ARCUS

GREAT KEI WIND ENERGY FACILITY
EA AMENDMENT REPORT

BAT ASSESSMENT

On behalf of

CES – Environmental and Social Advisory Services

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Prepared By:

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1 INTRODUCTION

Great Kei Wind Power (Pty) Ltd ("the applicant") received environmental authorisation for the Great Kei Wind Energy Facility (WEF) on 18 May 2016 (which was subsequently amended on 13 February 2017). The applicant is proposing to amend the turbine specifications for the Great Kei Wind Energy Facility as follows:

- Increase the rotor diameter from 140 m to up to 175 m (i.e. increase blade length from 70 m to up to 87.5 m)
- Hub height increase from 140 m to up to 140 m
- Reduce the number of turbines from 45 to 37

1.1 Terms of Reference

The report has been compiled under the following terms of reference and provides:

- An assessment of all impacts related to the proposed changes;
- Advantages and disadvantages associated with the changes;
- Comparative assessment of the impacts before the changes and after the changes; and
- Measures to ensure avoidance, management and mitigation of impacts associated with such proposed changes, and any changes to the EMPr.

2 METHODOLOGY

In carrying out this assessment, Arcus conducted a literature review on bats and wind energy impacts with a focus on the relationship between turbine size and bat fatality. The literature review was carried out using the Web of Science® and Google Scholar using the following search terms:

bat OR fatality OR wind energy OR turbine OR wind turbine OR fatalities OR mortality OR mortalities OR kill* OR tower height OR height OR rotor swept zone OR rotor zone OR rotor swept area OR blades OR turbine blades OR influence OR increas* OR trend OR positive OR decreas* OR relation* OR wind farm OR wind energy facility OR carcass* OR chiroptera OR rotor diameter OR correlat* OR size*

To compare the current assessed impacts of the Great Kei WEF to those related to the proposed changes, the final environmental impact report (September 2015) was reviewed. The environmental management plan was also reviewed to assess the current mitigation measures that are to be adhered to. In addition, all relevant Environmental Authorisations and the pre-construction bat monitoring report for the Great Kei WEF were reviewed. The pre-construction monitoring was conducted between September 2013 and February 2015. Finally, to assist with the cumulative impact assessment, the post-construction monitoring report of the operational neighbouring Chaba Wind Farm was also reviewed.

3 REVIEW

The core issue relevant to this assessment is the impact to bats of amending the size of the turbines at the Great Kei WEF. Currently, the rotor swept area for each turbine will be 15,394 m^2 assuming turbines with blade lengths of 70 m. The amendment would result in an increase of the rotor swept area to 24,053 m^2 assuming turbines with blade lengths of 87.5 m. The minimum and maximum tip heights currently approved will be 70 m and 210 m respectively.

Numerous studies support the hypothesis that taller wind turbines are associated with higher numbers of bat fatalities. Rydell et al. (2010) found a significant positive correlation between bat mortality with both turbine tower height and rotor diameter in Germany. However, there was no significant relationship between bat mortality and the minimum distance between the rotor and the ground. The maximum tower height in their study was

98 m and data on rotor diameter were not given. In addition, there was no relationship between bat fatality and the number of turbines at a wind energy facility.

In Greece, Georgiakakis et al. (2012) found that bat fatalities were significantly positively correlated with tower height but not with rotor diameter. In their study, maximum tower height and rotor diameter were 60 m and 90 m respectively. In Minnesota and Tennessee, USA, both Johnson et al. (2003) and Fiedler et al. (2007) showed that taller turbines with a greater rotor swept area killed more bats. The maximum heights of turbines in these two studies were 50 m and 78 m respectively. In Alberta, Canada, bat fatality rates differed partly due to differences in tower height but the relationship was also influenced by bat activity (Baerwald and Barclay 2009). For example, sites with high activity but relatively short towers had low bat fatality and sites with low activity and tall towers also had low bat fatality. At sites with high bat activity, an increase in tower height increased the probability of fatality. Maximum turbine height and rotor diameter in this study was 84 m and 80 m respectively. Despite the above support for the hypothesis that taller wind turbines kill more bats, in a review of 40 published and unpublished studies in North America, Thompson et al. (2017) found no evidence that turbine height or the number of turbines influences bat mortality. Berthinussen et al. (2014) also found no evidence of modifying turbine design to reduce bat fatalities. The relationship between bat mortality and turbine size, or number of turbines at a wind energy facility, is therefore equivocal.

Turbine size has increased since the above studies were published and no recent data of the relationship between bat fatality and turbine size are available. The maximum size of the turbines in the literature reviewed (where indicated in each study) for this assessment had towers of 98 m and rotor diameters of 90 m. Some towers were as short as 44 m and had blade tips extending down to only 15 m above ground level.

It is possible that some bats species, particularly those not adapted to use open air spaces, are being killed at the lower sweep of the turbine blades so having a shorter distance between the ground and the lowest rotor tip point may have a negative impact and potentially place a greater diversity of species at risk. Higher hub height and longer blades can intrude more into the higher air space and possibly have a negative impact on free-tailed bats. In South Africa, evidence of fatality for species which typically do not forage in open spaces high above the ground, is available from several wind energy facilities (Aronson et al. 2013; Doty and Martin 2012; MacEwan 2016). Although Rydell et al. (2010) did not find a significant relationship between bat mortality and the minimum distance between the rotor and the ground, data from Georgiakakis et al. (2012) suggest that as the distance between the blade tips and the ground increases, bat fatality decreases.

It is not known what the impact of the size of turbines proposed for the Great Kei WEF would be to bats because of a lack of published data from wind energy facilities with turbines of a comparative size. Hein and Schirmacher (2016) suggest that bat fatality should continue to increase as turbines intrude into higher airspaces because bats are known to fly at high altitudes (McCracken et al. 2008; Peurach et al. 2009; Roeleke et al. 2018). However, McCracken et al. (2008), who recorded free-tailed bats in Texas from ground level up to a maximum height of 860 m, showed that bat activity was greatest between 0 and 99 m. This height band accounted for 27 % of activity of free-tailed bats, whereas the 100 m to 199 m height band only accounted for 6 %.

In South Africa, simultaneous acoustic monitoring at ground level and at height is a minimum standard for environmental assessments at proposed wind energy facilities. Based on unpublished data from 18 such sites Arcus has worked at, bat activity and species diversity is greater nearer ground level than at height. Therefore, even though bats are recorded at heights that would put them at risk from taller turbines, the proportion of bats that would be at risk might be less. Further, the number of species that might be impacted would decrease because not all bat species use the airspace congruent with the rotor swept area of modern turbines owing to morphological adaptations related to flight and echolocation. Bats that are adapted to use open air space, such as free-tailed and sheath-tailed bats, would be more at risk.

In the United Kingdom, both Collins and Jones (2009) and Mathews et al. (2016) showed that fewer species, and less activity, were recorded at heights between 30 m and 80 m compared to ground level. In two regions in France, Sattler and Bontadina (2005) recorded bat activity at ground level, 30 m, 50 m, 90 m and 150 m and found more species and higher activity at lower altitudes. Roemer et al. (2017) found that at 23 met masts distributed across France and Belgium, 87 % of bat activity recorded was near ground level. However, the authors also showed a significant positive correlation between a species preference for flying at height and their collision susceptibility, and between the number of bat passes recorded at height and raw (i.e. unadjusted) fatality counts. In a similar study in Switzerland, most bat activity was recorded at lower heights for most species but the European free-tailed bat had greater activity with increasing height (Wellig et al. 2018).

4 IMPACT ASSESSMENT

4.1 Effect of the Amendment on Current Impacts

Of the impacts identified in the EIA (September 2015), only mortality of species due to collision with turbine blades are relevant to this amendment. According to the results of the pre-construction monitoring, the potential significance of bat mortality was rated as high before and moderate after mitigation in the EIA. Although the amendment would result in an increase in impacts to bats because of the larger rotor swept area and changes to turbine dimensions, the significance remains high before and moderate after mitigation.

The applicant is undertaking this amendment to allow for flexibility in choosing the size of the turbines. This choice will presumably be made based on the wind regime at the site and the availability of cost effective wind turbines. However, this flexibility makes it difficult to assess impacts because turbines of different size may have different impacts.

At the Chaba Wind Farm, which is adjacent to Great Kei, the minimum blade tip height is 28 m and fatalities of Cape serotine, Natal Long Fingered bat and Temmink’s Myotis were reported. These are clutter-edge foraging species which typically do not forage in the open air, high above the ground. These fatalities suggest that a minimum blade tip height of 28 m is not sufficient to reduce the impacts on lower flying species in the area. The Cape serotine and Natal Long Fingered bat have been recorded flying at higher heights (e.g. 90 m) but their activity levels appear to decline exponentially with height (Arcus, unpublished data). Therefore, a minimum blade tip height of at least 45 m must be used and the impact assessment assumes this. If the blades sweep down closer to the ground, the associated impacts would be higher. An appropriate combination of hub height and rotor diameter will therefore need to be selected to order to limit the blade sweep to 45 m above the ground. Apart from the minimum blade sweep, it is also important to select a blade length that limits impacts to higher flying species.

Higher flying species that may occur in the study area include the Egyptian free-tailed bat, Mauritian tomb bat, Egyptian rousette, Wahlberg's epauletted fruit bat, Angolan free-tailed bat and Little free-tailed bat. The Egyptian free-tailed bat and Little free-tailed bat have been confirmed to occur in the study area. The pre-construction monitoring data showed that at 50 m the Egyptian free-tailed bat accounted for 85 % of the activity and at the Chaba Wind Farm it accounted for 80% of the fatalities. High flying species are clearly at greater risk but there are no activity data above 60 m for any of these species so it if difficult to determine what length to limit the blades to reduce this risk. In addition, all of these species may be active across most of the rotor swept zone so it is impractical to assign specific turbine dimensions for high flying species, other than to limit the rotor swept zone as much as possible.

4.2 Effect of the Amendment on Mitigation Measures

The main mitigation measures proposed in the EIA and current environmental management plan (EMP), both from September 2015, are adhering to buffer zones to avoid impacts and then to use curtailment for residual impacts.

The main avoidance measure is siting turbines away from important bat habitats. The pre-construction monitoring report defined areas in the study area as either moderate or high sensitivity for bats. Moderate sensitivity areas were buffered by 100 m, while high sensitivity areas were buffered by 200 m. However, current best practise requires a minimum buffer of 200 m for all important bat features. Therefore, the moderate sensitivity buffer of 100 m will need to be increased to 200 m.

While not explicitly stated in the pre-construction monitoring report, all buffers must be to blade tip. To determine the buffer distances required to ensure that no turbine blades enter the bat buffers, the following formula was used (Mitchell-Jones and Carlin 2014):

$$b = \sqrt{(bd + bl)^2 - (hh - fh)^2}$$

Where: bd = buffer distance, bl = blade length, hh = hub height and fh = feature height (zero in this instance)

The exact turbine dimensions are not known so a worst case scenario was used to update the bat buffer areas. A turbine with a low hub height (110 m) and with the maximum blade length being applied for (87.5 m) was used. Such a turbine would have a ground clearance of 22.5 m. Based on this, the turbine base must be 266 m from both the moderate and high sensitivity bat areas. This worst case results in 18 turbines falling within moderate buffers (Figure 1). These turbines will need mitigation measures applied to them (Table 2) and will need particular attention during the operational phase to monitor bat fatality.

Increasing evidence suggests that bats actively forage around wind turbines (Cryan et al. 2014; Foo et al. 2017). The installation of turbines in the landscape may alter bat activity patterns, either by increasing activity at height and/or increasing the diversity of species making use of higher airspaces. Therefore, there may still be residual impacts after these avoidance measures and additional mitigation measures may be needed to minimise residual impacts. Turbine design can help to reduce residual impacts.

Since bat activity and species composition tends to be greater and more diverse respectively at lower altitudes, maximising the lower blade tip height is preferable. This could be achieved by having either shorter blades, a higher hub height, or both. However, adjusting the hub height alone would not limit impacts to higher flying species, and a higher hub height would be detrimental to high risk species despite possibly being beneficial to lower flying species. A lower hub height would decrease blade intrusion into higher airspaces and reduce the potential impact to high flying species such as free-tailed bats, but depending on blade length, might increase impacts to lower flying species. It would therefore be preferential, for both high flying and lower flying species, to reduce rotor swept area by having shorter blades. It is difficult to determine an appropriate turbine size that would reduce impacts to both high and low flying species and as such it is likely that additional residual impacts would occur. Beyond turbine design, curtailment is a more active mitigation option to reduce these residual impacts.

Curtailment is the most effective way to reduce residual impacts to bats (Arnett and May 2016; Hayes 2019) whereas deterrent technology is still in testing stages and its effect on reducing bat fatality less known (Arnett 2013). The amendment to the turbine specifications may increase the probability that curtailment or deterrents will need to be used, especially if a larger rotor swept area is used, and the hub height lowered. A detailed curtailment plan is included in the pre-construction monitoring report and EMP. Carcass searching must take place during the operational phase for at least two years and these data must be used to refine the curtailment plan in an adaptive manner. This could result in changes to the curtailment regime such as the data and time periods under which curtailment is needed. Alternatively, or in conjunction with curtailment, deterrents can be tested to determine if they are successful in reducing bat fatalities.

4.3 Effect of the Amendment on Current EA Conditions

The amendment will result in a greater rotor swept area and there will likely be residual impacts to bats after avoidance and turbine design measures are implemented. These residual impacts will result in bat mortality and curtailment is required to reduce these impacts. Therefore, the EA and EMP need to be amended to include a condition that curtailment for bats must be implemented following the recommendations in this report. The EA and EMP must also stipulate that the curtailment regime must be continually assessed and adapted in response to bat fatality levels. Condition 36 of the EA states that a 500 m buffer must be kept around all streams, farm reservoirs, dams and farm buildings. For bats, the appropriate buffer areas have already been applied based on best practise and as such the 500 m buffer is not applicable to bats. Condition 44 of the EA must include that operational monitoring reports must be sent to the South African Bat Assessment Advisory Panel on a quarterly basis.

The pre-construction bat monitoring report stated that blade feathering must be used as the initial curtailment regime and this is reflected in condition 37 of the EA. This would need to be implemented at all turbines during certain time and date periods (Table 2), and continue for at least two years, in parallel with operational carcass search monitoring. In addition, the 18 turbines situated in the moderate sensitivity buffers must all be feathered across all seasons except for winter (Table 2). The curtailment regime must be adapted based on incoming bat mortality and activity data, and, if needed, environmental conditions must be used to refine the curtailment regime.

Table 2: Great Kei Curtailment Plan

Period	Times	Curtailment
01 January – end of February	Sunset – 00:00	Full feathering of blades below the manufacturers cut in speed, for all turbines
01 September – 15 October	Sunset – 00:00	Full feathering of blades below the manufacturers cut in speed, for all turbines
Summer, Spring, and Autumn	Sunset – 22:00	Full feathering of blades below the manufacturers cut in speed, for the following turbines: WTG02, WTG09, WTG10, WTG14, WTG16, WTG18, WTG19, WTG20, WTG22, WTG26, WTG29, WTG31, WTG38, WTG39, WTG43, WTG44, WTG47, WTG48

4.4 Effect of the Amendment on Cumulative Impacts

The potential significance of cumulative bat mortality was not properly assessed in the original EIA, 2015. There is one operational facility in the 50 km radius assessment area (the Chaba WEF), and one proposed facility. Within a 100 km radius there are at least four proposed wind energy facilities. Limited information on bat activity in the region is therefore available with only data from pre-construction and operational phase monitoring at the Chaba WEF available. Based on our review of these data, impacts to bats in the region appear high. The introduction of another wind farm, particularly one with turbines with larger rotor swept areas is likely to have a very high negative cumulative impact to the bat community in these areas. With mitigation measures, these impacts could reduce to moderate but may still be high depending on the success of the mitigation measures at each of the wind farms in the cumulative impact assessment area. The moderate rating therefore assumes that all wind farms will apply and adhere to appropriate mitigation, which may not occur.

Table 2: Cumulative Impacts of the Great Kei WEF on Bats

RATING		Temporal Scale		Spatial Scale		Severity of Impact		Risk or Likelihood		Total
	Without Mitigation	Long term	3	Regional	3	Very Severe	8	Definite	4	18
	With Mitigation	Long term	3	Regional	3	Moderate	3	May Occur	2	11
Overall Significance without mitigation										Very High -
Overall Significance with mitigation										Moderate -

5 CONCLUSION

Compared to the previous impact assessment undertaken in 2015, it is likely that the amendments to the turbine dimensions proposed for the Great Kei WEF will increase the predicted impacts to bats. However, the significance of these impacts remains high before and moderate after mitigation.

The primary mitigation is to avoid impacts which can be achieved through appropriate turbine siting. The buffers have been increased to 266 m from those proposed in the pre-construction bat monitoring to meet current best practise standards. There will still be residual impacts to bats because bat activity is high during certain time periods and for certain species. Turbine design can reduce these impacts and the blades must not sweep done further than 45 m above ground level. However, there will be additional residual impacts even with these design parameters because it is difficult to select a competitive turbine that limits impacts to both low and high flying species. Curtailment must therefore be used as described in this amendment report and this must be included in the EMP and the EA. If these mitigation measures are adhered to, the specialist accepts the proposed amendments.

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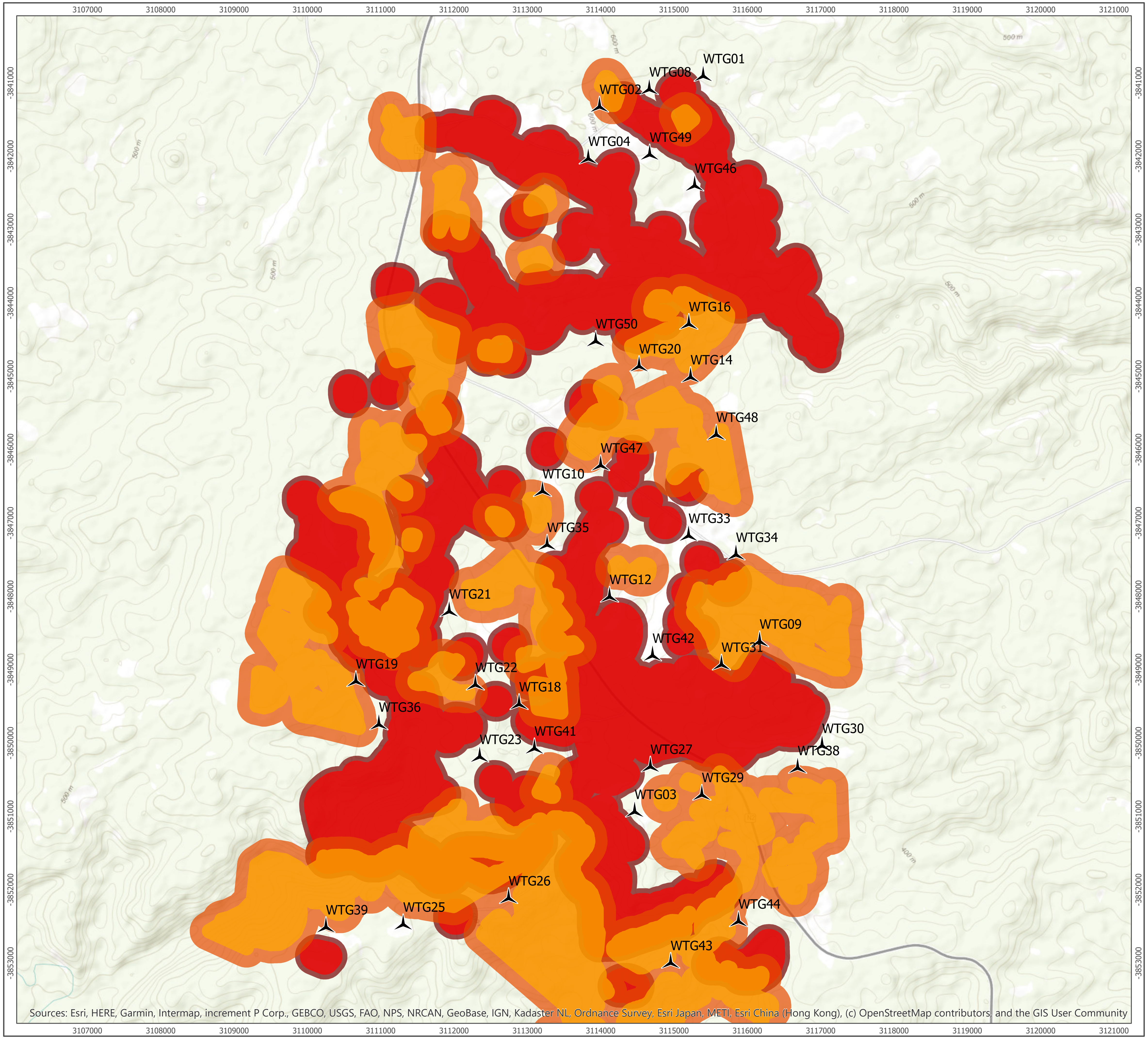

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- Turbine layout
- Current Moderate Sensitivity Area (100 m Buffer)
- Updated Moderate Sensitivity Area (266 m Buffer)
- Current High Sensitivity Area (200 m Buffer)
- Updated High Sensitivity Area (266 m Buffer)

1:50 000 Scale @ A3

0 1 2 km

NORTH

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Bat Sensitivity Map
Figure 1

Great Kei Wind Energy Facility
EA Amendment Report
Bat Assessment