Scoping Report of a 12 month Long-Term Bat Monitoring Study

-For the proposed Maralla Wind Energy Facility, Northern Cape

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For:	12 Month pre-construction bat sensitivity monitoring

Independence:

Animalia Zoological & Ecological Consultation CC has no connection with the developer. Animalia Zoological & Ecological Consultation CC is not a subsidiary, legally or financially of the developer; remuneration for services by the developer in relation to this proposal is not linked to approval by decision-making authorities responsible for permitting this proposal and the consultancy has no interest in secondary or downstream developments as a result of the authorization of this project.

Applicable Legislation:

Legislation dealing with biodiversity applies to bats and includes the following:

NATIONAL ENVIRONMENTAL MANAGEMENT: BIODIVERSITY ACT, 2004 (ACT 10 OF 2004; especially sections 2, 56 & 97)

The Act calls for the management and conservation of all biological diversity within South Africa. Bats constitute an important component of South African biodiversity and therefore all species receive additional attention to those listed as Threatened or Protected.

TABLE OF CONTENTS

1 INTRODUCTION

This is the scoping report for a bat monitoring study for the proposed Maralla Wind West Energy Facility and Maralla Wind East Energy Facility near Sutherland. **Figure 1** below displays the study areas with the proposed turbine layout.

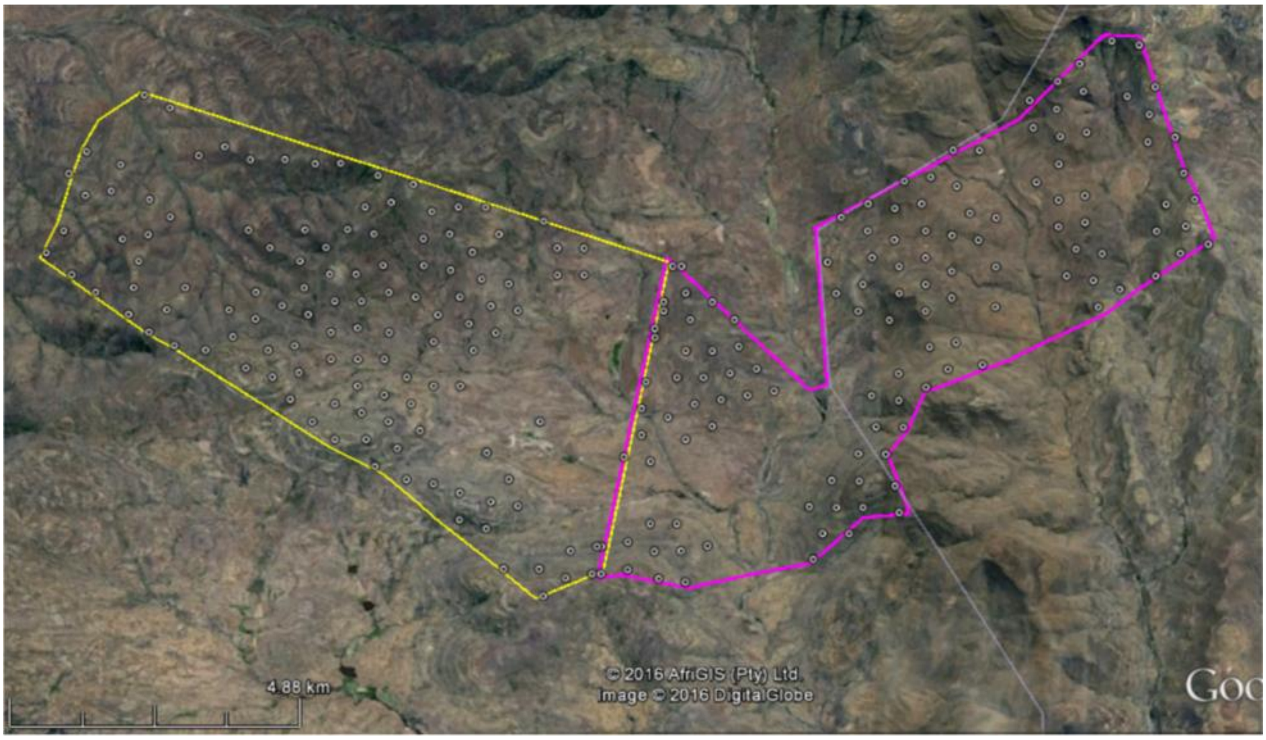


Figure 1: Map overview of the proposed Maralla West (yellow) and Maralla East (purple) WEF turbine layouts.

Three factors need to be present for most South African bats to be prevalent in an area: availability of roosting space, food (insects/arthropods or fruit), and accessible open water sources. However, the dependence of a bat on each of these factors depends on the species, behaviour and ecology. Nevertheless, bat activity, abundance and diversity are likely to be higher in areas supporting all three above-mentioned factors.

The site is evaluated by comparing the amount of surface rock (possible roosting space), topography (influencing surface rock in most cases), vegetation (possible roosting spaces and foraging sites), climate (can influence insect numbers and availability of fruit), and presence of surface water (influences insects and acts as a source of drinking water) to identify bat species that may be impacted by wind turbines. These comparisons are done chiefly by studying the geographic literature of each site, available satellite imagery and observations during site visits. Species probability of occurrence based on the above mentioned factors are estimated for the site and the surrounding larger area (see Section 4.4).

General bat diversity, abundance and activity are determined by the use of a bat detector. A bat detector is a device capable of detecting and recording the ultrasonic echolocation calls of bats which may then be analysed with the use of computer software. A real time expansion type bat detector records bat echolocation in its true ultrasonic state which is then effectively slowed down 10 times during data analysis. Thus the bat calls become audible to the human ear, but still retains all of the harmonics and characteristics of the call from which bat species with characteristic echolocation calls can be identified. Although this type of bat detection equipment is advanced technology, it is not necessarily possible to identify all bat species by just their echolocation calls. Recordings may be affected by the weather conditions (i.e. humidity) and openness of the terrain (bats may adjust call frequencies). The range of detecting a bat is also dependent on the volume of the bat call. Nevertheless, it is a very accurate method of recording bat activity.

1.1 The Bats of South Africa

Bats form part of the Order Chiroptera and are the second largest group of mammals after rodents. They are the only mammals to have developed true powered flight and have undergone various skeletal changes to accommodate this. The forelimbs are elongated, whereas the hind limbs are compact and light, thereby reducing the total body weight. This unique wing profile allows for the manipulation wing camber and shape, exploiting functions such as agility and manoeuvrability. This adaption surpasses the static design of the bird wings in function and enables bats to utilize a wide variety of food sources, including, but not limited to, a large diversity of insects (Neuweiler 2000). Species based facial features may differ considerably as a result of differing life styles, particularly in relation to varying feeding and echolocation navigation strategies. Most South African bats are insectivorous and are capable of consuming vast quantities of insects on a nightly basis (Taylor 2000, Tuttle and Hensley 2001) however, they have also been found to feed on amphibians, fruit, nectar and other invertebrates. As a result, insectivorous bats are the predominant predators of nocturnal flying insects in South Africa and contribute greatly to the suppression of these numbers. Their prey also includes agricultural pests such as moths and vectors for diseases such as mosquitoes (Rautenbach 1982, Taylor 2000).

Urban development and agricultural practices have contributed to the deterioration of bat populations on a global scale. Public participation and funding of bat conservation are often hindered by negative public perceptions and unawareness of the ecological importance of bats. Some species choose to roost in domestic residences, causing disturbance and thereby decreasing any esteem that bats may have established. Other species may occur in large communities in buildings, posing as a potential health hazard to residents in addition to their nuisance value. Unfortunately, the negative association with bats obscures their importance as an essential component of ecological systems and their value as natural pest control agents, which actually serves as an advantage to humans.

Many bat species roost in large communities and congregate in small areas. Therefore, any major disturbances within and around the roosting areas may adversely impact individuals of different communities, within the same population, concurrently (Hester and Grenier 2005). Secondly, nativity rates of bats are much lower than those of most other small mammals. This is because, for the most part, only one or two pups are born per female per annum and according to O'Shea *et al*. (2003), bats may live for up to 30 years, thereby limiting the amount of pups born due to this increased life expectancy. Under natural circumstances, a population's numbers may accumulate over long periods of time. This is due to the longevity and the relatively low predation of bats when compared to other small mammals. Therefore, bat populations are not able to adequately recover after mass mortalities and major roost disturbances.

1.2 Bats and Wind Turbines

Although most bats are highly capable of advanced navigation through the use of echolocation and excellent sight, they are still at risk of physical impact with the blades of wind turbines. The corpses of bats have been found in close proximity to wind turbines and, in a case study conducted by Johnson *et al*. (2003), were found to be directly related to collisions. The incident of bat fatalities for migrating species has been found to be directly related to turbine height, increasing exponentially with altitude, as this disrupts the migratory flight paths (Howe *et al*. 2002, Barclay *et al*. 2007). Although the number of fatalities of migrating species increased with turbine height, this correlation was not found for increased rotor sweep (Howe *et al*. 2002, Barclay *et al*. 2007). In the USA it was hypothesized that migrating bats may navigate without the use of echolocation, rather using vision as their main sense for long distance orientation (Johnson *et al*. 2003, Barclay *et al*. 2007). Despite the high incidence of deaths caused by direct impact with the blades, most bat mortalities have been found to be caused by barotrauma (Baerwald *et al*. 2008). This is a condition where low air pressure found around the moving blades of wind turbines, causes the lungs of a bat to collapse, resulting in fatal internal haemorrhaging (Kunz *et al*. 2007). Baerwald *et al*. (2008) found that 90% of bat fatalities around wind turbines involved internal haemorrhaging consistent with barotrauma. A study conducted by Arnett (2005) recorded a total of 398 and 262 bat fatalities in two surveys at the Mountaineer Wind Energy Centre in Tucker County, West Virginia and at the Meyersdale Wind Energy Centre in Somerset County, Pennsylvania, respectively. These surveys took place during a 6 week study period from 31 July 2004 to 13 September 2004. In some studies, such as that taken in Kewaunee County (Howe *et al.* 2002), bat fatalities were found exceed bird fatalities by up to three-fold.

Although bats are predominately found roosting and foraging in areas near trees, rocky outcrops, human dwellings and water, in conditions where valleys are foggy, warmer air is drawn to hilltops through thermal inversion which may result in increased concentrations of insects and consequently bats at hilltops, where wind turbines are often placed (Kunz *et al*. 2007). Some studies (Horn *et al*. 2008) suggest that bats may be attracted to the large turbine structure as roosting spaces or that swarms of insects may get trapped in low pressure air pockets around the turbine, also encouraging the presence of bats. The presence of lights on wind turbines have also been identified as possible causes for increased bat fatalities for non-cave roosting species. This is thought to be due to increased insect densities that are attracted to the lights and subsequently encourage foraging activity of bats (Johnson *et al*. 2003). Clearings around wind turbines, in previously forested areas, may also improve conditions for insects, thereby attracting bats to the area and the swishing sound of the turbine blades has been proposed as possible sources for disorienting bats (Kunz *et al*. 2007). Electromagnetic fields generated by the turbine may also affect bats which are sensitive to magnetic fields (Kunz *et al*. 2007). It could also be hypothesized, from personal observations that the echolocation capabilities of bats are designed to locate smaller insect prey or avoid stationary objects, and may not be primarily focused on the detection of unnatural objects moving sideways across the flight path.

A pilot wind turbine in the Coega Industrial Development Zone, Port Elizabeth, Eastern Cape, South Africa was surveyed for bird and bat carcasses. Over a period of one year, three surveys per week (total 154 inspections) were performed to search for bat and bird casualties. 17 bat fatalities and one live but injured bat was collected. Two bat species were involved, Cape serotine (*Neoromicia capensis*) and Egyptian free-tailed bat (*Tadarida aegyptiaca*). Of the 18 casualties, 15 were recorded mid-December to mid-March. One bird, a little swift (*Apus affinis*), was hit by a rotor blade. This is the first study to document bat and bird mortalities over the period of a year at a wind turbine in sub-Saharan Africa (Doty and Martin, 2013).

A pilot study was conducted at the Darling Wind Farm in the Western Cape to determine if bats are being killed by wind turbines at the facility. One bat carcass was found and identified as an adult female *Neoromicia capensis*. A necropsy showed that both lungs had pulmonary haemorrhaging and had collapsed. Histological examination revealed extensive haemorrhaging in the lungs consistent with barotrauma (Aronson et al., 2013).

Both of these South African studies point to South African bats being just as vulnerable to mortality from turbines as international studies have previously indicated. Thus the two main species of concern are *Neoromicia capensis* and *Tadarida aegyptiaca*.

Whatever the reason for bat fatalities in relation to wind turbines, it is clear that it will result in an ecological problem if wind energy facilities are irresponsibly developed and go unmitigated. During a study by Arnett *et al*. (2009), 10 turbines monitored over a period of 3 months showed 124 bat fatalities in South-central Pennsylvania (America), which can cumulatively have a catastrophic long-term effect on bat populations if this rate of fatality continues. Most bat species only reproduce once a year, bearing one young per female, therefore their numbers are slow to recover from mass mortalities. It is very difficult to assess the true number of bat deaths in relation to wind turbines, due to carcasses being removed from sites through predation, the rate of which differs from site to site as a result of habitat type, species of predator and their numbers (Howe *et al*. 2002, Johnson *et al*. 2003). Mitigation measures are being researched and experimented with globally, but are still only effective on a small scale. An exception is the implementation of curtailment processes, where the turbine cut-in speed is raised to a higher wind speed. This relies on the principle that the prey of bats will not be found in areas of strong winds and more energy is required for the bats to fly under these conditions. It is thought, that by the implementation of such a measure, that bats in the area are not likely to experience as great an impact as when the turbine blades move slowly in low wind speeds. However, this measure is currently not effective enough to translate the impact of wind turbines on bats to a category of low concern.

1.3 Scope and Limitations

Distribution maps of South African bat species still require further refinement such that the bat species proposed to occur on the site (that were not detected) are assumed accurate. If a species has a distribution marginal to the site, it was assumed to occur in the area. The literature based table of species probability of occurrence may include a higher number of bat species than actually present.

The migratory paths of bats are largely unknown, thus limiting the ability to determine if the wind farm will have a large scale effect on migratory species. This limitation however will be overcome with this long-term sensitivity assessment.

The satellite imagery partly used to develop the sensitivity map may be slightly imprecise due to land changes occurring since the imagery was taken.

Species identification with the use of bat detection and echolocation is less accurate when compared to morphological identification, nevertheless it is a very certain and accurate indication of bat activity and their presence with no harmful effects on bats being surveyed.

It is not possible to determine actual individual bat numbers from acoustic bat activity data, whether gathered with transects or the passive monitoring systems. However, bat passes per night are internationally used and recognized as a comparative unit for indicating levels of bat activity in an area.

Spatial distribution of bats over the study area cannot be accurately determined by means of transects, although the passive systems can provide comparative data for different areas of the site. Transects may still possibly uncover high activity in areas where it is not necessarily expected and thereby increase insight into the site.

Exact foraging distances from bat roosts or exact commuting pathways cannot be determined by the current methodology. Radio telemetry tracking of tagged bats is required to provide such information if needed.

Costly radar technology is required to provide more quantitative data on actual bat numbers as well as spatial distribution of multiple bats.

2 APPROACH AND METHODOLOGY

Bat activity will be monitored using active and passive bat monitoring techniques. Active monitoring will be done through site visits with transects made throughout the site with a vehicle mounted bat detector. Passive detection has commenced through the mounting of passive bat monitoring systems placed on five monitoring masts on site, specifically three short 10m masts and two 80m meteorological masts. **Figure 2** below displays the locations of the bat monitoring systems on the study area.

The monitoring systems consist of SM3BAT+ time expansion bat detectors that are powered by 12V, 18Ah, sealed lead acid batteries and 20W solar panels that provide recharging power to the batteries. Each system also has an 8-amp low voltage protection regulator and SM3PWR step down transformer. Four SD memory cards, class 10 speed, with a capacity of 32GB each were utilized within each SM3BAT+ detector; this is to ensure substantial memory space with high quality recordings even under conditions of multiple false wind triggers.

Three weatherproof ultrasound microphones were mounted at heights of 9.5 meters on the three 10m short masts, while two microphones were mounted at 10m and 80m heights on the two met masts. These microphones were then connected to the SM3BAT+ bat detectors.

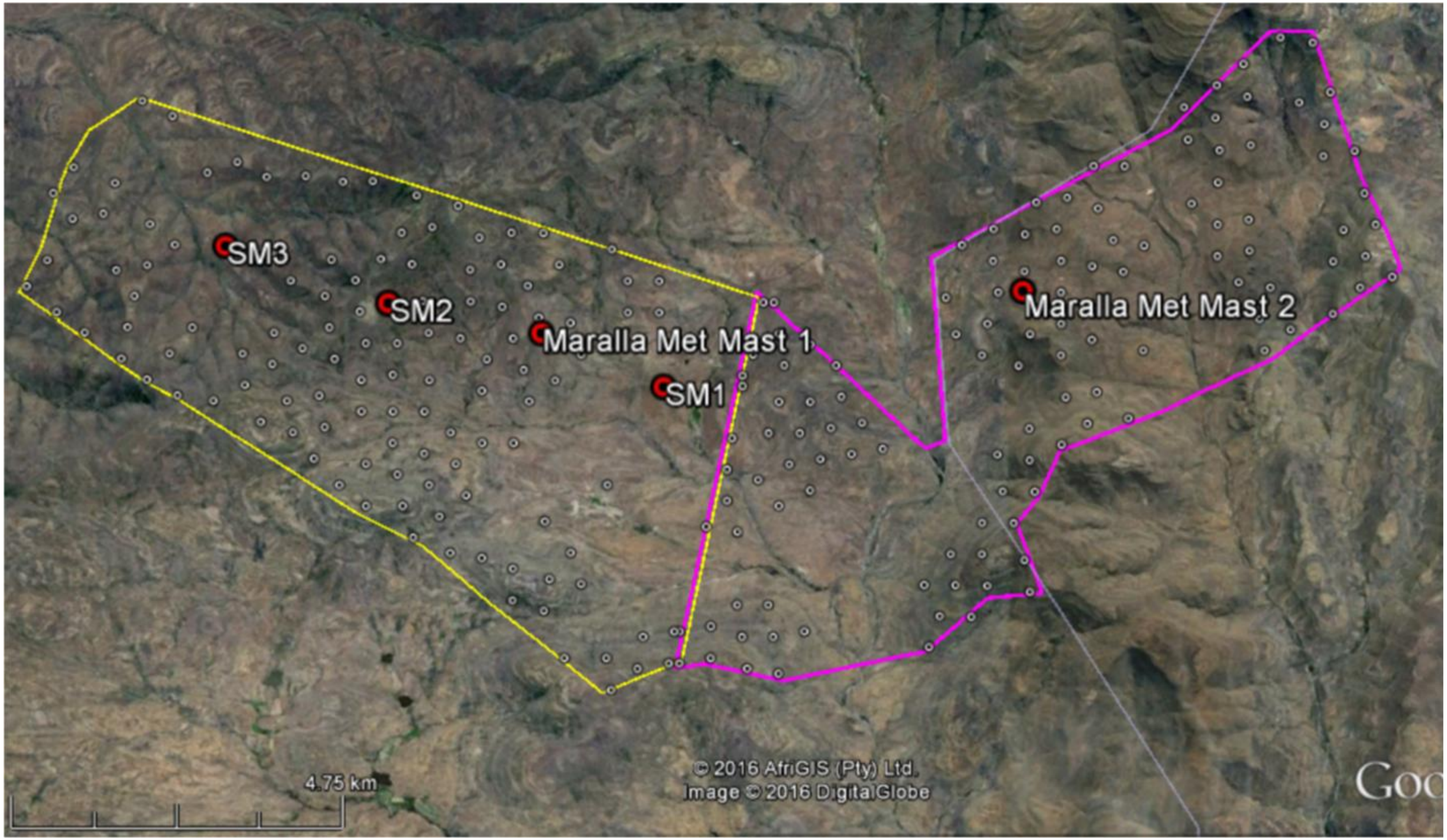


Figure 2: Overview of the passive bat monitoring system locations on the Maralla West and East WEFs.

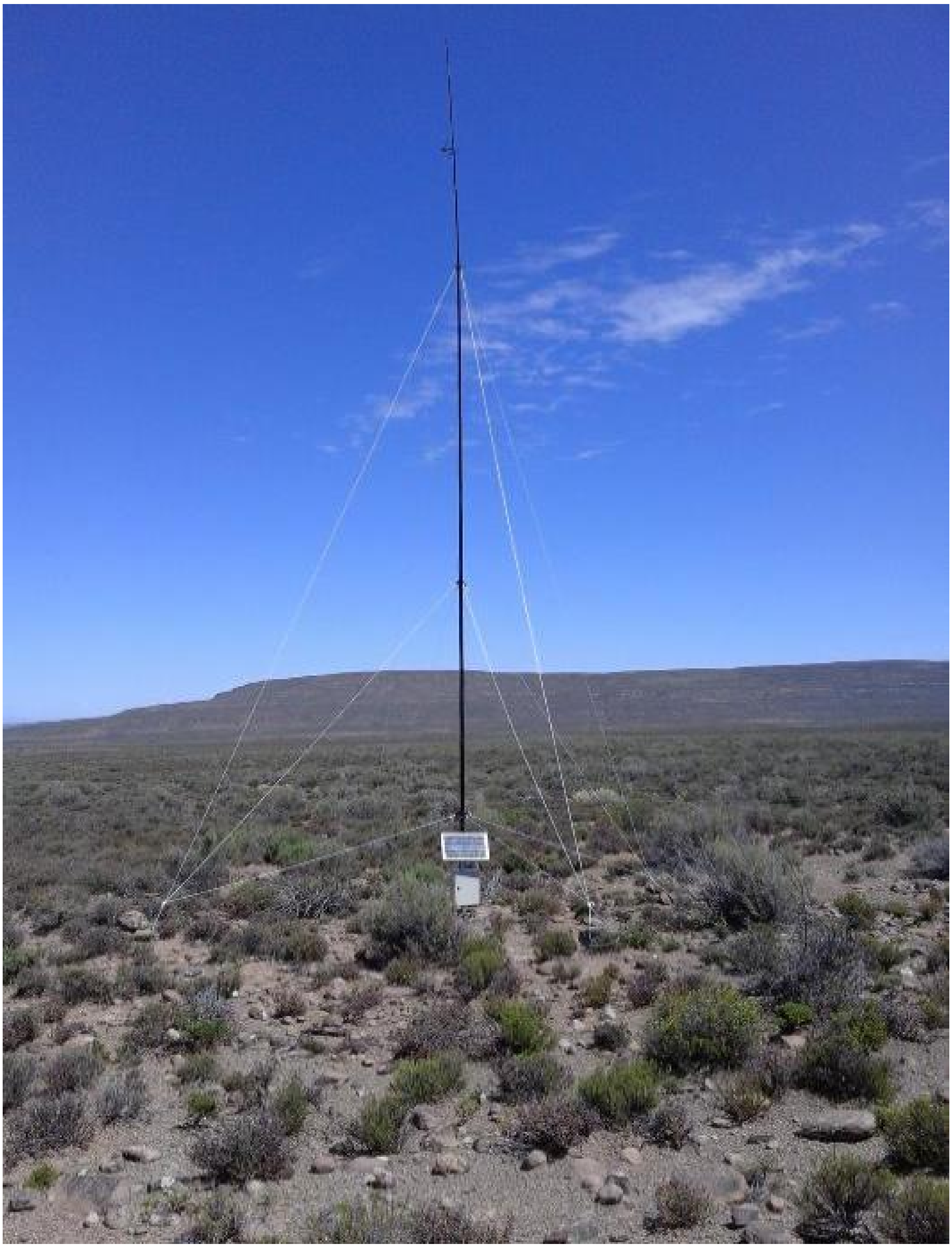


Figure 3: Short mast monitoring system set up

Each detector was set to operate in continuous trigger mode from dusk each evening until dawn (times were correlated with latitude and longitude). Trigger mode is the setting for a bat detector in which any frequency which exceeds 16 KHz and 18 dB will trigger the detector to record for the duration of the sound and 500 ms after the sound has ceased, this latter period is known as a trigger window. All signals are recorded in WAC0 lossless compression format.

The table below summarizes the above mentioned equipment set up.

2.1 First Site Visit

Site visit dates		First Visit	2 – 9 November 2015
Met mast passive bat detection systems	**Amount on site**	2	
	Microphone heights	10m; 80m	
	Coordinates	32° 43.229'S 20° 43.786'E 32° 42.904'S 20° 48.215'E	
Short mast passive bat detection systems	**Amount on site**	3	
	Microphone height	9.5m	
	Coordinates	32° 43.646'S 20° 44.907'E 32° 43.000'S 20° 42.398'E 32° 42.541'S 20° 40.827'E	
Replacements/ Repairs/ Comments		The microphones were mounted such that they pointed approximately 30 degrees downward to avoid excessive water damage. Measures were taken for protection against birds, without compromising effectiveness significantly. Crows have been found to peck at microphones and subsequently destroying them. The bat detectors were installed within their weatherproof containers and all peripherals attached.	
Type of passive bat detector		SM3BAT+, Real Time Expansion (RTE) type	
Recording schedule		Each detector was set to operate in continuous trigger mode from dusk each evening until dawn (times were automatically adjusted in relation to latitude, longitude and season).	
Trigger threshold		>16KHz, -18dB	
Trigger window (time of recording after trigger ceased)		500ms	
Microphone gain setting		36dB	
Compression		WAC0	
Single memory card size (each systems uses 4 cards)		32GB	
Battery size		18Ah; 12V	
Solar panel output		20 Watts	
Solar charge regulator		6 - 8 Amp with low voltage/deep discharge protection	
Other methods		Terrain was investigated during the day for signs of roosting and foraging habitat.	

Four additional site visits will be conducted following the same methodology as mentioned above, over the course of the 12-month preconstruction monitoring period.

After the second site visit, the passive data of the bat activity will be downloaded from each monitoring system. The data will be analysed by classifying (as near to species level as possible) and counting positive bat passes detected by the passive systems. A bat pass is defined as a sequence of ≥1 echolocation calls where the duration of each pulse is ≥2ms (one echolocation call can consist of numerous pulses). A new bat pass will be identified by a >500ms period between pulses. These bat passes will be summed into 10 minute intervals which will be used to calculate nocturnal distribution patterns over time. Bat activity will be grouped into 10 minute periods. Only nocturnal, dusk and dawn values of environmental parameters from the wind data will be used, as this is the only time insectivorous bats are active. Times of sunset and sunrise will be adjusted with the time of year.

The bat activity will be correlated with the environmental parameters of wind speed and air temperature, to identify optimal foraging conditions and periods of high bat activity.

2.2 Impact Screening Tool

The impact screening tool displayed below was used to determine the significance of the identified impacts.

		Severity / Beneficial Scale			
Probability Scale		**1**	**2**	**3**	**4**
	1	**Very Low**	**Very Low**	**Low**	**Medium**
	2	**Very Low**	**Low**	**Medium**	**Medium**
	3	**Low**	**Medium**	**Medium**	**High**
	4	**Medium**	**Medium**	**High**	**High**

Probability Scale

4	**Definite**
	Where the impact will occur regardless of any prevention measures
3	**Highly Probable**
	Where it is most likely that the impact will occur
2	**Probable**
	Where there is a good possibility that the impact will occur
1	**Improbable**
	Where the possibility of the impact occurring is very low

Severity / Beneficial Scale

4	**Very severe**	**Very beneficial**

	An irreversible and permanent change to the affected system(s) or party (ies) which cannot be mitigated.	A permanent and very substantial benefit to the affected system(s) or party(ies), with no real alternative to achieving this benefit.
3	**Severe**	**Beneficial**
	A long term impacts on the affected system(s) or party(ies) that could be mitigated. However, this mitigation would be difficult, expensive or time consuming or some combination of these.	A long term impact and substantial benefit to the affected system(s) or party(ies). Alternative ways of achieving this benefit would be difficult, expensive or time consuming, or some combination of these.
2	**Moderately severe**	**Moderately beneficial**
	A medium to long term impacts on the affected system(s) or party (ies) that could be mitigated.	A medium to long term impact of real benefit to the affected system(s) or party(ies). Other ways of optimising the beneficial effects are equally difficult, expensive and time consuming (or some combination of these), as achieving them in this way.
1	**Negligible**	**Negligible**
	A short to medium term impacts on the affected system(s) or party(ies). Mitigation is very easy, cheap, less time consuming or not necessary.	A short to medium term impact and negligible benefit to the affected system(s) or party(ies). Other ways of optimising the beneficial effects are easier, cheaper and quicker, or some combination of these.

3 REGIONAL OVERVIEW

3.1 Land Use, Vegetation, Climate and Topography

The site is situated in three vegetation units: Central Mountain Shale Renosterveld, Tanqua Escarpment Shrubland and Roggeveld Shale Renosterveld. Central Mountain Shale Renosterveld occupies the largest part of the site with Tanqua Escarpment Shrubland mostly in the west of the site and Roggeveld Shale Renosterveld in a small area of the northeast. (**Figure 4**).

The Central Mountain Shale Renosterveld vegetation unit consists of slopes and broad ridges of low mountains and escarpments, with tall shrubland dominated by renosterbos. Also there are large suites of mainly non succulent karoo shrubs with rich geophytic flora in the undergrowth. The geology of the area consists of clayey soils overlaying Adelaide subgroup mudstones and subordinate sandstones. Glenrosa and Mispah forms are prominent. The area has an Arid to Semi-arid climate with relatively even rainfall but still showing an increase in autumn and winter. Temperatures in the area range from a maximum of 29.9°C in January and a minimum of 0.9°C in July. There is a frost incidence 20-50 days a year. None of the unit is conserved. Only 1% of the unit has undergone transformation due to cultivation, urban development or plantations. Erosion is moderate.

Tanqua Escarpment Shrubland consists of steep flanks below an escarpment overlooking a basin generally facing southwest supporting succulent scrubland of medium height with an undergrowth of both succulent and non-succulent shrubs. Geology consists of mud rocks of the Adelaide subgroup and Permian Volksrust formation as well as brown to grey shale, siltstone and sandstone of the Permian Waterford formation broken by an intrusion of Jurassic Karoo dolerites. Less pronounced winter rainfall regime with most of the rain between March and August (peaking from June to August). Average temperature is 16° with the incidence of frost relatively high 30 days a year. Very small portions of the unit are conserved in the Tankwa Karoo National Park. No visible signs of transformation or invasion of alien plants. Erosion is moderate (59%) and low (41%).

The Roggeveld Shale Renosterveld vegetation unit consists of undulating slightly sloping plateau landscape with low hills and broad shallow valleys supporting mainly moderately tall shrubland dominated by renosterbos, with a rich geophytic flora in the wetter and rocky habitats. Mudrocks and sandstone of the Adelaide subgroup dominate the geology with some intrusions of the Karoo Dolerite Suite also present. Glenrosa and Mispah forms are prominent. MAP 180 - 430mm even throughout the year with a peak in March. Maximum and minimum temperatures are 29.3°C and 0.2°C in January and July, respectively. Frost is remarkably high for a Renosterveld type (30 - 70 days per year). None of the unit is conserved. Only 1% of the unit has undergone transformation but danger of overgrazing is locally high. Erosion is moderate (Mucina and Rutherford 2006).

Vegetation units and geology are of great importance as these may serve as suitable sites for the roosting of bats and support of their foraging habits (Monadjem *et al.* 2010). Houses and buildings may also serve as suitable roosting spaces (Taylor 2000; Monadjem *et al.* 2010). The importance of the vegetation units and associated geomorphology serving as potential roosting and foraging sites have been described in **Table 1**.

Table 1: Potential of the vegetation to serve as suitable roosting and foraging spaces for bats

Vegetation Unit	Roosting Potential	Foraging Potential	Comments
Central Mountain Shale Renosterveld	Moderate - High	Moderate - High	The mountain ridges, slopes and escarpments provide a wide variety of landscape features to enable the successful roosting and foraging of several insectivorous bat species.
Roggeveld Shale Renosterveld	Moderate	Moderate	The landscape features provides roosting space for bat species inhabiting rock crevices and caverns. The shrub vegetation provides a foraging niche which can be filled by clutter-edge and open air foraging bat species.
Tanqua Escarpment Shrubland	Moderate - High	Moderate	The mountain ridges, cliffs and escarpments provide suitable roosting and foraging habitat for a number of insectivorous bat species.

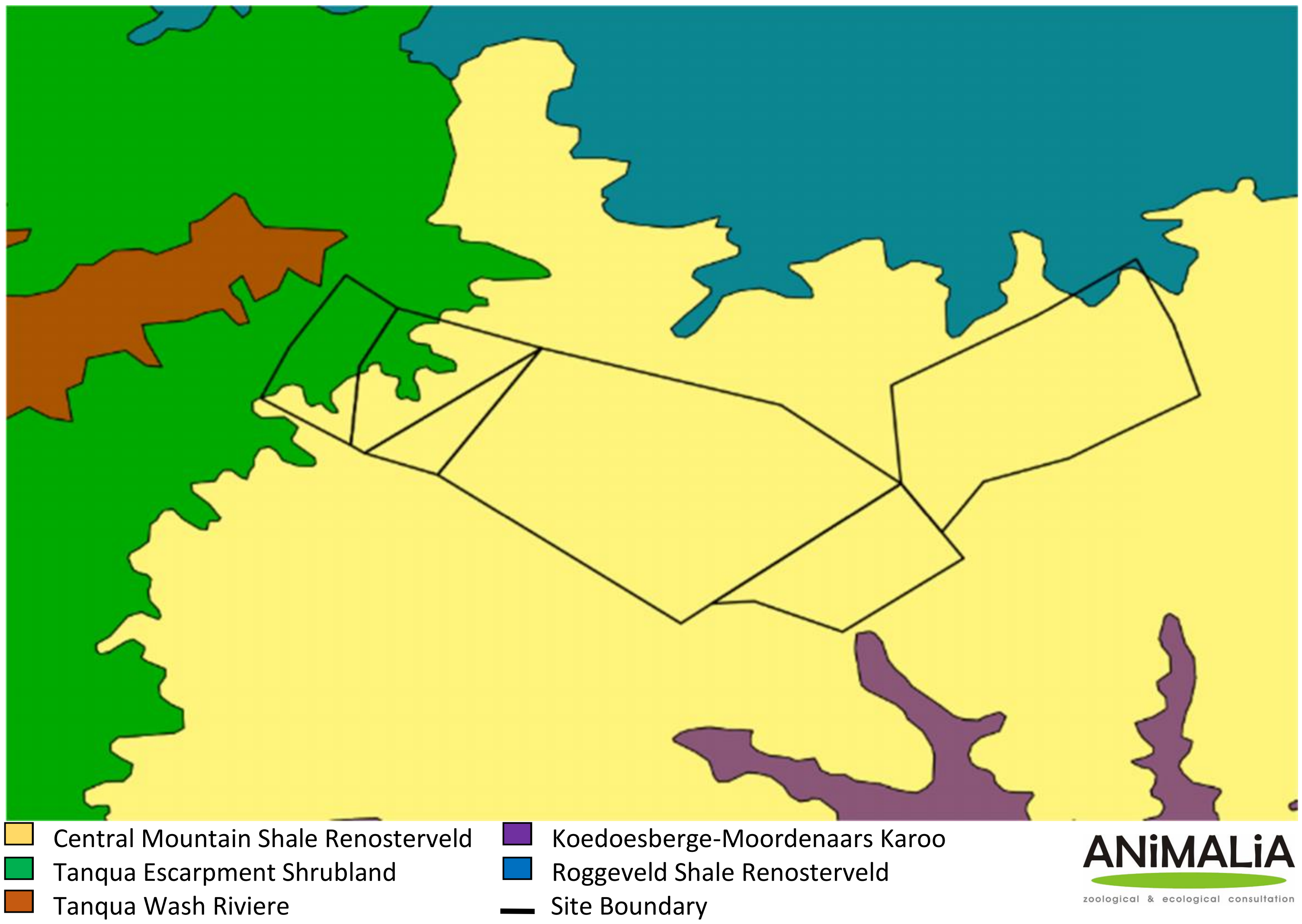


Figure 4: Vegetation units present on the site (Mucina and Rutherford 2006).

3.2 Literature Based Species Probability of Occurrence

"Probability of Occurrence" is assigned based on consideration of the presence of roosting sites and foraging habitats on the site, compared to literature described preferences. The probability of occurrence is indicative of the likelihood of encountering the bat species on site.

The column of "Likely risk of impact" describes the likelihood of risk of fatality from direct collision or barotrauma with wind turbine blades for each bat species. The risk was assigned by Sowler and Stoffberg (2014) based on species distributions, altitudes at which they fly and distances they traverse; and assumes a 100% probability of occurrence. The ecology of most applicable bat species recorded in the vicinity of the site is discussed below.

Table 2: Table of species that may be roosting or foraging on the study area, the possible site specific roosts, and their probability of occurrence based on literature (Monadjem *et al.* 2010).

Species	Common name	Probability of occurrence	Conservation status	Possible roosting habitat on site	Possible roosting habitat utilized on site	Likelihood of risk of fatality (Sowler and Stoffberg 2014)
Rhinolophus clivosus	Geoffroy's horseshoe bat	20-30	Least Concern	Culverts, rock hollows and any other suitable hollow. Usually roosts in caves and mine adits	Clutter forager, may be found near dwellings and in denser vegetative valleys.	Low
Nycteris thebaica	Egyptian slit-faced bat	20-30	Least Concern	Hollows and culverts under roads.	Clutter forager, may be found near dwellings and in denser vegetative valleys.	Low
Tadarida aegyptiaca	Egyptian free-tailed bat	90-100	Least Concern	Caves, rock crevices, under exfoliating rocks, in hollow trees, and behind the bark of dead trees	Open-air forager	High
Sauromys petrophilus	Robert's flat-headed bat	90-100	Least Concern	Narrow cracks and slabs of exfoliating rock. Rocky habitat in dry woodland, mountain fynbos or arid scrub.	Open-air forager	High
Miniopterus natalensis	Natal long-fingered bat	90-100	Near Threatened	Cave and hollow dependent, but forage abroad. Also take refuge in culverts and vertical hollows, holes.	Clutter-edge forager	Medium - High
Eptesicus hottentotus	Long-tailed serotine	80-90	Least Concern	Roosts in rock crevices	Clutter-edge forager	Medium - High
Myotis tricolor	Temmink'smyotis	40-50	Least Concern	Usually roosts gregariously in caves, and sometimes culverts or other hollows. No known caves or mine adits close to site.	Clutter-edge forager	Medium - High
Neoromicia capensis	Cape serotine	90-100	Least Concern	Roosts under the bark of trees and under roofs of houses.	Clutter-edge forager	Medium - High

3.3 Ecology of bat species that may be largely impacted by the Maralla WEF

There are several bat species in the vicinity of the site that occur commonly in the area. These species are of importance based on their likelihood of being impacted by the proposed WEF, due to high abundances and certain behavioural traits. The relevant species are discussed below.

Tadarida aegyptiaca

The Egyptian Free-tailed Bat, *Tadarida aegyptiaca*, is a Least Concern species as it has a wide distribution and high abundance throughout South Africa, and is part of the Free-tailed bat family (Molossidae). It occurs from the Western Cape of South Africa, north through to Namibia and southern Angola; and through Zimbabwe to central and northern Mozambique (Monadjem *et al*. 2010). This species is protected by national legislation in South Africa (ACR 2010).

They roost communally in small (dozens) to medium-sized (hundreds) groups in caves, rock crevices, under exfoliating rocks, in hollow trees and behind the bark of dead trees. *Tadarida aegyptiaca* has also adapted to roosting in buildings, in particular roofs of houses (Monadjem *et al*. 2010). Thus man-made structures and large trees on the site would be important roosts for this species.

Tadarida aegyptiaca forages over a wide range of habitats, flying above the vegetation canopy. It appears that the vegetation has little influence on foraging behaviour as the species forages over desert, semi-arid scrub, savanna, grassland and agricultural lands. Its presence is strongly associated with permanent water bodies due to concentrated densities of insect prey (Monadjem *et al*. 2010).

The Egyptian Free-tailed bat is considered to have a High likelihood of risk of fatality due to wind turbines (Sowler and Stoffberg 2014). Due to the high abundance and widespread distribution of this species, high mortality rates due to wind turbines would be a cause of concern as these species have more significant ecological roles than the rarer bat species.

After a gestation of four months, a single young is born, usually in November or December, when females give birth once a year. In males, spermatogenesis occurs from February to July and mating occurs in August. Maternity colonies are apparently established by females in November.

Neoromicia capensis

Neoromicia capensis is commonly called the Cape serotine and has a conservation status of Least Concern as it is found in high numbers and is widespread over much of Sub-Saharan Africa.

High mortality rates of this species due to wind turbines would be a cause of concern as *N. capensis* is abundant and widespread and as such has a more significant role to play within the local ecosystem than the rarer bat species. They do not undertake migrations and thus are considered residents of the site.

It roosts individually or in small groups of two to three bats in a variety of shelters, such as under the bark of trees, at the base of aloe leaves, and under the roofs of houses. They will use most man-made structures as day roosts which can be found throughout the site and surrounding areas (Monadjem *et al*. 2010).

They are tolerant of a wide range of environmental conditions as they survive and prosper within arid semi-desert areas to montane grasslands, forests, and savannas; indicating that they may occupy several habitat types across the site, and are amenable towards habitat changes. They are however clutter-edge foragers, meaning they prefer to hunt on the edge of vegetation clutter mostly, but can occasionally forage in open spaces. They are thought to have a Medium-High likelihood of risk of fatality due to wind turbines (Sowler and Stoffberg 2014).

Mating takes place from the end of March until the beginning of April. Spermatozoa are stored in the uterine horns of the female from April until August, when ovulation and fertilisation occurs. They give birth to twins during late October and November but single pups, triplets and quadruplets have also been recorded (van der Merwe 1994 and Lynch 1989).

Miniopterus natalensis

Miniopterus natalensis, also commonly referred to as the Natal long-fingered bat, occurs widely across the country but mostly within the southern and eastern regions and is listed as Near Threatened (Monadjem *et al*., 2010). This bat is a cave-dependent species and identification of suitable roosting sites may be more important in determining its presence in an area than the presence of surrounding vegetation. It occurs in large numbers when roosting in caves with approximately 260 000 bats observed making seasonal use of the De Hoop Guano Cave in the Western Cape, South Africa. Culverts and mines have also been observed as roosting sites for either single bats or small colonies. Separate roosting sites are used for winter hibernation activities and summer maternity behaviour, with the winter hibernacula generally occurring at higher altitudes in more temperate areas and the summer hibernacula occurring at lower altitudes in warmer areas of the country (Monadjem *et al*., 2010)

Mating and fertilisation usually occur during March and April and is followed by a period of delayed implantation until July/August. Birth of a single pup usually occurs between October and December as the females congregate at maternity roosts (Monadjem *et al.,* 2010 & Van Der Merwe, 1979).

The Natal long-fingered bat undertakes short migratory journeys between hibernaculum and maternity roosts. Due to this migratory behaviour, they are considered to be at high risk of fatality from wind turbines if a wind farm is placed within a migratory path (Sowler and Stoffberg, 2013). The mass movement of bats during migratory periods could result in mass casualties if wind turbines are positioned over a mass migratory route and such turbines are not effectively mitigated. Very little is known about the migratory behaviour and paths of *M. natalensis* in South Africa with migration distances exceeding 150 kilometres. If the site is located within a migratory path the bat detection systems should detect high numbers and activity of the Natal long-fingered bat. This will be examined over the course of the 12-month monitoring survey.

A study by Vincent *et al.* (2011) on the activity and foraging habitats of Miniopteridae found that the individual home ranges of lactating females were significantly larger than that of pregnant females. It was also found that the bats predominately made use of urban areas (54%) followed by open areas (19.8%), woodlands (15.5%) orchards and parks (9.1%) and water bodies (1.5%) when selecting habitats. Foraging areas were also investigated with the majority again occurring in urban areas (46%), however a lot of foraging also occurred in woodland areas (22%), crop and vineyard areas (8%), pastures, meadows and scrubland (4%) and water bodies (4%).

Sowler and Stoffberg (2014) advise that *M. natalensis* faces a medium to high risk of fatality due to wind turbines. This evaluation was based on broad ecological features and excluded migratory information.

4 IMPACTS AND ISSUES IDENTIFICATION

4.1 Sensitivity Map

Figure 5 - 7 depicts the sensitive areas of the site, based on features identified to be important for foraging and roosting of the species that are most probable to occur on site. Thus the sensitivity map is based on species ecology and habitat preferences. This map can be used as a pre-construction mitigation in terms of improving turbine placement with regards to bat preferred habitats on site.

Table 5: Description of parameters used in the construction of a sensitivity map

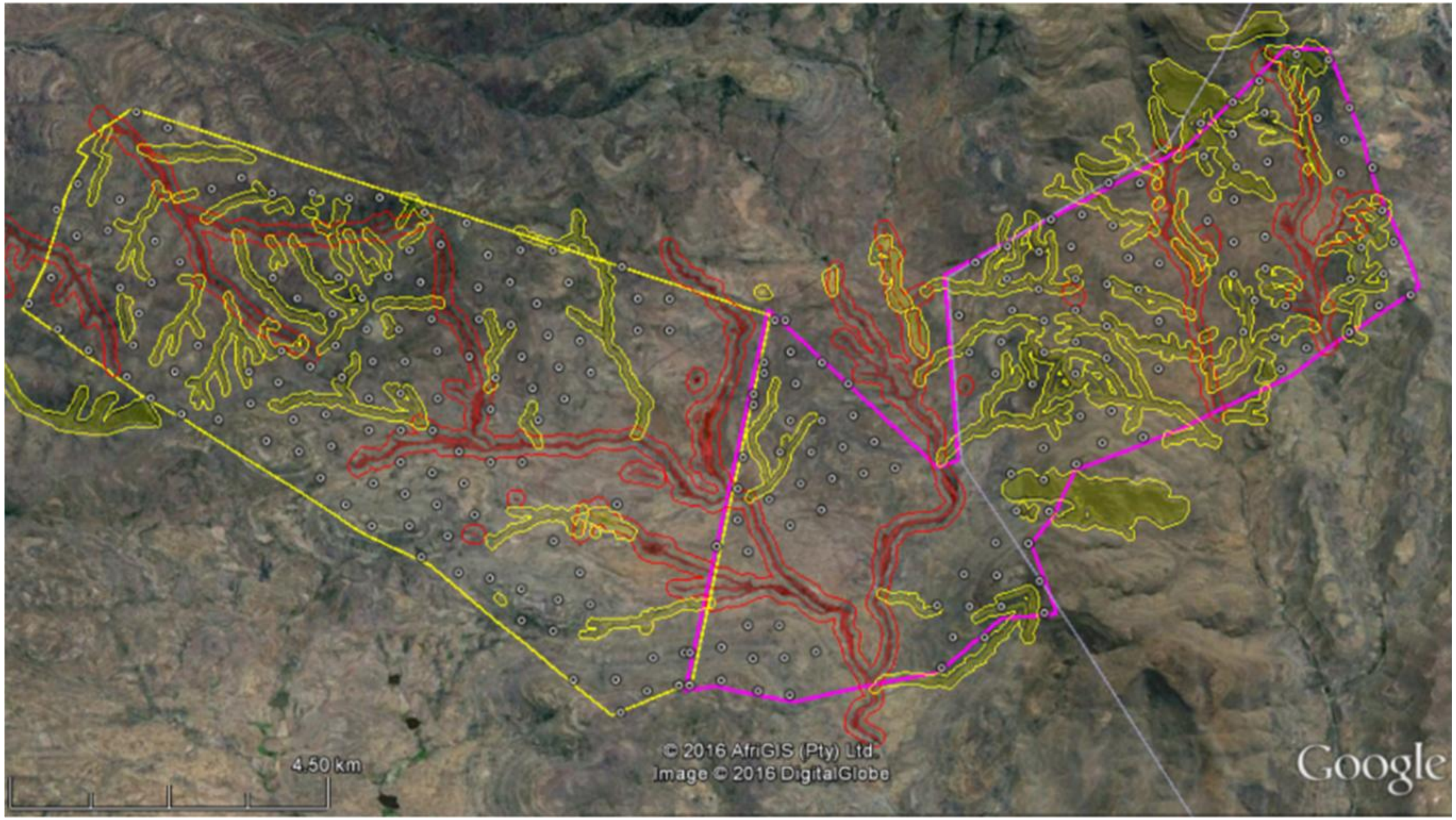
Last iteration	July 2016
High sensitivity buffer	100m radial buffer
Moderate sensitivity buffer	50m radial buffer
Features used to develop the sensitivity map	Manmade structures, such as houses, barns, sheds and road culverts, these structures provide easily accessible roosting sites.
	The presence of probable hollows/overhangs, rock faces and clumps of larger woody plants. These features provide natural roosting spaces and tend to attract insect prey.
	The different vegetation types and presence of riparian/water drainage habitat is used as indicators of probable foraging areas.
	Open water sources, be it man-made farm dams or natural streams and wetlands, are important sources of drinking water and provide habitat that host insect prey.
	Areas frequented often by cattle and livestock (e.g. congregation areas and kraal areas) were assigned a moderate sensitivity since large groups of animals tend to attract insects.
	Areas frequented often by cattle and livestock (e.g. congregation areas and kraal areas) were assigned a moderate sensitivity since large groups of animals tend to attract insects.

Table 6: Description of sensitivity categories utilized in the sensitivity map

Sensitivity	Description
Moderate Sensitivity	Areas of foraging habitat or roosting sites considered to have significant roles for bat ecology. Turbines within or close to these areas must acquire priority (not excluding all other turbines) during pre/post-construction studies and mitigation measures will need to be applied immediately from the start of operation.
High Sensitivity	Areas that are deemed critical for resident bat populations, capable of elevated levels of bat activity and support greater bat diversity than the rest of the site. These areas are 'no-go' areas and turbines must not be placed in these areas and their buffers.

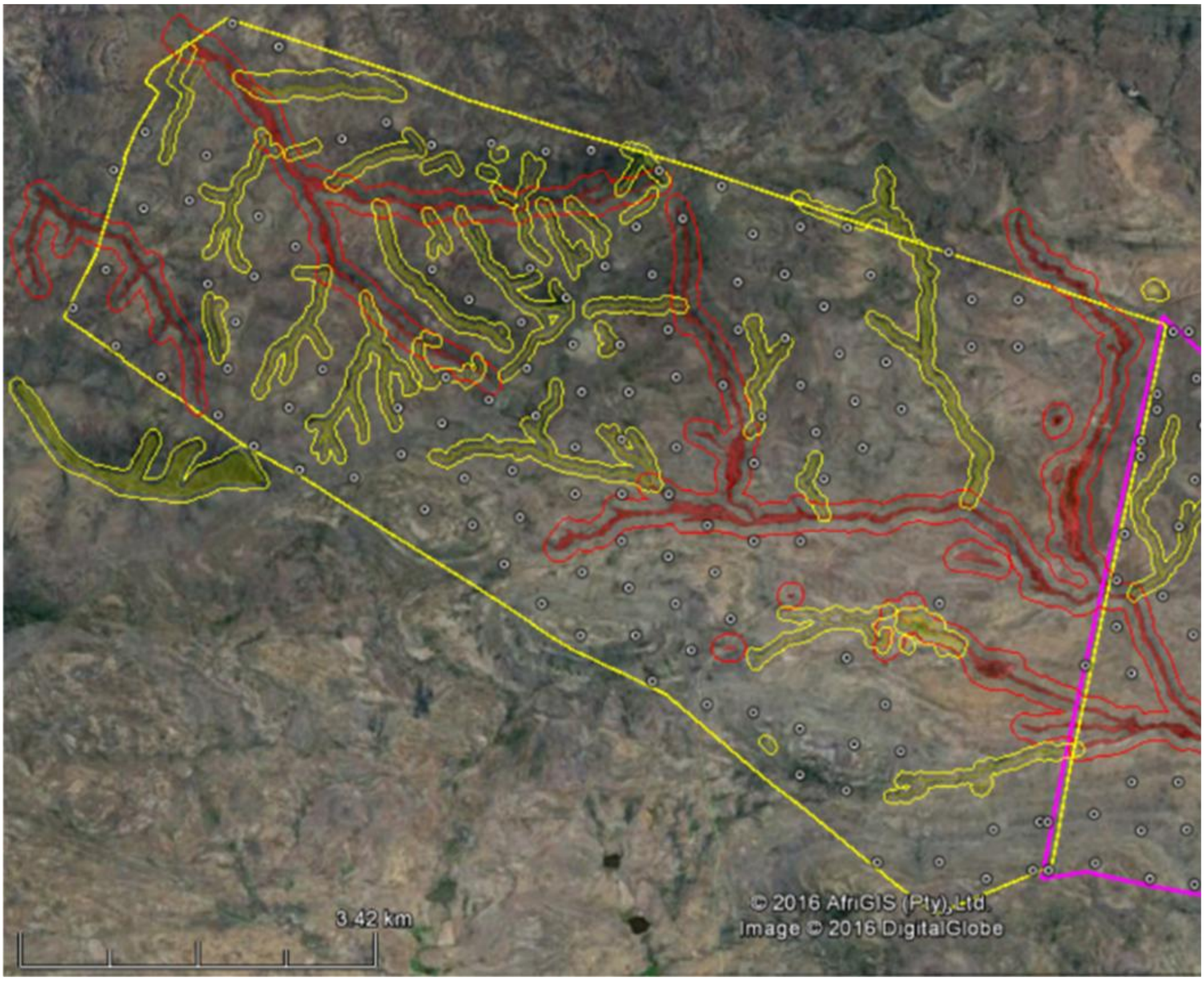
The bat sensitivity map has been reviewed and revised from the original version compiled at the onset of the bat monitoring study. The map has been revised based on the results of this monitoring survey. A number of high sensitivity areas have been downgraded to moderate sensitivity areas. The buffer distances have also been reduced; the high sensitivity buffer distance has been reduced from 200m to 100m and the moderate sensitivity buffer has been reduced from 100m to 50.

A number of turbines remain within bat sensitive areas and their respective buffers. All turbines within high sensitivity areas and buffers need to be relocated or removed from the layout. It is advised that turbines located within moderate sensitivity areas and buffers be moved out of these areas too or they will be subjected to mitigation measures during the operational phase (dependent on the results of the full 12-month monitoring study).



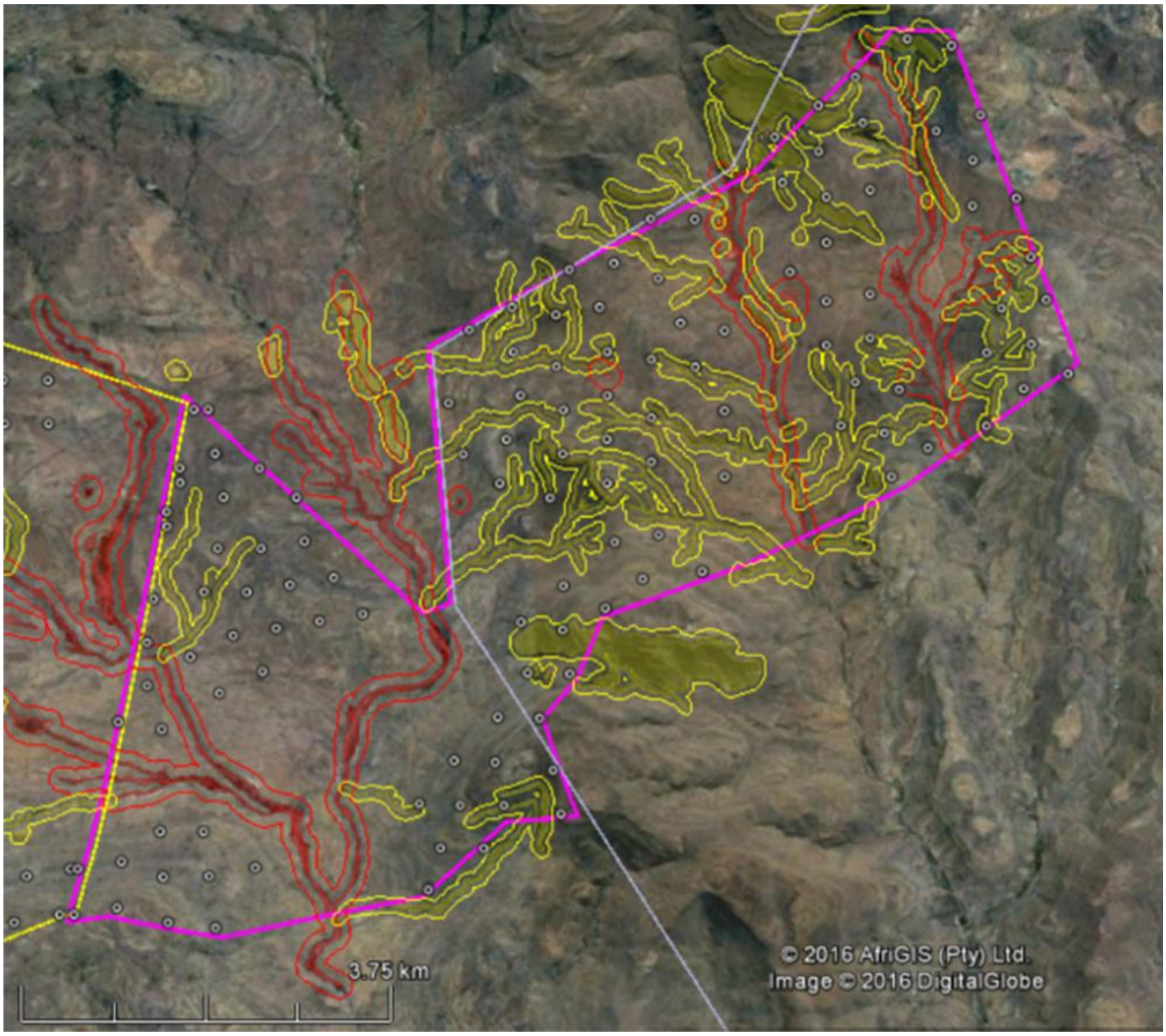
High bat sensitivity area
High bat sensitivity buffer
Moderate bat sensitivity area
Moderate bat sensitivity buffer

Figure 5: Bat sensitivity map of the Maralla WEF site



High bat sensitivity area
Moderate bat sensitivity area
High bat sensitivity buffer
Moderate bat sensitivity buffer

Figure 6: Bat sensitivity map of the Maralla West site with the proposed turbine layout



High bat sensitivity area
High bat sensitivity buffer
Moderate bat sensitivity area
Moderate bat sensitivity buffer

Figure 7: Bat sensitivity map of the Maralla East WEF with proposed turbine layout

4.2 Impact Assessment of Proposed Maralla WEF on Bat Fauna

The below impacts and significance ratings are applicable to both Maralla East and Maralla West Wind Farms

4.2.1 Construction phase

4.2.1.1 Impact: Destruction of bat roosts due to earthworks and blasting

<table>
<tr><td colspan="5">Impact Phase: Construction phase</td></tr>
<tr><td colspan="5">Impact Description: Destruction of bat roosts due to earthworks and blasting. During construction, the earthworks and especially blasting can damage bat roosts in rock crevices. Any type and duration of blasting in close proximity to a rock crevice roost or man-made structure (barns, sheds, abandoned houses, pump houses etc.), can cause mortality to the inhabitants of the roost.</td></tr>
<tr><td></td><td>Status</td><td>Severity</td><td>Probability</td><td>Significance</td></tr>
<tr><td>Without Mitigation</td><td>Negative</td><td>Very Severe (4)</td><td>Definite (4)</td><td>High</td></tr>
<tr><td>With Mitigation</td><td>Negative</td><td>Negligible (1)</td><td>Improbable (1)</td><td>Very Low</td></tr>
<tr><td>Will impact cause irreplaceable loss of resources?</td><td colspan="4">Yes, if blasting occurs close to a roost of any kind mortality of the inhabitants is highly plausible.</td></tr>
<tr><td>Can impact be avoided, managed or mitigated?</td><td colspan="4">Yes, the impact can be mitigated.</td></tr>
<tr><td>Mitigation measures to reduce residual risk or enhance opportunities.</td><td colspan="4">Adhere to the sensitivity map during turbine placement, road and infrastructure building. Blasting should be minimised and used only when absolutely necessary. If blasting is scheduled to occur near exfoliating rock or manmade structures (listed above), a bat specialist must certify there are no bat roosts or signs of bat inhabitants in the affected areas.</td></tr>
<tr><td>Impact to be addressed/ further investigated and assessed in Impact Assessment Phase?</td><td colspan="4">Yes, identifying rock crevice roosts and other roost types in the development area.</td></tr>
</table>

4.2.1.2 Impact: Loss of foraging habitat

Impact Phase: Construction phase				
Impact Description: Loss of foraging habitat. Foraging habitat will be permanently lost by construction of turbines, crane pads, infrastructure and access roads. Temporary foraging habitat loss will occur during construction due to storage areas and movement of heavy vehicles.				
	Status	**Severity**	**Probability**	**Significance**
Without Mitigation	Negative	Moderately Severe (2)	Highly Probable (3)	**Medium**
With Mitigation	Negative	Negligible (1)	Probable (2)	Very Low
Will the impact cause irreplaceable loss of resources?	Yes, foraging habitat will be permanently lost in development areas.			
Can impact be avoided, managed or mitigated?	Yes, the impact can be managed.			
Mitigation measures to reduce residual risk or enhance opportunities.	Adhere to the bat sensitivity map and avoid development in sensitive areas. Keep to designated areas when storing building materials, resources, turbine components. Construction vehicles must keep to designated roads. Damaged areas not required after construction should be rehabilitated by an experienced vegetation succession specialist.			
Impact to be addressed/ further investigated and assessed in Impact Assessment Phase?	Yes, through compiling sensitivity maps to indicate the areas that will need to be avoided or managed.			

4.2.2 Operational phase

4.2.2.1 Impact: Bat mortalities due to direct blade impact or barotrauma during foraging activities (not migration)

Impact Phase: Operational phase				
Impact Description: Bat mortalities due to direct blade impact or barotrauma during foraging activities (not migration). If the impact is too severe (e.g. in the case of no mitigation) local bat populations may never recover from mortalities.				
	Status	**Severity**	**Probability**	**Significance**
Without Mitigation	Negative	Very Severe (4)	Highly Probable (3)	**High**
With Mitigation	Negative	Severe (3)	Probable (2)	**Medium**
Will impact cause irreplaceable loss or resources?	Yes, it will have an impact on the resident bat population numbers.			
Can impact be avoided, managed or mitigated?	Yes, the impact can be mitigated.			
Mitigation measures to reduce residual risk or enhance opportunities.	Adhere to the sensitivity maps for turbine placement. Apply mitigation measures deemed necessary from the 12-month preconstruction study.			
Impact to be addressed/ further investigated and assessed in Impact Assessment Phase?	Collection of the necessary long term data through the pre-construction monitoring study.			

4.2.2.2 Impact: Cumulative bat mortalities due to direct blade impact or barotrauma during migration.

Impact Phase: Operational phase				
Impact Description: Mortalities of bats due to wind turbines during migratory activities can have significant ecological consequences as the bat species at risk are insectivorous and thereby contribute significantly to the control of nocturnal flying insects. On a project specific level insect numbers in a certain habitat can increase if significant numbers of bats are killed off. But if such an impact is present on multiple projects in close vicinity of each other, insect numbers can increase regionally and possibly cause outbreaks of colonies of certain insect species. Additionally, if migrating bats are killed off it can have detrimental effects on the cave ecology of the caves that a specific colony utilises. This is due to the fact that bat guano is the primary form of energy input into a cave ecology system, given that no sunshine that allows photosynthesis exists in cave ecosystems.				
	Status	**Severity**	**Probability**	**Significance**
Without Mitigation	Negative	Very Severe (4)	Highly probable (3)	**High**
With Mitigation	Negative	Moderately Severe (2)	Probable (2)	Low
Will impact cause irreplaceable loss or resources?	Yes, it will have an impact on the population numbers of migratory bats across South Africa.			
Can impact be avoided, managed or mitigated?	Yes, impact can be mitigated.			
Mitigation measures to reduce residual risk or enhance opportunities.	Adhere to the sensitivity map for turbine layout, and avoid placement of turbines in any bat sensitivity areas, where possible. Precise mitigation measures will be recommended on conclusion of the 12-month pre-construction bat monitoring study. They must be implemented and effectivity verified during the operational monitoring study. It is essential that project specific mitigations be applied and adhered to for each project, as there is no overarching mitigation that can be recommended on a regional level due to habitat and ecological differences between project sites.			
Impact to be addressed/ further investigated and assessed in Impact Assessment Phase?	Compiling refined sensitivity maps and collecting necessary data through the pre-construction monitoring study.			

4.2.2.3 Impact: Artificial lighting

Impact Phase: Operational phase				
Impact Description: Artificial lighting. During operation, artificial lights that may be used at the turbine base or immediately surrounding infrastructure will attract insects and thereby also bats to the turbines. This will significantly increase the likelihood of mortality from collision with turbine blades of bats foraging around such lights.				
	Status	**Severity**	**Probability**	**Significance**
Without Mitigation	Negative	Moderately Severe (2)	Highly Probable (3)	**Medium**
With Mitigation	Negative	Negligible (1)	Improbable (1)	Very Low
Will impact cause irreplaceable loss or resources?	Yes, it will most likely have an impact on the population diversity and abundance.			
Can impact be avoided, managed or mitigated?	Yes, it can be avoided.			
Mitigation measures to reduce residual risk or enhance opportunities.	Utilise lights with wavelengths that attract less insects (low thermal/infrared signature). If not required for safety or security purposes, lights should be switched off when not in use or equipped with passive motion sensors.			
Impact to be addressed/ further investigated and assessed in Impact Assessment Phase?	No			

4.2.3 Decommissioning phase

4.2.3.1 Impact: Loss of foraging habitat

Impact Phase: Decommissioning phase				
Impact Description: Loss of foraging habitat. Foraging habitat will be temporarily lost during decommissioning of turbines and wind farm infrastructure.				
	Status	**Severity**	**Probability**	**Significance**
Without Mitigation	Negative	Moderately Severe (2)	Highly Probable (3)	**Medium**
With Mitigation	Negative	Negligible (1)	Probable (2)	Very Low
Will impact cause irreplaceable loss or resources?	Possibly, if not adhered to the mitigation measures.			
Can impact be avoided, managed or mitigated?	Yes, by keeping the removal of foraging habitat to a minimum and adhering to the sensitivity maps.			

Mitigation measures to reduce residual risk or enhance opportunities.	Adhere to the sensitivity map. Keep to designated areas when storing building materials, resources, turbine components and/or heavy vehicles and keep to designated roads with all heavy vehicles. Damaged areas should be rehabilitated by an experienced vegetation succession specialist.
Impact to be addressed/ further investigated and assessed in Impact Assessment Phase?	No

4.3 Cumulative Impacts

Cumulative impacts might occur due to the number of proposed wind farms in proximity to the study area. The high number of proposed wind farms potentially increases the cumulative risk for bat fatalities, especially where the routes of migratory bat species are found. Cumulative impacts will be identified and assessed during the 12-month pre-construction study.

The study area is located within the Renewable Energy Development Zones (REDZ). The DEA and CSIR are undertaking a Strategic Environmental Authorisation (SEA) in order to identify geographical areas most suitable for the rollout of wind and solar PV energy projects and the supporting electricity grid network.

5 TERMS OF REFERENCE FOR THE IMPACT ASSESSMENT PHASE

The long-term monitoring study will aim to identify bat species at risk of fatality to wind turbines, and patterns in their activity and distributions (temporal and spatial). Ultimately, on completion of the long-term monitoring study refined mitigation measures will be proposed, if needed.

The following objectives will be used for the monitoring study:

- Study bat species assemblage and abundance on the site.
- Study temporal distribution of bat activity across the night as well as the four seasons of the year in order to detect peaks and troughs in activity.
- Determine whether weather variables (wind, temperature, humidity and barometric pressure) influence bat activity.
- Determine the weather range in which bats are mostly active.
- Develop long-term baseline data for use during operational monitoring.

- Identify which turbines need to have special attention with regards to bat monitoring during the operational phase and identify if any turbines occur in sensitive areas and need to be shifted into less sensitive areas or removed from the layout.
- Detail the types of mitigation measures that are possible if bat mortality rates are found to be unacceptable, including the potential times/ circumstances, which may result in high mortality rates.

6 CONCLUSIONS AND RECOMMENDATIONS

The site was visited over the period of 2 – 9 November 2015 wherein five SM3BAT+ detectors were installed on three 10m masts and two met masts. These monitoring systems will record bat activity every night for 12 months from installation. The long-term monitoring study aims to identify bat species at risk of fatality to wind turbines, and patterns in their activity and distributions (temporal and spatial). Ultimately, on completion of the long-term monitoring study refined mitigation measures will be proposed, if needed.

A sensitivity map was drawn up indicating potential roosting and foraging areas. From the sensitivity map, it can be seen that a few turbines are located within High Bat Sensitivity areas and Moderate Bat Sensitivity areas.

The High Bat Sensitivity areas are expected to have elevated levels of bat activity and support greater bat diversity. High Bat Sensitivity areas are 'no – go' areas due to expected elevated rates of bat fatalities due to wind turbines. Thus turbines located within these areas and their respective buffers must be removed or relocated.

The turbines located within Moderate Bat Sensitivity areas and buffers must be prioritised during operational monitoring and will require mitigation measures outlined on conclusion of the full 12-month study.

The site will be visited four more times during the 12-month pre-construction phase to identify areas of dominant bat activity using the passive bat monitoring systems mounted on the masts, transect data will be gathered with a vehicle mounted microphone and searches will be conducted for additional possible bat roosting sites on foot. If any roosts are found they will be visited during each season.

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