bio³

Prepared for Savannah Environmental (Pty) Ltd

Kangnas Wind Energy Facility, Northern Cape Province

Bat Monitoring

Final Report (pre-construction phase)

October 2013

at the cutting edge of biodiversity

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EXECUTIVE SUMMARY

The main results of the bat community pre-construction monitoring programme of the Kangnas Wind Energy Facility are presented in this report. Active detection, passive detection at ground level and 50m height, and bat roost searches and inspection were implemented during the monitoring surveys conducted between September 2012 and July 2013.

The pre-construction monitoring confirmed the occurrence of 4 bat species and the potential occurrence of 6 additional species in the study area. One of the confirmed species is of conservation concern, classified as "Near Threatened" by the South Africa Red List: the Natal long-fingered bat *(Miniopterus natalensis)*. Bat activity in the study area appears higher during spring and winter months. It also appears that bat activity is generally higher at 50m height, although the statistical analysis did not confirm this hypothesis. Wind speed was considered to have a significant influence among bat activity. Three bat roosts were identified and confirmed in the vicinity of study area. Confirmation of the utilization of these roosts was confirmed through enquiries and observation of bat droppings on site. These roosts were located outside of the development area, concentrated at the north-western part of the study area where rocky formations are present.

Both the analysis of bat activity and environmental features in the study area led to the classification of the study area as a generally low sensitivity area for bats, with some localized areas of higher interest for bats. The proposed turbine layout is not coincident with any of the areas considered to be of higher sensitivity.

Considering the potential impacts of collision fatalities of bat species occurring in the area, it was important to analyse the risk of bat collision with wind turbines. This analysis has shown that one confirmed species has a high risk of collision with wind turbines and the remaining three species have medium to high potential collision risk. These species may be affected by the operational phase of this project and mitigation measures are proposed to reduce the probability and significance of such impacts on local bat communities.

Technical team

The technical team responsible for the monitoring surveys and report compilation is presented in Table 1.

Table 1 – Technical team.

Technician	Qualifications	Role on project
David Anger	Level 1 Nature Guide	Field technician
Francisco Cervantes	Master in Environmental Management Environmental and Marine Biology Majors Degree in Biology	Field technician
Hugo Zina	Degree in Terrestrial Environmental Biology Master in Conservation Biology	Field technician
Joana Marques	Masters in Ecology and Environmental management Degree in Environmental Biology	Report compilation
Ricardo Ramalho	Doctor of Philosophy: Environmental studies BSc Honours Degree in Biological Sciences	Technical coordination
Dr. M. Corrie Schoeman	Evolutionary Ecologist at, University of KwaZulu-Natal Ph.D (University of Cape Town) B.Sc Honours summaÂ cum laude (University of Cape Town) B.Sc with distinction (University of Cape Town)	Scientific advisory (bat echolocation identification)
Karen Jodas	Masters of Science degree in Natural Science BSc Honours Degree in Natural Science Registered Professional Natural Scientist (Pr.Sci.Nat)	Report review

PREFACE: BATS AND WIND TURBINES

Currently wind is considered worldwide as one of the most promising renewable energy sources. Wind farm infrastructures in operation do not produce any carbon emissions. Even considering the total carbon emissions associated with the installation of wind turbines and ancillary infrastructure and its maintenance, this is the source of energy with the lowest emissions developed to date (EWEA, 2011). For this reason, it is considered that the expansion of wind power contributes positively to the reduction of climate change caused by increasing human energy needs.

Wind power has grown exponentially in the last decade and it is one of the main alternative energy sources to fossil fuels (Gsänger & Pitteloud, 2013). Its development in South Africa has just started and by the end of 2012 only 10 MW were installed in the country (Gsänger and Pitteloud, 2013). Due to the growing demand for electricity in South Africa and concerns about climate change, the South African government has set targets to produce 17.8GW of energy from renewable sources by 2030. South Africa, the largest CO_2 emitting country on the African continent, is also considered to represent one of the fastest growing wind energy industry markets (Mukasa *et al.*, 2013).

This energy source is however not free from environmental impacts. The installation of wind energy facilities around the world has revealed some issues regarding wildlife conservation (Eichhorn and Drechsler, 2010), especially related to bird (Barrios & Rodriguez, 2004; Drewitt & Langston, 2008) and bat communities (Johnson *et al.*, 2003; Barclay *et al.*, 2007; Arnett *et al.*, 2011). Beyond the birds and bats, habitat loss affects all existing biodiversity (Kikuchi, 2008).

The impact on natural populations is not only due to direct mortality caused by collisions and barotrauma[1], the latter affecting bats only (Baerwald *et al.*, 2008). Impact on natural populations may also be caused by the disturbance effect, barrier effects and habitat loss (Drewitt & Langston, 2006). These impacts, especially mortality, have become a source of major concern among a number of stakeholder groups (Estep, 1989; Erickson *et al.,* 2002). Results obtained during several international monitoring studies indicated that wind farms were responsible for the decrease in population of some species'

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[1] Barotrauma is used in the present report referring to bat deaths due to tissue damage to air- containing structures caused by rapid or excessive pressure change close to the rotating wind turbine blades surface. Death is usually caused by pulmonary barotrauma where lungs are damaged due to expansion of air in the lungs that is not accommodated by exhalation (Baerwald *et al.*, 2008).

(Hunt, 2002; Carrete *et al.*, 2009) although many other studies revealed that these impacts were not important when compared to those originating from other man-made infrastructures (Erickson *et al.,* 2001; Drewitt & Langston, 2008). Nevertheless, the potential for wind farms to affect bat populations should not be underestimated (Hunt, 2002; Madders & Whitfield, 2006).

Extensive research has been conducted internationally regarding bats and wind farms (e.g. Arnett and Kunz, 2008; Baerwald *et al*., 2008; Horn, 2008; Arnett *et al*., 2011). However, not much research has been conducted on these matters in South Africa until recently. Research regarding seasonal and daily movement patterns of bat species and the potential impacts of the development of multiple wind energy facilities and a large number of turbines across the country has been lacking and has only recently commenced.

In addition, information regarding bat distribution, seasonal and daily movements and migration is very limited for South African bat communities. Therefore, the need to evaluate the potential effects and interactions between bats and wind energy facilities is more relevant in South Africa, since the country's experience in wind energy generation has been extremely limited to date and wind energy developments are currently under expansion. Until recently only eight wind turbines had been constructed within the country, 3 at a demonstration facility at Klipheuwel in the Western Cape, 4 at a site near Darling, and 1 at Coega near Port Elizabeth. Moreover, to date only a 1 year preliminary study assessing bird and bird fatalities has been completed in South Africa and the results published, reporting bat and bird fatalities produced by wind energy facilities (Doty & Martin, 2013). This study was undertaken at a pilot turbine installed in the Coega Industrial Development Zone, Port Elizabeth, Eastern Cape, where a total of 18 bat fatalities were recorded over a 12-month period. Another short pilot study (over a 2-month period, solely covering a bat migration period) was conducted at the Darling wind energy facility where only one bat fatality was recorded (Aronson *et al.,* 2013). The potential impacts of wind turbines on South African bat communities is therefore still largely unknown, due to a lack of research on bats in the country and a poor level of knowledge on bat abundance, locations of roost sites, and both foraging and migratory behaviour. Therefore, data collection and further investigations are needed. Pre- and post-construction monitoring at wind energy facilities can go some way to filling these gaps and informing the sustainability of wind energy developments in South Africa.

The Guidelines for Surveying Bats in Wind Farm Developments (Sowler & Stoffberg, 2012) were developed in collaboration with the Endangered Wildlife Trust (EWT). These guidelines provide technical guidance for consultants to carry out impact assessments and monitoring programmes for proposed wind energy facilities, in order to ensure that pre-construction monitoring surveys produce the required level of detail for authorities reviewing environmental authorisation applications. These guidelines outline basic standards of best practice and highlight specific considerations relating to the pre-construction monitoring of proposed wind energy facility sites in relation to bats.

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Citation

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1. Introduction

This document is the final report of the 12-month pre-construction phase of the bat community monitoring programme at the Kangnas Wind Energy Facility in the Northern Cape being developed by South Africa Mainstream Renewable Power Developments (Pty) Ltd.

One year of survey and monitoring of the local bat community within the Kangnas Wind Energy Facility site has been completed prior to the commencement of construction of the wind farm. The purpose of this monitoring was to undertake a general characterization of the bat community, provide baseline data to assess future changes produced by the installation and/or operation of the project and give inputs and general recommendations regarding the infrastructure layout, aiming to minimize the impacts of the project on bats. The data collected during the first year of monitoring surveys, conducted between September 2012 and August 2013, is presented in this report.

1.1. Scope of work and Objectives

The main objective of the monitoring programme is to characterise the bat community present in the area and to assess the potential impact of the Kangnas Wind Energy Facility on this bat community. The specific objectives of the monitoring programme are:

a) Establish the baseline reference and characterization of the bat communities occurring within the development area (e.g. species occurrence, activity and distribution).

b) Identify the potential changes in the bat community present within the Kangnas wind energy facility site and the eventual exclusion effect caused by the project's presence and/or operation (avoidance of the wind facility area during the operational phase of the project).

c) Assess the use of roosts in the wind energy facility development footprint and its immediate vicinity.

d) Quantify bat fatalities associated with the wind energy facility during the operation phase of the project and determine the species affected[2].

e) Identify potential impacts from the wind energy facility on the bat community and propose adequate monitoring, mitigation or, if unavoidable, compensation measures.

In order to achieve the objectives of the bat monitoring programme an experimental protocol was established, covering the wind energy facility site. This programme was developed to hence comply with the main requirements of the "South African Good Practice Guidelines for Surveying Bats in Wind Farm Developments" (Sowler and Stoffberg, 2012) and the major indications from the Environmental Impact Assessment (EIA) report of the proposed Kangnas Renewable Energy Facility (including wind and solar (photovoltaic) energy facilities) on a site near Springbok, Northern Cape (Aurecon, 2013).

In order to accomplish the above-mentioned objectives, the monitoring programme included the following tasks:

- Sampling of ultrasound in the wind energy facility site and in a control area – to be conducted during pre-construction, construction and operation phases. This task will provide data that will enable the accomplishment of Objectives a) and b).
- Bat carcass searches around the turbines - to be conducted during the operation phase. This task will provide data that will enable Objective d) to be accomplished.
- Searcher efficiency and carcass removal (by scavengers or decomposition) trials during the operation phase. This task will provide data that will enable Objective d) to be accomplished.
- Inventory, search, inspection and monitoring of shelters in the area surrounding the wind energy facility during the pre-construction and operation phases. This task will provide data that will enable Objective c) and complementary compliance with Objective b) to be accomplished.

All the above methodologies will enable the accomplishment of Objective e).

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2 This goal will only be achieved during the operational phase of the project.

The results of the pre-construction monitoring will contribute to the establishment of the baseline situation, allowing the accomplishment of all the objectives stated in future phases of the project. More specifically, the pre-construction monitoring phase will contribute to the characterization of the bat community present in the study area and evaluate bat habitat use within the proposed development site. The assessment of potential bat fatalities associated with the Kangnas Wind Energy Facility will be the subject of the monitoring programme to be implemented during the operational phase of the development.

1.2. Report Structure

This report content was adapted to the monitoring work completed and is organized in the following chapters:

- Chapter 1: Introduction – description of aims and scope of the study;
- Chapter 2: Monitoring programme description – description of field methodology and data analysis techniques implemented;
- Chapter 3: Results and Discussion – presentation and discussion of the results;
- Chapter 4: Potential impacts identified – synthesis of the potential impacts identified and sensitivity analysis of the layout;
- Chapter 5: Conclusions and recommendations for the next phases of the project;
- Chapter 6: Proposed bat monitoring programme;
- Chapter 7: References – literature references;
- Chapter 8: Appendices.

1.3. Terms of reference

The following assessment was conducted according to the specialist terms of reference:

- Conduct a review of international literature and experience relating to operational wind farms - including other facilities around the world.
- Describe the affected environment and determine the bat species present in the future impacted site.
- Identify species of special concern and assess potential effects of the development on the bat community.
- Assess how the bat community will be affected by the proposed development, listing, describing and evaluating potential impacts.
- Map sensitive areas in and around the proposed wind energy facility site.
- Provide recommendations for relevant mitigation measures which will allow the reduction of negative effects and maximization of the benefits associated with any identified positive impacts.
- Propose a suitable monitoring programme for the evaluation of the impacts expected during the operational phase of the development, if considered necessary.

1.4. Legal Framework

There are no permit requirements dealing specifically with bats in South Africa. It is considered best practise for bat monitoring to be undertaken on wind energy facility sites, in order to fulfil the requirements outlined by the **South African Good Practice Guidelines for Surveying Bats in Wind Farm Developments** (Sowler & Stoffberg, 2012). Legislation dealing with mammals applies to bats and includes the following:

National Environmental Management: Biodiversity Act, 2004 (Act 10 of 2004):

The National Environmental Management: Biodiversity Act (Act 10 of 2004) (NEMBA) provides for listing threatened or protected ecosystems, in one of four categories: critically endangered (CR), endangered (EN), vulnerable (VU) or protected. The Act calls for the management and conservation of all biological diversity within South Africa.

NEM:BA also deals with endangered, threatened and otherwise controlled species, under the ToPS Regulations (Threatened or Protected Species Regulations). The Act provides for listing of species as threatened or protected, under one of the following categories:

- Critically Endangered: any indigenous species facing an extremely high risk of extinction in the wild in the immediate future.
- Endangered: any indigenous species facing a high risk of extinction in the wild in the near future, although it is not a critically endangered species.
- Vulnerable: any indigenous species facing an extremely high risk of extinction in the wild in the medium-term future; although it is not a critically endangered species or an endangered species.
- Protected species: any species which is of such high conservation value or national importance that it requires national protection. Species listed in this category include, among others, species listed in terms of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

A ToPS permit is required for any activities involving any ToPS-listed species. A number of bat species are listed as critically endangered, endangered, vulnerable and protected in terms of Regulations published under this Act.

Northern Cape Nature Conservation Act (Act No. 9 of 2009)

The purpose of the Act is to provide for the sustainable utilisation of wild animals, aquatic biota and plants and to provide for the implementation of CITES. Schedules 1 and 2 list Specially Protected and Protected species. Bat species are only listed in Schedule 2 as Protected. A permit is required for any activities which involve endangered or protected flora and fauna.

IUCN Red List of Threatened Species

The International Union for the Conservation of Nature (IUCN) Red List of Threatened Species ranks plants and animals according to threat levels and risk of extinction, thus providing an indication of biodiversity loss. This has become a key tool used by scientists and conservationists to determine which species are most urgently in need of conservation attention. In South Africa, a number of bats are listed on the IUCN Red List.

1.5. Proposed Wind Energy Facility and Survey Area

The proposed Kangnas Wind Energy Facility will be developed in up to four stages of 140 MW each with a future maximum total installed capacity to 560 MW. Each phase may consist of 35 to 94 turbines, depending on the type of turbine used (4 MW or 1.5 MW machines, respectively). The layout considered in the present report consisted of 65 wind turbines. The type of wind turbine to be used at the Kangnas wind energy facility has not yet been selected; however the rotor blades will be 40 – 60 m long, with an 80 – 120m rotor diameter and a 90 – 120 m tower height. The project also includes:

- Transmission power lines;
- Two on-site substations;
- Internal access roads.

The site is located south of the N14 and falls on the following farms: Koeris 78, Kangnas 77 and Groot Kau 128 in the Northern Cape Province. The control site used within this monitoring programme is located on the farm Taaibosmond 580. The farm portions of the wind energy facility site cover an area of 9 223.4 ha (refer to Figure 4).

The area is mainly occupied by natural vegetation, used mostly for grazing of sheep and cattle. There are also degraded areas, which are more intensively used by livestock and do not have vegetation, usually surrounding water sources and windmills (Figure 1).

The area is characterised by plains, with a mean altitude of 1000m and granite inselbergs in the northwest. The inselbergs consist of ridges and rocky cliff faces and are important sources of lift for soaring bird species, notably raptors and possibly bustards. The ridge slopes and boulder-koppies provide habitat for species with montane habitat preferences, cliff-nesting and foraging species. Two main temporary wetland areas are present in the study area (Granite Pan and Steenbok Pan), providing seasonal habitat for wetland associated species.

The site falls within the Nama-Karoo and Succulent-Karoo biomes, which comprises of three main vegetation types: Bushmanland Arid Grassland, Bushmanland Inselberg Shrubland and Platbakkies

Succulent Shrubland (Mucina & Rutherford, 2006) (refer to Figure 2). All of these vegetation types are considered Least Threatened (Mucina & Rutherford, 2006)..

The Kangnas Wind Energy Facility is located approximately 28 km west of the Goegab Nature Reserve at its closest point. The wind energy facility location is also approximately 46 km southeast of the Haramoep & Black Mountain Mine Nature Reserve, 50 km east of the Bitterputs Conservation Area, 70 km northeast of the Skilpad Nature Reserve and 75 km northeast of the Namaqua National Park (refer to Figure 3).

- The Goegab Nature Reserve comprises about 15 000 ha of typical granite koppies and sandy plains of Namaqualand. This area is quite rich in indigenous plant species, but is also provides habitat for several mammal, reptile, amphibian and bird species. At least 94 bird species can occur in this area, including Ostrich, Verreaux's Eagle, Spotted Thick-knee and Ground Woodpecker.
- Haramoep & Black Mountain Mine Nature Reserve consists of sandy and gravel plains with perennial desert grassland and shrubs (BirdLife, 2013a). Some endangered bird species are known to occur within the park, including Black Harrier, Ludwig's Bustard, Red Lark and Sclater's Lark, all as residents (BirdLife, 2013a). This IBA is also coincident with other two protected areas: Aggeneys farm Conservation Area and Black Mountain Mine Nature Reserve.
- Bitterputs Conservation Area consists mainly of flat gravel plains with a red dune system from north to south in the central and western portion of the property. This is one of the few sites protecting both the globally threatened Red Lark (*Certhilauda burra*) and the near-threatened Sclater's Lark (*Spizocorys sclateri*). 16 of the 23 Namib-Karoo biome-restricted assemblage species and other arid-zone birds are also known to occur in the area. The plains support Black Harrier (*Circus maurus*), Kori Bustard (*Ardeotis kori*), Ludwig's Bustard (*Neotis ludwigii*), Karoo Korhaan (*Eupodotis vigorsii*), Burchell's Courser (*Cursorius rufus*), Namaqua Sandgrouse (*Pterocles namaqua*), Stark's Lark (*Spizocorys starki*) and Tractrac Chat (*Cercomela tractrac*). During good rains the nomadic Black-eared Sparrow-lark (*Eremopterix australis*) and Lark-like Bunting (*Emberiza impetuani*) can be super-abundant. All the farms that composed this area are privately owned and are not conserved in any manner (BirdLife, 2013b).
- Skilpad Nature Reserve located west of Kamieskroon is most notably known for its annual spring flower displays. This area is also part of the Namaqua National Park, being created mostly to protect the numerous species of bulbs and flowers present.

* The Namaqua National Park is characterized by its great variety of smaller succulent plants as part of the succulent Karoo biome. The eastern area of this park is characterised by hills and mountains of the Kamiesberg Range (SAN Parks, 2004-2013).

Figure 1 – Photographs indicating the general landscape of the Kangnas Wind Energy Facility site (left) and control area (right).

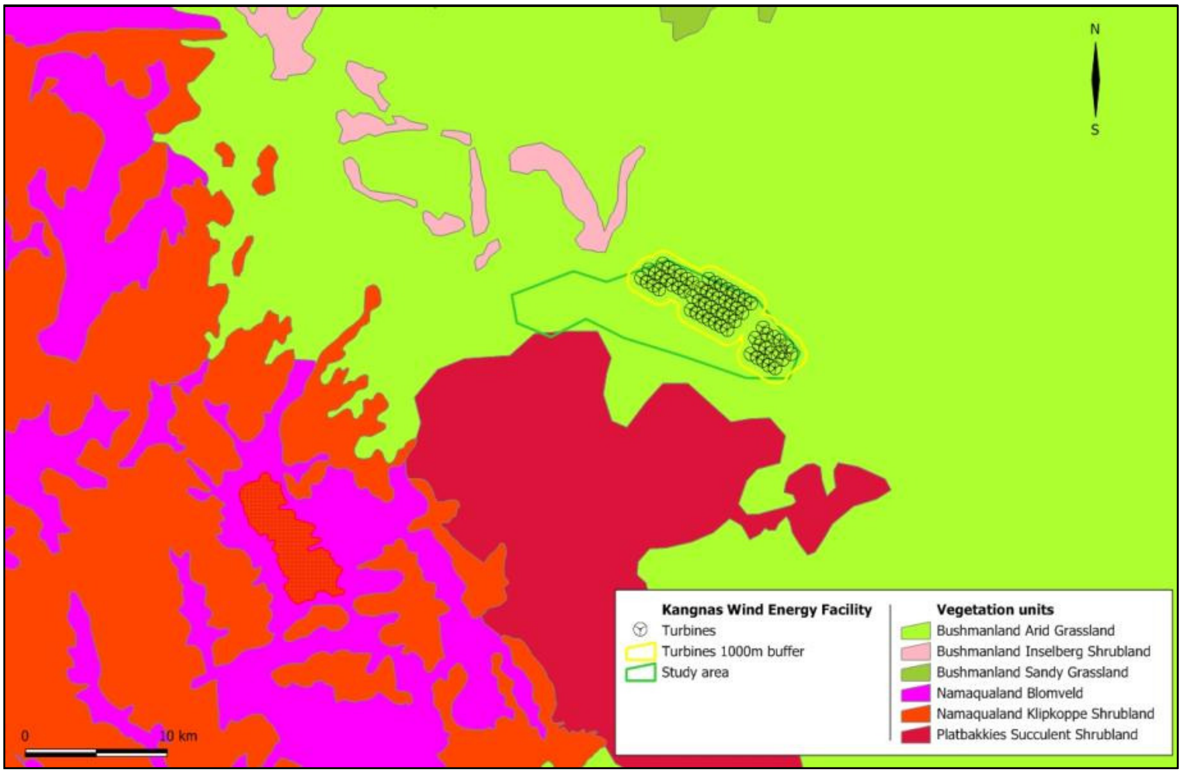


Figure 2 - Location of the study site in relation to the vegetation units defined by Mucina & Rutherford (2006).

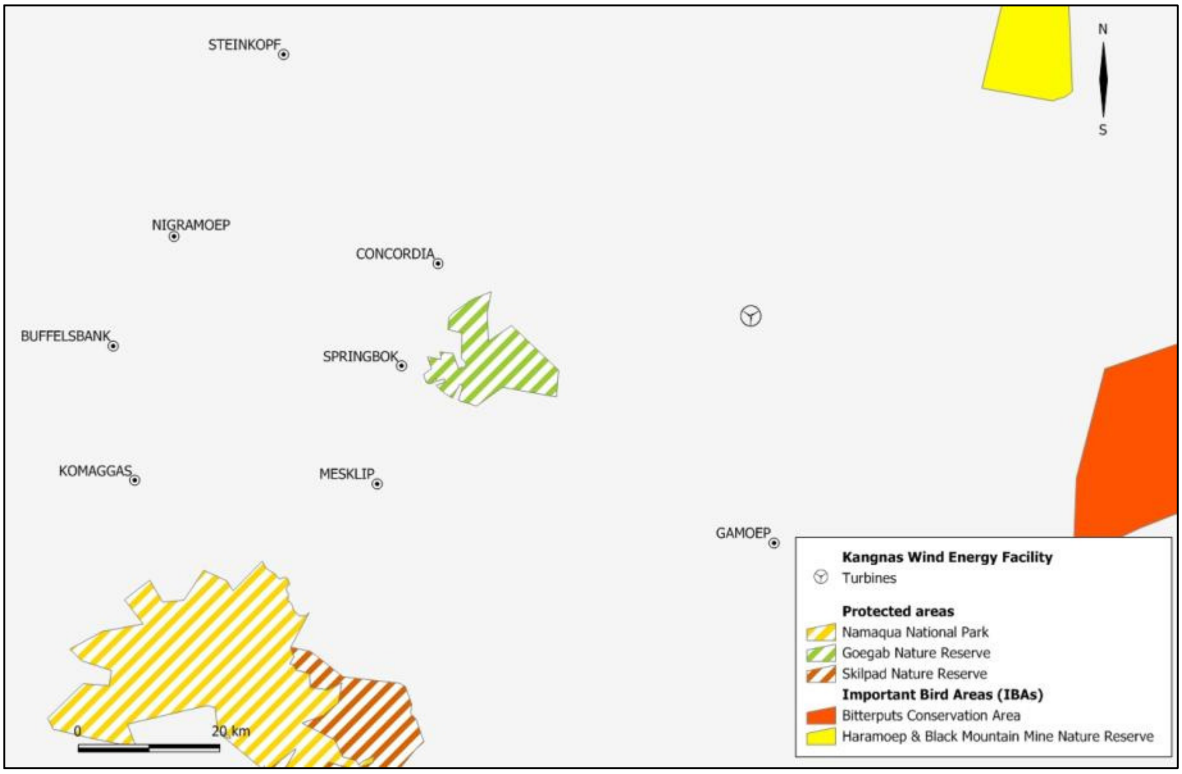


Figure 3 – Wind energy facility site location in relation to important conservation areas in the broader region.

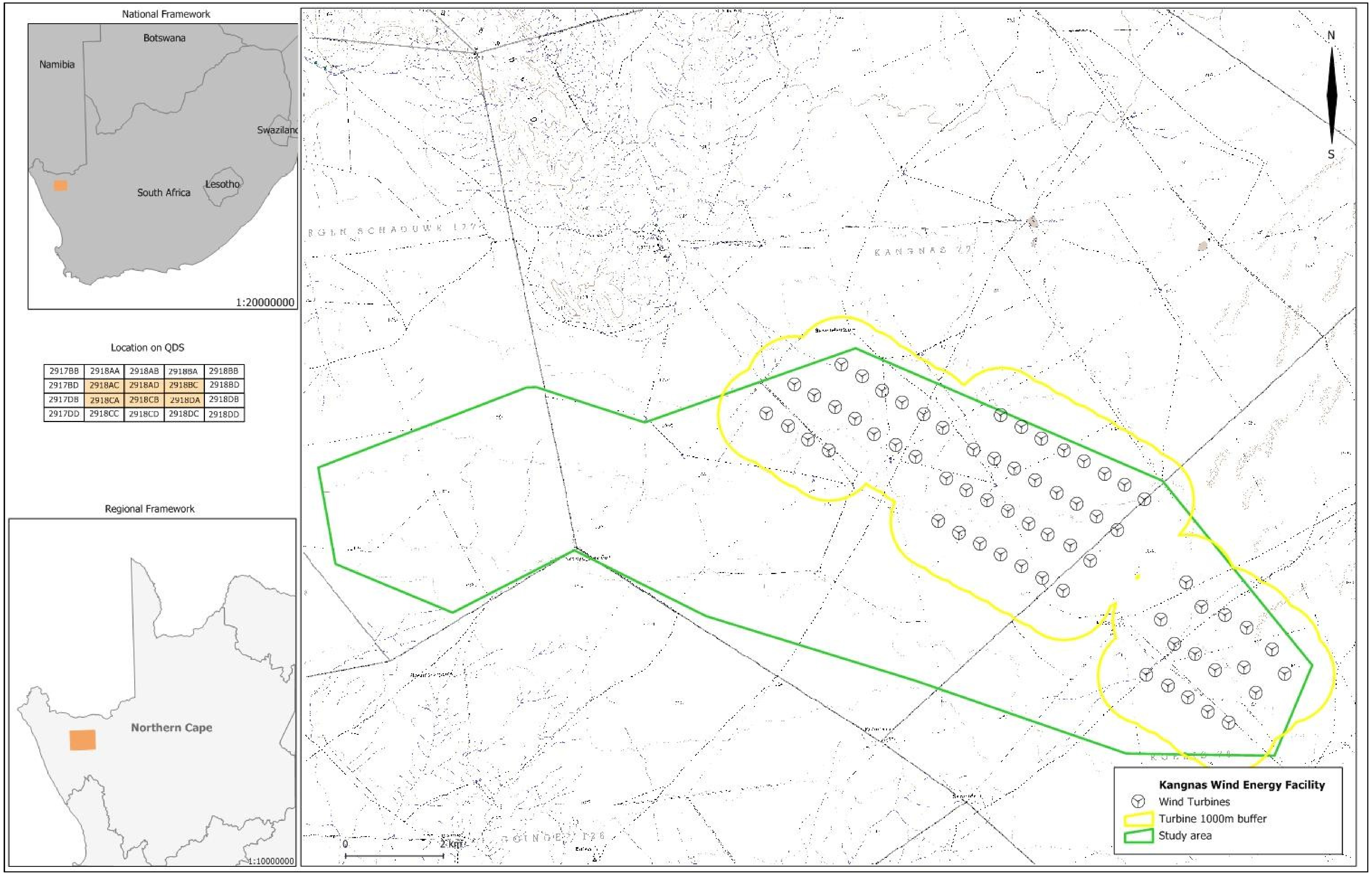


Figure 4 – Estimated location of the proposed Kangnas wind energy facility.

1.6. Summary of EIA

An Environmental Impact Assessment (EIA) was undertaken for the Kangnas wind energy facility (Aurecon, 2013) with a specific Impact Assessment for the bat community (Marais, 2012). This Bat Impact Assessment refers to the potential occurrence of 10 species, one of which was confirmed during fieldwork: the Egyptian free-tailed bat (*Tadarida aegyptiaca*). From the species considered to have the potential to occur in the study area, two are near threatened species – Lesueur's wing-gland bat (*Cistugo leseueri*) and Natal long-fingered bat (*Miniopterus natalensis*) –, and two have a high risk of collision with wind turbines – the Egyptian free-tailed bat (*Tadarida aegyptiaca*) and Robert's flat-headed bat (*Sauromys petrophilus*). In spite of the featureless terrain of the south eastern part of the site, some high altitude rocky outcrops which may supply roosting features for bats are present in the north-west corner of the site.

Potential impacts on the bat community of the study area identified though the EIA include i) the destruction of foraging habitat during the construction phase, considered to have an impact of moderate to low significance (if mitigation measures are implemented); and ii) bat fatalities due to blade collisions and barotrauma during foraging and migration. Bat fatalities are expected to occur during the operational phase and have been considered to have a moderate significance.

Due to the impacts expected to occur on the bat community, an analysis of the sensitivity of the study area was presented, with the identification of two no-go areas (areas of high sensitivity) were identified on the basis of potential high levels of bat activity and possibly greater bat diversity (Figure 5). Areas of moderate sensitivity were also identified on the basis of the presence of foraging habitat or roosting sites with a significant role for bat ecology. No turbines were proposed for the no-go areas. However, some turbines were located within areas of moderate sensitivity and were recommended as focus areas for post-construction monitoring and mitigation measures.

Three main mitigation measures were proposed:

a) Avoidance of placement of infrastructures in the areas considered to be of high or moderate sensitivity, and rehabilitation of the affected vegetation.
b) Implementation of curtailment, feathering or ultrasonic deterrents to be studied and tested if necessary.

c) Implementation of a pre-monitoring programme for at least four seasons focused on the Moderate sensitivity areas and the areas around two small caves in the area, as well as a post-construction monitoring programme in order to inform mitigation measures.

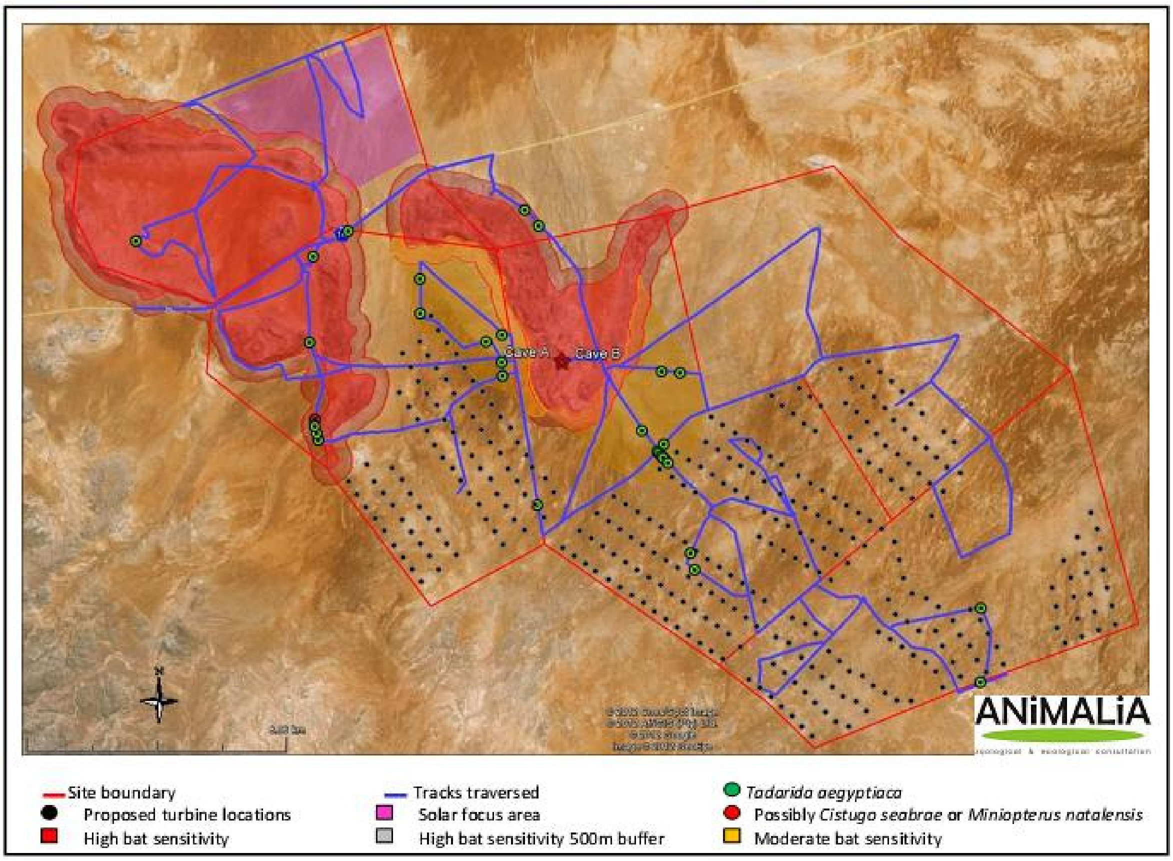


Figure 5 – Bat sensitivity map presented on the Bat Impact Assessment of Kangnas Wind Energy Facility (Marais, 2012).

2. Monitoring Programme Description

The methodology used for the present monitoring programme was developed by bat specialists in order to comply with the *South African Good Practice Guidelines for Surveying Bats in Wind Farm Developments* (Sowler & Stoffberg, 2012) and the main findings from the Environmental Impact Assessment (EIA) report for the proposed Kangnas Renewable Energy Facility near Springbok in the Northern Cape Province (Aurecon, 2013).

2.1. Desktop preparatory work

Prior to the initiation of the field surveys, a desk-top survey was conducted to compile the best information possible to provide a better evaluation of all the conditions present within the study area. Therefore, available data sources (Table 2) were consulted to assess which species could occur with certainty in the different habitats occurring at Kangnas Wind Energy Facility. In order to evaluate and interpret the results obtained, literature references and bat specialists were consulted for any available information regarding possible migration routes; patterns of bat activity throughout the year in the study area; the presence of known roosts surrounding the study area that may be important for bats occurring at the Kangnas site; local or regional echolocation variation in the sound parameters; or other information that could be relevant for the contextualization of the importance of the study area for bats occurring in South Africa, particularly, in the Northern Cape.

Potential roosting sites and potential important areas for bats were identified, in a preliminary stage, by means of a desktop survey taking into consideration the 1:50 000 maps of South Africa, aerial imagery and any other relevant information overlaid in a Geographic Information System (GIS), as well as information from the EIA.

These locations were then validated during a first visit to the site, to fine tune and adjust the methodological protocol to the site characteristics and any other particular conditions found in the area. Whenever considered necessary, the methodology and techniques were adjusted for a better assessment of the bat communities present at the site.

Table 2 below includes, but is not limited to, the list of data sources and reports consulted and taken into consideration, for the compilation of this report, in varying levels of detail. Other references were consulted for particular issues (these are detailed in section 6).

Table 2 – Main data sources consulted.

Type	Name	Reference	Detail of information
Data sources	Bats of Southern and Central Africa	Monadjem *et al.*, 2010	National level
	African Chiroptera Report	African Bats (ACR, 2012)	National level
	Red Data Book of the Mammals of South Africa	Friedmann & Daly, 2004	National level
	Caves and Caving in the Cape	http://www.darklife.co.za/Caves/	Regional level
	Literature on bat interactions with wind energy facilities	Refer to section 6	International level
	Bat fatality at a wind energy facility in the Western cape, South Africa	Aronson *et al.*, 2013	Regional level
	The Vegetation of South Africa, Lesotho and Swaziland	Mucina & Rutherford, 2006	National level
	Global List of Threatened Species	IUCN, 2012	International level
	Renewable Energy Application Mapping – Report version 1	CSIR, 2013	National level
Guidelines and other international references	South African Good Practice Guidelines for Surveying Bats in Wind Farm Developments	Sowler & Stoffberg, 2012	Methodological approach
	Wind energy development and Natura 2000	European Commission, 2010	International level Methodological approach and analysis
	Good Practice Wind Project	www.project-gpwind.eu/	International level Methodological approach and analysis
	Comprehensive Guide to Studying Wind Energy/Wildlife Interaction	Strickland *et al.*, 2011	International level Methodological approach and analysis
	U.S. Fish and Wildlife Service Land-Based Wind Energy Guidelines	USFWS, 2012	International level Methodological approach and analysis
	Bat surveys: Good practice guidelines, 2nd edition	Hundt, 2012	Methodological approach
	Guidelines for consideration of bats in wind farm projects	Rodrigues *et al.*, 2008	International level Methodological approach and analysis
	Directrices para la evaluación del impacto de los parques eólicos en aves y murciélagos	Atienza *et al.*, 2011	International level Methodological approach and analysis

Species occurrence

The probability of occurrence of bat species in the study area was evaluated according to several criteria, as described below. The distribution maps used to evaluate species occurrence were the ones included in Monadjem *et al.* (2010) and ACR (2012). The probability of occurrence of bat species within the Kangnas study area (within 100 km buffer from the wind energy facility site) was characterised as:

- **High probability** – the species has been historically confirmed on or near the site within the last 20 years; the habitat present on site is suitable for the species preferences.
- **Moderate probability** – the species is within the higher probability modelled distribution of potential occurrence according to Monadjem *et al.* (2010); has been historically confirmed in the area within the past 20-50 years; the habitat is adequate for the species requirements.
- **Low probability** – the species is within the lower probability modelled distribution of potential occurrence according to Monadjem *et al.* (2010); has been historically confirmed in the study area more than 50 years ago; the habitat present in the site is adequate for the species preferences.

The utilization of these two sources of information may cause some differences in the evaluation on the probability of a species occurrence, since ACR (2012) presents a compilation of records of the species and Monadjem *et al.* (2010) presents a modelled distribution of the species based on several factors such as previous records and habitat conditions. Nonetheless both types of information were considered and evaluated according with the type of biotopes present at the Kangnas study area. The output of this exercise was then evaluated by a bat specialist according to his expertise and knowledge.

2.2. Field Surveys

Surveys of the monitoring programme of the bat community included the implementation of several field techniques appropriate for the specific characteristics of the study area. Active surveys were conducted from September 2012 to July 2013, through fixed sampling point surveys, established along vehicle based transects; passive echolocation surveys at ground level and at rotor height; and roost searches and inspections to any structure considered as having any potential as a bat roosting location.

2.2.1. Sampling Period

The surveys of the bat community monitoring programme in the study area were conducted between September 2012 and July 2013 and included six surveys evenly distributed over the year, as detailed in

Table 3.

The surveys covered the spring, summer, autumn and winter seasons and two surveys were conducted in the most relevant seasons for the bats in the area (spring and autumn). Monitoring at height (50 m) was conducted only from March 2013 onwards, since it became apparent that the bat fraternity (SABAT) at that moment in time changed the requirement to mandatory in the best principles guide to measure within rotor swept area. The required conditions to install the microphone on the lattice mast were only present at this survey. Passive detection was therefore conducted at ground level and at height, during a minimum of 6 nights per survey, and covering all seasons of the year. The sampling periods were considered to be adequate for the proposed study considering to the conditions and potential bat community present within the study area.

Considering the indications provided by Sowler & Stoffberg (2012) the survey effort may be adjusted to suit the requirements of the study area. Therefore the monitoring programme covered four seasons: autumn, winter, spring and summer. The sampling effort was adapted to the site conditions for bats, with most of the area not being rich in features favouring bat species occurrence and with very few features with high potential for bat roosting in the area where the wind turbines are being proposed. The area was also considered to have low potential for foraging bats since it is mostly used for extensive cattle grazing, with vegetation indicative of semi-desert conditions, as described previously (refer to section 0). However, some rocky outcrops with adequate conditions for some cave-dependent bats to use as roosts are present in the north western portions of the study area, being potentially important as permanent or temporary roosts for some local bat species. This fact, associated with the reduced number of species potentially occurring in the study area (Marais, 2012; Aurecon, 2013) support the possibility of this being an area with low bat activity, hence, not justifying a higher survey effort.

Table 3 – Schedule of bat monitoring field work conducted at the Kangnas wind energy facility.

Year	Season	Survey	Passive detection	Active detection	Roost search and monitoring
2012	Spring	September	3rd to 9th	4th to 7th	X
		November	November 27th to December 3rd	November 28th to December 2nd	X
2013	Summer	January	January 31st to February 5th	January 31st to February 3rd	X
	Autumn	March	23rd to 29th	25th to 26th	X
		May	20th to 25th	21st to 23rd	X
	Winter	July	8th to 13th	9th to 13th	X

2.2.2. Weather conditions

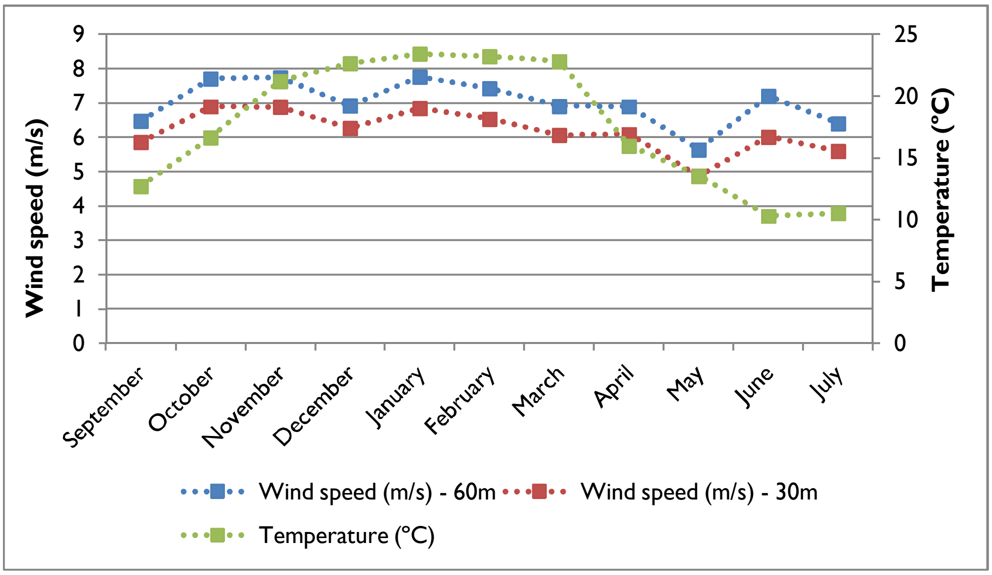
Active surveys were conducted under mild weather conditions, with the exception of the summer and early autumn months, when average air temperatures were above 25°C, which is quite warm for the night period. Throughout the year, maximum temperatures of up to 32°C were registered during the summer, while minimum temperatures of 12°C where recorded in winter (Table 4). Wind speed conditions were also acceptable, with general low average wind speeds, approximately 1m/s. Nonetheless, some peaks of higher wind speed were recorded in late spring and summer (maximum wind speed of 8 m/s), with no wind speed recorded for half of the surveys (minimum wind speed of 0 m/s in September, March and July). Very windy nights were registered only during spring and summer, with average wind speeds of 4m/s. No precipitation was recorded during the days when surveys were conducted.

Table 4 – Average weather conditions recorded during the active surveys conducted at Kangnas Wind Energy Facility

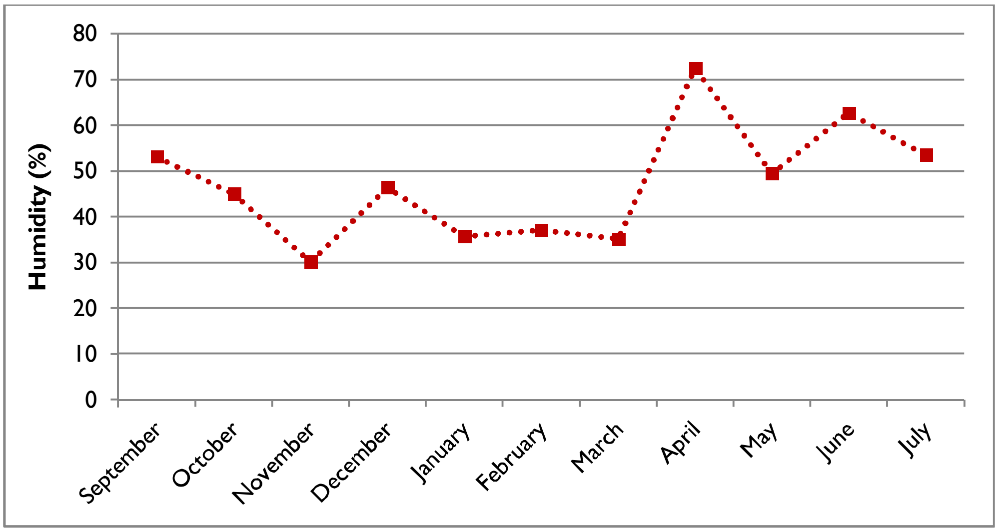
Year	Season	Survey	Average Wind speed (m/s)	Average Temperature (°C)
2012	Spring	September	1.39	17.57
		November	4.11	20.43
2013	Summer	January	4.44	25.27
	Autumn	March	1.63	24.59
		May	1.71	17.89

Year	Season	Survey	Average Wind speed (m/s)	Average Temperature (°C)
	Winter	July	0.48	16.53

The prevalent meteorological conditions most relevant to the study (average wind speed and average air temperature) were evaluated in terms of the data from the meteorological mast located within the wind energy facility development area, (Figure 6a). The average wind speed was mostly constant at approximately 6 m/s. Temperature and humidity presented some variation, with high temperatures and humidity values recorded between January and March (summer) with a decrease in temperature between summer and autumn, as expected (Figure 6a, b).



(a)



(b)

Figure 6 – Average wind speed (m/s) at 60 and 30m height, temperature (ºC) (a) and humidity (%) (b) per month between September 2012 and July 2013 conducted at Kangnas wind energy facility (data from on-site meteorological mast).

2.2.3. Evaluated Parameters

In order to characterise the bat community present in the study area, the following parameters where evaluated both for the Kangnas wind energy facility area and a similar control area:

- Species richness;
- Activity index;
- Location and use of roosts within and around the site; and
- Type of utilization of the study area by bats.

2.2.4. Data collection techniques and methods

Bats are usually divided in two main groups: echolocating and non echolocating bats, the former that usually uses highly evolved ultrasound echolocation to navigate, forage and communicate (Schnitzler & Kalko, 2001) and the latter that uses mostly vision for orientation, to navigate and search for food sources (Monadjem *et al.,* 2010). Non echolocating bats are commonly known as fruit bats (feed mostly on fruits); whereas echolocating bats are known as insectivorous bats (insects are their main food source). The different flight and echolocation inter-specific characteristics are directly related to differences in species' foraging habitats (Schnitzler & Kalko, 2001).

Tracking the status of insectivorous bat populations through the abundance and distribution of echolocation calls has the potential to offer a more efficient alternative to trapping or visual sampling methods for bat survey and monitoring programmes (Walters *et al.*, 2012). The detection, recording and analysis of ultrasounds is very useful in the detection and identification of different bat species, since these mammals are nocturnal and, in the majority of the species, emit ultrasound calls to guide them, to detect prey and to communicate. Details pertaining to the collection techniques are provided below.

2.2.4.1. Active detection

The active detection of ultrasounds was conducted with a Pettersson D240X ultrasound detector with a heterodyne incorporated, that allows the detection of bats in real time and a time expansion function. A time expansion detector first stores a portion of the ultrasonic signal in its digital memory and then replays it at a slower speed, in the case of D240Xx at a 10x rate. The entire ultrasonic range is audible all the time. While the "South African Good Practice Guidelines for Surveying Bats in Wind Farm Developments" (Sowler & Stoffberg, 2012) do not mention the utilisation of this type of equipment, the experience and knowledge acquired over the years in monitoring bats at wind energy facilities internationally have shown that the frequency division detectors do not provide sufficient data to analyse all the sound parameters like harmonics and the pulse amplitudes. The harmonics are essential in identifying some of the species that occur in South Africa, such as *Nycteris* sp., *Cloeotis percivali*, *Hipposideros caffer* and *Taphozous* sp. These sound characteristics also help in the identification of other species such as some *Neoromicia* sp., *Pipistrellus* sp., *Miniopterus* sp., *Chaerephon* sp., *Laephotis* sp. or *Rhinolophus* sp. The amplitude is also useful not only to see the shape of the pulse but also to measure the pulse duration in a more precise way.

The harmonics, as well as other pulse characteristics, such as modelling, allows for the collection of behaviour data, through the analyses of social calls. These kinds of calls provide indications of bat interactions in the area, and show that they are not only navigating or feeding. Bats use social calls to attract and communicate with females during breeding season, in territorial disputes, to communicate with other individuals in a colony and also in the mother and offspring communication.

When recording bat echolocations, the most important factor is the call quality. Using detectors, as for example such that from Pettersson Elektronik AB, the collection of too many recordings with no bats calls is avoided and at the same time good quality recordings are collected. The fact that the use of this bat detector is attached to a recorder that records the time expansion means that the technician has to handle the device manually in a non-automatic way, and this allows him to be more alert and therefore can easily detect problems in the field, such as interference from electric lines, cell phone towers or other devices. By detecting these interferences the points or transect locations can be readjusted to avoid interference in the recording quality. Sometimes insects can also emit sounds very close to the ultrasound and that can also decrease the quality of the recordings and sometimes overlap with the low frequency bat calls or social calls. This can be avoided by adjusting the microphone direction.

Active surveys comprised undertaking 5 minutes sampling points along vehicle transects. Transects, and sampling points, were established after the desktop survey followed by an initial inspection and evaluation of the different habitats present in the area by an expert. The established transects and sampling points were intended to be representatives of the biotopes present at the study area, which is mainly comprised of scrubs characteristic from semi-desert environments and areas used for cattle grazing (Appendix I). Four transects of about 2 km each were established (two in the wind energy facility and two in the control area), across the main biotopes present in the area (Figure 7). In each transect, 11 sampling points were established within the various types of vegetation. Each point was characterised according to: minimum distance to the future turbines, slope, dominant orientation, existing biotope, minimum distance to a water source and minimum distance to known roosts (Appendix I).

The active detection surveys were conducted once per survey (each sampling point was conducted one night per survey). Each sampling point was characterised in terms of lunar phase, cloudiness, temperature, precipitation and wind (speed and direction) at the time it was conducted. At each 5 minute sampling point, all bat passes[3] heard and observed were recorded, as well as the entire bat passes detected between sampling points. The output from bat detector can be recorded for later analysis first in its internal digital memory of 1.7s, that associated with a time expanded (10x) repeater will be stored than in an external recorder for 17s each recording, with a sampling rate of 44.1 kHz. The time of usage of the area by a bat, during the 5 minutes sampling period, was also determined meaning that all the passes were timed even if not recorded. During each 17 second period when the ultrasound bat pass was recorded to the external recorder, the number of passes and time of usage of the area continued to be recorded. The surveys started 30 minutes before the sunset ensuring that bat species that emerge early in the evening are included in the surveys (Sowler & Stoffberg, 2012). The active surveys were not performed in adverse weather conditions (rain, very strong wind, fog, thunderstorms).[4]

[3] Contacts with bats detected by visual observation or ultrasonic detection of calls.

[4] The equipment is also extremely sensitive to high levels of humidity as well as to electromagnetic changes.

2.2.4.2. Passive detection

Static detection was performed by means of a Wildlife Acoustics® SM2BAT+ automatic ultrasound detector, with a SMX-US ultrasonic omni-directional microphone (http://www.wildlifeacoustics.com) installed at ground level and rotor height, at the most representative biotope of the study area. Static detectors were installed at ground level (at a height of approximately 2.7 m) from November to January, and since the March survey, one detector was installed on the wind monitoring mast (at a height of 50m). The detectors were configured with a sampling ratio of 384 kHz, so that the maximum detected frequency would be 192 kHz. In order to use this maximum frequency, the detectors were configured with mono-channel, using only the left channel for recording. No compression or gain (+0,0dB) was used, since compression of files may lead to loss of information at frequencies above 70 kHz and the third stage of gain has no effect on ultrasonic recording on the 384 kHz sample ratio. Therefore files were saved with *.WAV format. As advanced settings, the static detectors were configured with:

- Digital high-pass filter (HPF) Left - fs/64 (filters frequencies below 6kHz);
- Low-pass filter (LPF) – Off;
- Trigger Level +6dB SNR;
- Trigger win 2.0s;
- Div ratio 16.

The equipment was scheduled to automatically record bat calls every day over the monitoring period for a 12-hour period starting 30 min before sunset.

In September 2012, 3 detectors were installed at ground level (on portable aluminium poles of 2.5 m in height) at 3 different locations (two within the wind facility site (PQKGA01 and PQKGA02) and the other within a control area (PQKGA03)) considered to be within similar biotopes (Figure 7). In the March 2013 survey an additional detector was installed on a lattice mast at 50m height within the wind energy facility (PQKGA05). In order to have a comparison with the activity observed between 50m height and ground level, the detector PQKGA01 installed at the wind energy facility, and closer to the met mast location, was relocated closer to the PQKGA05, being renamed PQKGA04 (

Table 5; Figure 7).

Table 5 – Timeline of the detectors placed at the Kangnas Wind Energy Facility and Control area.

Area	Detector	September	November	January	March	May	July
Wind Energy facility	PQKGA01						
	PQKGA02						
	PQKGA04						
	PQKGA05						
Control	PQKGA03						

Each passive sampling point was characterised according to: minimum distance to the proposed wind turbine locations, slope, dominant orientation, biotope, minimum distance to a water source and minimum distance to known roosts. The equipment automatically recorded the temperature at each recording event.

Passive detection was undertaken for at least 6 nights per month as detailed in

Table 3. The passive detection locations were selected during the first site visit, in order to sample the most representative biotopes at the wind energy facility site and at the control area. This approach allowed for the recording of bat activity in different weather conditions.

2.2.4.3. Non echolocating bats

Bats are usually divided into two different groups, mostly by their diet: fruit-eating bats and insectivorous bats. The South African fruit bats feed on the fruits, flowers and nectar of a wide range of indigenous trees as well on domestic or commercial fruit trees (Monadjem *et al.,* 2010). The potential occurrence of any of the South African fruit bat species is not considered possible due to the terrain characteristics (featureless and absence of fruit trees in the study area or in the vicinity). However to determine the occurrence of fruit-eating bat species within the study area, searches were directed to potential roosting sites suitable for these species during daytime. Favourable foraging habitats were also inspected in the area (areas with favourable food supply). As a complementary methodology, visual and acoustic (attempts to hear vocalizations) searches were conducted at night.

2.2.4.4. Roost search and monitoring

All structures that can potentially provide roosting locations for bats (caves, mines, abandoned buildings, bridges, etc) were identified in the study area and its surroundings by means of a GIS based desktop study and during the fieldwork visits to the area. The potential roosting locations identified were then inspected in the subsequent surveys through the monitoring programme in order to record evidence of bat presence and occupation (such as, live bats roosting, guano[5] accumulation, bat carcasses or insect remains). Additional information was also recorded, including: the season, the individual's activity rate, presence of progeny, degree of human disturbance and type of roost.

During the fieldwork, the location of each roost inspected was recorded with a handheld GPS (Garmin® ETREX 10), as well as photographed.

[5] Name given to bat droppings.

When a roost showed signs of potential occupation by bats (through an investigation of the population or observation of traces of occupation), a manual survey was conducted outside of the potential roost whenever possible. The surveys were conducted using the same equipment as described in section 2.2.4.1, and lasted for one hour, starting half an hour before sunset and finishing half an hour after sunset.

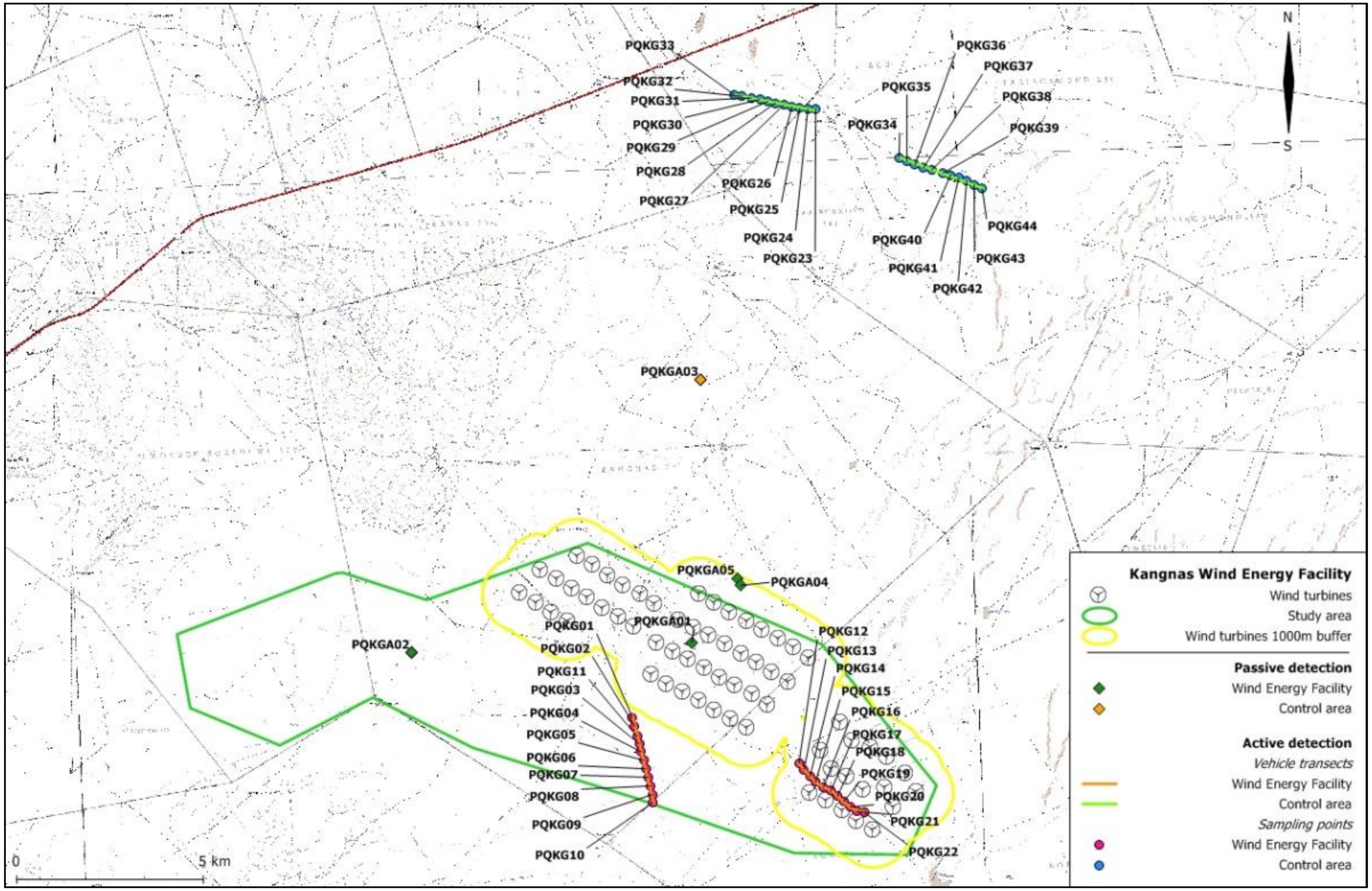


Figure 7 – Sampling points and transects location at the Kangnas wind energy facility site and Control area.

2.2.5. Data analysis and criteria

2.2.5.1. Ultra-sounds analysis

Acoustic monitoring produces huge amount of data, therefore the call data was recorded by the SM2BAT as a compressed format (*.WAC files) that was later converted using Wildlife Acoustics Kaleidoscope® Software to *.WAV files to allow species acoustic identification by expert technicians. Using the same software, an acoustic scrubbing for filtering non-biological noise such as rain, wind, birds and insects, false triggers or anthropogenic noise was conducted. With this operation it was intended to eliminate periods of rain or wind, long periods of noise with low frequencies, within the audible frequencies. It is however necessary to consider that the software is not perfect and that biological noise is highly variable. Therefore, whenever considered necessary, a manual scrubbing was performed using software developed specifically to address this issue (by the IEETA – Institute of Engineering and Telematics of Aveiro University in Portugal). This software allowed an expedited visualisation of the recordings and was used as a complementary scrubbing to Kaleidoscope® tool software, assuring that all activity recorded was considered.

Identification of bat species through analysis of echolocation calls is a very time consuming task[6], as specialized technicians have to go through each call, extract the necessary acoustic parameters with specific software and then identify the species using a reference echolocation call library for South African bats. Considering the amount of data produced it was necessary to conduct a sub-sampling methodology of the overall calls recorded by the static detectors. This sub-sampling methodology was intended to estimate the proportion of bats that belong to a certain species, among the total bat calls recorded. Since the surveys were conducted throughout time and in several different locations, a simple random sampling would not be suitable. Therefore, the adequate method applied was a stratified random sampling (Cochran, 1977), using as factors the sampling location and survey.

[6] We estimate that one specialized technician can identify, on average, 30 echolocation recordings during a working day (8 hours).

The total size of the sample was then calculated according to the following equation (Cochran, 1977):

$$n = P(1-P)\left(\frac{z_{1-\alpha/2}}{e}\right)^2$$

, where: n = number of elements of the sample; P = estimated proportion of the interest characteristic (bat species); $z_{1-\alpha/2}$ = critical value associated to the degree of confidence; e = maximum error of estimation.

The number of elements of the sample of each of the considered factors was obtained through proportional affectation, using the equation (Cochran, 1977):

$$n_i = N_i\left(\frac{n}{N}\right)$$

, where: n_i = number of elements of the sample in the factor; N_i = number of elements in the factor; n = number of elements of the sample; N = number of elements of the population.

With the number of elements to analyse in each of the factors (location and survey), resulting from this process of stratified random sampling, the recordings for analysis were randomly selected through a random algorithm. The randomly selected recordings were then processed by a specialized technician, considering the several parameters that allow the identification of bat species. One of the characteristics of echolocation pulses that have to be considered for the identification of bat species is the shape of echolocation pulses - frequency modulation (FM), quasi-constant frequency (QCF) and constant frequency (CF) (Altringham, 1996; Russo & Jones, 2002). However most of the bats use a combination of both FM/QCF (Altringham, 1996), where the initial part of the pulse uses frequency modulation, and the end presents almost a constant pulse frequency. Further characteristics of the pulses are used for the species identification such as the frequency of maximum energy (FMaxE), pulse duration, initial and final frequencies, bandwidth, interval between pulses, shape of the pulse, among others (Fenton & Bell, 1981).

The analysis of the recorded calls was performed using *Audacity 2.0.0 – Cross-Platform Digital Audio Editor*, from Dominic Mazzoni. Through the analysis of pulse characteristics, the identification of detected species was possible. The reference values used were the ones presented in ACR (2012), Pierce (2012), Gauteng and Northern Regions Bat Interest Group (2012), Monadjem *et al.* (2010), Hauge (2010), Kopsinis (2009) and Taylor *et al.* (2005). This acoustic echolocation parameters reference table was reviewed and adjusted where necessary by professor Corrie

Schoeman in order to use the most accurate reference parameters possible, considering the limitations of the current knowledge on South African bats echolocation (refer to section 2.3).

To effectively use echolocation as a means of surveying bats, it is important that the species detected can be reliably identified. Even with their similar sensory aims, many bat species have evolved a species-specific echolocation call structure (O' Farrell *et al.*, 1999; Simmons *et al.*, 1979) providing the potential to use their echolocation calls to identify bats to species level (O' Farrell 1997; O' Farrell *et al.*, 1999; Sattler *et al.*, 2007). However, these call structures are extremely flexible and may depend on various factors including habitat structure, foraging strategy, age, gender, morphology, and the presence of other conspecifics (Bell & Fenton, 1987). As different species face similar sensory challenges, call convergence has led to overlap in frequencies and call shapes used, by some species making it difficult to distinguishing between some calls (Preatoni *et al.*, 2005).

As a result, for some recordings the identification was only possible to the level of genus, family or to some phonic groups with very similar acoustic identification parameters. If the species was identified through recording analysis and its occurrence in the study area is considered plausible, then it was classified as *Confirmed* in the study area. If a species could not be confirmed through recordings analysis, due to uncertainty with the call parameters obtained, and could only be identified as a group of species, its occurrence in the study area was considered as *Possible* (e.g. if the parameters obtained in a recording are coincident with call parameters from different species and none of them was confirmed in other recordings, then all these species are considered possible, if the habitat is suitable). When the pulses recorded were too weak, and no diagnosis parameters could be obtained, the identification was only up to the level where the specialists had a high degree of confidence that they were not making any inaccurate identification (family, gender, family group or species group).

Through call analysis it was also possible to identify the occurrence of different bat behaviours according to different types of pulses, such as echolocation pulses (searching phase and feeding buzz[7]) or social calls.

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[7] Feeding buzz: when a bat identifies a potential prey it starts to approach the insect prey. In this process it will increase the rate of its echolocation pulses and each pulse will become shorter until it is difficult to distinguish between different

2.2.5.2. Spatial-temporal analysis

The results obtained from the six surveys undertaken (between September 2012 and July 2013) were analysed separately and compared. The selection of bat pulses was made through the automatic scrubbing performed by the Kaleidoscope® Software as well as the manual scrubbing, as described in the previous section. For each sampling point (at the wind energy facility area and the control area) the species identified were listed, as well as their conservation status and distinctive behaviour.

Space and time use of the site was also studied. The number of bat passes and time use of each sampling point allowed the determination of the following parameters for active and passive detection:

- Average number of bat passes[8]/hour (Active and Passive detection);
- Average time of use (seconds)/hour (Active detection);
- Frequency of occurrence of each specie/group of species identified (number of contacts of a specie or group of species / total number of records identified).

The calculation of the activity index, has defined by Miller (2001), is performed by counting the number of periods of time where a certain species was recorded. This method could be applied in areas of high species diversity, where files contain calls from more than one species. Considering that in Kangnas wind energy facility the analysis of the ultra-sounds revealed that this was not the case, a simpler approach was considered, **by calculating the number of bat passes per hour, as the activity index, for each of the sampling points**.

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pulses. This method of increasing its echolocation resolution while homing in on its prey is referred to as a feeding buzz.

[8] For the calculation of the above parameters it was necessary to define a "bat pass". There is a standard widely used definition of bat pass: *two call notes from one bat not separated by more than 1 second* (White & Gehrt, 2001; Gannon *et al.,* 2003). However, this is not very consensual since the duration and frequency of call notes vary according with the species present. In South Africa, and considering the species present, the current possible definition of bat pass is that of **a sequence of ≥1 echolocation calls where the duration of each pulse is ≥2 ms** (Weller and Baldwin, 2011). Single call fragments do not apply, only complete pulses were considered for the analysis. Where there is a gap between pulses of >500ms in one file, this then represents a new bat pass.

Note however that the activity index does not provide an absolute number of individuals, indicating solely a relative index of abundance (Hayes, 2000; Kunz *et al.*, 2007). An analysis of the activity index for the recording time period was also performed in order to evaluate the variation of activity throughout time, and which periods have higher bat activity.

These parameters were also analysed in terms of environmental factors, such as environmental conditions (temperature and wind speed) and biotope. The same parameters were analysed in terms of space, according to the point locations (wind energy facility site and control area).

The existence of possible relationships between bat activity in the study area (number of passes) and the environmental conditions recorded while conducting the fieldwork was tested. The data sets were tested for the assumptions of the parametric tests: normality (through Kolmogorov–Smirnov test) and homoscedasticity (with Bartlett's tests). Considering that data was not parametric, the following tests were used to test for differences between areas, season, detector height, air temperature, wind speed, air humidity and lunar fraction: Kruskall-Wallis, Mann–Whitney–Wilcoxon and Regression Analysis. All calculations were performed with R software (R Development Core Team, 2012).

The occupation rate, species present and conservation status were determined to each roost inspected.

2.3. Assumptions & Limitations

Some of the conclusions of the present study are constrained by the lack of baseline information concerning bat ecology and distribution in South Africa, such as detailed information of species migration and dispersal patterns, known roosts, existing populations, bioacoustics synthesized information, among other factors. This lack of published and peer-reviewed information also leads to difficulties in the ultrasound acoustic identification of less studied species and some complex species or sibling species, since very few or no reliable references may exist for the study area or its surroundings. Many published papers refer to acoustic parameters that relate to bats that were first captured and recordings were then made through hand release or in other special circumstances (e.g. trapped in cages, in habitats different the ones present in the studied area) that can misrepresent the sound parameters (Kutt, 1993; Surlykke *et al.*, 1993; Parsons, 1998). This type of information may be very important when analysing recordings collected in the field because differences from the natural echolocation parameters of the species can occur in relation to the reference echolocation parameters, leading to incorrect or uncertain identifications. In order to solve these echolocation problems, a southern African bat specialist was contacted to standardize all data collected from scientific references.

It is also important to consider and review the information published given that some publications have some uncertainty associated with the data, due to records that are not confirmed or given by bat specialists and species may have been incorrectly identified, as it was confirmed during the compilation of Monadjem *et al.* (2010). Therefore an effort was made in this report to verify the information collected from several literature sources with a local bat specialist in order to present the most accurate results.

The large number of recordings produced through passive recordings, leads to a great effort of work hours for analysis in office (e.g. recordings scrubbing, call identification). Due to this constraint a sampling procedure had to be implemented for the recordings that were analysed for species identification as it was not viable to identify every single recording collected in the field. Therefore in order to make the best possible evaluation, it was assumed that all recordings analysed represented the population in study with a minimal margin of error.

It was also noticed that some of the recordings collected through passive detection had poor quality (blurry recording, noise masking the bat pulses, only segments of bat pulses recorded) which did not allow for the identification to the species level with certainty in some of the recordings analysed. This limitation can influence the results, leading to the identification of fewer species than those that really exist in the study area. Nonetheless, it was assumed that the best approach would be to consider the families identified with certainty, as a good measurement of the possible species present, rather than present results that do not have a good degree of certainty associated. During the call identification conducted the detail of the identification was determined by the certainty that could be obtained, so in some cases it was possible to identify groups of species, or up to the genus if possible.

Another limitation is related with the survey techniques implemented and the limitations intrinsic to the field methodologies. Species that echolocate at high frequencies are more difficult to capture through ultrasound detection, since ultrasounds with very high frequencies do not travel very long distances (compared to low frequency ultrasounds) (Limpens & MccrAcken, 2002). Therefore these species would have to be very close to the ultrasound detector to be captured.

During the September survey the passive detectors presented problems due to an electrical malfunction which led to the loss of all data collected during that survey, since the malfunction was only detected upon the detectors collection. The malfunction was corrected and the following surveys were conducted normally; however this constraint led to the loss of information of one of the spring surveys. Nonetheless the spring season was sampled in November, allowing for collection of information regarding bat activity in the spring season.

3. Results and discussion

3.1. Desktop review

3.1.1. Species with potential occurrence at the site

According to Monadjem *et al.* (2010), a total of 67 species of bats occur in South Africa. Through the analysis of probability of species occurrence in the study area, a total of 10 bat species were considered to have some likelihood of occurrence, which corresponds to 15% of the overall species in the country (Table 6). This low percentage of species may be attributable to the study area characteristics, with not many environmental features favourable to bat occurrence, little water available throughout the year and general high temperatures, corresponding to semi desert conditions.

From the 10 bat species considered with potential occurrence in the site, 2 are considered to have a high probability of occurrence, 7 with moderate and 1 with low probability of occurrence (Table 6).

Regarding the 2 species considered with high probability of occurrence at the site only one is considered "Vulnerable" in South Africa (Angolan wing-gland bat – *Cistugo seabrai*) (Friedmann & Daly, 2004) and this species is considered to have a potential low collision risk with wind turbines (Sowler & Stoffberg, 2012). The Egyptian free-tailed bat (*Tadarida aegyptiaca*), also considered to have a high probability of occurrence in the study area has a potential high risk of collision with wind turbines, in spite of being considered of Least Concern in South Africa (Friedmann & Daly, 2004). This conservation status is justified by its abundance, as it is a locally common species found throughout most of South Africa, with an unknown population tendency worldwide (Monadgjem *et al.*, 2010; IUCN, 2012).

From the 7 species with moderate probability of occurrence in the study area, four have a conservation status of concern – Natal long-fingered bat (*Miniopterus natalensis*), Cape horseshoe bat (*Rhinolophus capensis*), Geoffroy's horseshoe bat (*Rhinolophus clivosus*) and Darling's horseshoe bat (*Rhinolophus darlingi*) – all with populations considered "Near Threatened" in South Africa (Friedmann & Daly, 2004) (Table 6). Also 2 of the species with moderate probability of occurrence in the area have medium to high risk of collision with wind turbines, one of them, the previously mentioned *Miniopterus natalensis,* with "Near Threatened" conservation status. The remaining five species have medium to low risk of collision with wind turbines.

From the list of species considered to have potential occurrence at the Kangnas study area, one was included despite having a low probability of occurrence: the Robert's flat-headed bat (*Sauromys petrophilus*). This species is endemic to southern Africa and, in spite of the lack of modelled distribution for this species (Monadjem *et al*., 2010) and the lack of recent records of this species in the study area vicinities (ACR, 2012), the IUCN (2012) distribution given for this species is coincident with the study area. *Sauromys petrophilus* is an open-air forager with high risk of collision with wind turbines, though having a "Least Concern" conservation status (Friedmann & Daly, 2004).

A brief description of the species with potential to occur in the study area is presented in Appendix IV.

Table 6 – List of species considered with possible occurrence at the Kangnas wind energy facility study area. Labels: IUCN (2012) and South African Red List (Friedmann & Daly, 2004): CR – Critically Endangered; EN – Endangered; VU – Vulnerable; NT – Near Threatened; LC – Least Concerned; NE – Not Evaluated; Data Deficient; Flight Height: LH – Low Height (below 2 meters); MH – Medium Height (between 2 and 10 meters); HH – High Height (above 10 meters).

Scientific name	Common name	IUCN	South African Red List	Roosts	Habitat preferences	Foraging habits *Type of flight*	Foraging habits *Flight height*	Risk of collision (Sowler & Stoffberg, 2012)	Probability of occurrence
Nycteris thebaica	Egyptian slit-faced bat	LC	LC	Caves, culverts and trunks of large trees.	Savannah and Karoo biomes	Clutter forager	LH	Low	Moderate
Miniopterus natalensis	Natal long-fingered bat	LC	NT	Caves	Savannas and grasslands	Clutter-edge forager	MH, HH	Medium-High	Moderate
Eptesicus hottentotus	Long-tailed serotine	LC	LC	Caves and rock crevices	Woodland and rocky regions	Clutter-edge forager	MH, HH	Medium	Moderate
Neoromicia capensis	Cape serotine	LC	LC	Under the bark of trees, foliage and buildings	Semi-arid areas to montage grassland, forests and savannah	Clutter-edge forager	MH	Medium-High	Moderate
Rhinolophus capensis	Cape horseshoe bat	LC	NT	Caves and mines	Fynbos and succulent Karoo biomes	Clutter forager	LH	Low	Moderate
Rhinolophus clivosus	Geoffroy's horseshoe bat	LC	NT	Caves and mines	Savannah, woodland and riparian forest.	Clutter forager	LH	Low	Moderate
Rhinolophus darlingi	Darling's horseshoe bat	LC	NT	Caves, mines adits, culverts and cavities in piles of boulders	Savannah and woodland	Clutter forager	LH	Low	Moderate
Tadarida aegyptiaca	Egyptian free-tailed bat	LC	LC	Caves, rock crevices, under exfoliating rocks, hollow trees, behind the bark of dead trees and buildings	Semi-arid scrubs, savannah, grassland and agricultural land	Open-air forager	HH	High	High
Sauromys petrophilus	Robert's flat-headed bat	LC	LC	Narrow cracks, under slabs of exfoliating rock	Rocky habitats in woodland, fynbos or arid scrub	Open-air forager	HH	High	Low

Scientific name	Common name	IUCN	South African Red List	Roosts	Habitat preferences	Foraging habits *Type of flight*	Foraging habits *Flight height*	Risk of collision (Sowler & Stoffberg, 2012)	Probability of occurrence
Cistugo seabrai	Angolan wing-gland bat	LC	VU	Buildings	Arid and semi-arid, riverine vegetation of dry river beds	Clutter-edge forager	MH	Low	High

3.1.2. Known roosting locations

Due to its arid conditions and flat plains with no features for adequate bat roosts, there are no known bat roosts in the vicinities of the study area. The Bat Impact Assessment has highlighted that the rocky outcrops in the north-west corner of the study area may support bat roosts, since small caves where found in this area. However these were not confirmed as bat roosts at the time that this report was compiled. The nearest known roost (cave) is located at approximately 450km east at Soetfontein (Northern Cape) (Monadjem *et al*., 2008). Other mines and caves are located in this area, at approximately 460 to 470km from Kangnas study area: Koegelbeen (cave), Hopefield (mine) and Blinkklip Grot (cave). At these locations at least five species of bats are present: *Rhinolophus clivosus, Rhinolophus darlingi, Rhinolophus denti, Neoromicia capensis* and *Miniopterus natal*ensis (Monadjem *et al*., 2008). From these species only *Miniopterus natalensis* is a migratory species; however it is unlikely that the individuals present in these caves, at more than 400km from the study area would be the same to use roosts found in the wind energy facility site.

3.1.3. Known migration routes

There is a lack of information in South Africa regarding the distribution and abundance of bats as the migratory habits and migration routes of bats through the country are not yet clearly understood. However, there is some evidence that some species undertake long-distance migration and seasonal movements within South Africa. For example, Natal Long-fingered Bat (*Miniopterus natalensis*) is known to migrate up to 260 km (Van der Merwe, 1975 *in* Monadjem *et al*., 2010) between summer maternity roosts (caves) and those used during the mating and hibernation period during the winter months. Considering that the closest roost known of this species is located at approximately 450 km from the study area it is considered very unlikely that the Kangnas wind energy facility is coincident with a migration route.

3.2. FIELD SURVEYS

3.2.1. Confirmed bat species at the site

3.2.1.1. Echolocating bat species

Through the bat monitoring programme carried out within the Kangnas wind energy facility area and control area during the pre-construction phase of the project, a total of 452 bat records (61 from active and 391 from passive detection methodologies) were collected (Table 7). All the recordings collected from active detection were submitted for ultrasound identification of the bat species. A sub-sampling was conducted on the identification of bat species from the passive detection results[9] (due to the large amount of information produced through this methodology), leading to the random selection of 335 recordings (approximately 85.6% of the total number of recordings), from the passive detection surveys for analysis (with 95% of confidence and an approximate error of 2% in the estimates) (Table 7). From the total 335 recordings randomly selected, it was verified that there was still some false positive recordings and, after a final scrubbing, only 239 recordings were selected to be identified. The results from the recordings analysis allowed the identification of the family or species of the individuals detected in 93.8% of the passive recordings analysed. The remaining records had weak pulses or very low volume and in those cases the identification of the individuals to the species was not possible and was considered to be a species "not identified" (n=19 records).

Table 7 – Summary of the number of recordings obtained through passive detection and the number of recordings randomly selected for analysis in each survey.+ Recordings lost due to malfunction of equipment; * All recordings analysed and no sub-sampling was implemented due to the small number of recordings.

Year	Survey	Active detection	Passive detection	
		Number of recordings	Recordings Collected	Recordings analysed
2012	September	35*	+	+
	November	2*	176	71

[9] All the recordings made through manual detection were processed in order to identify the bat species.

Year	Survey	Active detection	Passive detection	
		Number of recordings	Recordings Collected	Recordings analysed
2013	January	2*	14	14*
	March	2*	42	42*
	May	2*	31	31*
	July	18*	128	81
Total		**61**	**391**	**239**

From all the records analysed from both active and passive detection 4 bat species were confirmed in the study area, i.e.: *Eptesicus hottentotus, Miniopterus natalensis, Neromicia capensis* and *Tadarida aegyptiaca*. Only one of these species is classified as "Near Threatened", according with the South African Red List: *Miniopterus natalensis* (Friedmann & Daly, 2004; Monadgem *et al.,* 2010). The remaining species are considered as "Least Concern" conservation species.

In spite of the conservation status of the species confirmed in the study area, it is important to analyse their presence in the study area bearing in mind the potential risk caused by the project for any of these species. Therefore, it is of note that one of the species with confirmed presence in the study area has a potential high risk of collision with wind turbines: *Tadarida aegyptiaca.* This is due mostly to the species' characteristic flight type and foraging behaviour, since this species forages in open areas and may fly at high altitudes, potentially coincident with the rotor swept area (Sowler & Stoffberg, 2012). There are also records of mortality of species from *Tadarida* sp. in other wind energy facilities in Europe, as well as from the *Tadarida aegyptiaca* in South Africa (Doty & Martin, 2013; EUROBATS, 2013). This species is also the most frequently detected in the study area accounting for 52% of the detections obtained in all surveys conducted (n=234).

From the remaining confirmed species, 2 are considered to have a medium to high potential of collision risk with wind turbines: *Miniopterus natalensis* and *Neoromicia capensis. Miniopterus natalensis* was detected in approximately 2% of the recordings (n=7) while *Neoromicia capensis* was detected in less than 1% of the recordings (n=3). Both species are clutter-edge foragers (Monadjem *et al.,* 2010) and have specific morphologic and acoustic adaptations to allow the required manoeuvrability refined acoustic echolocation in order to hunt for its insect preys while avoiding colliding with the background vegetation (e.g. short and broad wings that facilitate slow, manoeuvrable flight) (Schnitzler & Kalko, 2001). This means that this species will forage primarily around vegetation (clutter), either forested areas or tall bushes and it is not expected to fly higher than 2 to 10m above or far from the vegetation clutters. Therefore its absolute flight height (distance from the individuals to the ground) will depend mainly on the height of the vegetation, and its foraging areas. There are records of mortality with wind turbines of species within the genus *Miniopterus sp.* and *Pipistrellus sp.* (genus similar to *Neoromicia sp.*) in Europe (EUROBATS, 2013). Records of fatalities of *Neoromicia capensis* have also been found in South Africa, in two distinct locations (Aronson *et al.*, 2013; Doty & Martin, 2013).

The remaining confirmed species in the study area (*Eptesicus hottentotus*) is also a clutter-edge forager, with medium collision risk with wind turbines. This was not a frequent species, with only three recordings in the wind energy facility, representing less than 1% of the recordings obtained (n=3). Nonetheless there is evidence of collisions with turbines of the genus *Eptesicus sp.* in wind facilities in Europe and United States (EUROBATS, 2013; Arnett *et al.*, 2008).

At least one of the species confirmed to occur in the study area through ultrasound analysis (*Miniopterus natalensis*) is a known migrant species, known to migrate from winter to summer roosts over distances up to 150km. It is of note that for the remaining species there is no information regarding migratory movements, and therefore it is very difficult to assess possible migration patterns.

Since not all recordings where identified to the species level, some groups of species and families were identified, leaving the possible occurrence of other species to be confirmed. Due to the low activity recorded in the study area, the high percentage of recording identified and considering that in some surveys all the recordings were processed, the occurrence of other species in the recordings collected in the field is considered unlikely.

As explained in Table 11 some recordings (n=3) were identified that could belong to *Eptesicus hottentotus* or *Sauromys petrophilus* since the frequency of maximum energy of the calls (FMaxE) of both species overlap between 28 and 32 kHz (Schoeman & Jacobs, 2003; Schoeman & Jacobs, 2008). However it is considered most likely that these recordings were from individuals of *Eptesicus hottentotus* since *Sauromys petrophilus* is a species of low probability of occurrence in the study area, according to the literature sources consulted.

Through passive detection some records from the Rhinolophidae family were also obtained, allowing the confirmation of the genus *Rhinolophus* sp. in the study area, but not enabling the confirmation of which species are present (Table 11). The quality of the recordings did not allow the confirmation of the exact species within the genus. This family was recorded in approximately

5% of the recordings analysed (n=16). Nonetheless all species of *Rhinolophus* sp. possibly present in the study area have a low collision risk with wind turbines and are not expected to be highly affected by this development.

3.2.1.2. Non-echolocation species

As indicated in chapter 3.1.1, no fruit-eating bat species are likely to occur in the study area, due to the lack of suitable foraging sites (e.g. lack of fruit trees) in the vicinity of the Kangnas wind energy facility. Nonetheless the methodology detailed in chapter 2.2.4.3 for the detection of fruit eating bats was implemented. As expected, no bats belonging to this group were detected during the surveys conducted between September 2012 and July 2013.

3.2.2. Spatial-temporal activity

Most of species that can occur in the study area are insectivorous and their annual cycle is related to the abundance of food resources. Since the insect population increases in spring and summer, it is expected that the bat activity follows a similar pattern. In the Northern Cape, due to the dry conditions of the arid semi-desert, higher bat activity is expected between late autumn and spring, due to the presence of lower temperatures and higher precipitation (Monadjem *et al*., 2010). This is expected due to the pattern of insect availability which should follow the temperature and precipitation pattern. The high level of activity will be reflected in a high usage time of the area. Bat activity levels may also be influenced by other factors, such as weather, biotope or distance to water sources. In this chapter possible differences between the wind energy facility area and the control site are assessed in order to create a baseline scenario for future reference when evaluating real impacts of the project on bats in the subsequent phases of the project.

3.2.2.1. Seasonal activity

3.2.2.1.1. Active detection

Figure 8 presents the average bat activity index as number of bat passes (± standard error) per hour in the study area obtained from the active detection. This parameter has shown that bat activity in the wind energy facility and control area have some differences: during spring and winter surveys, bat activity was generally higher at the control area, while in summer and autumn the little activity present in the study area was recorded in the wind energy facility site. The higher activity recorded in the control area may be explained by the presence of nearby houses with cattle, which may be related to a higher abundance of insects. Also many of the species identified can roost inside buildings, particularly roofs of houses, presenting a possibility that the farm houses within the study area provide occasional roost for bats. This variation between the activity recorded in both areas proved to be statistically significant ($W = 9414.5$, *p-value* $= 0.039$).

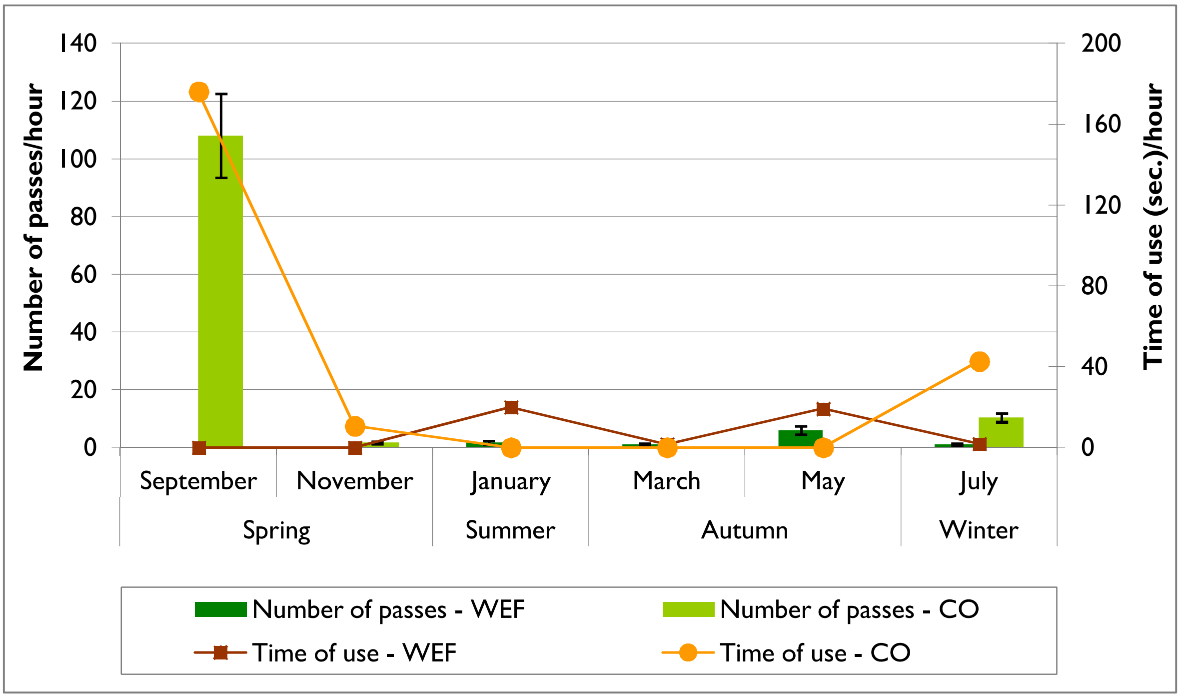

Figure 8 – Average time of use (seconds/hour) and average number of passes per hour from September 2012 to July 2013 in the Kangnas wind energy facility and control area (Active detection). Vertical bars indicate the standard error.

In the September 2012 survey, a higher bat activity (both number of passes and time of use) was recorded in the Control area, when comparing with the average activity of the remaining months. This pattern of higher activity in early spring may be due to the presence of lower temperatures in the study area (wind energy facility and control) which creates better conditions for food availability and forage (e.g. water and insect availability). As indicated previously, it was expected that the seasons when most rainfall is present (e.g. winter and spring) would be the most active time of the year for bats. This has been confirmed through this analysis, revealing higher numbers of passes and time of use during the September 2012 and July 2013 surveys. The differences observed in the activity registered throughout seasons was statistically significant (K-W chi-squared = 12.2633, df = 3, p-value = 0.006).

Only one species was confirmed through active detection, i.e. *Tadarida aegyptiaca* which was observed in both the wind energy facility and in the Control area (Appendix II). While this species was recorded only during May and July 2013 at the wind energy facility, in the control area the species was present in September 2012, November 2012 and July2013. Individuals of the Molossidae and Miniopteridae or Vespertilionidae families, which could not be further specified due to low quality of the pulses detected (Appendix II) were also detected in the Control area.

3.2.2.1.2. Passive detection

In passive detection, bat activity was inferred from the total number of bat records (the sub-sampling methodology results were not used to determine the overall bat activity). Since the volume of information is much higher and longer continuous periods were monitored, the activity estimated in the study area tends to be more representative of reality compared with the active detection results.

Through the analysis of Figure 9 it is possible to observe a similar pattern of bat activity in relation to that recorded through active surveys: i.e. higher bat activity in winter and spring seasons. Also unlike what was observed through active detection, the activity in the wind energy facility site and in the control area was very similar during most surveys. However it is noticeable that bat activity was higher in the wind energy facility in September 2012 and higher in the control area in July 2013, without overlap of the standard errors. Nonetheless no statistical significant differences were found between the wind energy facility area and the control area (W = 68989.5, *p-value* = 0.845). Both areas have shown a similar pattern of activity with higher average number of bat passes per hour in spring, decreasing in summer and autumn, and a second increase of activity in winter. This variation of activity between seasons has a statistical significance (K-W chi-squared = 38.873, df = 3, *p-value* = $1.847e^{-08}$).

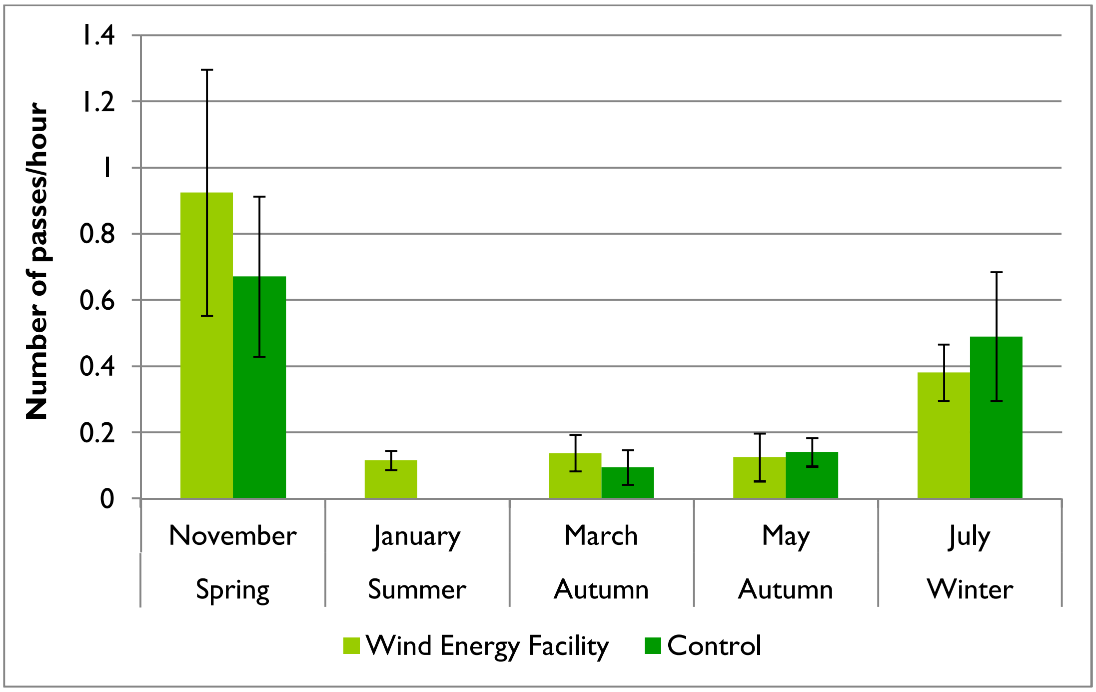

Figure 9 – Average number of bat passes/hour in the Kangnas wind energy facility and control between November 2012 and July 2013 (Passive detection). Vertical bars represent standard error.

In terms of species occurrence at the study area, one species was confirmed only in the wind energy facility, *Eptesicus hottentotus* and the Verpertilionidae family, while the Rhinolophidae family was only recorded in the Control area (Appendix II). The remaining species were recorded in both areas, including *Miniopterus natalensis*, the *Neoromicia capensis*, *Tadarida aegyptiaca* and the group of *Eptesicus hottentotus / Sauromys petrophilus* species. The most common species was *Tadarida aegyptiaca*, which occurred in more than 50% of the recordings obtained in both the wind energy facility and control area, and was recorded in all surveys sampled. However it was observed that the months when the species was mostly present in the study area were coincident with the patterns of bat activity in the study area: November 2012 (spring) and July 2013 (winter) (Figure 10). Regarding the other three confirmed species, *Eptesicus hottentotus* was recorded only in November 2012 and later in May 2013; *Miniopterus natalensis* was only detected in March 2013 (autumn season) in both sampling areas; and *Neoromicia capensis* was recorded in March and May 2013 (autumn season).

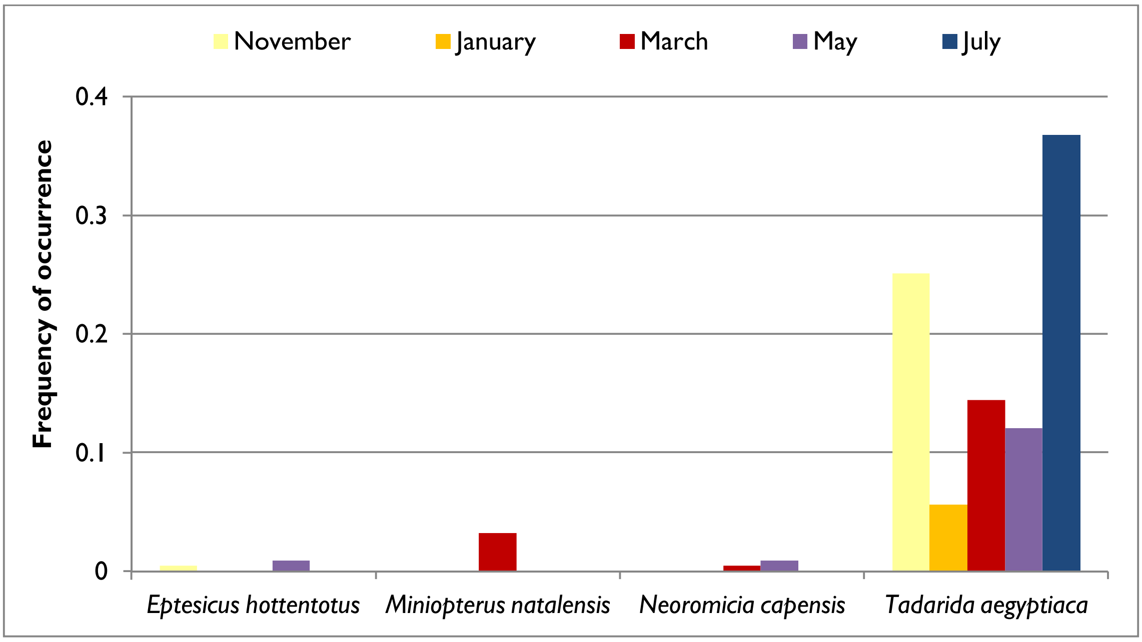

Figure 10 - Frequency of occurrence of the confirmed bat species through passive detection, in each survey between November 2012 and July 2013. Analysis considering the total data collected in all passive detectors.

Besides the analysis of bat activity at ground level it is also important to assess differences between bat activity at different heights: below rotor swept area (ground height) and at rotor swept area. The average activity index in the detectors PQKGA04 and PQKGA05, considering the height that each detector or microphone was installed is presented in Figure 11. Only these two locations were used to assess this since only PQKGA05 was installed at height (50m), and the correspondent location for comparison is the closest bat detector at ground level (PQKGA04). Since these two detection locations were installed in March 2013 (see chapter 2.2.4.2) data is presented from March to July 2013.

It was observed that in March and July bat activity was slightly higher in the rotor swept area; while in May activity was clearly higher at ground height. However these apparent differences had no statistical significance (W = 19671.5, *p-value* = 0.078). A reason doe this may be related with the bats present in the study area, since the most common and abundant species detected during the monitoring was *Tadarida aegyptiaca* which is an open-air forager with the ability to fly above 10m in height, being therefore more likely to be captured by the upper microphone detector. It is also of note that July was one of the surveys when this species was most frequently recorded, therefore producing more records at 50m.

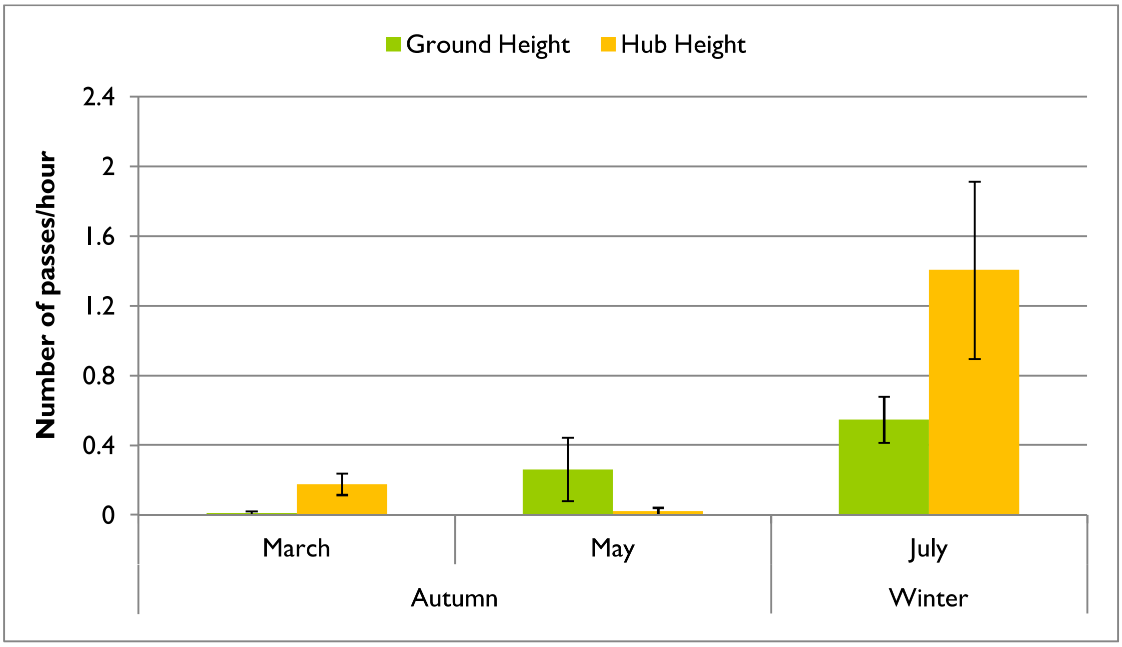

Figure 11 – Average number of passes/hour at each of the detector installed at ground level and at height, in the Kangnas wind energy between March and July 2013 (Passive detection).Vertical bars represent standard error.

The activity of the confirmed species at different heights is represented in Figure 12. For this comparison, only the detectors placed at different heights, but in the same location were considered: PQKGA04 and PQKGA05. The species confirmed in these locations were: *Eptesicus hottentotus, Miniopterus natalensis* and *Tadarida aegyptiaca*. As the previous analysis indicated, bat activity tends to be higher above rotor height for all of the species detected. All of the species were detected at the 50m height, with *Tadarida aegyptiaca* being the most frequent species. The frequency of occurrence at ground level was also high but only one species was confirmed: *Tadarida aegyptiaca*. The other two species confirmed at these locations were only recorded at 50m height. Nonetheless a family of species was also identified at ground height, the Vespertilionidae family with a frequency of occurrence of 0.01.

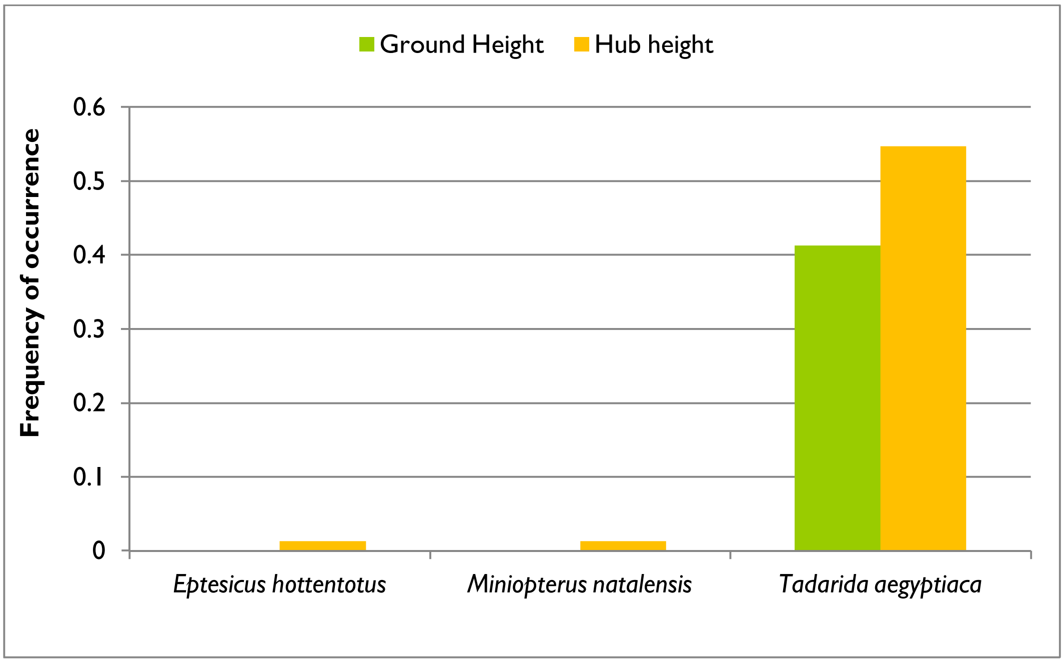

Figure 12 – Frequency of occurrence of the confirmed bat species through passive detection, at different heights in the Kangnas wind energy facility site between March and July 2013. Analysis considering the total data collected in passive detectors PQKGA04 and PQKGA05.

A total of 8 *feeding buzz* events were detected within the analysed recordings from all surveys conducted between September 2012 and July 2013 (Table 8). Most of those feeding buzz pulses were emitted by *Tadarida aegyptiaca*, mostly in November, while one of the *feeding buzz* records was made by an individual of the Vespertilionidae family, during the July survey. Most of these calls were recorded in the Wind Energy Facility, with only one event detected at the Control area, in the July survey. Bats emit pulses to navigate, to avoid collision with objects and to locate prey. At first the pulses are spaced to verify the presence of prey and once a potential prey is detected the interval of emission of pulses decreases and, as the bat gets closer to the prey, the time between pulses decreases, originating the "buzz". Those buzzes are identified as feeding buzzes, corresponding to the moment when the bat is closest to its prey. During a feeding buzz the pulse frequency gets closer to the audible (Ahlen, 1990; Tupinier, 1996; Briggs & King, 1998). While an individual is navigating or looking for prey it is also foraging, although no feeding buzzes are produced. So the feeding buzzes are a confirmation that the bat is using the area to forage, but the possibility that bats are foraging in the area in the absence of the feeding buzz being detected should always be considered. A large number of passes can also indicate that the area is used as a foraging site. Since *feeding buzzes* are indicators of feeding activity, it is logical to assume that bats use the study area for foraging and hunting activities, although very sporadically. Feeding buzzes are events that are also less likely to be recorded, in relation to navigation pulses. Therefore, this information needs to be considered with due caution.

In the study area, no social calls were identified within the recordings analysed. Social calls are pulses emitted at lower frequencies and generally shorter in duration. The reason why those social calls are emitted is not fully understood. It is speculated that this type of call occurs in several situations: a) interaction / communication between mothers and offspring, for mutual recognition, b) male attraction of females during mating c) repel other males during mating, or repel other bats in feeding areas with low prey densities since the number of social calls rise when the insect densities diminish; d) used to promote group cohesion, especially at roost exits, as a way to defend from predators and in breeding colonies; e) used when bats are in stressful situations (Altringham, 1996; Fenton, 2003; Kunz & Fenton, 2003; Pfalzer & Kusch 2003). The absence of social calls detected may indicate that the area is not used extensively by bats for reproduction or interaction purposes. On the other hand these events are extremely rare and, similarly to the feeding buzz events, assumptions regarding their absence must be made with due care.

Table 8 – *Feeding buzz* pulses identified during passive surveys conducted at the Kangnas wind energy facility site. Considering the data analyzed thought the sub-sampling methodology implemented.

Species	Wind Energy Facility				Control	Total
	November	March	May	July	July	
Tadarida aegyptiaca	3	1	1	1	**1**	**7**
Vespertilionidae	0	0	0	1	**0**	**1**
Total	**3**	**1**	**1**	**2**	**1**	**8**

3.2.2.2. Influence of environmental variables (passive detection)

Since bat activity depends on environmental conditions, such as temperature, wind speed and illuminated lunar fraction, as well as on biotope and distance to water, it is important to analyse possible relationships between bat activity and each one of these factors.

- **Wind speed**

Wind speed affects bat activity since insects are less active in strong wind situations and also during strong wind conditions, as bats require higher energy expenditure, especially the smaller bat species. It is also important to mention that wind speed is an unstable factor and therefore affects bat activity daily. Bats are usually more active when wind speed is low, and therefore a monthly pattern may not occur (Sowler & Stoffberg, 2012). Bat activity is expected to be inversely proportional to wind speed.

According to the results obtained during the monitoring period, the average monthly values obtained for the wind speed were very similar between the two heights evaluated (60 and 30m). In the first survey when wind speed was higher, bat activity was also higher. This was also the case in the last survey, when wind speed increased (Figure 13). Between January and May, wind speed and the average number of bat passes recorded per hour decreased.

The results of the analysis of the relationship of this variable with bat activity in the study area has shown a significant relationship (R^2 = 0.059; Adjusted R^2 = 0.053; *p-value* = 0.004), however only 5% of the data variability was explained by the model. Therefore, although significant differences were obtained indicating a significant negative influence of wind speed over bat activity, these results are to be interpreted with caution since this variable only explains a portion of the bat activity recorded in the study area. Therefore the collection of further data in the monitoring activities in the next phases of the project is very important to validate this conclusion.

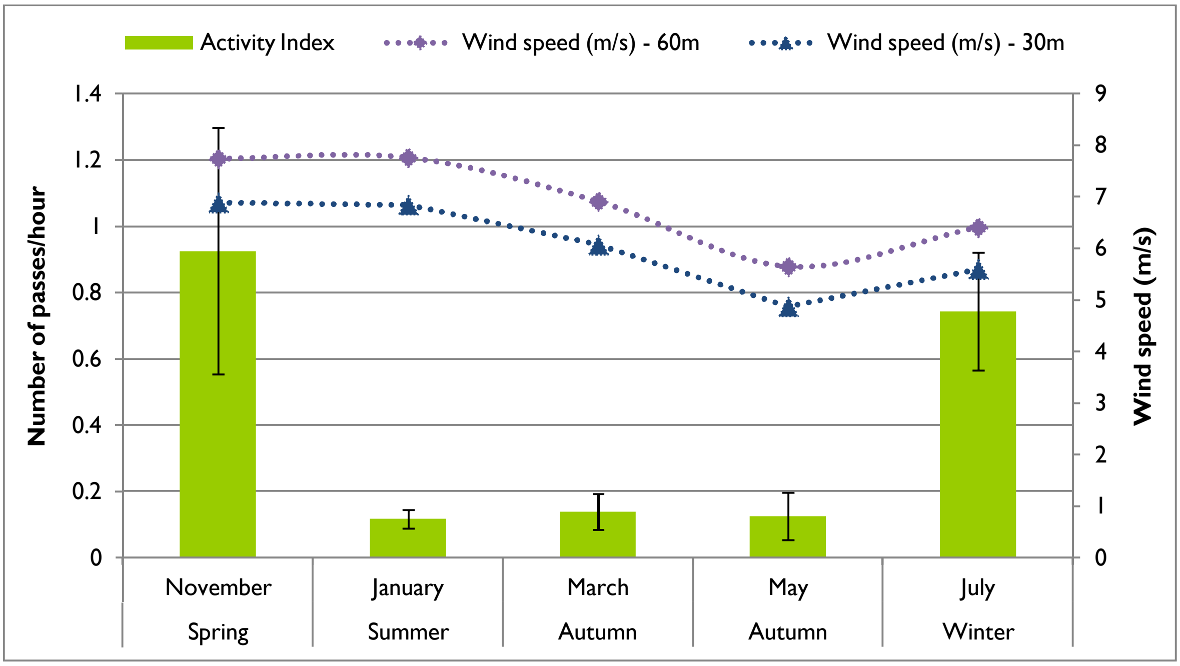

Figure 13 – Average activity index (average number of passes/hour) and average wind speed (m/s) at ground level (30m) and height (50m) in the Kangnas wind energy facility site between November 2012 and July 2013 (Passive detection). Bars represent standard error.

- **Temperature**

Higher temperature values correspond, in general, to a higher availability of insects and therefore higher food source for insectivorous bats. Therefore, a directly proportional relationship between temperature and bat activity should be expected (Speakman & Rowland, 1999; Kusch *et al.*, 2004; Müller *et al.*, 2012).

The temperature recorded during the passive surveys fluctuated between the minimum recorded in March (approximately 15°C) and the maximum recorded in January (approximately 22°C) (Figure 14). Considering the presented results, there is no evidence that temperature has affected the average number of passes. This graphical analysis was confirmed by the absence of a significant relationship between the air temperature and bat activity index in the study area (R^2 = 0.004; Adjusted R^2 = 0.003; *p-value* = 0.065).

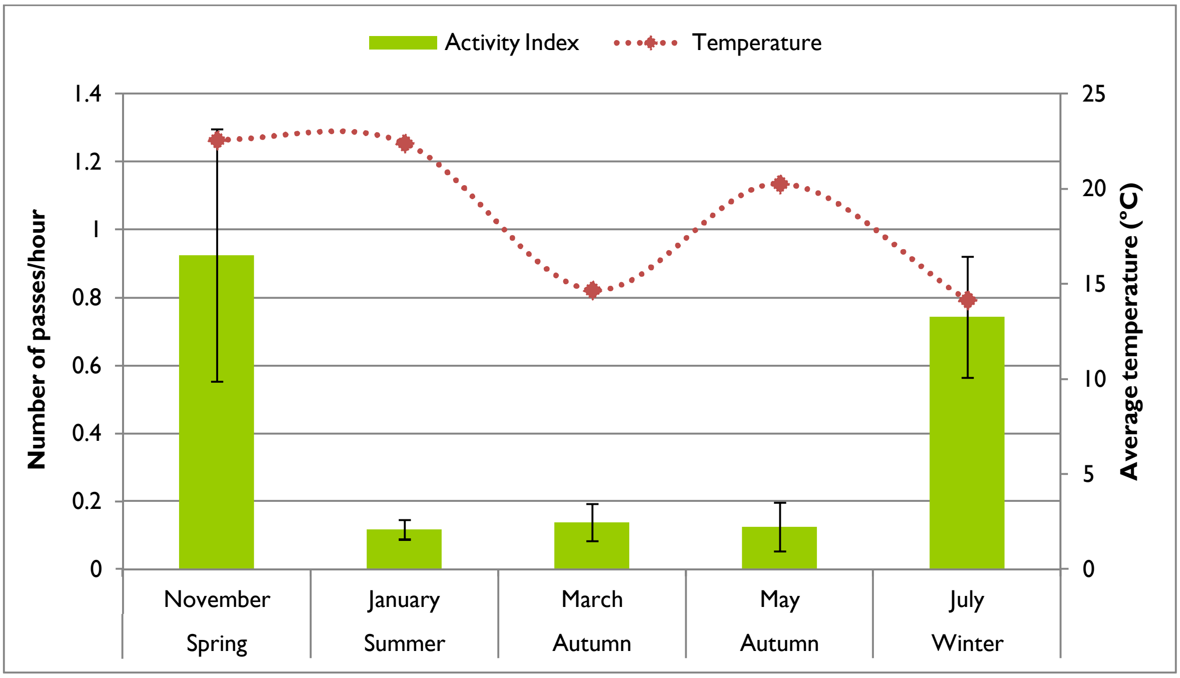

Figure 14 – Average activity index (number of passes/hour) and average temperature (°C) in the wind energy facility site November 2012 and July 2013 (Passive detection). Bars represent standard error.

- **Illuminated lunar fraction**

The illuminated lunar fraction can also influence the bat activity since bats are expected to be more exposed to predators, such as owls, snakes or genets, and some studies indicate that bat activity is inversely proportional to illuminated lunar fraction (Lang *et al.*, 2005; Cryan & Brown, 2007; Esberard, 2007).

The illuminated lunar fraction recorded during the surveys conducted at the wind energy facility ranged the full spectrum of possible interval (0 and 1) (Figure 15). However, it was not possible to identify any pattern that relates the average number of passes and the illuminated lunar fraction. The absence of a relationship between bat activity and this variable was also confirmed through the statistic results (R^2 = 0.003; Adjusted R^2 = 0.001; *p-value* = 0.117).Therefore it is considered that in this case, the illuminated lunar fraction was not the major influence on the activity recorded in the Kangnas study area.

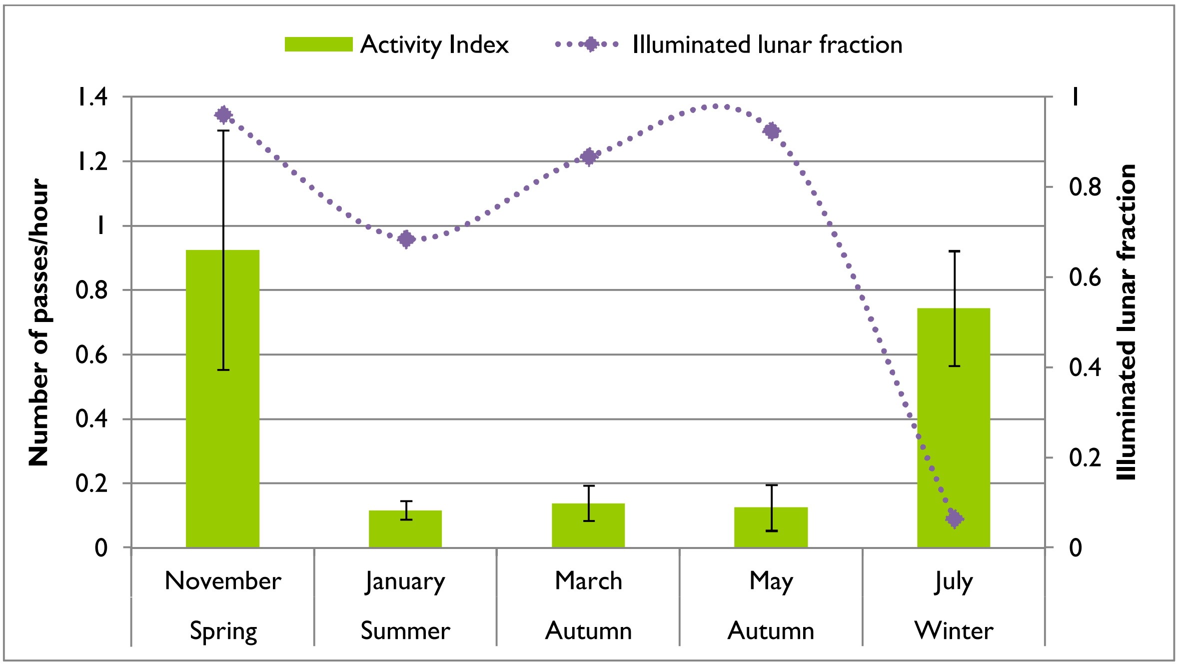

Figure 15 – Average activity index (number of passes/hour) and illuminated lunar fraction in the wind energy facility site between November 2012 and July 2013 (Passive detection). Fraction illuminated at New Moon is 0,0 and at Full Moon is 1,0. Bars represent standard error.

- **Air Humidity**

Among the studied variables to explain bat activity in the study area, air humidity (Figure 16) does not directly related with the average number of passes recorded in each of the surveys conducted. Between November 2012 and July 2013, air humidity increased over time, while bat activity presented fluctuations among the seasons. This absence of a relationship was verified through statistical analysis (p = 0.09).

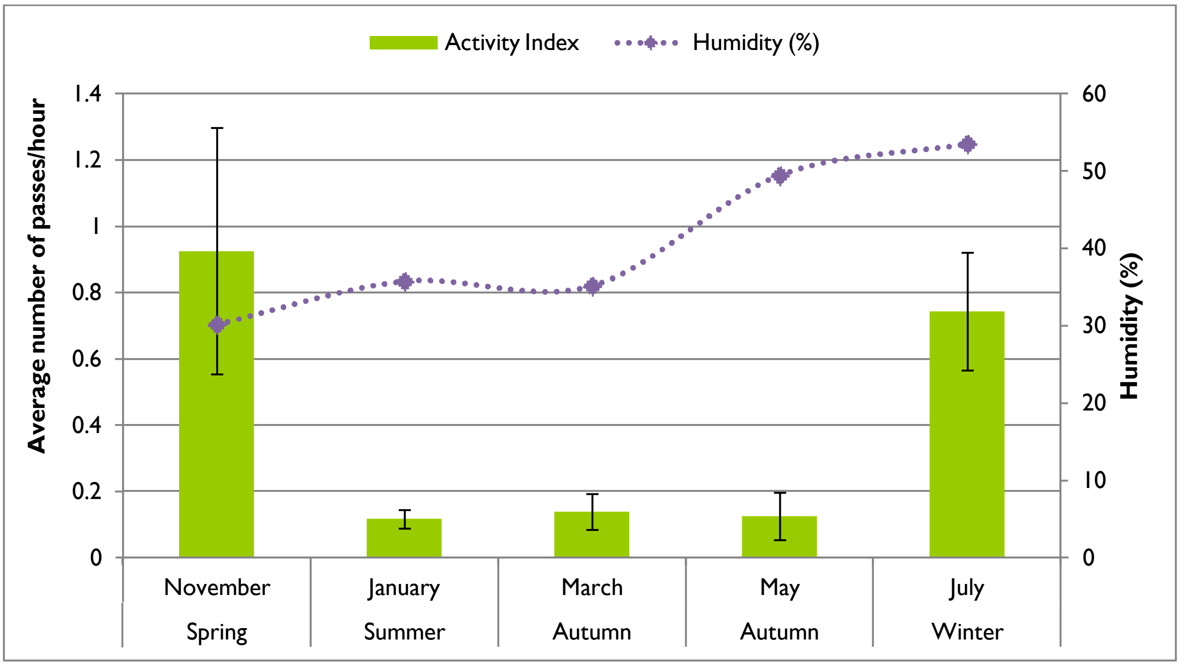

Figure 16 – Average activity index (number of passes/hour) and air humidity (%) in the Kangnas wind energy facility site between November 2012 and July 2013 (Passive detection). Bars represent standard error.

3.2.3. Habitat use (active detection)

The habitat present in the Kangnas wind energy facility development area is very homogeneous. Figure 17 and Figure 18 spatially depicts the total number of passes and total time of use recorded in each point sampled during monitoring programme. The total number of passes recorded in the study area was not very high, which did not allow for the determination of accentuated differences between the wind energy facility site and control area. In the wind energy facility, the total number of passes recorded was lower in relation to the control area, with the highest number of passes recorded as 10 passes in several sampling points. 11 of the 22 sampling points at the wind energy facility had no bat passes recorded during the surveys conducted.

In the control area, the highest total number of passes recorded in two of the sampling points (PQKG26 and PQKG30) was more than 30. However, less than 10 passes were recorded in most of the sampling points, and in five locations, no bat passes were detected throughout the surveys conducted.

The same pattern was recorded for the total time of use at each sampling point conducted during monitoring surveys (Figure 18). This is not unexpected since both parameters can be related, as an area with more bat passes is expected to have a higher usage time. The highest time of use was recorded in three sampling points located at the control area (PQKG26, PQKG29 and PQKG30), coincident with the above sampling points with a higher number of passes detected.

This pattern of activity indicates that, although the control area seems to be more used than the wind energy facility site, both locations have generally low bat activity.

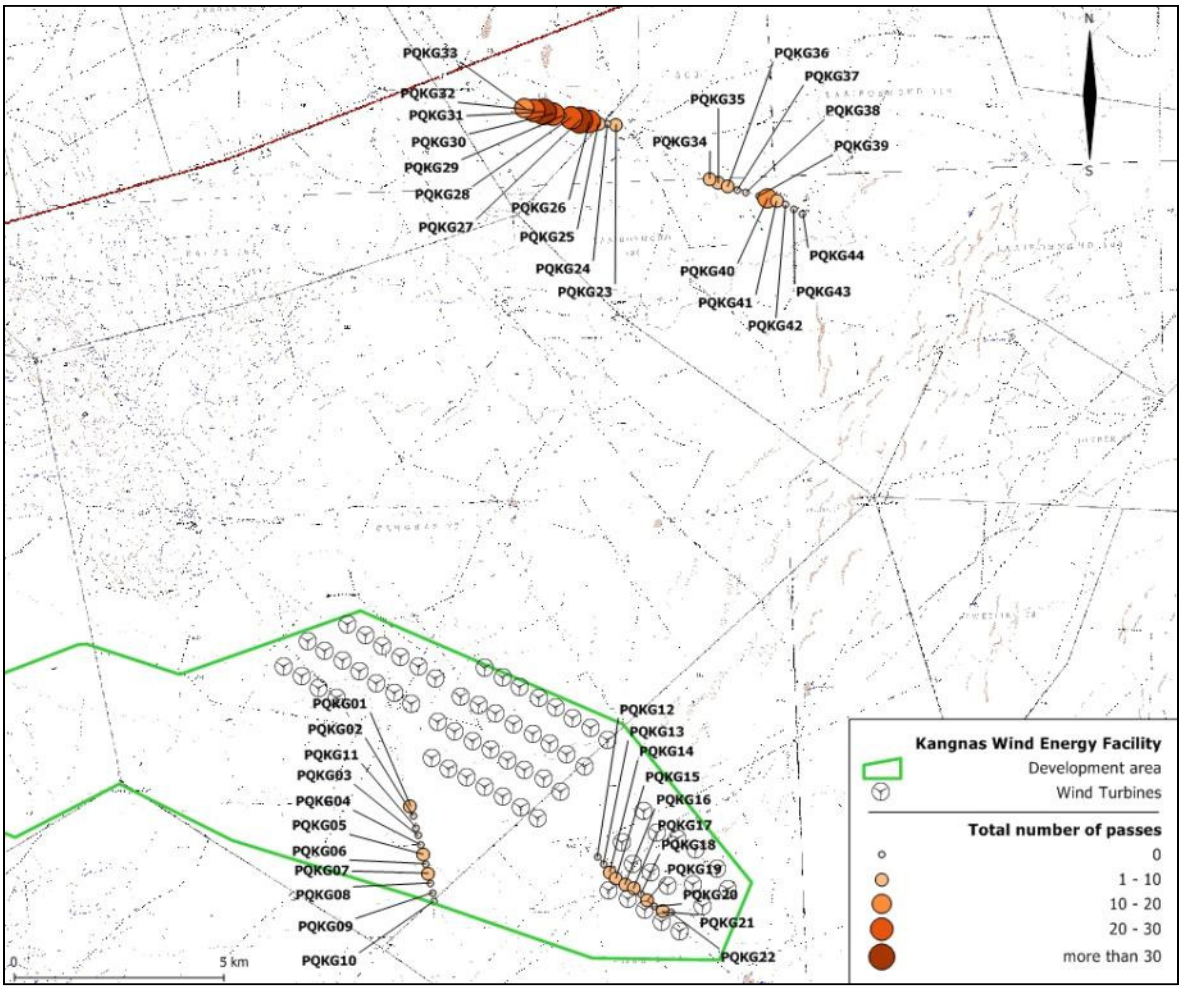

Figure 17 - Total number of passes recorded in each active detection sampling point, at the wind energy facility and control, between September 2012 and July 2013.

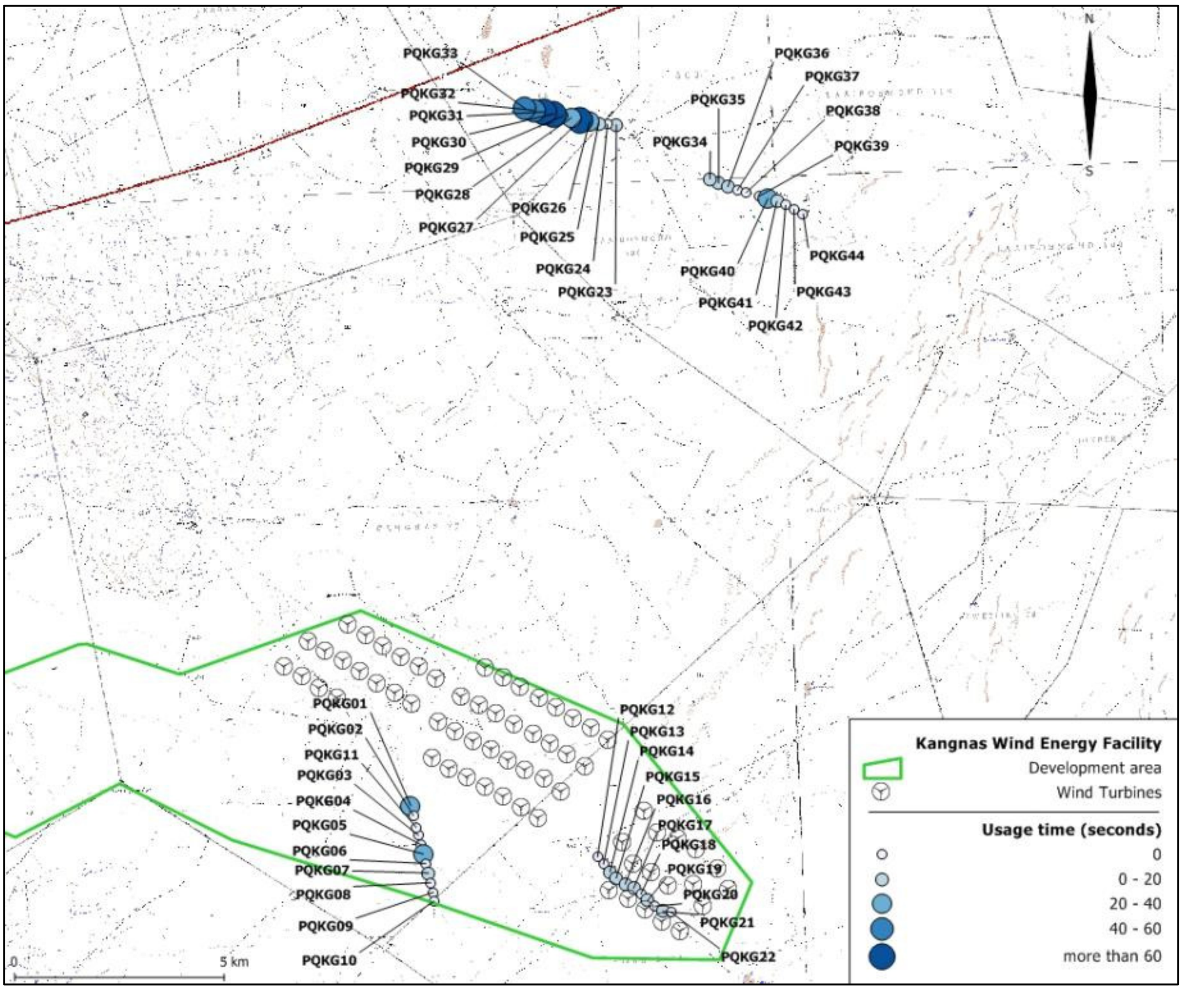

Figure 18 – Total time of use (seconds) recorded in each active detection sampling point, at the wind energy facility and control, between September 2012 and July 2013.

Bat activity also varies according to the biotopes present, since the same biotopes provide shelter from wind and predators and favours food availability (Verboom & Huitema, 1997). In addition, different species also have different biotope preferences (Monadjem *et al.*, 2010). This evaluation is generally very important in order to give guidance concerning the micro-siting of the wind turbines, allowing the developer to relocate turbines from areas of highly intense use biotopes, to other biotopes with less interest for bats. Nonetheless considering that the study area is quite featureless and that the study area is located on plains with considerable extensions of the same vegetation type (as referred in chapter 0), it is not possible to provide a comparison of the bat activity recorded in different types of biotopes on this site. Therefore, it is considered that bat activity in the study area would not be influenced by the type of vegetation present, and that this variable should not be a major concern to influence the decision on the final location of the wind turbines.

3.2.4. Overnight activity (passive detection)

Considering that species have different periods of higher activity between sunset and sunrise, the analysis of which periods of the night have higher bat activity can contribute to minimizing the impacts of wind energy facilities on bats.

Figure 19 presents the average number of bat passes per hour recorded within each hour period, since sunset to sunrise, between November 2012 and July 2013. In the wind energy facility site the period of greatest activity of bats was observed in the fourth and sixth hour after sunset. At the control area, the peak of activity was recorded in the third hour after sunset. Considering the average temperatures recorded in these periods of time, the values recorded were below 20ºC, indicating that bats may prefer this range of temperature. The pattern of higher activity in the beginning of the night, and decrease towards sunrise has already been noted in several studies, where a higher activity is recorded in the first two hours after sunset and then decreased towards sunrise, especially in open habitats, have been reported (Brooks, 2009). However other studies indicate that bat activity may vary greatly during the night, according with the type of habitat present in the study area, as well as the availability of insects, indicating the potential to observe a second period of higher activity closer to sunrise (O' Donnel, 2000; Meyer *et al.*, 2004).

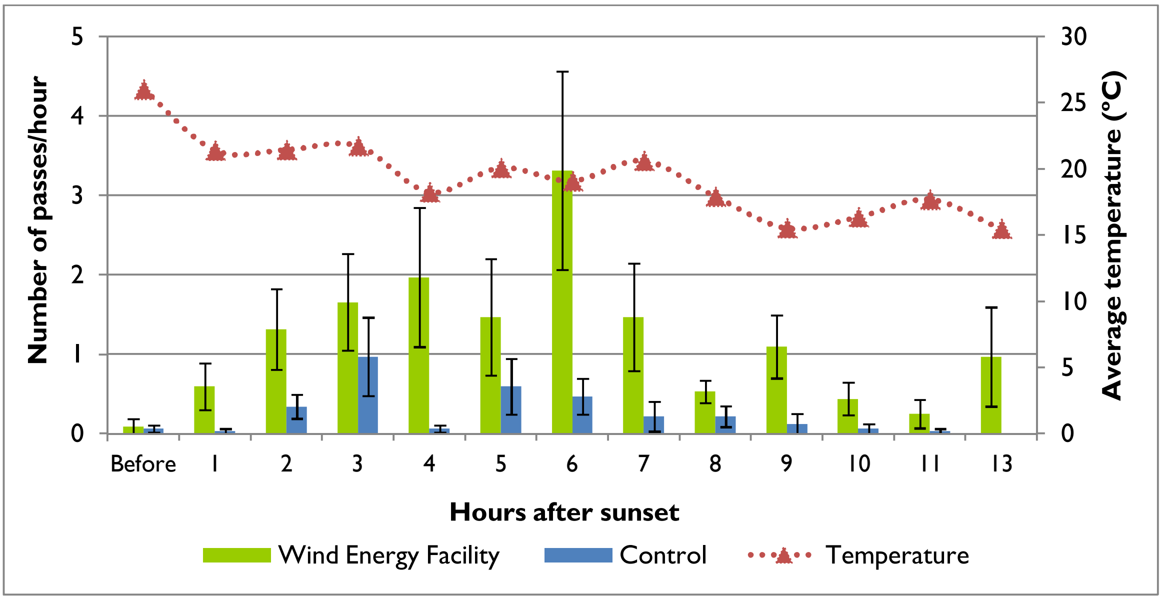

Figure 19 – Average number of passes per hour (± standard error) after sunset in relation to average temperature (°C) recorded between November 2012 and July 2013, in the Kangnas wind energy facility site. Analysis considering the total data collected through all passive detectors.

Not all species have the same activity patterns throughout the night, as some are more active only during the first hours after sunset, while other species spend less time active, but are active during more time periods throughout the night (Agosta *et al.*, 2005; Brooks, 2009). In Figure 20 an analysis of the activity index throughout the night of the species confirmed is presented.

Considering the activity of *Tadarida aegyptiaca* (Molossidae), this species was mostly active between the 2nd and 3rd, as well as between the 5th and 7th hour after sunset (Figure 20). This species is considered to have a high potential risk of collision with wind turbines (Sowler & Stoffberg, 2012) due to its flight characteristics (high flight and open-forager), existing records of collisions of *Tadarida aegyptiaca* with wind turbines in South Africa (Doty & Martin, 2013) and of the same genus (*Tadarida sp.*) in Europe (EUROBATS, 2013), and North America (Arnett *et al.*, 2008).

Miniopterus natalensis (Miniopteridae) individuals were active mostly in the fifth and sixth hours following sunset, with a second activity period in the eighth and tenth hour after sunset (Figure 20). This species is a clutter forager with medium to high flight patterns and can migrate several kilometres between roosts. This type of behaviour provides some level of risk of collision with wind turbines, being classified as having medium to high potential risk of collision with wind turbines (Sowler & Stoffberg, 2012).

Neoromicia capensis* and *Eptesicus hottentotus* (Vespertilionidae) were mostly active in the study area in the 2nd, 3rd and 4th hour after sunset, indicating that they are mostly active in the first half of the night (Figure 20). These species have a medium-high risk of collision with wind turbines (Sowler & Stoffberg, 2012) - there are known collisions of the *Neoromicia capensis* with wind turbines in South Africa (Aronson *et al.*, 2013; Doty & Martin, 2013) and of the genus (*Eptesicus sp.*) in Europe (EUROBATS, 2013).

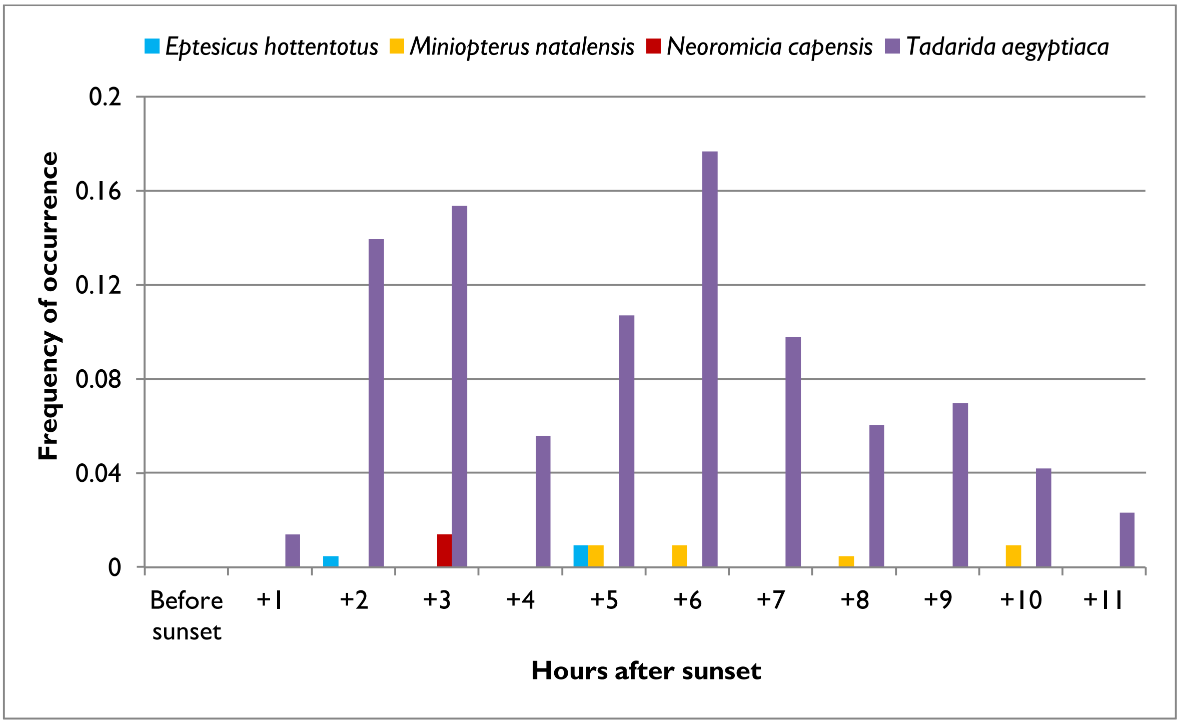

Figure 20 – Frequency of bat records of each identified species between November 2012 and July 2013 (passive detection).

3.3. USE OF ROOSTS

During the field surveys, a total of 12 structures were inspected and assessed for their potential as bat roosts as well as evidence of bat presence (Table 9; Figure 22; Appendix III). Roost potential was assessed based on the site characteristics to provide an adequate roost for any of the possible species present in the study area.

Table 9 – Structures with potential to support roost for bats identified from September 2012 to July 2013 surveys (I – inspection; U – Ultrasound detection; Q – Query to locals).

Roost reference	Description	Sampling type	Traces	Potential
Kangnas 1	Farm building	I, Q	Droppings and individuals	High
Kangnas 2	Cave	I, U	Droppings	High
Kangnas 3	Cave	I	-	High
Kangnas 4	Cave	I	Droppings	High
Karas 1	Building with tin shed	I	-	Low
Karas 2	Building with tin shed	I	-	Low
Karas 3	Building with tin shed	I	-	Low
Goebees 1	Abandoned building	I, U	-	Low
Goebees 2	Abandoned building	I, U	-	Low
Goebees 3	Abandoned building	I, U	-	Low
Goebees 4	Abandoned building	I, U	-	Low
Goebees 5	Abandoned building	I, U	-	Low

From the locations identified throughout the field surveys, traces of bat presence were found in three of them: Kangnas 1, Kangnas 3 and Kangnas 4. At all of these 3 locations bat droppings where detected (Figure 21); however at Kangnas 1 individuals are reported as being seen by the Kangnas landowner (Mr van Niekerk) who, during the interviews conducted, mentioned that some bat individuals (normally two individuals) are usually observed resting upside down in a porch at the early evening. Considering this characteristic, which is exclusive to some groups of bats, it is possible that this potential roost is occupied by individuals of the Rhinolophidae or Hipposeridae family. The confirmed bat roost closest to a proposed wind turbine is Kangnas 1, at approximately 3.8km. The remaining roosts are located at a minimum distance of approximately 5 km from any proposed wind turbine location.

During the May and July surveys, Kangnas 2 and the roosts Goebees 1 to Goebees 5 were monitored through ultra-sound detection at sunset. However no individuals were observed entering or leaving these roosts, leaving unconfirmed their possible utilization by bats.

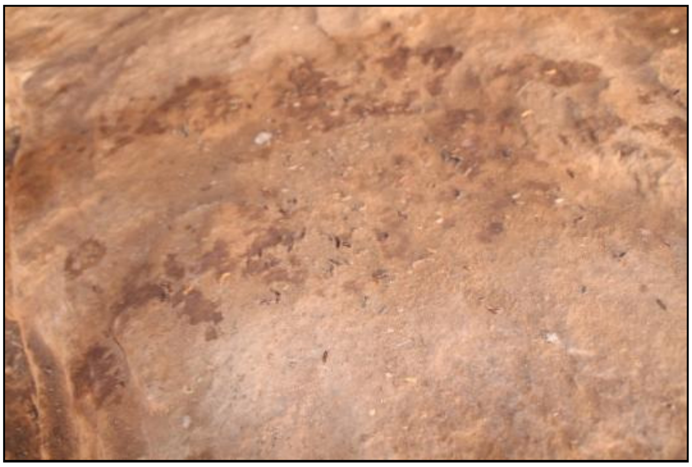

Figure 21 – Bat droppings observed at the set of caves of Kangnas (Kangas 2 and Kangnas 4).

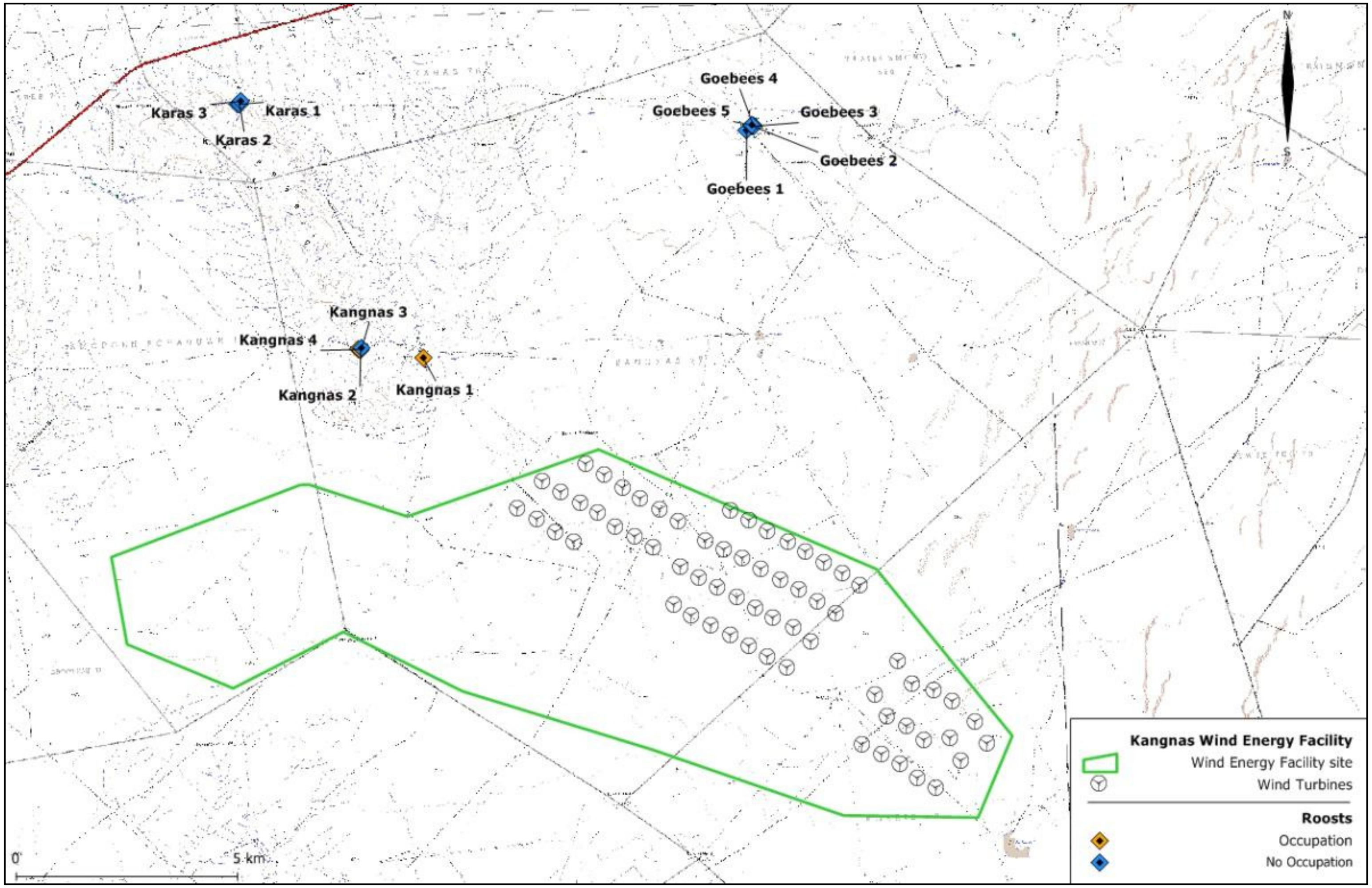

Figure 22 – Identified potential bat roosts locations on the site and immediate surroundings.

4. Potential impacts identified on the bat community

4.1. Species with potential and confirmed occurrence on the site

Considering the species with potential and confirmed occurrence at the Kangnas wind energy facility, it is important to conduct a preliminary general analysis of the main potential effects that the construction and implementation of this kind of development on the study area may have on them. Assuming that bat monitoring may not detect all bat species present in the study area in the first surveys, this analysis allows to predict the possible impacts to consider in a future analysis, once bat species that are listed in this report are identified in the study area.

From the 10 bat species presented in Table 6 indicated as more or less likely to occur in the study area, 5 are considered to have a high probability of occurrence, 7 are considered to have a moderate probability of occurrence, and 1 has a low probability of occurrence in the study area.

According to the South African Red List, four species (all with moderate probability of occurrence) have a "Near Threatened" conservation status: *Miniopterus natalensis*, *Rhinolophus capensis*, *Rhinolophus clivosus* and *Rhinolophus darlingi*. Also one species is considered as "Vulnerable", having a high probability of occurrence in the study area: *Cistugo seabrai*. The remaining species are considered to be of "Least Concern" by the South African Red List (Friedmann & Daly, 2004) and the IUCN (2012).

Analysing the collision risk pointed by Sowler & Stoffberg (2012) for the species with potential occurrence at the site (Figure 23) it is noted that most of the species with potential presence in the study area have a low risk of collision with wind turbines; only one species has a medium risk of collision; and 4 species have a medium to high and high risk of collision. The species with a potential high risk of collision with turbines belong to the Molossidae family, known to be open-air foragers and have high altitude flights (*Tadarida aegyptiaca* and *Sauromys petrophilus*). Although *Tadarida aegyptiaca* has a high probability of occurrence in the study area, being one of the species confirmed through the monitoring, *Sauromys petrophilus* has a low probability of occurrence in the study area, being therefore not expected to be significantly affected by this development.

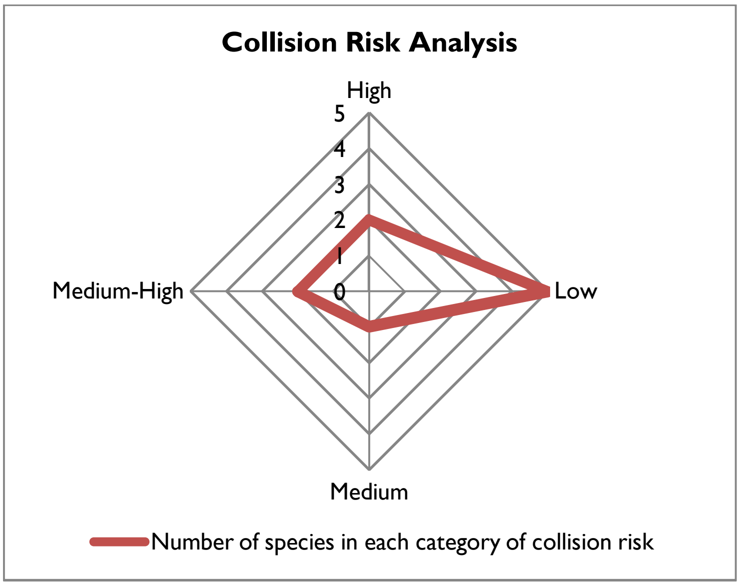

Figure 23 – Representation of the number of species (with potential occurrence in the Kangnas wind energy facility) in each category of collision risk (Sowler & Stoffberg, 2012).

Although wind energy facilities provide a clean source of energy without long term impacts on the planet, unlike fossil fuels, the existence of impacts over faunal resources was detected not long after its first implementation. Bats appear to be one of the most affected groups by the implementation of wind energy facilities, since large numbers of bat fatalities have been detected throughout North America and Europe (Arnett *et al.* 2008; EUROBATS, 2013; Hein *et al.*, 2013).

Literature review and specialist expertise have suggested that the impacts wind energy facilities have on bat species result mostly from fatalities, caused by direct collision with the turbine tower, collision with rotation blades and barotrauma (Kunz *et al.*, 2007b; Cryan & Barclay, 2009).

It is also possible to impact on bat populations by affecting roosts, being temporary roosts, for daytime use, or more important roosts, such as breeding or hibernation roosts that have an important role in bats life cycle. During the monitoring conducted, several potential locations for bat roost were found, as well as locations with evidence of bat presence. However, these locations are not apparently used for hibernation or reproduction purposes, being most likely used as daytime or temporary roosts. Considering that the information regarding foraging distances of South African bat species is very scarce, a comparison with the foraging distances of similar species was made. For *Tadarida sp.* published information regarding forage distance of approximately 5 km to 30 km (Marques *et al.*, 2004); *Eptesicus sp.* can forage up to 5 km from roosts (Whitaker Jr. & Weeks Jr., 2001); and *Miniopterus sp.* has been recorded mostly at 10 km from their roost during foraging (Rainho *et al.*, 2011). As wind turbines are located at a minimum distance of 3 km from the closest identified roost, possible impacts may occur in species that forage at distances of 5 km or more from roosts and find the area of the wind energy facility suitable for searching for prey. Considering the low levels of activity detected in the wind energy facility to date, it is expected that any impacts from the development on the overall bat community would not be significant.

Regarding wind energy facilities impact over bats and their fatalities record, it is important to analyse the confirmed species in the study area and their predicted risk of collision with any of the wind turbines. The species confirmed include 1 species with high risk of collision with wind turbines (*Tadarida aegyptiaca*), 2 species with medium-high risk of collision with wind turbines (*Miniopterus natalensis* and *Neoromicia capensis*) and 1 species with medium risk of collision (*Eptesicus hottentotus*). From these, only *Miniopterus natalensis* has a conservation status of concern, being considered as "Near Threatened" by the South African Red List (Friedmann & Daly, 2004).

It is possible to assume that the species expected to be mostly affected by the wind energy facility could potentially be *Tadarida aegyptiaca*, as an open air forager with behaviours that pose higher impact risks, and also being the more abundant species in the area. However clutter-edge foragers may also be affected by the wind energy facility and collisions could potentially occur. Nevertheless, it is considered that if mortality due to collision with wind turbines occurs with these medium and medium-high risk species it would be at a lesser extent than the fatalities expected for the high risk collision species, and it will depend mainly on the habitats where turbines will be sited. Since the study area is mostly open habitats it is expected that clutter-edge species will be not highly affected by this development.

This is shown in Figure 24, where the frequency of occurrence of bat fatalities of the species confirmed in different countries/continents is compared. The species with the higher frequency of bat fatalities in most of the locations analysed (South Africa, Europe and United States) where the *Tadarida sp.* and *Neoromicia sp.* (*Neoromicia sp.* does not occur in Europe and United States, however the genus *Pipistrellus* is considered as quite similar, and therefore this species is compared with this genus). In addition, the published records of bat fatalities found in South Africa to date, were of these two species. Few records of fatalities of *Eptesicus sp.* and *Miniopterus sp* have been noted in wind energy facilities in both Europe and the United States.

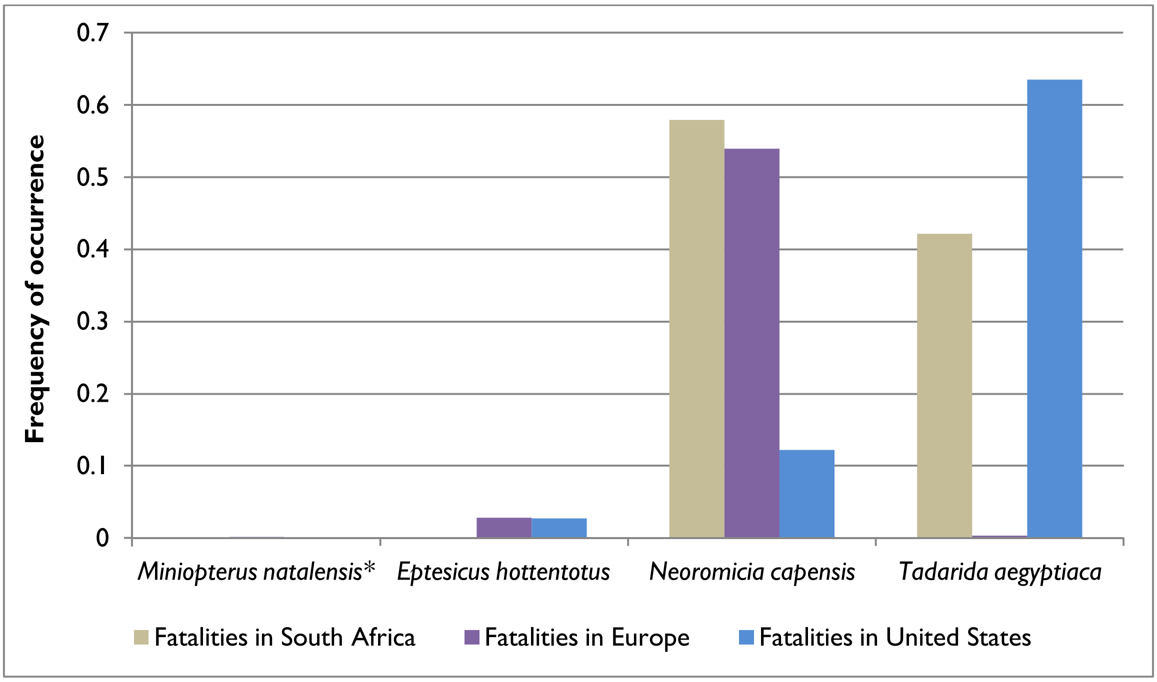

Figure 24 – Frequency of occurrence of bat species fatalities in Wind Energy Facilities in South Africa (Aronson *et al.*, 2013; Doty & Martin, 2013), in Europe – for species with the same or similar genus (EUROBATS, 2013) and North America – for species with the same or similar genus (Arnett *et al.*, 2008). * - species with conservation status in South Africa (Near Threatened).

Cumulative impacts of a development project may be defined as *"impacts resulting from incremental actions from the project, by addition with other past, present or future impacts resulting from other actions/project reasonable predictable"* (Hyder, 1999) and more recently as "*additional changes caused by a proposed development in conjunction with other similar developments or as the combined effect of a set of developments, taken together*" (SNH, 2012). This assumes the knowledge of other projects or actions whose effects could be added to those resulting from the project being assessed. Since it has been determined not to be reasonably viable to consider all existing and proposed projects for a certain region, the analysis should focus on (Masden *et al.*, 2010; SNH, 2012):

- The projects known for the area and its surroundings and for which there is information readily available;
- The projects mentioned above and that could be relevant in terms of the expected impacts, in relation to the project under assessment;
- The target species more relevant and/or susceptible to the expected impacts.

The main known activities or projects, relevant for the cumulative impacts analysis, known in the broader area of the Kangnas wind energy facility are human activities, namely cattle grazing as well as other proposed wind energy facilities.

- *Human activities:*

The study area lies in a predominantly natural environment, with little transformed areas. Presently the transformed area is used for cattle grazing. In spite of the existing natural vegetation it is expected that the human activities can expand in the future, leading to the conversion of some of the areas of unspoiled natural vegetation into more pasture areas. However, since this is a relatively unproductive area, it is also expected that this transformation will be a progressive process, making it possible to control and minimize its effects.

- *Other wind energy facilities:*

There is at least six other known proposed wind energy facility developments in the broader region of the Kangnas development (Figure 25): Poffader Wind Energy Facility (91 km to the east), Namies Wind Energy Facility (68 km to the east), Blue Wind Energy Facility (123 km to the west), Kleinsee Wind Energy Facility (127 km to the west), Koingnaas Wind Energy Facility (128 km to the south-west) and Kannikwa Vlakte Wind Energy Facility (132 km to the north-west). The project with the largest number of wind turbines proposed is the Poffader WEF, with approximately 500 wind turbines, followed by the Kleinsee WEF, with 150-200 wind turbines. The remaining four projects are proposed to comprise less than 100 turbines each: Kannikwa Vlakte WEF - 50-80 turbines; Blue WEF - 75 turbines; Namies WEF - 46 to 58 wind turbines; and Koingnass WEF - 24 turbines. Of these facilities, the Kannikwa Vlakte WEF and Koingnaas WEF are already authorised by the Department of Environmental Affairs.

Considering the distance that separates these wind energy facilities from the Kangnas wind energy facility, it is not expected that most of the present and possibly occurring species in the study area will be significantly affected by the resulting cumulative impacts, since most of these bats usually do not travel distances of more than 50 km between summer and winter roosts (Kunz *et al.*, 2007; Monadjem *et al.*, 2010). Therefore the main concern from the wind facilities located in the region relates to bat species that are known to undertake medium to long migrations such as *Miniopterus natalensis*. There are no known winter or summer roosts of *Miniopterus natalensis* in the study area (refer to chapter 3.1.2), and therefore it is not expected that this species would be using the study area to commute between roosts present over 400 km away. Nevertheless, baseline information on migration and dispersion of bat species in South Africa is lacking and it is possible that the individuals identified where not using the area while on migration, but rather as a foraging area, which diminishes the probability of impact on these species, from a cumulative impact perspective.

It is also of note that the Kangnas Wind Energy Facility is expected to have a higher number of turbines implemented in up to four phases. This report considers only the first stage of the project. Depending on the layout and number of turbines to be implemented, the remaining three phases of turbines to implement at Kangnas may result in further cumulative impacts over the bat populations. In the next phases of this wind energy facility, cumulative impacts could potentially occur in terms of the roosts identified in the rocky outcrops in the northern part of the study area. Therefore these cumulative impacts should be taken into consideration when developing further phases of Kangnas wind energy facility.

Figure 25 – Location of known proposed wind energy facilities in the vicinity of Kangnas wind energy facility (Yellow – Study area; Green – Projects on process; Red – Projects approved).

4.2. Potential sensitive areas within the wind energy facility

Considering bat activity recorded in the area to date, the biotopes present and the number of species confirmed, it is considered that the Kangnas wind energy facility area is of low sensitivity to bats in general, particularly due to the absence of vegetation of interest to bats, the low bat activity and the absence of important roosts identified to date.

Nonetheless some areas present more relative interest to the bat species detected in the study area, such as the existence of rocky outcrops northwest of the study area, of several buildings with possible interest for roosting and some seasonal water features.

The few water bodies present in the surrounding area were considered as important areas for bats (Figure 26), although they are only temporary. Rivers and water bodies, and associated riverside vegetation, are important landmarks for bat orientation (Serra-Cobo *et al.,* 2000) and preferential locations for bat drinking and feeding due to the abundance of insects in the surroundings (Loyd *et al.,* 2006; Scott *et al.*, 2009; Hagen & Sabo, 2012), especially emergent insects, such as Diptera and some Lepidoptera, important for many bat species' diets. In the case of the species present or possibly present in the study area not many are specifically associated with riparian vegetation, which is not unusual since most of the water features do not have water present for long enough to have this type of vegetation. Therefore, and considering that all water features found outside of the study area, it is not considered that they represent areas with associated risk of collision to the bat community.

Additionally to the water features found, the rocky outcrops present in the north-western part of the study area were selected as important areas for bats. These features may represent very important places for bats to roost, since they can provide adequate conditions for hollow-roosting bats, as well as crevice-roosting bats. Eighty per cent of the bats with potential occurrence in the study area roost in this type of structure, and 75% of the bats confirmed in the study area roost in caves and rock crevices (Table 6). Two potential roosting caves were found in the rocky areas located a few kilometres northwest of the study area.

According to recent recommendations from the South African Bat Assessment Advisory Panel (SABAAP), a minimum buffer of 200 m around all water features considered to be of importance to bats in the study area was defined, as well as around the rocky outcrops (Figure 26).

The spatial-temporal analysis results (from both active and passive surveys) showed that bat activity in the wind energy facility area was very low, with a lower average number of passes per unit of time in relation to the utilization of the remaining area (for this analysis were considered areas of high activity as superior to 20 bat passes/hour – Figure 17 and Figure 18). This consideration is motivated by the difference in the activity index observed in this study, when compared with other study areas throughout South Africa: in the Kangnas wind energy facility the average activity observed was 2 passes passes/hour, while in other wind energy facility sites being monitored, activity indexes were quite superior – on average between 10 and 20 passes/hour in the Western and Northern Cape Provinces, and more than 30 bat passes per hour in KwaZulu-Natal.

Considering the confirmed roosts previously referred to in chapter 3.3, buffers of 500 m were established since in most of the roosts no species were able to be identified, being considered to belong to Least Concern Bats, with a small number of individuals. This distance took the recent recommendation from the SABAAP workshop results into consideration, as well as results from studies that indicate that the environmental features present within a 1.5km distance from a roost are important to determine its occupation and that the alteration of the surrounding features of the roost at a minimum distance of 500 m may cause bats to abandon the roost, or alternatively that habitat management may be implemented within this radius to have better effects (Jenkins *et al.*, 1998).

Considering these statements, the development area is considered to be of low sensitivity in terms of potential bat collision risk with wind turbines, since none of the features referred to previously are coincident with the development area (Figure 26).

For an optimal turbine layout any of the identified sensitive areas for bat communities should be avoided. Disturbance within the considered sensitive areas should be avoided both during the construction and operation phase of the development. Therefore it is considered that the currently proposed layout is acceptable in terms of the bat activity detected as none of the turbines are coincident with any of the sensitive areas identified.

In order to minimize potential impacts from the construction and operational phases of the project some recommendations are proposed in chapter 5.2. Note that these are to be considered only as recommendations at this stage and should only be taken into consideration if necessary and technically viable.

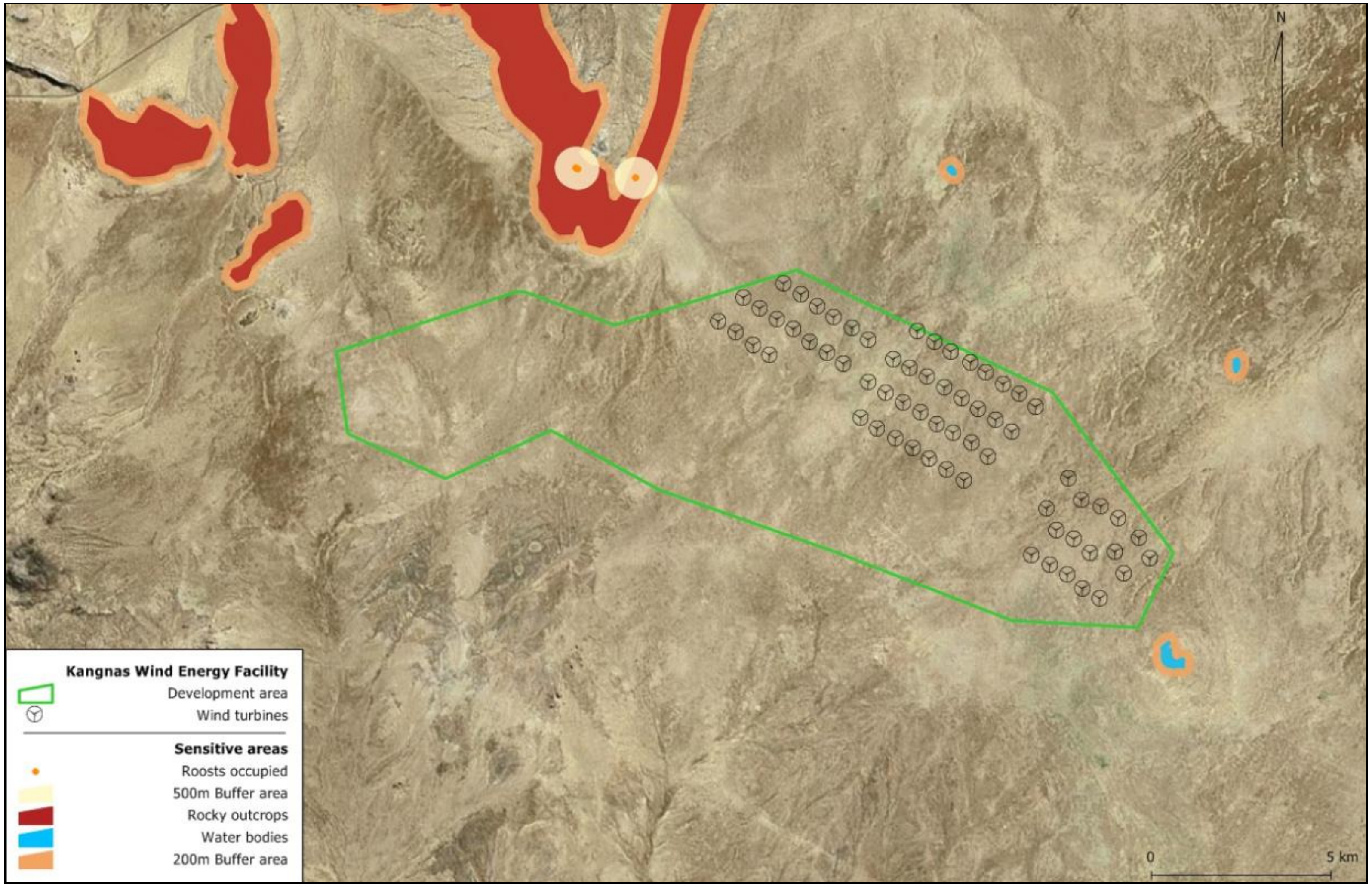

Figure 26 – Sensitive areas within the Kangnas wind energy facility site and surrounding area

5. Conclusions and Recommendations

5.1. Main results of the pre-construction monitoring programme

The following activities were undertaken during the surveys conducted for the pre-construction bat monitoring programme of the Kangnas wind energy facility:

- Forty-four active detection sampling points (22 at the wind energy facility and 22 at the control area) established along vehicle-based transects.

- Five passive sampling points, not all simultaneously but up to four detectors simultaneously at different heights (ground level and rotor height).

- Roost searches, identification and visits.

All the above-mentioned activities were conducted between September 2012 and August 2013 with the objective to characterise and map the bat activity in the Kangnas wind energy facility area to subsequently assess the impact of the proposed wind energy facility on bat communities.

During the surveys conducted, 4 bat species were identified and confirmed in the study area from the 10 species that could potentially occur in the study area:

- 1 species considered as "Near Threatened" by the South Africa Red List: Natal long-fingered bat (*Miniopterus natalensis*);

- 3 species classified as "Least Concern" by the South Africa Red List: Long-tailed serotine (*Eptesicus hottentotus*), Cape serotine (*Neromicia capensis*) and Egyptian free-tailed bat (*Tadarida aegyptiaca*).

Of the remaining species that may potentially occur in the study area, the Angolan wing-gland bat (*Cistugo seabrai*) is classified as "Vulnerable"; Cape horseshoe bat (*Rhinolophus capensis*), Geoffroy's horseshoe bat (*Rhinolophus clivosus*) and Darling's horseshoe bat (*Rhinolophus darlingi*) are "Near Threatened"; Egyptian slit-faced bat (*Nycteris thebaica*) and Robert's flat-headed bat (*Sauromys *petrophilus*) are "Least Concern" according with the South Africa Red List (Friedmann & Daly, 2004).

The analysis of bat activity in the study area, considering the results from both active and passive detection, indicates that bat activity in the study area was higher in spring and winter surveys (September, November and July). The high activity peaks may be related to environmental variables as it is expected that precipitation increases towards the end of summer, between December and April, and that temperature decreases between May and September (Mucina & Rutherford, 2006), providing favourable conditions for insect proliferation and active foraging behaviour from bats.

The examination of the average number of passes at each of the detectors with microphones installed at different heights allowed the comparison between the activity closer to the ground level and within the rotor swept area height (50 m above ground level). This comparison indicated that recorded bat activity in the study area was generally higher at 50m above ground level. The possibility that bats in the study area forage and travel at the rotor swept height may influence the collision risk of some species, as the possibility of intersecting the path of moving blades is higher. Some authors have found that in the US an increase in fatalities was related to the increase in tower height, due to migratory bats intercepting the swept area of blades, which is usually at ~65m above ground level (Barclay *et al.,* 2007). In this study area, at least two of the confirmed species may have high flight behaviour, i.e. *Tadarida aegyptiaca* - an open-air forager, and *Miniopterus natalensis* - a migratory species. It is recommended that the specifications of the wind turbines to be implemented in this wind energy facility consider the characteristics of the flight behaviour of the resident bats in order to minimise the utilisation of the rotor swept area by these species, where the probability of fatality is higher.

Considering bat activity observed through the night in the study area, a predominant peak of activity was found between the fourth and sixth hour after sunset, indicating a possible relationship with temperature values below 20ºC. Using this knowledge, it is possible to reduce the probability of bat fatality by implementing mitigation measures specific for these critical periods of activity. Also, considering that one bat species which has conservation status of concern, and medium to high probability of collision with wind turbines was confirmed to use the study area during this time period, it is important to consider the continuation of the monitoring programme, during the construction and operation phases of the development to obtain a better understanding of the potential risk. This will provide confirmation of the time periods of possible higher risk, as well as the collection of more information to identify mitigation measures, if then deemed necessary.

Statistical analysis indicated that wind speed and season may contribute to explaining the occurrence of bat activity in the study area, although the collection of more data for a longer period of time would allow for a more robust analysis. Bat activity is influenced by wind speed to some extent, and by seasonal variations in atmospheric conditions, with bat activity diminishing significantly in summer and autumn, and increasing in winter and spring.

In the study area, 2 species with possible occurrence are perceived as having a potential high risk of collision with wind turbines due to their behaviour (Sowler & Stoffberg, 2012) - one of these species (*Tadarida aegyptiaca*) was confirmed to occur in the area through this monitoring programme. The potential high risk of collision of this species, as an open-air forager, is related with it foraging behaviour, which promotes the entry of individuals in the turbine blade swept area, therefore increasing the probability of collision. There are also references to mortality incidents of *Tadarida aegyptiaca* in wind facilities in South Africa (Doty & Martin, 2013); in Europe with several species of *Tadarida sp.*; and USA (*Tadarida brasiliensis*) (EUROBATS, 2013; Arnett *et al.*, 2008).

Two species with possible occurrence have medium-high risk of collision, and 1 species has a medium risk of collision (Sowler & Stoffberg, 2012). All of these species were confirmed to occur in the area through this monitoring programme, being in general clutter-edge foragers who hunt in the edge of forest often switching between open and clutter-edge habitat space (Monadjem *et al.*, 2010). Favoured vegetation/habitat by these bat species is almost completely absent when considering the current turbine layout, and therefore, the potential risk of collision of such species is considered very low. At least two of these species (*Miniopterus natalensis* and *Eptesicus hottentotus*) have known collisions with wind turbines in Europe and USA, from the same or similar genus, such as *Miniopterus* sp., and *Eptesicus* sp. (also similar to *Neoromicia* sp.) (EUROBATS, 2013). Collisions of *Neoromicia capensis* with wind turbines have already been documented in two different facilities in South Africa, in the Western Cape (Aronson *et al.*, 2013) and Eastern Cape (Doty & Martin, 2013).

The data collection analysis during this first year of monitoring, and prior to construction, allowed the characterisation of the bat community present in the Kangnas wind energy facility, and assists in the prediction of the potential effects that the implementation of this project may have to bat populations in the study area. This study showed that the general area of the wind energy development is used infrequently by bats, although the confirmed species occurring in the area present some potential risk of collision with wind turbines. The north-western area has potential to provide important roosting structures, where some of the species confirmed in the study area may roost. This area was considered of higher sensitivity than the south eastern areas of the study area to bat species. The remaining area of the development was considered of low sensitivity.

The risk of some bat fatalities due to the impacts from the wind energy facility cannot however be completely ruled out. Therefore, measures should be implemented in order to minimise disturbance of these locations during the construction phase of the project. During the operational phase of the project, bat fatalities can be anticipated due to the documented occurrence of fatalities of two of the species present in the study area (common and locally abundant species), but the risk and extent of this impact is expected to be low. The implementation of an adequate monitoring programme during the subsequent phases of the project will contribute to the validation of predicted impacts, and verify if the mitigation measures proposed and implemented are adequate and if necessary implement any adjustments. If other impacts are identified through this on-going monitoring, then additional mitigation measures can be proposed, when necessary.

5.2. RECOMMENDATIONS FOR THE NEXT PHASES OF THE PROJECT

The Kangnas wind energy facility development area was considered to be of low sensitivity in terms of bat communities, as indicated by the results from the pre-construction bat monitoring programme. No wind turbines are proposed within the sensitive areas identified.

It is, however, considered important to minimise any noise or perturbation[10] of the roosting sites, at least during the construction phase and during the maintenance activities during the operational phase of the project. This may be achieved by identifying the roosts that are occupied before the construction works commence, and to implement an area of no-disturbance of at least 500 m,

[10] In ecology, a disturbance is a temporary change in average environmental conditions that causes a pronounced change in an ecosystem.

where the presence of machinery, workers or particularly noisy activities should be avoided as far as possible.

As bat fatalities at the Kangnas wind energy facility can be anticipated to occur, is proposed that a monitoring programme be implemented during the construction and operational phase of the project. A well-planned and rigorous monitoring programme is one of the most effective measures at this stage to determine and monitor any impacts, and propose adequate, site specific and cost-effective mitigation measures. During the construction phase, the bat monitoring programme should contribute to a better understanding of bat communities on the area, and add further data to better assess the relationship between bats and environmental variables. During the operational phase, the bat monitoring programme will contribute to assessing the real bat mortality associated with the wind energy facility, verifying the efficacy of the proposed and implemented mitigation measures and recommend adjustments if necessary. The identification of any critical areas or situations should be promptly evaluated by the bat specialist in order to implement adequate and specific mitigation measures.

The proposed location of the wind turbines at the Kangnas Wind Energy Facility is not expected to cause major impacts over bat populations as the current layout does not coincide with the sensitive areas identified to date.

For the construction phase some measures are suggested in order to minimize the potential impacts identified:

- Minimize areas of construction to the maximum extent possible.
- Appropriate training should be provided to all the construction personnel. Everybody working in the area should be aware of the sensitive areas and be alert to the possible presence of bats, mostly when in abandoned buildings with proper rooftops.
- During the construction phase any disturbance within the roosting locations or other sensitive areas (Figure 26) should be avoided or, if inevitable, kept to the minimum necessary levels.
- If any building or structure with potential to provide bat roosting needs to be demolished, then a visit should be conducted by a specialist to verify the presence / absence of bats prior to the commencement of the works.

- The confirmed and potential roosting locations, natural vegetation and the vegetation along water bodies should be avoided or, if inevitable, kept to the minimum necessary levels.

- Consider the implementation of a construction monitoring programme to survey bat communities on the wind energy facility and the impacts resulting from the installed infrastructure (refer to Appendix V). This programme should have a minimum duration of 1 year.

The occurrence of at least two species considered with high collision risk with wind turbines and/or with recorded fatalities in wind energy facility in South Africa (*Neoromicia capensis* and *Tadarida aegyptiaca*) were recorded in the study area. These species have medium-high and high risk of collision, respectively, due to their flight characteristics. Since these species are considered to be potentially affected by the operational phase of the project a set of measures are proposed in order to minimize the potential bat fatalities:

- Ensure the implementation of a post-construction monitoring programme (operation phase) to survey bat communities on the wind energy facility and the impacts resulting from the installed infrastructure (refer to Appendix V). This plan should have a minimum duration of three years after the commercial operation date of the project.

- The results of the operational phase monitoring programme must be taken into account for the implementation of further mitigation measures, if necessary.

- If high collision risk areas are identified during the operational phase, or a high number of bat fatalities due to wind turbines are recorded, this should be evaluated by the designated bat specialists as soon as possible. Subsequent mitigation measures, adjusted to the risk situation identified, should be then proposed and implemented.

- Lighting of wind energy facility (for example security lights) should be kept to a minimum[11] and should be directed downwards (with the exception of aviation security lighting).

[11] Provided this complies with all the legal requirements (e.g. Civil Aviation Authority regulations)

The monitoring programme should have a minimum duration of at least 4 years (1 year during construction and 3 years during operational phase) and be revisited after this period. If after 3 years of post-construction monitoring the need to extend the monitoring programme further is verified, the monitoring programme could then be revisited every 12 months. It should include both the continuation of the assessment of bat communities in the site, complementing the information gathered during the pre-construction phase and allowing the determination of any exclusion effects over the bat community. The operational phase monitoring programme should include carcass searches and the determination of correction factors (observer's efficiency and carcass removal) in order to accurately determine the impact of the wind turbines on bats and determine any potential critical area and/or wind turbines. This will allow proposing mitigation measures, if necessary, adjusted to the site specific conditions. These mitigation measures must be evaluated on a case by case scenario. An effective mitigation measures plan is one that shows an accurate determination of the most problematic areas and/or wind turbines and the characterisation of the environmental variables with higher influence on bat fatalities (Arnett *et al.*, 2013). The implementation of such mitigation measures should be undertaken if deemed necessary, and they should be carefully planned in order to maximize their efficacy in reducing bat mortality and assure the compatibility of the development with conservation of bat communities (Arnett *et al.*, 2010; Arnett *et al.*, 2011).

5.3. Analysis of the suitability of the Monitoring Programme

It is concluded that the current bat monitoring programme was suitable to the project specifications and allowed the achievement of the established objectives. The programme was conducted over a year of the pre-construction phase, with surveys covering the all seasons: autumn, winter, spring and summer. As recommended in the best practice guidelines the monitoring activities included bat activity monitoring at ground level and at rotor height, as well as roost search and monitoring in the vicinity of the future wind energy facility.

The monitoring programme to be implemented during the construction and operational phase of the project should include the same methodological approach (as per the pre-construction phase). During the operational phase the monitoring programme should include carcass searches and correction factors assessment to assess bat fatality associated with the wind energy facility.

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7. Appendices

7.1. Appendix I - Sample Point description

<table>
<tr><th></th><th>Area</th><th>Point</th><th>Description</th><th>Photo</th></tr>
<tr><td rowspan="3">Active detection</td><td rowspan="3">Wind Energy Facility</td><td>PQKG01</td><td>Biotope: Semi-desert scrubs
Minimum distance to future turbine location: 1128m
Orientation: N
Altitude: 1080m
Slope: 0.86%
Minimum distance to a water source: 7682m
Minimum distance to a known roost: 8485m
Average temperature: 21.67 °C
Average wind speed: 2.07 m/s
Dominant wind direction: S</td><td></td></tr>
<tr><td>PQKG02</td><td>Biotope: Semi-desert scrubs
Minimum distance to future turbine location: 1401m
Orientation: N
Altitude: 1080m
Slope: 0.80%
Minimum distance to a water source: 7884m
Minimum distance to a known roost: 8709m
Average temperature: 21.44 °C
Average wind speed: 1.75 m/s
Dominant wind direction: S</td><td></td></tr>
<tr><td>PQKG03</td><td>Biotope: Semi-desert scrubs
Minimum distance to future turbine location: 1745m
Orientation: N
Altitude: 1080m
Slope: 0.56%
Minimum distance to a water source: 8305m</td><td></td></tr>
</table>

			Minimum distance to a known roost: 341m Average temperature: 21.53 °C Average wind speed: 2.36 m/s Dominant wind direction: S	
Active detection	Wind Energy Facility	**PQKG04**	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 1919m Orientation: N Altitude: 1080m Slope: 0.50% Minimum distance to a water source: 8496m Minimum distance to a known roost: 9169m Average temperature: 21.70 °C Average wind speed: 2.83 m/s Dominant wind direction: S	
		PQKG05	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 2087m Orientation: N Altitude: 1080m Slope: 0.57% Minimum distance to a water source: 8701m Minimum distance to a known roost: 9596m Average temperature: 22.02 °C Average wind speed: 2.65 m/s Dominant wind direction: S	
		PQKG06	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 2258m Orientation: N Altitude: 1080m Slope: 0.58% Minimum distance to a water source: 8906m Minimum distance to a known roost: 9187m Average temperature: 21.02 °C Average wind speed: 3.08 m/s Dominant wind direction: S	

Active detection	**Wind Energy Facility**	**PQKG07**	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 2440m Orientation: N Altitude: 1080m Slope: 2.04% Minimum distance to a water source: 9114m Minimum distance to a known roost: 10040m Average temperature: 22.34 °C Average wind speed: 2.85 m/s Dominant wind direction: SE	
		PQKG08	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 2613m Orientation: N Altitude: 1080m Slope: 1.99% Minimum distance to a water source: 9326m Minimum distance to a known roost: 10267m Average temperature: 21.78 °C Average wind speed: 2.81 m/s Dominant wind direction: SE	
		PQKG09	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 2787m Orientation: N Altitude: 1080m Slope: 2.27% Minimum distance to a water source: 9538m Minimum distance to a known roost: 10489m Average temperature: 21.93 °C Average wind speed: 2.8 m/s Dominant wind direction: SE	

Active detection	**Wind Energy Facility**	**PQKG10**	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 2969m Orientation: N Altitude: 1080m Slope: 2.61% Minimum distance to a water source: 9736m Minimum distance to a known roost: 10675m Average temperature: 22.23 °C Average wind speed: 2.67 m/s Dominant wind direction: SE	
		PQKG11	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 1591m Orientation: NE Altitude: 1060m Slope: 0.70% Minimum distance to a water source: 8134m Minimum distance to a known roost: 8977m Average temperature: 21.48 °C Average wind speed: 2.55 m/s Dominant wind direction: S	
		PQKG12	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 682m Orientation: NE Altitude: 1060m Slope: 0.54% Minimum distance to a water source: 8729m Minimum distance to a known roost: 12488m Average temperature: 19.87 °C Average wind speed: 2.14 m/s Dominant wind direction: SW	

Active detection	Wind Energy Facility	**PQKG13**	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 665m Orientation: NE Altitude: 1060m Slope: 0.56% Minimum distance to a water source: 8931m Minimum distance to a known roost: 341m Average temperature: 18.93 °C Average wind speed: 2.18 m/s Dominant wind direction: SW	
		PQKG14	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 464m Orientation: NE Altitude: 1060m Slope: 0.58% Minimum distance to a water source: 9145m Minimum distance to a known roost: 12944m Average temperature: 18.63 °C Average wind speed: 2.18 m/s Dominant wind direction: SW	
		PQKG15	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 343m Orientation: NE Altitude: 1060m Slope: 0.63% Minimum distance to a water source: 9330m Minimum distance to a known roost: 13156m Average temperature: 18.23 °C Average wind speed: 2.21 m/s Dominant wind direction: SW	

Active detection	**Wind Energy Facility**	**PQKG16**	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 395m Orientation: NE Altitude: 1060m Slope: 0.54% Minimum distance to a water source: 9522m Minimum distance to a known roost: 13408m Average temperature: 17.96 °C Average wind speed: 2.47 m/s Dominant wind direction: SW	
		PQKG17	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 312m Orientation: NE Altitude: 1060m Slope: 0.63% Minimum distance to a water source: 9678m Minimum distance to a known roost: 13627m Average temperature: 18.02 °C Average wind speed: 1.22 m/s Dominant wind direction: SW	
		PQKG18	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 321m Orientation: NE Altitude: 1060m Slope: 0.61% Minimum distance to a water source: 9866m Minimum distance to a known roost: 13852m Average temperature: 17.78 °C Average wind speed: 2.18 m/s Dominant wind direction: SW	

Active detection	Wind Energy Facility	**PQKG19**	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 243m Orientation: NE Altitude: 1060m Slope: 0.65% Minimum distance to a water source: 10053m Minimum distance to a known roost: 14072m Average temperature: 17.69 °C Average wind speed: 2.04 m/s Dominant wind direction: SW	
		PQKG20	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 226m Orientation: NE Altitude: 1060m Slope: 0.72% Minimum distance to a water source: 10246m Minimum distance to a known roost: 14298m Average temperature: 17.83 °C Average wind speed: 2.25 m/s Dominant wind direction: SW	
		PQKG21	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 280m Orientation: NE Altitude: 1060m Slope: 0.71% Minimum distance to a water source: 10419m Minimum distance to a known roost: 14511m Average temperature: 17.63 °C Average wind speed: 2.22 m/s Dominant wind direction: SW	

Active detection	**Wind Energy Facility**	**PQKG22**	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 320m Orientation: NE Altitude: 1060m Slope: 0.69% Minimum distance to a water source: 10521m Minimum distance to a known roost: 14695m Average temperature: 17.93 °C Average wind speed: 1.98 m/s Dominant wind direction: SW	
Active detection	**Control Area**	**PQKG23**	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 13385m Orientation: N Altitude: 960 m Slope: 0.82% Minimum distance to a water source: 573m Minimum distance to a known roost: 13872m Average temperature: 20.23 °C Average wind speed: 3.15 m/s Dominant wind direction: S	
		PQKG24	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 13343m Orientation: N Altitude: 960 m Slope: 0.74% Minimum distance to a water source: 624m Minimum distance to a known roost: 13723m Average temperature: 19.90 °C Average wind speed: 2.98 m/s Dominant wind direction: S	

Active detection	**Control Area**	**PQKG25**	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 13313m Orientation: N Altitude: 960 m Slope: 0.71% Minimum distance to a water source: 743m Minimum distance to a known roost: 13582m Average temperature: 19.74 °C Average wind speed: 3.28 m/s Dominant wind direction: S	
		PQKG26	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 13316m Orientation: N Altitude: 960 m Slope: 0.68% Minimum distance to a water source: 918m Minimum distance to a known roost: 13463m Average temperature: 19.6 °C Average wind speed: 3.03 m/s Dominant wind direction: S	
		PQKG27	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 13291m Orientation: N Altitude: 960 m Slope: 0.65% Minimum distance to a water source: 1114m Minimum distance to a known roost: 13344m Average temperature: 19.3 °C Average wind speed: 2.25 m/s Dominant wind direction: S	

Active detection	Control Area	**PQKG28**	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 13247m Orientation: N Altitude: 960 m Slope: 0.67% Minimum distance to a water source: 1323m Minimum distance to a known roost: 13230m Average temperature: 19.53 °C Average wind speed: 2.43 m/s Dominant wind direction: S	
		PQKG29	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 13206m Orientation: N Altitude: 960 m Slope: 0.69% Minimum distance to a water source: 1517m Minimum distance to a known roost: 13124m Average temperature: 19.27 °C Average wind speed: 2.67 m/s Dominant wind direction: S	
		PQKG30	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 13174m Orientation: N Altitude: 960 m Slope: 0.71% Minimum distance to a water source: 1733m Minimum distance to a known roost: 13020m Average temperature: 18.94 °C Average wind speed: 2.66 m/s Dominant wind direction: S	

Active detection	**Control Area**	**PQKG31**	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 13130m Orientation: N Altitude: 960 m Slope: 0.70% Minimum distance to a water source: 1959m Minimum distance to a known roost: 12902m Average temperature: 18.86 °C Average wind speed: 2.68 m/s Dominant wind direction: S	
		PQKG32	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 13085m Orientation: N Altitude: 960 m Slope: 0.68% Minimum distance to a water source: 2186m Minimum distance to a known roost: 12781m Average temperature: 18.72 °C Average wind speed: 2.90 m/s Dominant wind direction: S	
		PQKG33	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 13058m Orientation: N Altitude: 960 m Slope: 0.68% Minimum distance to a water source: 2403m Minimum distance to a known roost: 12682m Average temperature: 19.08 °C Average wind speed: 2.89 m/s Dominant wind direction: S	

Active detection	Control Area	**PQKG34**	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 12887m Orientation: NW Altitude: 980 m Slope: 0.81% Minimum distance to a water source: 2328m Minimum distance to a known roost: 14813m Average temperature: 22.08 °C Average wind speed: 2.23 m/s Dominant wind direction: S	
		PQKG35	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 12887m Orientation: NW Altitude: 980 m Slope: 0.76% Minimum distance to a water source: 2560m Minimum distance to a known roost: 14935m Average temperature: 22.5 °C Average wind speed: 1.9 m/s Dominant wind direction: S	
		PQKG36	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 12900m Orientation: NW Altitude: 980 m Slope: 0.85% Minimum distance to a water source: 2794m Minimum distance to a known roost: 15067m Average temperature: 22.43 °C Average wind speed: 1.79 m/s Dominant wind direction: S	

Active detection	Control Area	**PQKG37**	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 12933m Orientation: NW Altitude: 980 m Slope: 1.14% Minimum distance to a water source: 3037m Minimum distance to a known roost: 15219m Average temperature: 22.22 °C Average wind speed: 1.22 m/s Dominant wind direction: S	
		PQKG38	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 12982m Orientation: NW Altitude: 980 m Slope: 1.15% Minimum distance to a water source: 3257m Minimum distance to a known roost: 15370m Average temperature: 22.16 °C Average wind speed: 1.61 m/s Dominant wind direction: S	
		PQKG39	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 13062m Orientation: NW Altitude: 980 m Slope: 1.04% Minimum distance to a water source: 3578m Minimum distance to a known roost: 15596m Average temperature: 22.29 °C Average wind speed: 1.38 m/s Dominant wind direction: S	

Active detection	Control Area	**PQKG40**	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 13111m Orientation: NW Altitude: 980 m Slope: 1.15% Minimum distance to a water source: 3790m Minimum distance to a known roost: 15746m Average temperature: 22.20 °C Average wind speed: 1.68 m/s Dominant wind direction: S	
		PQKG41	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 13154m Orientation: NW Altitude: 980 m Slope: 1.06% Minimum distance to a water source: 4012m Minimum distance to a known roost: 15896m Average temperature: 22.04 °C Average wind speed: 1.41 m/s Dominant wind direction: S	
		PQKG42	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 13182m Orientation: NW Altitude: 980 m Slope: 1.04% Minimum distance to a water source: 4244m Minimum distance to a known roost: 16039m Average temperature: 21.93 °C Average wind speed: 1.27 m/s Dominant wind direction: S	

Active detection	**Control Area**	**PQKG43**	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 13186m Orientation: NW Altitude: 980 m Slope: 0.98% Minimum distance to a water source: 4465m Minimum distance to a known roost: 16170m Average temperature: 21.81 °C Average wind speed: 1.52 m/s Dominant wind direction: S	
		PQKG44	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 13193m Orientation: NW Altitude: 980 m Slope: 0.92% Minimum distance to a water source: 4707m Minimum distance to a known roost: 16314m Average temperature: 21.73 °C Average wind speed: 1.70 m/s Dominant wind direction: S	
Passive detection	**Wind Facility**	**PQKGA01**	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 379m Orientation: N Altitude: 1060 m Slope: 0.85% Minimum distance to a water source: 5344m Minimum distance to a known roost: 8250m Average temperature: 22.3 °C	

Passive detection	Wind Energy Facility	**PQKGA02**	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 3289m Orientation: N Altitude: 1060 m Slope: 0.96% Minimum distance to a water source: 10041m Minimum distance to a known roost: 5065m Average temperature: 18.6 °C	
		PQKGA04	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 787m Orientation: N Altitude: 1040 m Slope: 0.52% Minimum distance to a water source: 3767m Minimum distance to a known roost: 8679m Average temperature: 15.8 °C	
		PQKGA05	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 915m Orientation: N Altitude: 1040 m Slope: 0.52% Minimum distance to a water source: 3566m Minimum distance to a known roost: 8522m Average temperature: 20.0 °C	 

Passive detection	**Control Area**	**PQKGA03**	Biotope: Semi-desert scrubs Minimum distance to future turbine location: 5756m Orientation: N Altitude: 1000 m Slope: 0.75% Minimum distance to a water source: 1876m Minimum distance to a known roost: 7364m Average temperature: 20.0 °C	

7.2. Appendix II – Summary of the number of recordings analysed per species

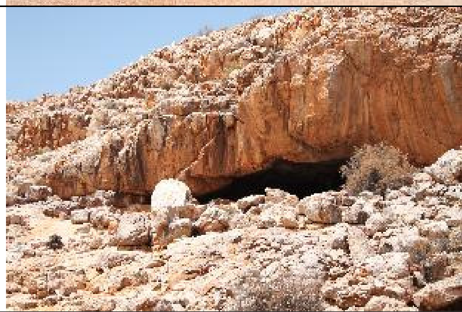
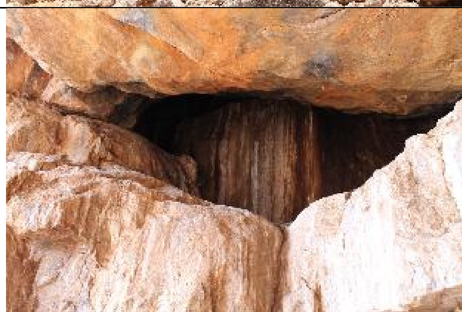
Table 10 – Number of recording analyzed per species and group of species from active detection.

	Wind energy facility							Control area						
Species	**September**	**November**	**January**	**March**	**May**	**July**	**TOTAL**	**September**	**November**	**January**	**March**	**May**	**July**	**TOTAL**
Tadarida aegyptiaca	0	0	0	0	2	2	**4**	10	2	0	0	0	16	**28**
Molossidae	0	0	0	0	0	0	**0**	17	0	0	0	0	0	**17**
Miniopteridae/Vespertilionidae	0	0	0	0	0	0	**0**	1	2	0	0	0	0	**3**
Unidentified	0	0	2	2	5	0	**9**	6	0	0	0	0	0	**6**
TOTAL	**0**	**0**	**2**	**2**	**7**	**2**	**13**	**34**	**4**	**0**	**0**	**0**	**16**	**54**

Table 11 – Number of recording analyzed per species and group of species from passive detection.

	Wind energy facility						Control area					
Species	**November**	**January**	**March**	**May**	**July**	**TOTAL**	**November**	**January**	**March**	**May**	**July**	**TOTAL**
Eptesicus hottentotus	1	0	0	2	0	**3**	0	0	0	0	0	**0**
Eptesicus hottentotus / Sauromys petrophilus	0	2	0	0	0	**2**	0	0	1	0	0	**1**
Miniopterus natalensis	0	0	4	0	0	**4**	0	0	3	0	0	**3**
Neoromicia capensis	0	0	1	1	0	**2**	0	0	0	1	0	**1**
Tadarida aegyptiaca	40	12	27	19	51	**149**	14	0	4	7	28	**53**
Rhinolophidae	0	0	0	0	0	**0**	16	0	0	0	0	**16**
Vespertilionidae	0	0	0	0	1	**1**	0	0	0	0	0	**0**
Unidentified	0	0	3	0	0	**3**	0	0	0	1	0	**1**
TOTAL	**41**	**14**	**35**	**22**	**52**	**164**	**30**	**0**	**8**	**9**	**28**	**75**

7.3. APPENDIX III – ROOSTS DESCRIPTION

Reference	Description	Photo
Kangnas 1	Type: Building (main house). Minimum distance to future turbine location: 3924m Traces: Droppings and insect remains Species: Not identified (Rhinolophidae / Hipossideridae) Number of individuals: at least 2	
Kangnas 2	Type: Caves Minimum distance to future turbine location: 5066m Traces: Droppings and insect remains Species: - Number of individuals: 0	
Kangnas 3	Type: Caves Minimum distance to future turbine location: 5081m Traces: - Species: - Number of individuals: 0	
Kangnas 4	Type: Caves Minimum distance to future turbine location: 5112m Traces: Droppings Species: - Number of individuals: 0	
Karas 1	Type: House with tin shed Minimum distance to future turbine location: 11005m Traces: - Species: - Number of individuals: 0	

Karas 2	Type: House with tin shed Minimum distance to future turbine location: 10994m Traces: - Species: - Number of individuals: 0	
Karas 3	Type: House with tin shed Minimum distance to future turbine location: 11018m Traces: - Species: - Number of individuals: 0	
Goebees 1	Type: Abandoned Building Minimum distance to future turbine location: 8402m Traces: - Species: - Number of individuals: 0	
Goebees 2	Type: Abandoned Building Minimum distance to future turbine location: 8500m Traces: - Species: - Number of individuals: 0	
Goebees 3	Type: Abandoned Building Minimum distance to future turbine location: 8500m Traces: - Species: - Number of individuals: 0	

Goebees 4	Type: Abandoned Building Minimum distance to future turbine location: 8500m Traces: - Species: - Number of individuals: 0	
Goebees 5	Type: Abandoned Building Minimum distance to future turbine location: 8500m Traces: - Species: - Number of individuals: 0	

7.4. Appendix IV – Brief description of bat species with occurrence in the study area

Species	Brief description
Species with confirmed presence	
Natal long-fingered bat (*Miniopterus natalensis*)	This species occurs widely in South Africa, however with more records in the southern and eastern part, including KwaZulu-Natal. This species is mostly associated with savannahs and bushlands, using these habitats as a clutter-edge forager. As *Miniopterus fraterculus*, *M. natalensis* is a cave-dependent species, using different locations for hibernation and reproduction (Monadjem *et al.*, 2010). This specie is present in the Die Hel cave (Groot Wintershoek Wilderness Area).
Long-tailed serotine (*Eptesicus hottentotus*)	This species occurs widely but sparsely, is a clutter-edge forager that uses woodland and rocky regions. This species roosts in small groups, mainly in caves and rock crevices (Monadjem *et al.*, 2010).
Cape serotine (*Neoromicia capensis*)	This species has a widespread distribution in South Africa and apparently tolerates a wide range of environmental conditions, being present in arid semi-desert, grassland, forests and savannas, using clutter-edges for foraging. This species can use diverse roosts, such as buildings, barks of trees and foliage, and usually a single or a small number of individual occupy each roost (Monadjem *et al.*, 2010).
Egyptian free-tailed bat (*Tadarida aegyptiaca*)	This species is abundant and widespread throughout Southern Africa. This species roosts in small to medium-sized groups, from dozens to hundreds of individuals. The preferred structures for roosting vary from caves to rock crevices, hollow trees, and cracks in the bark of old trees. The Egyptian free-tailed bat can also be found in buildings, mostly in the roof of houses (Monadjem *et al.*, 2010).
Species with potential occurrence	
Robert's flat-headed bat (*Sauromys petrophilus*)	It is an endemic species to southern Africa, being widespread and abundant in the arid western parts of South Africa, extending south to the Western Cape. It roosts communally in narrow cracks and under slabs of exfoliating rock. This species is an open-air forager possible to find associated with rocky environment, usually dry woodland, mountain fynbos or arid scrub.

Egyptian slit-faced bat (*Nycteris thebaica*)	This species has been recorded in almost all southern African countries, with the exception of Lesotho. This specie roosts during the day in caves, burrows, culverts and large trees. It can also be found in night roosts where the individuals consume their prey and socialise with conspecifics (Monadjem et al., 2010). This species habitat appears to be related with savannah and karoo biomes, avoiding open grassland. Being a clutter forager, this specie forages at low altitudes.
Angolan wing-gland bat (*Cistugo seabrae*)	This species is endemic to the West Coast of southern Africa, with occurrence from the extreme northwest to the extreme southwest of South Africa. This species is restricted to desert and semi-desert conditions, in the arid parts of western parts of southern Africa. This is a clutter-edge forager (Monadjem *et al.*, 2010). According the South Africa Red List this is the only specie that is extension risk is considered Vulnerable.
Cape horseshoe bat (*Rhinolophus capensis*)	It is an endemic species to the extreme southwest of South Africa, with occurrence only between the Eastern Cape until the south border of Namibia. This specie roosts in caves and mines forming colonies of a thousand of individuals approximately. As a clutter forager this specie forages predominantly in the canopy of trees, in fynbos and karoo biomes (Monadjem *et al.*, 2010).The cave Die Hel (Groot Wintershoek Wilderness Area) is occupied by a population of this specie (see below).
Geoffoy's horseshoe bat (*Rhinolophus clivosus*)	This species occurs widely in South Africa although being absent from the arid interior. It roosts in caves and mine adits where it forms colonies of several thousands of individuals. They use night roosts (usually a tree) where they consume the captured prey. This species can be associated with arid savannah, woodland and riparian forest. This bat is a clutter forager (Monadjem *et al.*, 2010). This specie uses Die Hel cave (Groot Wintershoek Wilderness Area) as a roost.
Darling's horseshoe bat (*Rhinolophus darlingi*)	It occurs mostly in the northern part of South Africa, being also possible to find in the Western Cape. The species is associated with arid savannah in the west part of southern Africa. It roosts in caves and mine adits, being able to form groups of several dozens of individuals. This bat specie is a clutter forager (Monadjem *et al.*, 2010).

7.5. Appendix V – Proposed bat monitoring programme - Construction and Operation phases

Objectives

The primary aim of this monitoring programme is to assess the potential impacts resulting from the construction and operation of the Wind Energy Facility over the bat community of the study area. Therefore the main objectives of this monitoring programme are:

i. To identify the potential changes in the bat community present within the wind farm site and the eventual exclusion/displacement effect (avoidance of the wind facility area after construction);

ii. To follow the utilization of bat roosts in the Wind Energy Facility and surroundings;

iii. To quantify bat fatality associated to the Wind Energy Facility operation phase.

In order to meet these objectives the following tasks should be conducted throughout the monitoring programme:

- **Roost searches, inspection and monitoring** within and in the vicinity of the Wind Energy Facility – pre-construction (at least for a full one year before construction), construction and operational phase (for at least three years after the facility becomes operational);

- **Active detection** of ultra-sounds within the Wind Energy Facility and at control area(s) – pre-construction (at least for a full one year before construction), construction and operational phase (for at least three years after the facility becomes operational);

- **Passive detection** of ultra-sounds within the Wind Energy Facility and at a control area(s) – pre-construction (at least for a full one year before construction), construction and operational phase (for at least three years after the facility becomes operational);

- **Carcass searches and searcher efficiency and carcass removal trials** to register and document the fatality events associated with the Wind Energy Facility – operational phase (for at least three years after the facility becomes operational).

The methodologies to be implemented should follow the general guidelines presented in the *South African Good Practice Guidelines for Surveying Bats in Wind Farm Developments* (Sowler & Stoffberg, 2012) and consider the international experience and standards for bat monitoring at wind farms.

MONITORING PROTOCOLS

The overall monitoring programme should be implemented through all the phases of the Wind Energy Facility project, for the establishment of a baseline scenario (one full year prior to construction), during the construction phase and at least for three years after the facility becomes operational.

7.5.1. Roost searches, inspection and monitoring

A systematic approach should be implemented in order to determine the overall utilization of the study area by the bat community. The survey of the study area and its surroundings should allow verification of the occurrence of roosting activities within the Wind Energy Facility, and the collection of information regarding:

- Number of individuals;
- Species present (if possible);
- Presence/absence of evidence (guano, bat corpses, ceiling marks);
- Location and description of the type of roost (house, cave, mine, bridge).

All structures that can potentially serve as bat roosts (caves, mines, abandoned buildings, bridges, etc.) should be identified in the study area and its surroundings. The places identified should be inspected during the field work in order to record evidence of the presence of bats (such as guano accumulation, bat corpses or insect remains). Other information should also be recorded: season, the individual's activity rate, presence of progeny, degree of human disturbance and type of roost.

During the field work the location of each roost inspected should be registered with a GPS, as well as photographed, for later reference.

The occupation rate, species present and conservation status were determined to each roost inspected.

If roosts with high bat occupation are identified during pre-construction monitoring, the structures should be re-visited in the following surveys (construction and operational phase).

7.5.2. Active detection

The bat monitoring should be implemented in order to evaluate the activity patterns in the Wind Energy Facility site and, at least, one control area. By collecting this information, it should allow:

- Determination of the bat species that use the site;
- Determination of a bat activity index per sampling point;
- Location and time of bat's activity;
- Location and time of bat species' occurrence.

7.5.2.1. Methodology

The methodology to be implemented should follow the general guidelines presented in the *South African Good Practice Guidelines for Surveying Bats in Wind Farm Developments* (Sowler & Stoffberg, 2012). The active detection of ultrasounds should be conducted with a manual ultrasound detector with a heterodyne incorporated, that allows the detection of bats in real time. This equipment should have an internal recorder which can record between 1.7 and 3.4 seconds, associated with a expanded time 10x repeater. The bat recordings should be saved with an external digital recorder with a sampling rate of 44.1 kHz.

Active surveys should comprise sample points of 5 minutes each along vehicle transects. Each point should be characterised according to: minimum distance to the future turbines, slope, dominant orientation, biotope, minimum distance to a water source and minimum distance to known roosts, lunar phase, cloudiness, temperature and wind (speed and direction). At each 5 minute sampling point, all bat passes[12] heard and observed should be recorded, as well as all the passes detected between points. The parameter used should be 1.7 seconds, so each record will be reproduced during 17 seconds to be registered in the external recorder, with a sampling rate of 44.1 kHz. The bats use of the area should also be timed meaning that all the bat passes should be timed even if not recorded. During each 17 second period when the ultrasound passage is recorded to the external recorder, the number of passes and use time should continue to be accounted. The surveys should start 30 minutes before the sunset ensuring that bat species that emerge early in the evening can be included in the surveys (Sowler & Stoffberg, 2012).

7.5.2.2. Sampling locations and sampling periods

Transects should be established in the Wind Energy Facility and in a separate and similar control area(s), crossing the main biotopes present in the area. In each transect the sampling points, should be established with a minimum distance of 200m in between each other to avoid pseudo-replication.

Surveys should be conducted at least once a month (a minimum of one campaign per month). Each sampling point should be conducted at least once per month for at least a full calendar year during the construction phase and at least three years after the project becomes operational (operational phase).

7.5.2.3. Data analysis

The different species of bats emit distinct calls with variable pulses according to duration, shape, frequencies interval, maximum intensity frequency, mean pulse point frequency and interval between pulses.

The recorded calls analysis should be performed using appropriate software (for example, *Audacity, Bat Sound,* or others equivalent). The identification of detected species should be possible through the analysis of pulse characteristics, based on the reference values available (e.g. Monadjem *et al.* (2010)).

[12] Contacts with bats detected by visual observation or ultrasonic detection of bat calls.

Through call analysis it is also possible to understand different behaviours according to different types of pulses, such as navigation pulses, social calls or feeding buzz. For each sampling point the species identified should be listed, as well as their conservation status and behaviour.

The surveys should also be analysed separately and compared for spatial-temporal parameters. The number of bat passes and time of use of each sampling point should allow the determination of the following parameters:

- Average number of bat passes/hour;
- Average time of use (seconds)/hour;
- Frequency of occurrence of each specie/group of species identified (number of contacts of a specie or group of species / total number of records identified).

These parameters should also be analysed in terms of their relation with the environmental factors, such as weather conditions (temperature and wind speed), biotope and illuminated lunar fraction. The same parameters should be analysed in terms of space, accounting to the point's location.

7.5.3. Passive detection

The information collected through passive detection should allow evaluating activity patterns in the Wind Energy Facility and surrounding during a continuous period. Whenever technically viable passive detectors should be implemented at ground level (up to 10m) and at blade swept height. By collecting this information, it should allow:

- Average number of bat passes/hour;
- Frequency of occurrence of each specie/group of species identified (number of contacts of a specie or group of species / total number of records identified);
- Determination of bat activity and species at blade swept area (if technically viable).

7.5.3.1. Methodology

Passive detection should be made use of automatic ultrasound detectors with automatic triggering (starting an ultrasound recording when a bat echolocation is detected). The equipment should be scheduled to automatically record calls every day over the monitoring period for a 12-hour period starting half an hour before sunset.

Each monitoring sampling point should be characterised according to: minimum distance to the future turbines, slope, dominant orientation, biotope, minimum distance to a water source and minimum distance to known roosts. The equipment should, preferably, automatically record environmental variables at each recording event (e.g. air temperature). This approach will allow registering bat activity in different weather conditions.

7.5.3.2. Sampling locations and sampling periods

The passive detectors should be placed at different locations within the wind energy facility site, and in control areas considered to be within similar biotopes. Monitoring surveys should be conducted at least once per month throughout all the phases of the project for at least a full calendar year during the construction phase and at least three years after the project becomes operational (operational phase).

7.5.3.3. Data analysis

The different species of bats emit distinct calls with variable pulses according to duration, shape, frequencies interval, maximum intensity frequency, mean pulse point frequency and interval between pulses.

The recorded calls analysis should be performed using appropriate software (for example, *Audacity, Bat Sound,* or others equivalent). The identification of detected species should be possible through the analysis of pulse characteristics, based on the reference values available (e.g. Monadjem *et al.,* 2010).

Through call analysis it is also possible to understand different behaviours according to different types of pulses, such as navigation pulses, social calls or feeding buzz. For each sampling point the species identified should be listed, as well as their conservation status and behaviour.

The surveys should also be analysed separately and compared for spatial parameters. The number of passes and time use of each sampling point should allow the determination of the average number of passes/unit of time. This parameter should be analysed in terms of environmental factors, such as weather conditions (temperature) and illuminated lunar fraction.

7.5.4. Bat fatality

7.5.4.1. Methodology

The methodology to be implemented should follow the general guidelines presented in the Best *South African Good Practice Guidelines for Surveying Bats in Wind Farm Developments* (Sowler & Stoffberg, 2012) and the international best practices.

At onshore facilities, the fatality estimation is based on carcass searches around wind turbines. However, the number of carcasses found during the searches does not correspond to the real number of bats killed by the wind farm, since not all carcasses are detected by searchers or, given the time elapsed between searches, some carcasses are removed (e.g. by scavengers or decay) from the site. Thus, to estimate the real mortality is necessary to determine the associated bias correction factor and adjust the observed mortality through the use of appropriate fatality estimators.

Whenever bat and bird monitoring plans are simultaneously being implemented at a wind energy facility the bat collisions and bird collisions assessment could be combined, following the same general methodological approach.

7.5.4.1.1. Carcass searches

Regarding bat mortality evaluation, searches for dead bats around all the wind turbines during the operational phase is proposed. The search plot will depend on the wind turbine characteristics (hub height and rotor diameter) and should be larger than the area covered by the rotor diameter with an addition of at least 5 m. This area should be regularly inspected for bat casualties. The searcher should adjust its dislocation speed to the terrain characteristics, inspecting as much area as possible. According to the terrain characteristics the observer may conduct the survey through parallel transects, or by dividing the area in four different quadrants, and carefully searching for any signs of bat collision incidents (carcasses, dismembered body parts, injured bats). All evidence should be documented and recorded on a GPS, being the evidence collected in adequate preserving conditions, for further analysis in a laboratory.

7.5.4.1.2. Searcher efficiency and carcass removal trials

Field trials should be conducted to determine the observed mortality correction parameters such as the carcass detection by observers and carcass removal (e.g. by scavengers).

In carcass removal trials, carcasses should be placed at a minimum distance of 500m from each other, with 1 km being the preferable distance. Once placed, carcasses should be checked to determine the time of removal of each one.

For the searcher efficiency trials, carcasses should be randomly placed around the turbines and then searched by the observers in order to assess their efficiency rate.

In both trials, the type of carcasses used should mimic the dimensions and body size of the existing wild species in the study area, such as rats.

7.5.4.2. Sampling locations and sampling periods

Bat fatality monitoring should be implemented in the operational phase of the project for at least three years, except if stated otherwise by the regulating authority.

7.5.4.2.1. Carcass searches

Preferably the mortality inspection surveys should be conducted weekly (if not possible, then the surveys must be conducted at least every 15 days, or monthly in the worst case scenario) (Strickland *et al.,* 2011), covering the whole annual period (Bernardino, 2008).

7.5.4.2.2. Searcher efficiency and carcass removal trials

The carcass removal trials should be performed during four seasons: winter, spring, autumn and summer. In each campaign, the rat carcasses placed in the site should be checked daily. The number of carcasses used should be limited, in order not to attract too many scavengers.

In searcher efficiency trials, carcasses should be placed within the search plot of each turbine, If the habitats have no significant variation throughout the year, the trial could only be performed during one season of the year.

In order to obtain an accurate measure of the observed mortality, search efficiency rates and scavenging rates should be assessed during the first operational year of the Wind Energy Facility.

7.5.4.3. Data analysis

The results from the trials conducted should provide the evaluation of the following parameters:

- Correction factor for the carcass detection by field observers;
- Correction factor for the carcass removal by scavengers and environmental factors;
- Real fatality estimates in the Wind Energy Facility, during its operational phase.

To properly calculate the real fatality associated to the Wind Energy Facility it is essential to adopt a fatality estimator that adjusts the observed casualties by the estimated bias correction terms. In the last years research has been conducted on this matter and several estimators have been proposed. However, so far there is still lacking a universal estimator that ensures good quality estimates under all circumstances (Bernardino *et al.,* 2013).

Therefore, when estimating the bat fatality associated to the Wind Energy Facility the best estimator available at the time should be used, which performance must be demonstrated in peer-reviewed studies.

REPORT PREPARATION AND CONTENTS

A technical report containing the parameters referred to in the previous chapters should be delivered at the end of each year of monitoring. In this document an evaluation of the adequacy of the monitoring protocols should be conducted as well as an evaluation of the existence of any detectable potential impacts occurring over the bat community of the impacted area, caused by the Wind Energy Facility and associated infrastructures. In these reports, a data comparison with the results of previous years should be performed, in order to obtain more reliable conclusions. For this reason, the final reports of the monitoring programme should present a review of the results obtained over the previous years that the monitoring activities were implemented.

KANGNAS WIND ENERGY FACILITY, NORTHERN CAPE PROVINCE

ADDENDUM TO BAT MONITORING REPORT

The pre-construction bat monitoring programme was conducted at the Kangnas Wind Energy Facility from September 2012 to July 2013. The data collected during this period was analysed and compiled in the final pre-construction monitoring report, dated October 2013. The data collected and results were analysed in light of the information provided at that stage, namely one proposed layout consisting on 65 wind turbines of 1.5 MW to 4 MW, rotor swept area between 80 m and 120 m diameter and a 90 m to 120 m hub height.

An updated layout was provided to Bio3 in November 2013, and this addendum provides an evaluation of the proposed 104 turbine layout (two phases – a 43 (99MW) turbine cluster and a 61 (140MW) turbine cluster. The proposed turbines would have the same specifications as previously considered, and are located within the initial proposed developable area. The majority of the wind turbines on the updated layout are sited, in general terms, in the same area as the previous layout, only slightly deviated to the southwest up to 1 km to 1.5 km. This shift is most evident in the south-western section of the developable area, in the 61 (140MW) turbine cluster (refer to Figure 1), with 18 wind turbines extending towards the Karasberg inselberg.

The pre-construction bat monitoring programme collected data within the developable area proposed for the wind farm as well as the immediate vicinity. The pre-construction bat monitoring programme results indicate that the Kangnas Wind Energy Facility site has a low potential to support bat communities and low bat activity was recorded across the four seasons. The area was considered of low sensitivity for local bat populations with a few localized areas considered to have relatively higher bat activity and classified with higher sensitivity (Figure 2). All of these higher sensitivity areas for bat species are located outside the Kangnas developable area and the new proposed layout is sited in areas with low local bat activity. Therefore, it is considered that the expected impacts from the new proposed layout should not be significantly different from those considered for the layout previously evaluated. The increase in the turbine numbers could result in a higher potential for impacts on the local bat population, but considering the low bat activity in the area, this increment is not considered to be significant.

Stellenbosch, December the 3rd, 2013

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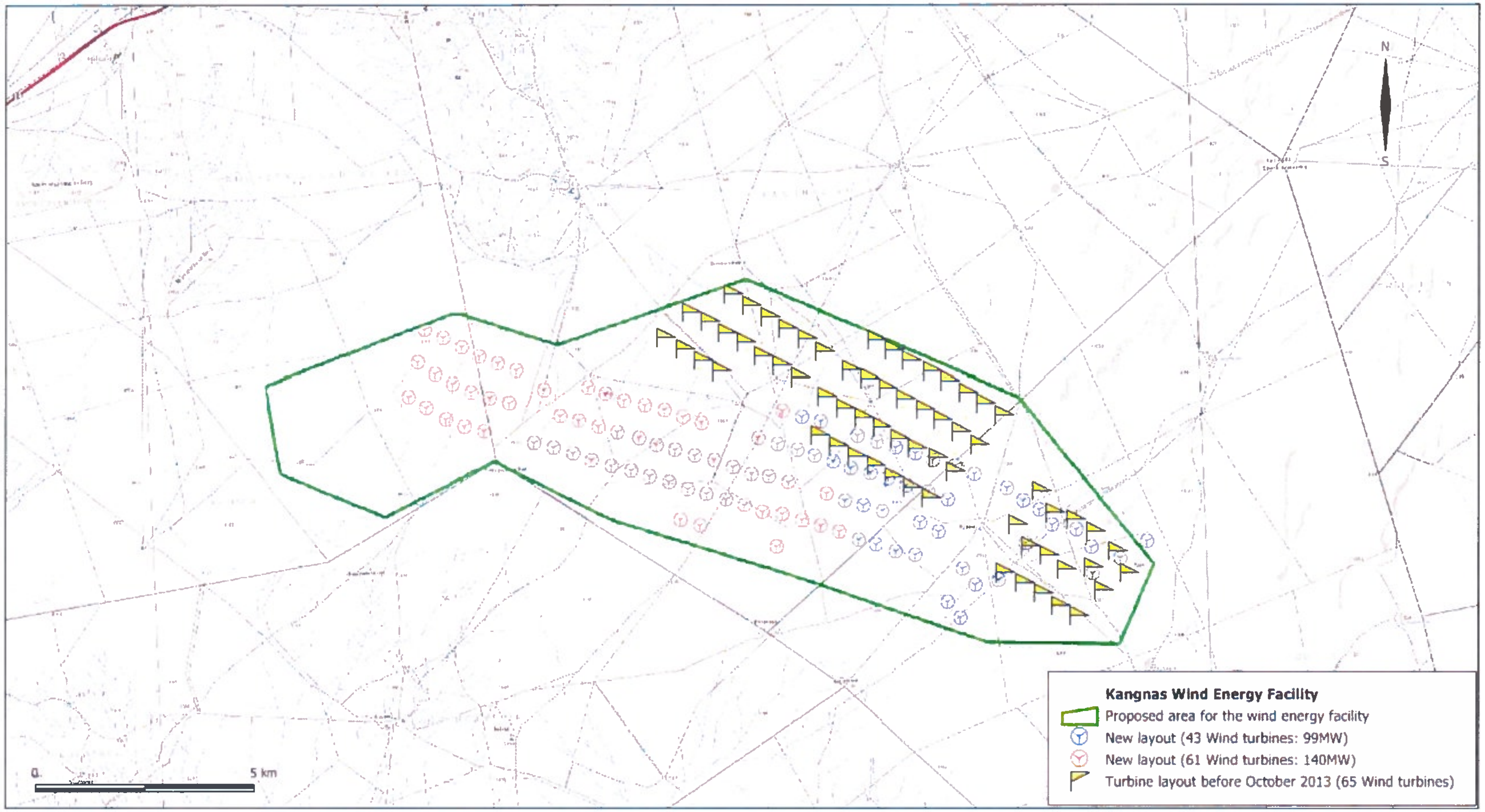

Figure 1 – Spatial representation of the preliminary turbine layout (65 wind turbines) considered on the pre-construction bat monitoring final report versus the updated layout version from November 2013 (104 wind turbines).

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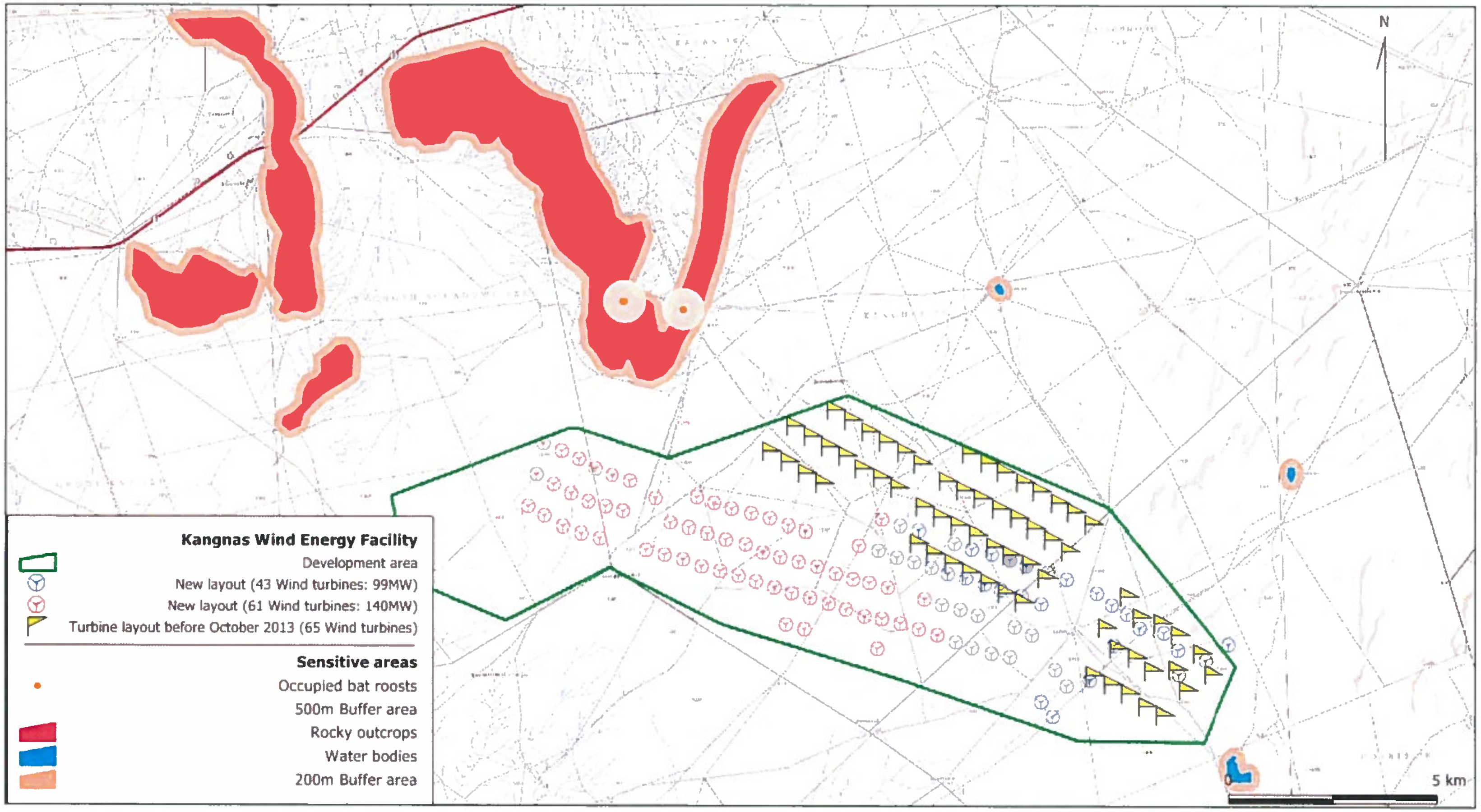

Figure 2 – Higher sensitivity areas on Kangnas Wind Energy Facility developable area, based on the pre-construction bat monitoring programme.