other studies showing a link between wind turbines and increased annoyance levels[19]. Annoyance levels can be further subdivided into people that are annoyed by increased noise levels to the point where people report having to leave their houses to get relieve from the noise.

How widespread annoyance and health issues reports are, is yet to be defined, as there has not been an industry wide scientific study covering noise from wind turbines. Values of 5 – 15% appear to be the most cited, although it depends on the source (it must be reiterated that these are simply reports[20]).

A search on the internet identifies groups that scour the internet for studies, reports and articles about wind energy; some focusing on the positive stories yet others gathering everything mentioned about the negatives, unfortunately also reporting all the negatives as fact without considering all the data. There are numerous wind farms where there has been no noise complaints (a UK study suggest that about 20% of wind farms generated noise complaints (Cummings, 2011), yet there has been no study assessing the differences between these wind farms.

Cummings (2012) also reports that:
"*it's notable that in ranching country, where most residents are leaseholders and many live within a quarter to half mile of turbines, health and annoyance complaints are close to non-existent; some have suggested that this is evidence of an antidote to wind turbine syndrome: earning some money from the turbines. More to the point, though, the equanimity with which turbine sound is accommodated in ranching communities again suggests that those who see turbines as a welcome addition to their community are far less likely to be annoyed, and thus to trigger indirect stress-related effects. Equally important to consider, ranchers who work around heavy equipment on a daily basis are*

[18] Gibbons, 2014; Crichton, 2014; Atkinson-Palmbo, 2014; Chapman, 2013; Pedersen, 2003.
[19] Thorne, 2010; *Ambrose, 2011; Pierpont, 2009; Nissenbaum, 2012; Knopper, 2011; Kroesen, 2011; Philips, 2011; Shepherd, 2011a; Shepherd, 2011b; Pedersen, 2011; Wang, 2011; Cooper, 2012; McMurtry, 2011; Havas, 2011; Jeffery, 2013*
[20] Cummings, 2012

also likely to be less noise sensitive than average, whereas people who live in the country for peace and quiet and solitude are likely more noise-sensitive than average. And, there are some indications that in flat ranching country, turbine noise levels may be more steady, less prone to atmospheric conditions that make turbines unpredictably louder or more intrusive. When considering the dozens of wind farms in the Midwest and west where noise complaints are minimal or non-existent, it remains true that the vast majority of U.S. wind turbines are built either far from homes or in areas where there is widespread tolerance for the noise they add to the local soundscape."

However, on the other hand, there are reports of significant annoyance (that can lead to increased stress levels that can result in other health problems or exacerbate existing problems) from individuals and communities, frequently from people that value the rural quiet and sense of place.

Therefore, when assessing the potential noise impacts one has to consider:

- the complex characteristic of noise from wind turbines (numerous factors that are not yet fully understood);
- the numerous reports about noise impacts;
- the rural character and existing sense of place from a noise perspective; and
- the recommendations from recognised acousticians.

The assessment methodology does consider these factors as discussed in the following section.

7 METHODOLOGY: CALCULATION OF FUTURE NOISE EMISSIONS DUE TO PROPOSED PROJECT

7.1 NOISE EMISSIONS INTO THE SURROUNDING ENVIRONMENT

The noise emissions into the environment from the various sources as defined by the project developer will be calculated using the sound propagation models described by ISO 9613-2 for the operational phase. The following will be taken into account:

- The octave band sound pressure emission levels of processes and equipment;
- The distance of the receiver from the noise sources;
- The impact of atmospheric absorption;
- The layout details of the proposed project;
- The height of the noise source under investigation;
- Topographical layout; and
- Acoustical characteristics of the ground.

8 METHODS: NOISE IMPACT ASSESSMENT AND SIGNIFICANCE

8.1 NOISE IMPACT ON ANIMALS[21]

While there are few specific studies focusing on noises from wind turbines, there are a number of publications where the effects of increased noises on certain species were studied. This is because hearing is critical to an animal's ability to:

- React
- Compete
- Seek mates and reproduce
- Hunt and forage
- Communicate
- Survive

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

- Various types of noise;
- Durations of noise; and
- Sources of noise.

The only animal species studied in detail are humans, and studies are still continuing today. These studies also indicate that there is considerable variation between individuals, highlighting the loss of sensitivity to higher frequencies as humans age. Sensitivity also varies with frequency with humans. Considering the variation in the sensitivity to frequencies and between individuals, this is likely similar with all faunal species. Some of these studies are repeated on animals, with behavioural hearing tests being able to define the hearing threshold range for some animals (see **Figure 8-1**).

Only a few faunal species have been studied in a bit more detail so far, with the potential noise impact on marine animals most likely the most researched subject with a few studies that discuss behavioural changes in other faunal species due to increased noises. Few studies indicate definitive levels where noises start to impact on animals, with most based on laboratory level research that subject animals to noise levels that are significantly higher than the noise levels these animals may experience in the environment (excluding the rare case where bats and avifauna fly extremely close to an anthropogenic noise, such as from a moving car or the blades of a wind turbine).

[21]Report to Congressional Requesters, 2005; USEPA, 1971; Autumn, 2007; https://en.wikipedia.org/wiki/Hearing_range; Noise quest, 2010; http://www.noisequest.psu.edu/noiseeffects-animals.html; Schaub, 2008; Dooling, 2007; Dooling, 2002; Guillaume, 2012; Bayne, 2008; Barber, 2009; Habib, 2007; Derryberry, 2016; Lohr, 2003; Rabin, 2006

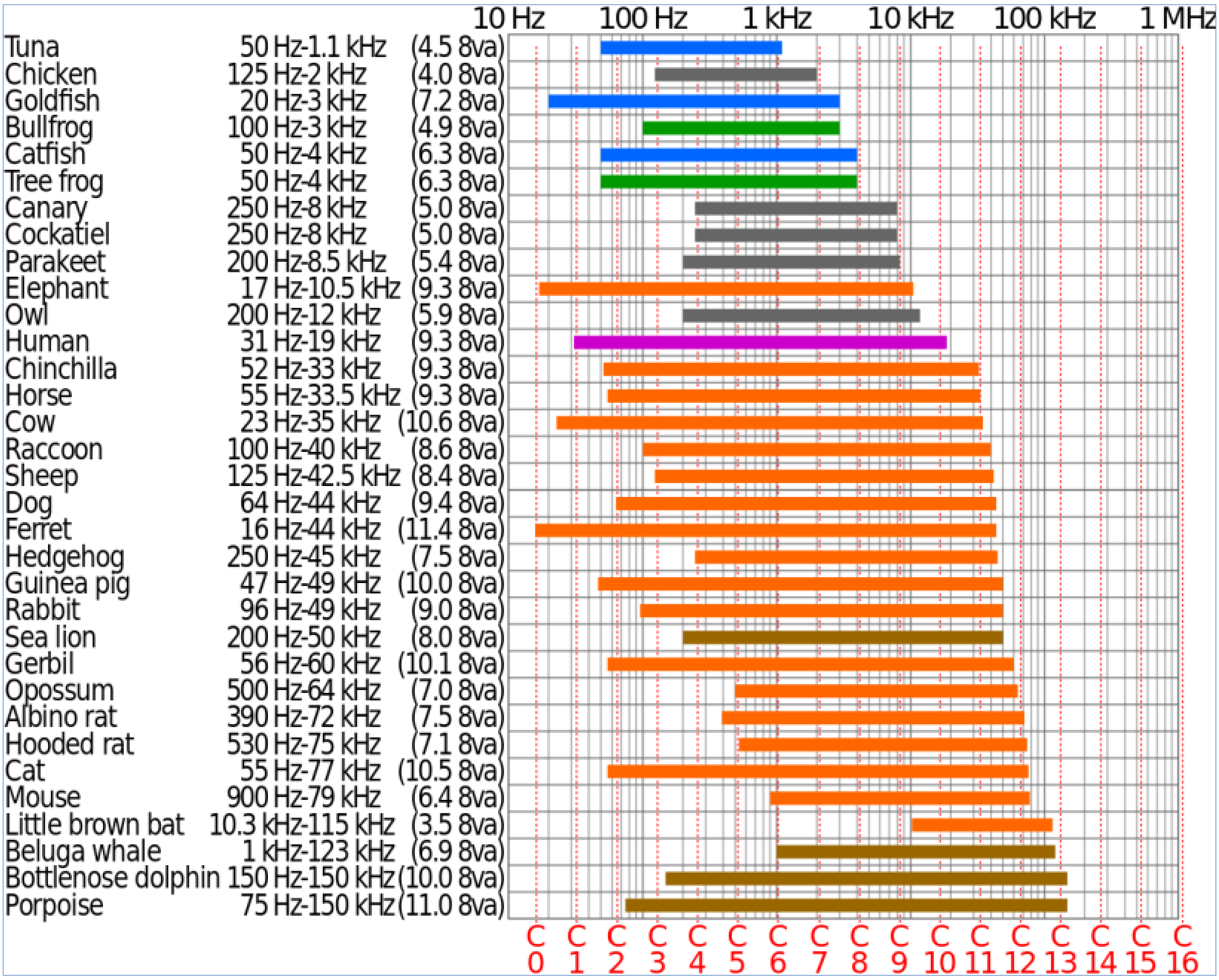

Figure 8-1: Logarithmic chart of the hearing ranges of some animals

A general animal behavioural reaction to impulsive noises 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; and
- 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.
- Animals of most species exhibit adaptation with noise, including impulsive noises by changing their behaviour.

- 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 does significantly impact on animals.

To date there are however no guidelines or sound limits with regards to noise levels that can be used to estimate the potential significance of noises on animals.

8.1.1 Domestic Animals

It has been observed that most domestic animals are generally not bothered by noise, excluding most impulsive noises.

8.1.2 Wildlife

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. Noise impacts are therefore very highly species dependent.

8.2 WHY NOISE CONCERNS COMMUNITIES[22]

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); and
- 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,

[22] World Health Organization, 1999; Noise quest, 2010; Journal of Acoustical Society of America, 2009

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; and
- The attitude of the receptor about the emitter (noise source).

8.3 IMPACT ASSESSMENT CRITERIA

8.3.1 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; and
- 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.

8.3.2 Noise criteria of concern

The criteria used in this report were drawn from the criteria for the description and assessment of environmental impacts considering the latest EIA Regulations, 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 8-2**.
- *Zone Sound Levels:* Previously referred to as the acceptable rating levels, it sets acceptable noise levels for various areas. See also **Table 8-1**.
- *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.

In South Africa, the document that addresses the issues concerning environmental noise is SANS 10103:2008 (See also **Table 8-1**). It provides the equivalent ambient noise 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.

Considering the developmental character of the areas, the potential noise impact will be evaluated in terms of (i.t.o.) the rural acceptable rating level as well as the IFC noise-limits as defined below:

- "Rural Noise Districts" (45 and 35 dBA day/night-time Rating i.t.o. SANS 10103:2008); and
- "Equator principles" (55 and 45 dBA day/night-time limits i.t.o. IFC Noise Limits).

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 sound level, the following criteria are of relevance (see also **Figure 8-2**):

- **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'.

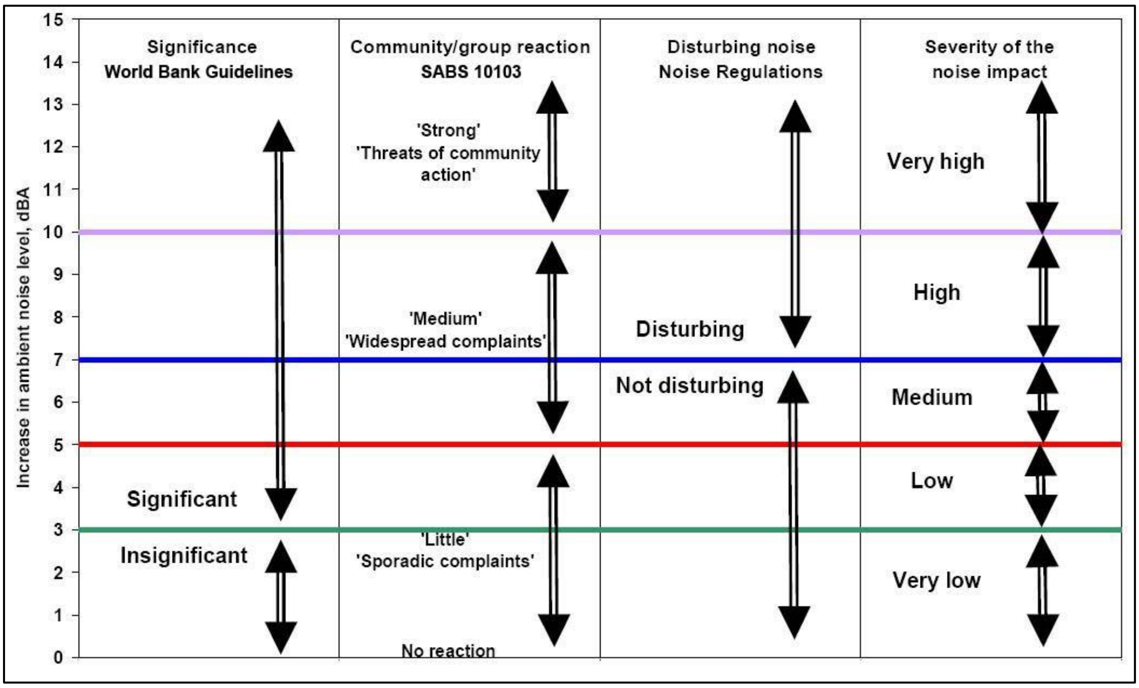

Figure 8-2: Criteria to assess the significance of impacts stemming from noise

Table 8-1: Acceptable Zone Sound Levels for noise in districts (SANS 10103:2008)

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

Note that an increase of more than 7 dBA is defined as a disturbing noise and prohibited (National and Provincial Noise Control Regulations).

8.3.3 Determining appropriate Zone Sound Levels

SANS 10103:2008 does not cater for instances when background ambient sound levels change due to the impact of external forces. Locations close (closer than 500 meters from coastline) from the sea for instance always has 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 only start to operate when wind speeds exceed 3 m/s. Noise emissions therefore relates to the wind speed and similarly, the environment in which they are heard also depends 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.

8.3.3.1 Using International Guidelines to set Noise Limits

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 3-5 m/s (the turbine cut-in wind speed) up to a wind speed range of 25-35 m/s measured at the hub height of a wind turbine. However, ETSU-R97 (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 10 m 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; and
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.

Night-time ambient sound vs. wind speed data is presented in **Figure 5-2**. This is based on quiet (as per the opinion of the author) locations[23] where there were no apparent or observable sounds that would have impacted on the measurements, presenting the A-Weighted sound levels at an inland area. The figures clearly indicate a trend where sound levels increase if the wind speed increases. This has been found at all locations where measurements have been done for a sufficiently long enough period of time (more than 30 locations – more than 38,000 measurements).

Considering the curve based on equivalent data (**Figure 5-2**), ambient sound levels would be less than 35 dBA at wind speeds below 4 m/s. Ambient sound level however will increase as wind speeds increase and considering international guidelines (MOE, see **Section 4.6.5**; IFC, see section **4.6.7**), noise limits starting at 40 dB that increases to more than 45 dB (as wind speeds increase) is acceptable. Therefore, project participants could be exposed to noise levels up to 45 dBA at lower wind speeds.

8.3.3.2 Using local regulations to set noise limits

The Western Cape Provincial Noise Control Regulations (PN 200 of 20 June 2013 – **section 4.2.2**) states that —

- a noise impact assessment should establish whether the proposed land use or activity will exceed the appropriate rating level for a particular district;
- where the results of an assessment indicate that the applicable noise rating level may be exceeded by 5 dB or more, that the applicant must provide a noise management plan, clearly specifying appropriate mitigation measures to the satisfaction of the local authority.

Accepting that the area is a rural district, night-time rating levels would be 35 dBA (wind speeds below 4 m/s) and a noise level exceeding 40 dBA would exceed could be a disturbing noise (therefore the noise limit). However, as wind speeds increase, ambient sound levels will also increase which will also be considered.

8.3.4 Other Factors that must be considered for Wind Energy Facilities

8.3.4.1 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

[23] Different area where longer measurements were collected.

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 than 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 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 turbine 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***).

Similarly, if the area frequently experience weather phenomena such as temperature inversion[24], the developer should consider this. Generally, this information is site specific and not available for remote areas and as a result it is difficult to consider in this study.

8.3.4.2 Annoyance associated with Wind Energy Facilities[25]

Annoyance is the most widely acknowledged effect of environmental noise exposure, and is considered to the most widespread. It is estimated that less than a third of the individual noise annoyance is accounted for by acoustic parameters, and that non-acoustic factors plays a major role. Non-acoustic factors that have been identified include age, economic dependence on the noise source, attitude towards the noise source and self-reported noise sensitivity.

On the basis of a number of studies into noise annoyance, exposure-response relationships were derived for high annoyance from different noise sources. These

[24] http://en.wikipedia.org/wiki/Inversion_(meteorology)
[25] Van den Berg, 2011; Milieu, 2010.

relationships, illustrated in **Figure 8-3**, are recommended in a European Union position paper published in 2002, stipulating policy regarding the quantification of annoyance.

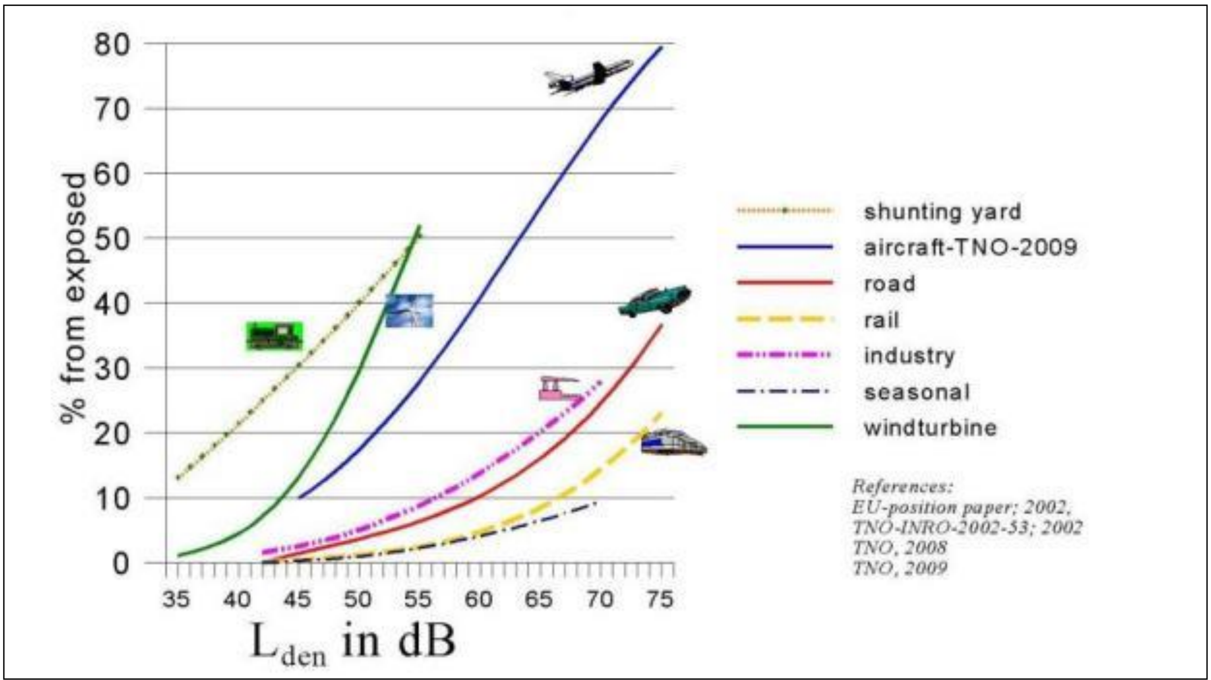

Figure 8-3: Percentage of annoyed persons as a function of the day-evening-night noise exposure at the façade of a dwelling

This can be used in Environmental Health Impact Assessment and cost-benefit analysis to translate noise maps into overviews of the numbers of persons that may be annoyed, thereby giving insight into the situation expected in the long term. It is not applicable to local complaint type situations or to an assessment of the short-term effects of a change in noise climate.

8.3.5 Determining the Significance of the Noise Impact

Impact assessment criteria were supplied by the main consultant SiVEST, and will be considered for the noise impact assessment. The methodology criteria are highlighted below. During the Environmental Noise Impact Assessment (EIA) these tables will be updated to suit the needs of an acoustical assessment.

The impact consequence is determined by the summing the scores of probability score (**Table 8-5**), duration (**Table 8-3**), extent (**Table 8-4**), reversibility (**Table 8-6**), irreplaceability (**Table 8-7**) and cumulative effect (**Table 8-8**). The impact significance) is determined by multiplying the consequence result with the Magnitude (**Table 8-2**).

An explanation of the impact assessment criteria is defined in the following tables.

Table 8-2: Impact Assessment Criteria - Magnitude

Describes the severity of an impact.		
Rating	**Description**	**Score**
Low	Impact affects the quality, use and integrity of the system/component in a way that is barely perceptible.	1
Medium	Impact alters the quality, use and integrity of the system/component but system/ component still continues to function in a moderately modified way and maintains general integrity (some impact on integrity).	2
High	Impact affects the continued viability of the system/component and the quality, use, integrity and functionality of the system or component is severely impaired and may temporarily cease. High costs of rehabilitation and remediation.	3
Very high	Impact affects the continued viability of the system/component and the quality, use, integrity and functionality of the system or component permanently ceases and is irreversibly impaired (system collapse). Rehabilitation and remediation often impossible. If possible rehabilitation and remediation often unfeasible due to extremely high costs of rehabilitation and remediation.	4

Table 8-3: Impact Assessment Criteria - Duration

This describes the duration of the impacts on the environmental parameter. Duration indicates the lifetime of the impact as a result of the proposed activity.		
Rating	**Description**	**Score**
Short term	The impact and its effects will either disappear with mitigation or will be mitigated through natural process in a span shorter than the construction phase (0 – 1 years), or the impact and its effects will last for the period of a relatively short construction period and a limited recovery time after construction, thereafter it will be entirely negated (0 – 2 years).	1
Medium term	The impact and its effects will continue or last for some time after the construction phase but will be mitigated by direct human action or by natural processes thereafter (2 – 10 years).	2
Long term	The impact and its effects will continue or last for the entire operational life of the development, but will be mitigated by direct human action or by natural processes thereafter (10 – 50 years).	3
Permanent	The only class of impact that will be non-transitory. Mitigation either by man or natural process will not occur in such a way or such a time span that the impact can be considered transient (Indefinite).	4

Table 8-4: Impact Assessment Criteria –Extent

This is defined as the area over which the impact will be expressed. Typically, the severity and significance of an impact have different scales and as such bracketing ranges are often required. This is often useful during the detailed assessment of a project in terms of further defining the determined.		
Rating	**Description**	**Score**
Site	The impact will only affect the site	1
Local/district	Will affect the local area or district	2
Province/region	Will affect the entire province or region	3
International and National	Will affect the entire country	4

Table 8-5: Impact Assessment Criteria - Probability

This describes the chance of occurrence of an impact		
Rating	**Description**	**Score**
Unlikely	The chance of the impact occurring is extremely low (Less than a 25% chance of occurrence).	1
Possible	The impact may occur (Between a 25% to 50% chance of occurrence).	2
Probable	The impact will likely occur (Between a 50% to 75% chance of occurrence).	3
Definite	Impact will certainly occur (Greater than a 75% chance of occurrence).	4

Table 8-6: Impact Assessment Criteria - Reversibility

This describes the degree to which an impact on an environmental parameter can be successfully reversed upon completion of the proposed activity.		
Rating	**Description**	**Score**
Completely reversible	The impact is reversible with implementation of minor mitigation measures	1
Partly reversible	The impact is partly reversible but more intense mitigation measures are required.	2
Barely reversible	The impact is unlikely to be reversed even with intense mitigation measures.	3
Irreversible	The impact is irreversible and no mitigation measures exist.	4

Table 8-7: Impact Assessment Criteria - Irreplaceability

This describes the degree to which resources will be irreplaceably lost as a result of a proposed activity.		
Rating	**Description**	**Score**
No loss of resource.	The impact will not result in the loss of any resources.	1
Marginal loss of resource	The impact will result in marginal loss of resources.	2
Significant loss of resources	The impact will result in significant loss of resources.	3
Complete loss of resources	The impact is result in a complete loss of all resources.	4

Table 8-8: Impact Assessment Criteria – Cumulative effect

This describes the cumulative effect of the impacts on the environmental parameter. A cumulative effect/impact is an effect which in itself may not be significant but may become significant if added to other existing or potential impacts emanating from other similar or diverse activities as a result of the project activity in question.		
Rating	**Description**	**Score**
Negligible Cumulative Impact	The impact would result in negligible to no cumulative effects	1
Low Cumulative Impact	The impact would result in insignificant cumulative effects	2
Medium Cumulative impact	The impact would result in minor cumulative effects	3
High Cumulative Impact	The impact would result in significant cumulative effects	4

8.3.6 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 Significance Rating (SR) value for each impact (prior to the implementation of mitigation measures).

Significance without mitigation is rated on the following scale:

Points	Impact Significance Rating	Description
6 to 28	Negative Low impact	The anticipated impact will have negligible negative effects and will require little to no mitigation.
6 to 28	Positive Low impact	The anticipated impact will have minor positive effects.
29 to 50	Negative Medium impact	The anticipated impact will have moderate negative effects and will require moderate mitigation measures.
29 to 50	Positive Medium impact	The anticipated impact will have moderate positive effects.
51 to 73	Negative High impact	The anticipated impact will have significant effects and will require significant mitigation measures to achieve an acceptable level of impact.
51 to 73	Positive High impact	The anticipated impact will have significant positive effects.
74 to 96	Negative Very high impact	The anticipated impact will have highly significant effects and are unlikely to be able to be mitigated adequately. These impacts could be considered "fatal flaws".
74 to 96	Positive Very high impact	The anticipated impact will have highly significant positive effects.

8.4 Representation of Noise Levels

Noise rating levels will be calculated in the ENIA report using the appropriate sound propagation models as defined. It is therefore important to understand the difference between sound or noise level as well as the noise rating level (also see Glossary of Terms, **Appendix A**).

Sound or noise levels generally refers to a level as measured using an instrument, whereas the noise rating level refers to a calculated sound exposure level to which various corrections and adjustments was added. These noise rating levels are further processed into a 3D map illustrating noise contours of constant rating levels or noise isopleths. In the ENIA it will be used to illustrate the potential extent of the calculated noises of the complete project and not noise levels at a specific moment in time.

9 ASSUMPTIONS AND LIMITATIONS

9.1 MEASUREMENTS OF AMBIENT SOUND LEVELS

- While the ambient sound levels discussed in this report was measured a number of years ago, the data will still be relevant. As the area did not experience developmental changes, ambient sound levels will still be similar.
- Ambient sound levels are the cumulative effects of innumerable sounds generated at various instances both far and near. High measurements may not necessarily mean that noise levels in the area are high. Similarly, a low sound level measurement will not necessarily mean that the area is always quiet, as sound levels will vary over seasons, time of the day, faunal characteristics, vegetation in the area and meteorological conditions (especially wind). This is excluding the potential effect of sounds from anthropogenic origin. It is impossible to quantify and identify the numerous sources that influenced one 10-minute measurement using the reading result at the end of the measurement. Therefore trying to define ambient sound levels using the result of one 10-minute measurement will be very inaccurate (very low confidence level in the results) for the reasons mentioned above. The more measurements that can be collected at a location the higher the confidence levels in the ambient sound level determined. The more complex the sound environment, the longer the required measurement. It is assumed that the measurement locations represents other residential dwellings in the area (similar environment), yet, in practice this can be highly erroneous as there are numerous factors that can impact on ambient sound levels, including;
    - the distance to closest trees, number and type of trees as well as the height of trees;
    - available habitat and food for birds and other animals;
    - distance to residential dwelling, type of equipment used at dwelling (compressors, air-cons);
    - general maintenance condition of house (especially during windy conditions); and
    - a number and type of animals kept in the vicinity of the measurement locations.
- Measurement locations for this project were selected to be in a relative quiet area, away from the residential dwelling to minimize the potential of extraneous noises impacting on the ambient sound levels,
- Exact location of a sound level meter in an area in relation to structures, infrastructure, vegetation and external noise sources will influence measurements. It may determine whether one is measuring anthropogenic sounds from a receptors dwelling, or environmental ambient soundscape contributors of significance (faunal,

roads traffic, railway line movement etc.). At times there are extraneous noises that cannot be heard during deployment, or not operational, that can significantly impact on readings (such as water pumps, transformers, faunal communication, etc.);

- Determination of existing road traffic and other noise sources of significance are important (traffic counts etc.) – when close to any busy or significant roads. Traffic however is highly dependent on the time of day as well as general agricultural activities taking place during the site investigation. Traffic noise is one of the major components in urban areas and could be a significant source of noise during busy periods. This study found that traffic in the area was very low, yet it cannot be assumed that it is always low.
- Measurements over wind speeds of 3m/s could provide data influenced by wind-induced noises. While the windshields used limits the effect of fluctuating pressure across the microphone diaphragm, the effect of wind-induced noises in the trees in the vicinity of the microphone did impact on the ambient sound levels. The site visit unfortunately coincided with a relatively windy period;
- Ambient sound levels are depended not only time of day and meteorological conditions, but also change due to seasonal differences. Ambient sound levels are generally higher in summer months when faunal activity is higher and lower during the winter due to reduced faunal activity. Winter months unfortunately also coincide with lower temperatures and very stable atmospheric conditions, ideal conditions for propagation of noise. Many faunal species are more active during warmer periods than colder periods. Certain cicada species can generate noise levels up to 120 dB for mating or distress purposes, sometimes singing in synchronisation magnifying noise levels they produce from their tymbals[26];
- Ambient sound levels recorded near rivers, streams, wetlands, trees and bushy areas can be high. This is due to faunal activity which can dominate the sound levels around the measurement location. This generally is still considered naturally quiet and understood and accepted as features of the natural soundscape, and in various cases sought after and pleasing;
- Considering one or more sound descriptor or equivalent can improve an acoustical assessment. Parameters such as L_{AMin}, L_{AIeq}, L_{AFeq}, L_{Ceq}, L_{AMax}, L_{A10}, L_{A90} and spectral analysis forms part of the many variables that can be considered; and
- As a residential area develops the presence of people will result in increased sounds. These are generally a combination of traffic noise, voices, animals and equipment (incl. TV's and Radios). The result is that ambient sound levels will increase as an area matures.

[26] Clyne, D. *"Cicadas: Sound of the Australian Summer, Australian Geographic"* Oct/Dec Vol 56. 1999.

9.2 CALCULATING NOISE EMISSIONS ADEQUACY OF PREDICTIVE METHODS

The noise emissions into the environment from the various sources as defined will be calculated for the operational phase in detail, using the sound propagation model described in ISO 9613-2.

The following was considered:

- The octave band sound pressure emission levels of processes and equipment;
- The distance of the receiver from the noise sources;
- The impact of atmospheric absorption;
- The operational details of the proposed project, such as projected areas where activities will be taking place;
- Topographical layout; and
- Acoustical characteristics of the ground. 25% soft ground conditions were modelled, as the area where the activity would be taking place is acceptably vegetated and sufficiently uneven to allow the consideration of relatively soft ground conditions. This is because the use of hard ground conditions could represent a too precautionary situation.

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.

It is important to understand the difference between sound or noise level as well as the noise rating level (also see Glossary of Terms).

Sound or noise levels generally refers to a sound pressure level as measured using an instrument, whereas the noise rating level refers to a calculated sound exposure level to which various corrections and adjustments was added. These noise rating levels are further processed into a 3D map illustrating noise contours of constant rating levels or noise isopleths. In this project it illustrates the potential extent of the calculated noises of the complete project and not noise levels at a specific moment in time. It is used to define potential issues of concern and not to predict a noise level at a potential noise-sensitive receptor. For this the selected model is internationally recognised and considered adequate.

9.3 ADEQUACY OF UNDERLYING ASSUMPTIONS

Noise experienced at a certain location is the cumulative result of innumerable sounds emitted and generated both far and close, each in a different time domain, each having a different spectral character at a different sound level. Each of these sounds are also impacted differently by surrounding vegetation, structures and meteorological conditions that result in a total cumulative noise level represented by a few numbers on a sound level meter.

As previously mentioned, it is not the purpose of noise modelling to accurately determine a likely noise level at a certain receptor, but to calculate a noise rating level that is used to identify potential issues of concern.

9.4 UNCERTAINTIES ASSOCIATED WITH MITIGATION MEASURES

Any noise impact can be mitigated to have a low significance, however, the cost of mitigating this impact may be prohibitive, or the measure may not be socially acceptable (such as the relocation of a NSD), or the mitigation may result in the project not being economically viable. These mitigation measures may be engineered, technological or due to management commitment.

For the purpose of the EIA (determination of the significance of the noise impact) mitigation measures will be selected that is feasible, mainly focussing on management of noise impacts using rules, policy and require a management commitment. This however does not mean that noise levels cannot be reduced further, only that to reduce the noise levels further may require significant additional costs (whether engineered, technological or management).

It will be assumed the mitigation measures proposed for the construction phase were implemented and continued during the operational phase.

9.5 UNCERTAINTIES OF INFORMATION PROVIDED

While it is difficult to define the character of a measured noise in terms of numbers (third octave sound power levels in this case), it is as difficult to accurately model noise levels at a receptor from any operation. The projected noise levels are the output of a numerical model with the accuracy depending on the assumptions made during the setup of the model. Assumptions include:

- The octave sound power levels selected for processes and equipment accurately represent the sound character and power levels of this processes/equipment. The determination of these levels in itself is subject to errors, limitations and assumptions with any potential errors carried over to any model making use of these results;
- Sound power emission levels from processes and equipment change depending on the load the process and equipment is subject too. While the octave sound power level is the average (equivalent) result of a number of measurements, this measurement relates to a period that the process or equipment was subject to a certain load. Normally these measurements are collected when the process or equipment is under high load. The result is that measurements generally represent a worst-case scenario;
- As it is unknown which processes and equipment will be operational (and when operational and for how long), modelling considers a scenario where all processes and equipment are under full load for a set time period. Modelling assumptions comply with the precautionary principle and operational time periods are frequently overestimated. The result is that projected noise levels would likely over-estimate noise levels;
- Ambient sound levels vary over time of day, season and largely depend on the complexity and development character of the surrounding environment. To allow the calculation of change in ambient sound levels, a potential ambient sound level of 35 dBA is assumed. This level represents a quiet environment;
- Modelling cannot capture the potential impulsive character of a noise that can increase the potential nuisance factor;
- The impact of atmospheric absorption is simplified and very uniform meteorological conditions are considered. This is an over-simplification and the effect of this in terms of sound propagation modelling is difficult to quantify; and
- Acoustical characteristics of the ground are over-simplified with ground conditions accepted as uniform. 50% hard ground conditions will be modelled even though the area is where the facility will be located is relatively well vegetated and uneven, this will allow a more worst-case scenario.

10 PROJECTED NOISE RATING LEVELS

10.1 OPERATIONAL PHASE NOISE IMPACT

Typical day time activities would include:

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

The daytime period was not considered for the EIA. Noise generated during the day by the WEF is generally masked by other noises from a variety of sources surrounding potentially noise-sensitive developments. However, times when a quiet environment is desired (at night for sleeping, weekends etc.) ambient sound levels are more critical. The time period investigated therefore would be a quieter 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 presented layout (see **Figure 3-2**) was modelled in detail. While the developer have not yet identified a wind turbine to use, this report makes use of the sound power emission levels for an Acciona AW125 3000 wind turbine as defined in the table below. This wind turbine was selected as it is a relatively loud wind turbine and it will illustrate a worst-cast scenario (precautionary principle).

Table 10-1: Sound Power Emission Levels used for modelling: Acciona AW125

Wind Turbine: Acciona AW125/3000 at hub height 120										
Source Reference: Acciona Windpower. General Document DG200383, Rev D dated 04/04/14										
Maximum expected A-weighted Octave Sound Power Levels										
Frequency	**16**	**31.5**	**63**	**125**	**250.0**	**500**	**1000**	**2000**	**4000**	**8000**
Lpa (dB)	*not reported*	117.3	111.5	110.9	109.9	107.0	103.3	97.0	86.6	81.3
L_{WA} (dBA)	*not reported*	77.4	85.3	94.7	101.2	103.8	103.3	98.2	87.6	81.3

A-Weighted Sound Power Levels (at wind speeds)		
Wind speed at 10 m height	**Wind speed at hub height**	**Sound Power Level**
6 m/s	8.5 m/s	107.3 dBA
7 m/s	9.9 m/s	108.4 dBA
8 m/s	11.3 m/s	108.2 dBA
9 m/s	12.7 m/s	107.8 dBA
10 m/s	14.1 m/s	107.7 dBA

Total noise rating level contours are illustrated in **Figure 10-2** with **Figure 10-1** defining the noise rating levels at the closest potential noise-sensitive receptors (using a maximum noise emission level of 108.4 dBA) for different wind speeds.

Considering **Figure 5-2**, at a wind speed of 7 m/s, ambient sound levels may be around 37 dBA and a noise level higher than 42 dBA could be considered disturbing by some people. A noise level higher than 45 dBA will be higher than the MoE, WHO and IFC guideline noise limit and will be considered the upper limit for noise levels due to operational activities.

The resultant maximum night-time noise rating levels are defined in **Table 10-2** together with the change in ambient sound levels for a 7 m/s wind speed.

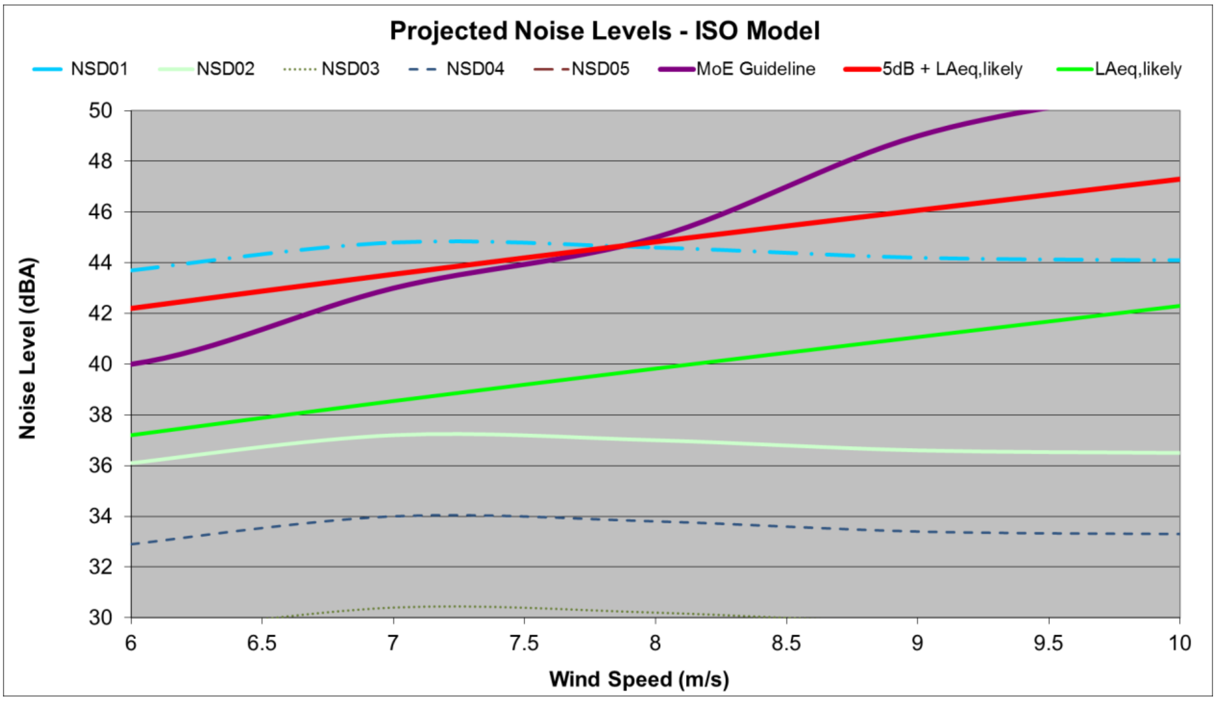

Figure 10-1: Projected noise levels at different wind speeds

10.2 POTENTIAL CUMULATIVE NOISE IMPACTS

Cumulative noise impacts generally only occur when noise sources (such as other wind turbines) are closer than 2,000m from each other (around 1,000m from the conceptual receptor located between them). The cumulative impact also only affects the area between the wind turbines of the various wind farms. However, if the wind turbines of one wind farm are further than 2,000m from the wind turbines of the other wind farm, the magnitude (and subsequently the significance) of the cumulative noise impact is reduced. If the distance between the wind turbines of two wind farms are further than 4,000m, cumulative noise impacts are non-existent.

The author reviewed the 2017 Renewable Energy Environmental Authorizations list (available from the Department of Environmental Affairs website) with only the Trakas WEF approved within 4 km from the project boundary. The cumulative noise rating levels were calculated using the sound power emission characteristics of the same Acciona wind turbine.

The resultant cumulative noise rating levels are defined in **Table 10-2** with the cumulative noise rating level contours illustrated in **Figure 10-3**. The addition of the Trakas WEF will cumulatively raise the ambient sound levels at NSD 01 significantly, mainly due to noises from the wind turbines from the Trakas WEF. The cumulative effect is less than 3 dBA (low) for all other NSD.

Table 10-2: Potential noise rating levels at a 7 m/s wind

NSD	Operational phase – Beaufort West WEF		Cumulative noise levels – Beaufort West and Trakas WEFs	
	Total projected noise level (dBA)	Potential change in ambient sound levels (dB)	Total projected noise level (dBA)	Potential change in ambient sound levels (dB)
*1**	*44.6*	*7.6*	*54.3*	*17.3*
2	37.0	0	37.3	0.3
3	30.2	0	30.4	0
4	33.8	0	34.7	0
*5**	*52.2*	*15.2*	*53.7*	*16.7*

- NSDs 01 and 05 confirmed not to be used for residential purposes

10.3 DECOMMISSIONING AND CLOSURE PHASE NOISE IMPACT

The potential for a noise impact to occur during the decommissioning and closure phase will be much lower than that of the construction and operational phases and noise from the decommissioning and closure phases will therefore not be investigated further.

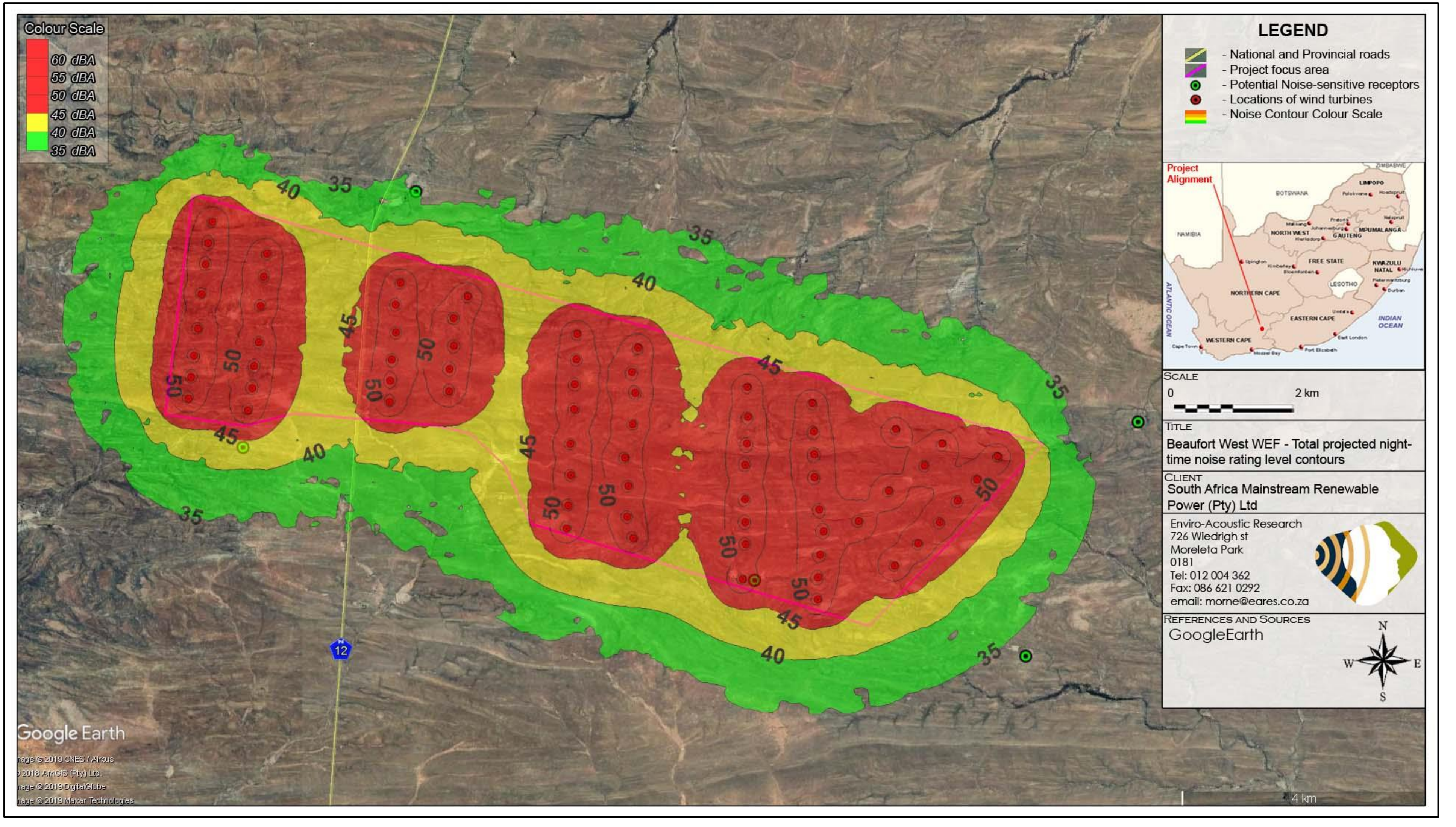

Figure 10-2: Projected conceptual night-time noise rating levels of the Beaufort West WEF during operation

Figure 10-3: Projected cumulative night-time noise rating levels in vicinity of the Beaufort West WEF

11 SIGNIFICANCE OF THE NOISE IMPACT

11.1 OPERATIONAL PHASE NOISE IMPACT

Only the night-time scenario was assessed, as this is the most critical time period when a quiet environment is desired. The noise rating levels are calculated in **section 10.1** for the various operational activities defined in **section 6.1**.

As can be seen from **Figure 10-1**, the projected noise rating levels:

- The duration (see **Table 8-3**) will be the full project life - **Long term (3)**;
- the probability (see **Table 8-5**) would be **Unlikely (1)** on NSD 02, 03 and 04;
- The wind turbines may be audible up to 1,500 m during quiet periods (see **Table 8-4**) – **Local (2)**;
- The noise impact will stop once the project terminates and the reversibility (see **Table 8-6**) is **Completely Reversible (1)**;
- The increase noise levels will **not result in an irreplaceable loss of any resource (1)** - (see **Table 8-7**);
- Excluding the impact on NSD 01 (goad shed), the operation of the wind turbines will **result in a low cumulative impact (2) -** (see **Table 8-8**);
- The intensity (see **Table 8-2**) of the projected noise levels will be low on NSD 02, 03 and 04 in the area.

The significance of the noise impact is considered to be low as assessed and summarized in **Table 11-1**.

Table 11-1: Impact Assessment: Operational Activities at night

Impact Phase: *Noise from operating wind turbines.*								
Possible Impact or Risk: *Increase in sound levels at the dwellings of receptors at night. Operating wind turbines will raise the ambient sound levels within approximately 800 m from the closest NSD.*								
Without Mitigation	**Extent**	**Probability**	**Reversibility**	**Loss of Resource**	**Duration**	**Cumulative**	**Magnitude**	**Significance**
	Local	Unlikely	Completely reversible	None	Long-term	Low	Low	Low
With Mitigation	**Extent**	**Probability**	**Reversibility**	**Loss of Resource**	**Duration**	**Cumulative**	**Magnitude**	**Significance**
	Local	Unlikely	Completely reversible	None	Long-term	Low	Low	Low
Can the impact be reversed?	*Yes – Impact will stop once activities stop.*							
Will impact cause irreplaceable loss or resources?	*No.*							
Can impact be avoided, managed or mitigated?	*Mitigation not required.*							
• *No mitigation is required.*								

11.2 CUMULATIVE NOISE IMPACT

The introduction of the Beaufort West WEF will not cumulatively raise the total noise rating level in the area.

11.3 DECOMMISSIONING PHASE NOISE IMPACT

Final decommissioning activities will have a noise impact lower than either the construction or operational phases. This is because decommissioning and closure activities normally take place during the day using minimal equipment (due to the decreased urgency of the project). While there may be various activities, there is a very small risk for a noise impact. The significance of any noise impact would be very low, similar to the construction noise impact.

11.4 EVALUATION OF ALTERNATIVES

11.4.1 Alternative 1: No-go option

The ambient sound levels will remain as is.

11.4.2 Alternative 2: Proposed Renewable Power Generation activities

The proposed renewable power generation activities (worst-case evaluated) will very slightly raise the ambient sound levels at the closest NSD (02). It is expected that the sounds from the wind turbines may be clearly audible at times but the sound level is not expected to be disturbing.

The project however, will greatly assist in the provision of energy, which will allow further economic growth and development in South Africa and locally. The project will generate short and long-term employment and other business opportunities and promote renewable energy in South Africa and locally. People in the area that are not directly affected by increased noises will have a positive perception of the project and will see the need and desirability of the project.

11.4.3 Location alternatives

The development of a WEF is highly dependent on the prevailing wind quality and character. The wind turbines will be located on the top of ridges that are not used by people. Located in an area where the population density is relatively low, the location of the facility is ideal.

12 MITIGATION OPTIONS

The study considers the potential noise impact on the surrounding environment due to operational activities during the night-time periods. It was determined that the potential noise impact would be of a low significance and no specific mitigation measures are required to further reduce noise levels.

The developer must however know that 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. At all stages surrounding receptors should be informed about the project, providing them with factual information without setting unrealistic expectations. It is counterproductive to suggest that the activities (or facility) will be inaudible due to existing high ambient sound levels. The magnitude of the sound levels 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 activities, the spectral character and that of the surrounding soundscape (both level and spectral character).

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.

12.1 MITIGATION OPTIONS AVAILABLE TO REDUCE OPERATIONAL NOISE IMPACT

The significance of noise during the operational phase is low and additional mitigation measures are not required.

It should be noted that the noise impact is based on sound power emission levels of the Acciona AW125 3000 wind turbine (sound power emission level of 108.4 dBA re 1 pW at 7 m/s) for the Beaufort West WEF. If the developer selects to use a different wind turbine with a significantly higher sound power emission level, the significance of the noise impact may rise and the noise impact should be re-evaluated.

12.2 SPECIAL CONDITIONS

12.2.1 Mitigation options that should be included in the EMP

1. The developer must investigate any reasonable and valid noise complaint if registered by a receptor staying within 2,000m from location where construction activities are taking place or operational wind turbine.

12.2.2 Special conditions that should be considered for the amended Environmental Authorization

1. The potential noise impact must again be evaluated should the layout be changed where any wind turbines are located closer than 1,000m from a confirmed NSD.
2. The potential noise impact must again be evaluated should the developer make use of a wind turbine with a sound power emission level exceeding 113 dBA re 1 pW.
3. Ensure that total noise levels are less than 45 dBA at NSD where structures are used for residential purposes.
4. The developer must investigate any reasonable and valid noise complaint if registered by a receptor staying within 2,000m from location where construction activities are taking place or operational wind turbine.

13 ENVIRONMENTAL MANAGEMENT PLAN

13.1 OPERATIONAL PHASE

Projected noise levels during operation of the Wind Energy Facility were modelled using the methodology as proposed by ISO 9613-2.

The resulting future noise projections indicated that the operation of the facility may not comply with the acceptable rating levels proposed in this report. The changes in ambient sound levels (as assumed) may exceed the 5 dBA limit set by the Western Cape Provincial Noise Control Regulations at the identified NSD. The significance of the noise impact will be **low** and further mitigation measures are not required or recommended. No additional sound and noise measurements are recommended.

The following measures are proposed to define the performance of the developer in terms of best international practice.

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; and • Disturbing character of noise from the wind turbines.
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; • Ensure that total noise levels are less than 45 dBA at NSD where structures are used for residential purposes; • Prevent the generation of nuisance noises; • Ensure acceptable noise levels at surrounding stakeholders and potentially sensitive receptors.

Mitigation: Action/Control	**Responsibility**	**Timeframe**
Add noise monitoring points at any complainants that registered a valid noise complaint relating to the operation of the WEF	- Acoustical Consultant	With monitoring programme

Performance indicator	**Ensure that the change in ambient sound levels as experienced by Potentially Sensitive Receptors is less than 5 dBA**
Monitoring	If a valid and reasonable complaint is registered (NSD within 2,000 m) relating to the operation of the facility additional noise monitoring should be undertaken as recommended by an acoustic consultant.

14 ENVIRONMENTAL MONITORING PLAN

Environmental Noise Measurement can be divided into two distinct categories, namely:

- Passive measuring – the registering of any complaints (reasonable and valid) regarding noise; and
- Active measuring – the measurement of noise levels at identified locations.

No active environmental noise monitoring is recommended due to the low significance of a noise impact occuring. Should a reasonable and valid complaint about noise be registered, it is the responsibility of the developer to investigate this complaint as per the following sections. It is recommended that the noise investigation be done by an independent acoustic consultant. A valid and reasonable noise complaint would be from a NSD staying within 2,000 m from the closest wind turbine.

While this section recommends a noise monitoring programme, it should be used as a guideline as site specific conditions may require that the monitoring locations, frequency or procedure be adapted.

14.1 MEASUREMENT LOCALITIES AND PROCEDURES

14.1.1 Measurement Localities

Noise measurements must be conducted at the location of the person that registered a valid and reasonable noise complaint. The measurement location should consider the direct surroundings to ensure that other sound sources cannot influence the reading. A second instrument must be deployed at a control point away from the potential noise source during the measurement period.

14.1.2 Measurement Frequencies

Once-off measurements if and when a reasonable and valid noise complaint is registered. Results and feedback must be provided to the complainant. If required and recommended by an acoustic consultant, there may be follow-up measurements or a noise monitoring programme can be implemented.

14.1.3 Measurement Procedures

Measurements should be collected in 10-minute bins defining the 10-minute descriptors such as $L_{Aeq,I}$ (National Noise Control Regulation requirement), $L_{A90,f}$ (background noise level as used internationally) and $L_{Aeq,f}$ (noise level used to compare with IFC noise limit).

Best fit analysis should be conducted on the data, where a best-fit graph are fitted through the sound (noise) levels versus the wind speeds to determine average noise levels at a set wind speed. Spectral frequencies should also be measured to define the potential origin of noise and illustrate the spectral character of the sounds measured. When a noise complaint is being investigated, measurements should be collected during a period or in conditions similar to when the receptor experienced the disturbing noise event.

14.2 RELEVANT STANDARD FOR NOISE MEASUREMENTS

Noise measurements must be conducted as required by the National Noise Control Regulations (GN R154 of 1992) and SANS 10103:2008. It should be noted that the SANS standard also refers to a number of other standards.

14.3 DATA CAPTURE PROTOCOLS

14.3.1 Variables to be analysed

Measurements should be collected in 10-minute bins defining the 10-minute descriptors such as $L_{Aeq,I}$ (National Noise Control Regulation requirement), $L_{A90,f}$ (background noise level as used internationally) and $L_{Aeq,f}$ (Noise level used to compare with IFC noise limit). Noise levels should be co-ordinated with the 10-m wind speed. Spectral frequencies should also be measured to define the potential origin of noise and illustrate the spectral character of the sounds measured.

14.4 STANDARD OPERATING PROCEDURES FOR REGISTERING A COMPLAINT

When a noise complaint is registered, the following information must be obtained:

- Full details (names, contact numbers, location) of the complainant;
- Date and approximate time when this non-compliance occurred;
- Description of the noise or event;
- Description of the conditions prevalent during the event (if possible).

15 CONCLUSIONS AND RECOMMENDATIONS

This report is an Environmental Noise Impact Assessment of the predicted noise environment due to the development of the proposed Beaufort West WEF south of Beaufort West, Western Cape Province. The report considers the ambient sound levels previously measured in similar areas, the author's expertise, as well as a output of sound propagation model (making use of the worst-case scenario in terms of the precautionary approach) to identify potential issues of concern.

The potential noise impact of operational activities is of a low significance on surrounding receptors staying in the area. The addition of the Trakas WEF will cumulatively increase the ambient sound levels in the area but the significance of the cumulative noise impact will be **low**. The Rietpoort Game Reserve area will be well outside the acoustic zone of influence from the wind turbines and noise impact will be insignificant.

The potential noise impact must again be evaluated should the layout be changed where any wind turbines are located closer than 1,000 m from a confirmed NSD (where the structure is used for residential purposes) or if the developer decides to use a different wind turbine that has a sound power emission level higher than the Acciona WTG used in this report (sound power emission level exceeding 113 dBA re 1 pW).

Considering the requirements of a Part 2 Amendment, the following can be concluded:

- The proposed change in turbine specifications will not result in a noise impact that is significantly different from the potential noise impact from the authorized wind turbine specifications;
- The proposed change in turbine specifications will not introduce any new advantages or disadvantages in terms of acoustics;
- This noise impact assessment provides clear and more specific mitigation measures to ensure that the projected noise impact will be managed to a low level at all the identified structures that may be used for residential purposes. This assessment did consider the worst-case scenario.

Considering the **low** significance of the noise impacts (after mitigation, inclusive of cumulative impacts), it is the opinion of the author that the proposed amendment to the hub height and rotor diameter (from 150m to 200m) of the Beaufort West WEF be authorised.

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APPENDIX A

Glossary of Acoustic Terms, Definitions and General Information

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 not 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.
Attenuation	Term used to indicate reduction of noise or vibration, by whatever method necessary, usually expressed in decibels.
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.
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.
Broadband Noise	Spectrum consisting of a large number of frequency components, none of which is individually dominant.
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.
Controlled area (as per National Noise Control Regulations)	a piece of land designated by a local authority where, in the case of- (a) road transport noise in the vicinity of a road- (i) the reading on an integrating impulse sound level meter, taken outdoors at the end of a period extending from 06:00 to 24:00 while such meter is in operation, exceeds 65 dBA; or (ii) the equivalent continuous "A"-weighted sound pressure level at a height of at least 1,2 metres, but not more than 1,4 metres, above the ground for a period extending from 06:00 to 24:00 as calculated in accordance with SABS 0210-1986, titled: "Code of Practice for calculating and predicting road traffic noise", published under

	Government Notice No. 358 of 20 February 1987, and projected for a period of 15 years following the date on which the local authority has made such designation, exceeds 65 dBA; (b) aircraft noise in the vicinity of an airfield, the calculated noisiness index, projected for a period of 15 years following the date on which the local authority has made such designation, exceeds 65 dBA; or (c) industrial noise in the vicinity of an industry- (i) the reading on an integrating impulse sound level meter, taken outdoors at the end of a period of 24 hours while such meter is in operation, exceeds 61 dBA; or (ii) the calculated outdoor equivalent continuous "A"-weighted sound pressure level at a height of at least 1,2 metres, but not more than 1,4 metres, above the ground for a period of 24 hours, exceeds 61 dBA;
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	The process whereby an acoustic wave is disturbed and its energy redistributed in space as a result of an obstacle in its path, 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). It is a calculated value.
F (fast) time weighting	(1) Averaging detection time used in sound level meters. (2) Fast setting has a time constant of 125 milliseconds and provides a fast reacting display response allowing the user to follow and measure not too

	rapidly fluctuating sound.
Footprint area	Area to be used for the construction of the proposed development, which does not include the total study area.
Free Field Condition	An environment where there is no reflective surfaces.
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 Greenfield is Brownfield, which is a site previously developed and used by an enterprise, especially for a manufacturing or processing operation. The term Brownfield 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.
I (impulse) time weighting	(1) Averaging detection time used in sound level meters as per South African standards and Regulations. (2) Impulse setting has a time constant of 35 milliseconds when the signal is increasing (sound pressure level rising) and a time constant of 1,500 milliseconds while the signal is decreasing.
Impulsive sound	A sound characterized by brief excursions of sound pressure (transient signal) that significantly exceed the ambient sound level.
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.
L_{A90}	the sound level exceeded for the 90% of the time under consideration
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.
L_{AMin} *and* L_{AMax}	Is the RMS (root mean squared) minimum or maximum level of a noise source.
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
Reflection	Redirection of sound waves.
Refraction	Change in direction of sound waves caused by changes in the sound wave velocity, typically when sound wave propagates in a medium of different density.
Reverberant Sound	The sound in an enclosure which results from repeated reflections from the boundaries.
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.
S (slow) time weighting	(1) Averaging times used in sound level meters. (2) Time constant of one [1] second that gives a slower response which helps average out the display fluctuations.
Sound Level	The level of the frequency and time weighted sound pressure as determined by a sound level meter, i.e. A-weighted sound level.
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).
Tread braked	The traditional form of wheel brake consisting of a block of friction material (which could be cast iron, wood or nowadays a composition material) hung from a lever and being pressed against the wheel tread by air pressure (in the air brake) or atmospheric pressure in the case of the vacuum brake.
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 SANS 10103:2008.

End of Report

Appendix C4

VISUAL IMPACT ASSESEMENT

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Established 1952

South Africa Mainstream Renewable Power
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7735

Your reference:	N/A
Our reference:	15656_BW
Date:	27 June 2019

ATTENTION: REBECCA THOMAS

Dear Ms Thomas

VISUAL SPECIALIST COMMENT IN RESPECT OF PROPOSED AMENDMENTS TO THE AUTHORISED TURBINE SPECIFICATIONS FOR THE BEAUFORT WEST WIND FARM NEAR BEAUFORT WEST, WESTERN CAPE PROVINCE

- **DEA Reference: 12/12/20/1784/1**

1. INTRODUCTION

South Africa Mainstream Renewable Power Developments (Pty) Ltd (hereafter referred to as Mainstream) was issued with an Environmental Authorisation (EA) for the proposed 140MW Beaufort West Wind Farm, near Beaufort West in the Western Cape Province on 13 February 2017 (DEA Reference 12/12/20/1784/1). This authorisation made provision for the construction of a total number of 70 wind turbines, each with a hub height of up to 150m and a rotor diameter of 150m.

Mainstream is now proposing to submit a Part 2 Amendment application to change the approved turbine specifications for the Beaufort West Wind Farm to allow for turbines with a hub height of up to 200m and a rotor diameter of up to 200m.

Following on from the visual assessment conducted for the Beaufort West Wind Farm, SiVEST has been requested to provide visual specialist comment in respect of the proposed amendments.

2. BACKGROUND

The Beaufort West Wind Farm originally formed part of development proposal for a Wind and Solar Energy facility which was authorised on 20 March 2012 (DEA Reference 12/12/20/1784). The VIA for this development, conducted by Visual Specialist Bernard Oberholzer in September 2010, assessed the potential visual impacts in relation to the PV array as well as the wind farm layouts, on non-adjacent land parcels, comprising 260 turbines. Turbine specifications included a hub height of 80m and a rotor diameter up to 101m (i.e. a maximum height of 130.5m at blade tip). This VIA found that the overall visual impact rating for the proposed 260 turbine development would be high and the significance of these impacts would also be high. It was however stated that impact ratings could be reduced with the implementation of recommended mitigation measures.

Subsequently, Mainstream proposed amendments to the authorisation which involved dispensing with the northern-most site and splitting the southern component of the development into two separate 140MW wind farms, namely Beaufort West Wind Farm and Trakas Wind Farm. Site layouts and turbine specifications were also amended to allow for up to 70 turbines on each wind farm, with a hub height and rotor diameter of 150m (i.e. a maximum height of 225m at blade tip). These amendments were assessed by Bernard Oberholzer and the results were provided in the visual specialist comment letter dated 5 February 2016. This assessment concluded that the change in visual significance of the proposed amendment would be marginal, and that the original visual impact significance ratings of the original VIA Report would therefore not change.

3. SPECIALIST COMMENT

The new turbine specifications being proposed as part of this amendment would allow for a maximum height (at blade tip) of 300m, approximately equivalent to a 100-storey building, some 75m higher than the height currently authorised. The significance of this change from a visual perspective is assessed below.

The increased height as proposed will increase the visibility of the turbines and extend the area from which the turbines will be visible (viewshed). This will be exacerbated by the lack of natural screening elements in the broader study area resulting from the relatively flat terrain and the prevalence of sparse shrubland vegetation cover. However, comparison of the viewshed based on the approved turbine height (225m) with the viewshed based on the proposed new turbine height (300m) showed only minor increases in the area of visibility within a 10km radius of the proposed WEF.

It is important to note that visual impacts are only experienced when there are receptors present to experience this impact. The original VIA for this development found that the broader study area is not typically valued for its tourism significance and there is limited human habitation resulting in relatively few potentially sensitive receptors in the area. In light of this and given the relatively remote location of the proposed Beaufort West Wind Farm, the extended viewshed is unlikely to affect any additional receptors.

Visual impacts resulting from the larger turbines would be greatest within a 1km to 2km radius, from where the increased height of the structure would be most noticeable. The VIA for Beaufort West identified one sensitive receptor within the viewshed of the proposed wind farm, this being Rietpoort Game Farm. The farm Rietpoort No 13 comprises multiple farm portions across a relatively extensive area. The exact location and extent of the Game Farm operation is not known and as such it is not possible to accurately determine the proximity of this receptor to the nearest turbine placement. Some portions of the site are only 2.2km from the nearest turbine location, while other portions are more than 10km from the nearest turbine. In addition, there are small areas on the farm which are outside the viewshed for the proposed development. Hence increases in the authorised turbine height would only be marginally noticeable from the north-eastern sector of the farm and visual impacts resulting from the larger turbines would only be marginally increased. The overall visual impact on the remainder of the farm is expected to remain largely unchanged.

The VIA also identified the N12 national route as being an important arterial route in the area and hence this route could be seen as a potentially sensitive receptor road. This road traverses the Beaufort West development site and passes within 600m of the nearest turbine. As such, increases in the turbine height will be noticeable from sections of this road. It was however noted in the VIA that the section of the N12 which passes through the study area is not considered a scenic route and as such the visual impact of the turbines on passing motorists would only be rated as moderate. Mitigation measures provided in respect of the possible effects of shadow flicker remain valid.

As previously stated, the Beaufort West Wind Farm VIA determined that the overall visual impact rating for the proposed development would be high and the significance of these impacts would also be high. It was however stated that impact ratings could be reduced with the implementation of recommended mitigation measures. In light of the above comments, the increase in the proposed turbine height will not change this impact rating. Furthermore, no additional recommendations or mitigation measures will be required and all of the mitigation measures set out in the VIA remain valid.

4. IMPACT STATEMENT

It is SiVEST's opinion that the proposed changes to the authorised turbine specifications for Beaufort West Wind Farm do not give rise to additional visual impacts or exacerbate the impacts previously identified in the VIA for this development. Given the low level of human habitation and the relative absence of sensitive receptors in the area, the increased turbine height is deemed acceptable from a visual perspective and the Environmental Authorisation (EA) should be amended. SiVEST is of the opinion that the impacts associated with the construction, operation and decommissioning phases can be mitigated to acceptable levels provided the recommended mitigation measures are implemented.

Yours sincerely

Andrea Gibb
Divisional Manager
SiVEST Environmental