SOUTH AFRICAN BEST PRACTICE GUIDELINES FOR PRE-CONSTRUCTION MONITORING OF BATS AT WIND ENERGY FACILITIES

5th Edition

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GLOSSARY OF TERMS & ABBREVIATIONS

Acoustic monitoring: Bat sampling conducted through recording and analysing echolocation calls.

BA: Basic Assessment. To follow the processes set out in regulation 19 of GN 326 of 7 April 2017.

Barotrauma: Physical damage to body tissue caused by a difference in pressure between a gas space inside, or in contact with the body, and the surrounding fluid.

Bat call: A single pulse of sound produced in the larynx of a bat and emitted out through their mouth or nose. Bat call and bat pulse can be interchanged for the purposes of this document.

Bat detector: Equipment capable of detecting and recording ultrasonic echolocation calls of bats.

Bat pass: A single crossing of a bat through a bat detector’s cone of detection. This can be displayed in the data by a single echolocation call or pulse or by a series of bat echolocation call pulses, known as a call sequence.

BCT: Bat Conservation Trust

Bioptope: A biotope is defined as the habitat, together with its recurring associated community of [plant and animal] species, operating together at a particular scale (Connor et al. 1997). It can be synonymous with the word habitat.

Blade: The aerodynamic surface of a wind turbine that catches the wind.

Buffer zone: Non-disturbance areas that provide a protected zone for sensitive resources such as bat foraging habitat and bat roosts. In the case of wind energy development, no part of the turbine infrastructure, including the blade can be positioned within the buffer zone, i.e. these are No-Go turbine development / spinning zones. Ancillary development in these zones should be avoided where possible, but if ancillary linear development is required to cross these zones, environmental care should be taken and mitigation measures applied. This is a horizontal distance that can be measured on a map and on the ground. It applies from the ground through the full length of the turbine sweep, i.e. all parts of the turbine, tower and rotor sweep must remain outside of this zone at ground level and in the airspace of the blades.

BWEC: Bats and Wind Energy Cooperative - www.batsandwind.org.

Civil Twilight: This is defined to be the time period when the sun is no more than 6 degrees below the horizon at either sunrise or sunset. The horizon must be clearly defined and the brightest stars must be visible under good atmospheric conditions (i.e. no moonlight, or other lights). One still must be able to carry on ordinary outdoor activities. Evening civil twilight begins at sunset and ends when the geometric centre of the sun reaches 6° below the horizon (civil dusk). Morning civil twilight begins when the geometric centre of the sun is 6° below the horizon (civil dawn) and ends at sunrise.

Clutter: Obstacles present in an area that can affect the flight behaviour of bats, bat call structure and recording of bat echolocation calls.

Colony: The term colony is used to identify a genetically related or socially interactive population of bats within an area that may associate within a number of roost sites during the annual cycle.

Critically Endangered: IUCN Red Data status for a species facing an extremely high risk of extinction in the wild.

Cumulative Impact: Means the past, current and reasonably foreseeable future impact of an activity, considered together with the impact of activities associated with that activity, that in itself may not be significant, but may become significant when added to the existing and reasonably foreseeable impacts eventuating from similar or diverse activities.

Data Deficient: IUCN Red Data status for a bat species where there is inadequate information to make an assessment of risk of extinction.

DEA: Department of Environmental Affairs

DEFF: Department of Environment, Forestry and Fisheries

Echolocation: Use of ultrasound and the returning echoes to orient and navigate in the environment.

EA: Environmental Authorization

EIA: Environmental Impact Assessment. It means a systematic process of identifying, assessing and reporting environmental impacts associated with an activity and includes basic assessment and Social and Environmental Impact Reports.

EMPr: Environmental Management Programme

Endangered: IUCN Red Data status for a species facing a very high risk of extinction in the wild.

EWT: Endangered Wildlife Trust

Harem: The mating and association of several adult females with one male.

Harp trap: Harp traps are composed of two (sometimes up to four) frames strung vertically with monofilament line. Bats attempting to pass through the trap are captured either by colliding with the exterior of the lines or by entering the space between the frames. Once captured, bats flutter down into a catch bag where they are confined until being removed for identification.

IAIA: International Association for Impact Assessment

Least Concern (LC): IUCN Red Data status for a Non-threatened species

Maternity roost: A maternity roost is the structure within which pregnant females aggregate in summer to give birth to young. The bats may utilise the maternity roost up until autumn, when they move on to winter hibernacula.

Microphone sensitivity: The minimal amplitude required at a given frequency for a microphone to detect a sound.

Minimum requirement: An action that is considered compulsory in these guidelines, unless scientifically motivated as to why it wasn't performed.

Mist net: A finely woven large mesh erected to entangle and capture bats.

Monitoring station: A monitoring station is a geographical location of a mast where one or more detectors may be installed, with microphones at varying heights.

Nacelle: The body of a propeller-type wind turbine, containing the gearbox, generator, blade hub and other parts.

Population: A population is the number of individuals of a given species occupying a certain area of land over a certain period of time.

Pulse: A single emission of sound; i.e. a bat call. See the definition of a bat call.

Roost: This term has a dual application and is used to describe the structure (house, shed, bridge, tree, cave, etc.) within or on which a number of bats take shelter. Secondly, the bats within or on such a structure are also referred to as a roost of bats. 'Roost' does not infer a genetic or social association between the bats within a structure.

Rotor Swept Area: The circular area through which the rotor blades of a wind turbine spin; the full airspace that the blades turn in.

SA: South Africa

SABAA: South African Bat Assessment Association

SACNASP: South African Council for Natural Scientific Professions

SAWEA: South African Wind Energy Association

Scoping Report: A report contemplated in regulation 21 of the NEMA amended EIA regulations R326 dated 7 April 2017. It requires identification of relevant policies and legislation relevant to the activity, need and desirability of project, identification of impacts and risks, including cumulative risks, identification of issues to be addressed in the assessment phase, roadmap for the assessment phase, identification of mitigation and management measures.

Species of Conservation Concern (SCC): A bat taxon (e.g. genus, species or subspecies) that is protected internationally (under e.g. CITES or the Bonn Convention), nationally (under the latest NEM:BA ToPS Regulations), or provincially (under relevant provincial legislation), or Red Listed as threatened (Vulnerable, Endangered or Critically Endangered), Near Threatened or Data Deficient internationally (by the IUCN) or nationally (by Child et al. 2016), or provincially protected, or is endemic or near-endemic to South Africa or a part thereof. These taxon may be especially vulnerable to disturbance due to one or more aspects of its ecology (such as roosting in large numbers), or biology (such as its high mortality from disturbance in winter), or is especially important in terms of the eco-services it provides.

Standard: The level of quality or something used as a measure, norm, or model in comparative evaluations.

Static detector: A bat detector placed in a set position for the period of monitoring that is capable of detecting and recording ultrasonic echolocation calls of bats.

Sunrise: Sunrise is the instant at which the upper edge of the sun appears over the eastern horizon in the morning.

Sunset: The time of sunset is defined in astronomy as the moment when the trailing edge of the sun's disk disappears below the horizon.

Vulnerable: IUCN Red Data status for a species facing a high risk of extinction in the wild.

Watercourse: In the context of important habitat for bats, a watercourse in this document is referred to as a water body or resource: Includes natural or man-made permanent, seasonal or ephemeral wetland systems including:

- springs, seeps and marshes.
- pans and lakes.
- ponds, reservoirs and dams.
- lakes and estuaries.
- drainage lines, streams and rivers.
- canals and channels.
- any other surface water bodies or resources not mentioned.

WEF: Wind Energy Facility

Wind energy facility: A group of wind turbines often owned and maintained by one company, also known as a wind power plant or wind farm.

Wind turbine: A device that converts kinetic energy from the wind, also called wind energy, into electrical energy in a process known as wind power.

WWF: World Wildlife Fund

1. INTRODUCTION

1.1 Scope of the Guidelines

These best practice guidelines are based on information gathered and compiled from North America, Europe and South Africa (SA), previous versions of these guidelines and input from South African scientists and specialists.

These guidelines seek to provide technical guidance for consultants charged with carrying out impact assessments for proposed wind energy facilities (WEFs), to ensure that pre-construction monitoring surveys produce the required level of detail and answers for authorities evaluating applications for WEF developments. It outlines basic requirements of best practice and highlights specific considerations relating to the pre-construction monitoring of proposed WEF sites for bats.

The objectives of this document are:

- To provide a brief summary of bat related issues associated with wind power development,
- Provide guidance on suggested minimum requirements for pre-construction monitoring for bats at proposed WEF sites, and
- Describe techniques for, and timing of, recommended pre-construction monitoring surveys.

Any deviation from the recommended minimum requirements must be acknowledged and motivated clearly. Such deviation must be informed by scientific knowledge, evidence and expertise. Financial or capacity constraints are not acceptable reasons for deviating from the minimum requirements.

It is further recommended that these guidelines be read in conjunction with the Operational Monitoring Guidelines (Aronson et al. 2020) and the Bat Fatality Threshold Guidelines (MacEwan et al. 2020) so that pre-construction monitoring and project design can be approached in such a way that will complement and/or facilitate the implementation of the requirements arising from the other guidelines.

1.2 Offshore Wind Energy Facilities

Offshore WEFs are excluded from this guidance, as there are currently no offshore WEFs in SA. Should proposed offshore developments occur off of SA, prior to the development of detailed guidance, a proportionate approach must be taken which considers the significance of the likely impact on bat populations and international guidelines can be used in conjunction with the current SA guidelines.

1.3 Impacts of Wind Energy on Bats

The main documented direct impacts of wind energy on bats includes fatality via mainly direct collision with turbine blades (Rollins et al. 2012) or less likely by barotrauma (Baerwald et al. 2008).

Indirect impacts include roost disturbances and/or destruction if construction, operational or decommissioning activities occur close to bat roosts, destruction of foraging habitat (due to WEF construction and habitat change), displacement of bats from their foraging habitat (bats avoid the WEF area) and obstruction of movement paths to drinking, foraging, roosting and migration sites.

Impacts of wind turbines on bats vary depending on site selection, specifications of the wind turbines, species occurring in the area, season and time of night. Bat fatalities may outnumber bird fatalities by 10:1 (Barclay et al. 2007) and fatality rates may be affected by turbine size (Barclay et al. 2007) and wind speed (low-wind nights associated with increased fatality (Arnett 2005; Arnett et al. 2008; Horn et al. 2008)). Some information available on the quantities of bat fatalities in various regions is presented in **Table 1.**

Table 1 Known numbers of bat fatalities in various regions of the world

Global Region	Author(s)	Findings	Notes
USA & Canada	Arnett & Baerwald (2013)	Synthesis of fatality surveys from 73 sites between 2002 – 2012, estimated 650,104 – 1,308,378 bats were killed.	These numbers are based on adjusted bat fatality estimates – adjusted for biases such as carcass persistence and searcher efficiency.
USA	Smallwood (2013)	An estimated 888,000 bat fatalities from wind turbine interactions occurred in 2012	These numbers are based on adjusted bat fatality estimates – adjusted for biases such as carcass persistence and searcher efficiency.
USA	Hayes (2013)	An estimated 600,000 bat fatalities from wind turbine interactions occurred in 2012	These numbers are based on adjusted bat fatality estimates – adjusted for biases such as carcass persistence and searcher efficiency.
Europe	Eurobats (2015)	6,429 actual bat carcasses were found below turbines between 2003 – 2014.	This a minimum number, as it is uncorrected for scavenger removal or searcher efficiency biases and is only from 19 countries in Europe.
South Africa	SABAA (unpublished 2019)	A synthesis of actual bat carcasses found at 20 WEFs between May 2014 to August 2019 yielded 1164 bat carcasses.	This a minimum number, as it is uncorrected for scavenger removal or searcher efficiency biases and is only from 20 WEFs, for only 4 to 61 months each from May 2014 to August 2019 only.

Until we have a better understanding of South African bat population levels and fluxes, bat ecology and migration, it is recommended that a precautionary approach is adopted.

Table 2 represents varying turbine fatality risk levels per family or genera. Some of the risk ratings are evidence-based, whereas others are based on an assumed likelihood of risk based on the foraging and flight ecology of the bats concerned, e.g. open air foragers such as *Tadarida aegyptiaca*

(Egyptian free-tailed bat) more likely to encounter turbines because of their higher flight heights, than clutter foraging species such as *Nycteris thebaica* (Egyptian slit-faced bat) which are known to forage close to vegetation. In addition, daily foraging and flight habits may vary significantly for species when migrating, and that all migrating species must be assumed to have a high fatality risk.

Table 2 The Likelihood of the risk of turbine related bat fatalities, based on broad ecological features, excluding migratory behaviour

Family / Genus	Relative Status	Likely risk of impact from wind turbine blades (direct collision/barotrauma)
Emballonuridae	Common – restricted distributions Species fly high enough to come into contact with turbine blades	High
Hipposideridae	Species with restricted distributions	Low
Miniopteridae	Common – widespread and restricted distributions Some species known to move large distances	High
Molossidae	Common – widespread Species fly high enough to come into contact with turbine blades.	High
Nycteridae	Common – widespread and restricted distributions	Low
Pteropodidae	Common – restricted distributions Some species known to move large distances	High
Rhinolophidae	Species with restricted distributions	Low
Vespertilionidae	Common – widespread and restricted distributions	
Cistugo	Restricted distributions – species endemic to Southern Africa or South Africa	Low
Eptesicus	Wide, but sparse distribution	Medium
Glauconycteris	Species with restricted distributions	Medium – High
Hypsugo	Wide, but sparse distribution	Low
Kerivoula	Species with wide but sparse distributions	Low
Laephotis	Species with restricted distributions	Low
Myotis	Species with wide or restricted distributions; some species may move large distances	Medium – High
Neoromicia	Species with wide or restricted distributions	High
Nycticeinops	Common throughout but restricted distribution	Medium - High
Pipistrellus	Species with wide or restricted distributions	Medium – High
Scotoecus	Sparse distributions	Medium – High
Scotophilus	Some with widespread or restricted distributions	Medium – High

1.4 The Economic and Ecological Role of Bats in South Africa

Bats make up just less than a quarter of all mammals on earth and provide important ecosystem services (Cleveland et al. 2006; Kunz et al. 2011; Boyles et al. 2011; 2013; Lopéz-Hoffman et al. 2014; Maas et al. 2015). They are major pollinators of fruiting trees, dispersers of seeds and controllers of insect populations, including those of agricultural pests. The relative value of bats may be greater in developing countries than in more developed regions, because even though the economic value of crops produced in developing countries is considerably less, their marginal value as food can be enormously greater (Boyles et al. 2013).

African miniopterid, molossid and vespertilionid bats, in particular, play an important role in suppressing agricultural insect pest species. In southern Africa, molossid bats preferentially select to forage within sugar cane fields rather than natural vegetation (Noer et al. 2012). A similar pattern is reported for Madagascar; total bat activity was higher across rice fields than natural forest (Kemp et al. 2019). Next generation DNA sequencing of insect remains from the faecal pellets of insectivorous bats foraging within sugarcane, macadamia and rice fields confirmed the presence of numerous economically-important agricultural pest species including green vegetable stinkbugs (*Nezara viridula* - Taylor et al. 2013, 2017), borer moth (*Eldana saccharina* – Bohman et al. 2011), paddy swarming armyworm (*Spodoptera mauritia* – Kemp et al. 2019) and grass webworm (*Herpetogramma licarsisalis* – Kemp et al. 2019). Taylor et al. (2018) estimated the cost avoidance loss of yield for the South African macadamia nut industry, through natural pest control provisioned by bats, to be ~R12.04 ± 8.34 million/yr. Bats may also play an important role in social health by combatting disease (e.g. malaria; Gonsalves et al. 2013). Next generation DNA sequencing analyses confirmed the presence of mosquitoes in the diet of several southern African insectivorous bat species (Bohmann et al. 2011; Taylor et al. 2013).

African pteropodids play a vitally important role as pollinators and seed dispersers of a variety of trees species. Straw-coloured fruit bats (*Eidolon helvum*), travel approximately 67 km from their roost on nocturnal foraging bouts (van Toor et al. 2019), and can traverse 90 km per day during their annual migration (Richter & Cumming 2008). Wahlbergs epauletted fruit bat (*Epomophorus wahlbergi*) can cover 2 – 5 km per foraging night, with males and females exhibiting average home ranges of 0.45 km2 and 0.78 km2, respectively (Rollinson et al. 2013). The potential for medium-to-long distance dispersal of ingested seed material by fruit bats is great and contribute towards the regeneration of tropical African rainforest trees (Aberdi-Lartey et al. 2016; van Toor et al. 2019).

The potential loss of these ecosystem services should be considered when assessing the environmental impact of wind energy facilities. The possible loss of bat colonies could potentially result in increased costs in pesticides and reduced agricultural productivity

1.5 How Preconstruction Bat Monitoring Fits in with Current SA Legislation

The environmental principles for sustainable development that are set out in Chapter 1 of the National Environmental Management Act (NEMA) Act 107 of 1998 state that: Sustainable development requires the consideration of all relevant factors including, but not limited to the following:

- That the disturbance of ecosystems and loss of biological diversity are avoided, or, where they cannot be altogether avoided, are minimized and remedied;
- That a risk-averse and cautious approach is applied, which takes into account the limits of current knowledge about the consequences of decisions and actions; and
- That negative impacts on the environment and on people's environmental rights be anticipated and prevented, and where they cannot be altogether prevented, are minimised and remedied.

Section 28(1) of NEMA imposes a duty of care on every person who causes, has caused or may cause significant pollution or degradation of the environment to take reasonable measures to prevent such pollution or degradation from occurring, continuing or recurring.

On the 7th April 2017, the Minister of Environmental Affairs published the following amendments to the NEMA: EIA Regulations of 2014: GNR 326 EIA Regulations; GNR 327 Listing Notice 1; GNR 325 Listing Notice 2; GNR 324 Listing Notice 3.

A Basic Assessment (BA) process is required for activities listed under Listing Notices 1 and 3, with the relevant activity for WEFs being:

1. The development of facilities or infrastructure for the generation of electricity from a renewable resource where—
   i. the electricity output is more than 10 megawatts but less than 20 megawatts; or
   ii. the output is 10 megawatts or less but the total extent of the facility covers an area in excess of 1 hectare;
2. Furthermore, only a BA is required for WEFs where their entire boundary area falls within a Renewable Energy Development Zone (REDZ), as gazetted by the minister on 16 February 2018,

A Scoping and Environmental Impact Assessment (EIA) process is required for activities listed under Listing Notice 2, with the relevant activity for WEFs being:

1. The development of facilities or infrastructure for the generation of electricity from a renewable resource where the electricity output is 20 megawatts (MW) or more, excluding where such development of facilities or infrastructure is for photovoltaic installations and occurs —
   a. within an urban area; or
   b. on existing infrastructure.

Whilst these guidelines are mainly aimed at multi-turbine WEFs (=/>20 MW) that require a Scoping and EIA process (or a BA in the case of the REDZ) to be followed in order to receive Environmental Authorization (EA), guidance is also provided for smaller-scale WEFs (<20 MW). These guidelines do not differentiate between WEFs within or outside of a REDZ; the same

guidance applies to both. There is only a difference in guidance between larger (=/>20 MW) and smaller (<20 MW) WEFs.

The pre-construction bat monitoring must be conducted prior to the finalisation of a BA or EIA to inform the final layout. The information gained from the monitoring must inform the BA or Scoping and EIA assessments and provide adequate information to the competent authority for them to make an informed decision. **Mitigation and management recommendations derived from the monitoring, must be carried forward into the EA and the Environmental Management Programme (EMPr).**

Each province in South Africa has its own environmental and biodiversity legislation, policies, conservation planning tools and protected species listings. These are to be adhered to for each project, depending on the province in which the project falls within.

1.6 Other Relevant Information and Guidance

There are several relevant national and international sources of information and guidance document and these are constantly being updated as new information becomes available. Therefore, it is important for each specialist to stay up to date on the latest available information and guidance. Some important web-based information sources are listed in **Table 3**, however, this is not a fully inclusive list. It is up to each specialist to do further research as required.

Table 3 Some important bat information websites

Country/ Region	Website
South Africa	www.sabaa.org.za
USA	www.batsandwind.org http://www.fws.gov/ecological-services/energy-development/wind.htm
UK	https://www.bats.org.uk/ https://www.nature.scot/
Europe	https://www.eurobats.org/

2. PREPARATION AND PLANNING OF PRE-CONSTRUCTION MONITORING

To adequately assess the likely impact of a wind energy development on local bat populations, appropriate data are required. The overall aim of monitoring at proposed WEF sites is to identify and assess the potential impacts that the proposed development will have on both local and regional bat populations. The objectives of long-term pre-construction bat monitoring must be to determine:

- The assemblage of potentially occurring and detected bats in species groups of higher, medium and lower risk of fatality from turbines.
- The presence of rare bats and bat Species of Conservation Concern (SCC) bat species in the study area.
- The location of bat roosting habitat in the study region.
- Differences in the assemblage and activity of bats between ground level and rotor sweep height.
- Differences in the assemblage and activity of bats between monitoring localities and between different habitat types.
- Seasonal variation in the assemblage and activity of bats during the 12-month monitoring period.
- The incidence of bat migration in the study area.
- Variation in the assemblage and activity of bats between sunset and sunrise.
- Wind speed and other meteorological conditions associated with bat activity.
- The relative importance/sensitivity of different parts of the site for bats based on e.g., vegetation, significant landscape features, proximity to water, buildings and caves.
- The relative importance/sensitivity of the site based on e.g. its proximity to protected areas and regionally important cave roosts, and the overall level of bat activity relative to that at other bat monitoring sites in similar habitat.
- Potential site-specific impacts of the proposed WEF on bats.
- Effective site- and habitat/turbine-specific bat mitigation measures.

Approval of the site selection and turbine localities must only be decided on completion of a long-term pre-construction monitoring programme. A description of each phase of the monitoring is described below:

2.1 Design and Planning for a Monitoring Study for a Large (=/>20 MW) WEF

2.1.1 Scoping

A key factor influencing the design of pre-construction monitoring methodology is information received from scoping studies: data searches, desktop studies (including literature reviews and site information from maps and aerial photographs), site walkovers/drive throughs and baseline data collection such as information from the early stages of the acoustic monitoring. The potential impacts of a WEF development will be site-specific and will depend on the habitats and species present. The presence of rarer species, SCC, known roosts, or species that have been identified to be at risk of impacts, must be considered from the outset and pre-construction monitoring designed to address any potential impacts related to them. The scoping studies must aim to collate existing information on bat activity, roosts, and landscape features that may be used by bats.

To ensure that these aspects are sufficiently covered, a scoping study must *always* be undertaken for a proposed WEF site as part of the EIA process. The scoping study must include the following:

- Collation and review of existing literature (including the latest research undertaken both locally and internationally); maps and aerial photographs; and habitat data (if available) to identify habitats which may be used by bats; data on bat distributions, roosts, bat sightings, migration routes, and likely foraging and commuting areas on or close to the proposed WEF site.
- Desktop search for any designated Protected Areas within 100 km of the site.
- The scoping study must include the entire area of interest supplied by the developer/ client. This is the full study boundary area in which all infrastructures could be placed.

A walkover survey for small sites or drive-through survey for large sites is an essential part of the scoping study. This is a 'ground truthing' exercise, where the site is traversed to search for the presence of features that may support bats such as trees, buildings, underground sites, vegetated cover, wetlands and linear features, including ridges and water courses. This will also allow an initial assessment to be made of the overall habitat quality and connectivity on the site and to identify likely areas of importance for bats (e.g. water bodies, riparian vegetation etc.). The walkover/ drive-through survey must be done by the specialist because information gathered during the walkover, together with the other data obtained from the scoping study, must be used by the specialist to inform the design of the pre-construction monitoring and the level of monitoring effort required. If possible, the use of a handheld or car-mounted bat detector(s) during the site visit may also provide some initial information on species present on the site and on areas/habitats being used by bats.

Although not a requirement for the scoping study (and often not possible in the time frames available for scoping studies), data on bat activity, through passive monitoring, could also be obtained and included in the scoping report. These data are not a requirement but would be beneficial in providing good information (e.g. activity patterns, species present, potential migration route through site, bat activity relative to weather conditions) which would help inform the level of effort required for the one year pre-construction monitoring.

A scoping report must list the potential impacts of the development and the data obtained must be used to inform the design of pre-construction monitoring methodology.

2.1.2 Environmental Impact Assessment

"It is unrealistic to present an accurate and complete EIA for a specific wind energy development without taking into account the possible presence of bats throughout a timescale which reflects the full cycle of bat activity" - Rodrigues et al (2008).

In South Africa, bats are active throughout the year and as such, **pre-construction monitoring must take place for a minimum period of one year (12 consecutive months)**. The minimum requirements for all pre-construction monitoring studies are detailed in **Appendix 1**.

This guideline document provides **guidance** on pre-construction monitoring techniques and the level of effort which may be required. In some instances deviations from the techniques and level of effort outlined in this document may be unavoidable, but these must be scientifically or practically (not economically or logistically) justified. **Financial or capacity constraints are not acceptable reasons for deviating from the minimum requirements.** Any deviation from the recommended monitoring guidelines must always be acknowledged clearly in any reports and accompanied with a clear rationale that is scientifically or practically (not economically or logistically) justified.

Habitats and features on a proposed site that must particularly inform the monitoring programme include:

- Buildings or other features or structures that provide potential as bat roosts, including, but not limited to, bridges, mines, caves, sinkholes, rock crevices etc.;
- Known roosts, especially important maternity roosts;
- Vegetated habitat (including non-indigenous (alien) forest plantations and agricultural land);
- Linear features, such as tree lines, topographical ridges, water courses with associated riparian vegetation, potentially used by bats as commuting/foraging/migrating routes;
- Any water bodies or wetlands, including manmade structures e.g. farm dams, swimming pools; and
- Within or adjacent to a Protected Area (as described in the National Environmental Management (NEMA): Protected Areas Act 57 of 2003).

Development on the sites with any of the features listed above, but not limited to these features, have the potential to impact bats and the potential impact of development is likely to increase the greater the number of features. To determine how many bat monitoring stations are required per site, please refer to **Appendix 2.**

The additional techniques employed and level of effort for the pre-construction monitoring will vary depending on the location of the proposed site, the characteristics of the site, the bat species present, potential use of the site by bats, and the size and associated risks of the development, and must be informed by the results of the scoping study. An overview of the factors a specialist must consider when designing pre-construction monitoring is provided in **Table 4**. **This table is not intended to be used as an absolute measure of survey effort required, but rather as an indication of the relative survey effort that may be required.**

Consideration must also be given to future changes in land use on the site. For example, a change from arable land to cattle pasture in habitats around wind turbines (following construction) could provide habitat of higher foraging quality for bats and lead to greater risk of fatality. This must be kept in mind when designing the monitoring to allow for assessment of any future impacts on bats as a result of a change in site management. For example, where mitigation and habitat enhancement for other ecological receptors is planned on-site an assessment of whether these measures may attract bats into the area following implementation must be considered. The potential effects of such operational site management must also be assessed.

It is important that climatic factors also be taken into consideration. Should the study take place during unusual weather conditions for that climatic area, this must be noted and potentially further verification work at a later time, once weather patterns have normalised, may be required. The specialist must advise on this.

2.2 Design and Planning for a Monitoring Study for a Smaller (<20 MW) WEF

Preconstruction monitoring for a smaller (<20 MW) WEF must consider all the requirements of a study for a larger (=/>20 MW) WEF but may not require as much survey effort as for a larger WEF. Information in **Table 4** should assist to develop a proportionate approach. However, the minimum survey period for a smaller (<20 MW) WEF is 6 months to be conducted between the months September to May. Whatever decision is made, it must be scientifically justifiable.

Table 4 Overview of examples of factors to consider when designing pre-construction monitoring methodology in relation to relative survey effort

Survey effort*	Habitat	Size of WEF	Type of roost
Lower	Homogenous landscape and biotope.	< 20 MW	Night roost
	No feature that could be used by bats for roosting, commuting or migrating.		
	Small number of potential roosts, most likely less significant.		
	Isolated habitat that could be used by foraging bats.		
	Isolated site not connected by prominent linear features or well vegetated areas.		
	Several potential roosts in buildings trees or other structures.		
	Habitat could be used by foraging bats.		
Medium	Heterogenous landscape and biotopes.		Daytime roost (but not maternity)
	Site is connected to the wider landscape by linear features such as topographical ridges and water courses.		
	Habitat of high quality for foraging bats.		
Higher	Heterogenous landscape and biotopes.	> 20 MW	Nursery roost Maternity
	Site is close to known roost, or suspected/known migration route.		
	Confirmed presence on or adjacent to site, either roosting, commuting or migrating.		Maternity roost/ Hibernaculum (winter roosts where hibernation occurs)
	Buildings, trees, water bodies or other structures with features of particular significance (Sirami et al. 2013).		

2.3 Amendment Reports or New Environmental Processes

If an amendment to a wind energy project is required or a new environmental process for the same project is required, the following must apply:

- In the case of a turbine dimension or specification change causing turbine blade tips to further encroach on bat sensitive areas/ buffers, the layout must be adjusted to move turbines (including the full rotor swept area) out of the bat sensitive areas/ buffers.
- Any turbine dimension or specification change (positive or negative) must be accompanied by *either*:
    - an official statement from the original specialist who did the preconstruction monitoring describing whether the monitoring conducted was sufficient to assess such a change, whether the impact assessment and/ or the mitigation recommendations change and if so, what those changes are, OR
    - a short field visit and brief report by a new specialist describing whether the monitoring conducted was sufficient to assess such a change, whether the impact assessment and/ or the mitigation recommendations change and if so, what those changes are.
- The need for additional monitoring must be according to the discretion and motivation of the specialist. If new monitoring is required, it must be done according to the latest version of the guidelines at the time of the amendment.
- Special attention must be given to changes where the lower rotor swept is likely to impact on another suite of bat species due to different flight patterns and foraging ecologies. The original monitoring must have covered various heights to determine which species were active closer to the ground and which were active nearer to the hub.
- Where buffer distances need to be amended according to the latest guidelines, these must be done.
- **The monitoring data used to make any of the above informed decisions must have been done according to the latest version of the guidelines at the time of the original monitoring and the results must still be valid according to Section 2.5 below.**

2.4 Phased Projects or Extension of Land Parcels

Where monitoring has been conducted for a large land parcel/ study area, and the monitoring has been done according to the applicable best practise guidelines at the time, and assuming the monitoring data is still within the validity period (see Section 2.5 below), the results from that monitoring can be used to conduct amendment applications for split phases or EIAs/ BAs for separate WEFs within the boundaries of the study area.

Where monitoring has been completed or is underway for a specific land parcel/ study area and a developer wants to develop on an immediately adjacent property outside of the original study area, assuming that the monitoring data is not older than five years, and the best practise guidelines were adhered to in the original monitoring, an additional six months of monitoring during the period October to April must be conducted on the new property according to the requirements of the relevant best practise guidelines at the time of the extension monitoring. With regard to monitoring at height, only if the combined area of the two study areas is less than 10 000 ha and they are similar in bat important biotopes, can the at height data from the previous study be used for the new study area. This clause assumes that the specialist conducting the extension monitoring will have full access to and use of the data from the original monitoring on the adjacent property.

2.5 When are New Editions of the Guidelines Applicable?

The guidelines are applicable from the date on the cover page, i.e. the date that the new edition has been finalised and released by SABAA to its members, the South African Wind Energy Association (SAWEA), Department of Environment, Forestry and Fisheries (DEFF), the Endangered Wildlife Trust (EWT), the South African Council for Natural Scientific Professions (SACNASP) and the International Association for Impact Assessment (IAIA) South Africa in an official email.

All bat monitoring appointments for potential WEFs being made on or after this date, must follow the latest edition of the guidelines. If a proposal process has been completed and a consultant has been appointed according to the previous version but has not yet commenced with the work, the consultant should be allowed to revise their proposal, if necessary. For studies that are only two months or less into the fieldwork, the specialist must assess how the new guidelines affect their scope of work and have the necessary discussions with the developer on whether any changes are required. For studies that are more than two months into the fieldwork, the studies can continue according to the previous guideline edition.

2.6 Validity Period of Bat Monitoring Studies

A bat monitoring study conducted in accordance with the latest guidance relevant at the time of commencement of the monitoring is valid for a period of 5 years following the completion of the 12 months of monitoring.

Should an application for environmental authorisation only be submitted 5 years or more after the completion of the fieldwork period:

- For a =/>20 MW project, a bat specialist must conduct a minimum of an additional consecutive 6 months of on-site pre-construction bat monitoring sometime between October and May. The new data collected must be compared to the old data from the same period and an amended impact assessment must be conducted.
- For a <20 MW project, a bat specialist must conduct a brief site visit and compile a letter stating whether the assessment of impacts on bats is still valid. If the study is still valid, the letter is sufficient. If it is not, the specialist must propose what additional work is required to amend the assessment.

3. PRE-CONSTRUCTION MONITORING METHODS

Pre-construction monitoring at proposed WEF sites must be site-specific and designed to provide the information required to complete a full impact assessment (for details on what is required in a monitoring report see Section 5). Monitoring will need to take seasonal, species, and geographical variation into account and will need to describe bat activity within the developable area and must cover the turbine locations within the site if these are known.

The area of influence (AOI)/ study area must be supplied to the specialist by the developer. If the turbine layout is unknown, the full AOI must be surveyed. If the developer supplies the specialist with a specific turbine development area as the AOI and requests the monitoring to cover that area only, then the assessment is only applicable to that area. Any development outside of the provided AOI would constitute a new study or an extension to a study.

Whilst the intensive monitoring must occur within the AOI of the wind turbines, the assessment should consider the potential impacts of ancillary developments, like access roads, powerlines, etc. (if known) and account for any light pollution, removal of vegetation, etc. This section outlines the basic requirements of best practice for each survey technique and highlights specific considerations relating to the monitoring of bats at proposed WEFs. This requires data to be collected using complementary survey techniques designed to confirm and further inform any potential impacts initially identified in the scoping report. The main monitoring techniques required to collect this data fits into two broad categories: Roost Surveys and Activity Surveys. Each of these techniques to be described will provide information on different aspects of the site and its use by bats.

3.1 Roost Surveys

3.1.1 Roost Surveys - On-site

All accessible and safe to access potential and known bat roosts (e.g. buildings, underground sites, caves, mines, trees, culverts, bridges, rock crevices, etc.) within the AOI must be surveyed. The survey must include a daytime inspection in summer and one in winter looking for any evidence of bats (actual bat presence, guano, oil smudges, etc.). Any evidence of presence of bats constitutes a confirmed roost.

Any other features that could not be inspected in detail, or require further survey and need to be observed at dusk, must be mapped and returned to during manual activity surveys at dusk. Roost Surveys - Surveys at known roosts

3.1.2 Roost Surveys - Off-site

Known medium, large or extra-large roosts (refer to Section 7.1 for definition of roosts and applicable buffers) and all caves within a 20km radius must be surveyed at least once during the preconstruction monitoring period for evidence of presence of bats.

If identified roosts are entered to identify species or estimate abundance, important precautions must be taken to ensure the safety of both the specialist and the bats themselves (if you are unsure of the detailed safety precautions to be followed, please contact either the Gauteng and Northern Regions Bat Interest Group (www.batsgauteng.co.za) or Bats KZN (www.batskzn.co.za). Permits must be acquired where necessary. Although some of this information could have been collected during the scoping phase, roosts and roost occupancy may change seasonally and must be checked during each season.

3.2 Activity surveys

3.2.1 Manual surveys

Manual activity surveys, such as walked or driven transects, are necessary to gain a spatial understanding of the bat species using the site and the features on site that the bats are using. Transects compliment the static monitoring points in terms of spatial coverage. They can also be used to identify key features, commuting routes and overall activity within and surrounding the site. Another method of manual sampling to compliment static monitoring is point sampling in key biotopes. If point sampling is used by the specialist, the reasons for deviating from transects must be well justified and enough sampling nights must be conducted to cover all the various biotopes on site for all four seasons each. These manual surveys DO NOT replace continuous static monitoring according to the minimum requirements.

Broadband bat detectors (frequency division or full spectrum, not time expansion) must be used for manual activity surveys, either connected to a recording device or with a built-in recording capability, to ensure that all bat calls are recorded and can be subsequently analysed for identification to species or species-group level.

The number and length of transects or number of point sampling sites required to cover the main habitat features of the site will depend on the proposed size and complexity of the site. Sufficient transects or point sampling sites must be set up to ensure that all identified features that may be used by bats, as well as all biotopes present, are sampled within the first two to four hours after dusk. More than one transect may therefore be required to cover all areas and habitats of the proposed site in one survey session. If certain features or biotopes are identified by the specialist as not being significant to bats, and therefore were not included in transects or point sampling sites, they must justify this decision.

Sampling points can be identified along the transect routes to divide the route into comparable sections. These points must be evenly distributed in distance and amongst the habitats across the site and must include both pristine and transformed habitats (Sirami et al. 2013). Bat activity must be recorded for a set amount of time at each sampling point (The Bat Conservation Trust (BCT) recommend at least three minutes) and continually between points and must aim to represent and compare bat activity across the site. The number of bat passes (or similar in accordance with current best practice and technology) and species concerned must be recorded at each sampling point and between sampling points. The number of sample points will be dependent on the size of the site. To ensure robust data collection, surveys must be undertaken from opposite directions throughout the year to allow for the differing emergence times of bat species. To ensure that data are comparable, transect routes must be kept as close to the original routes as possible.

Nights when weather conditions are favourable must be selected for transect/ point sampling nights where possible, as weather conditions largely affect bat activity.

Eight nights of manual surveys/ transects, spread evenly across all four seasons is considered reasonable. Some sites may only need one transect to cover what they need in a night, other larger sites may require more transects to achieve this. Once again this will be up to the specialist to decide what is appropriate at a particular site.

The use of bat detectors connected to a GPS unit - which unequivocally indicates the exact transect walked and where each sampling point was, and can thus be used by any person instructed to walk the transect - may obviate the need for the specialist to conduct each of the manual surveys. Similarly, at sites where more than one transect will be needed to cover the area of the site, other people will be required to participate in the manual survey. Where other people are used in the monitoring protocol, this must be stated in the report together with their relevant experience and knowledge (Section 5).

3.2.2 Static monitoring

Manual bat activity surveys only provide a snapshot of activity across a site and therefore, automated bat detector systems (remote acoustic monitoring) must be used to assess bat activity at proposed WEF sites. These 'static detectors' provide an invaluable volume of data on the bats present on the site at a set series of fixed locations (representative of area to be covered and all biotopes present in a study site) and altitudes and are essential to gauge the relative importance of features and locations, and potential migratory routes and how these may change throughout the year and throughout the night in different seasons or months.

Although static acoustic monitoring at exact turbine locations would be preferential in most cases, this will be difficult because provisional layouts may change throughout the development process and the cost of having a bat detector per proposed turbine in unfeasible. Therefore, the distribution of static detectors must aim to cover the variety of biotopes found on site and must aim to monitor activity occurring near ground level and in the rotor swept area – preferably both the lower and upper rotor swept zone. Static detectors must remain in a fixed location within each biotope and at each height throughout the 12 month monitoring period. This will allow a full 12 months of monitoring to compare seasonal variation within each biotope type and at each height. A guide on how many detectors must be used for static monitoring is provided in **Appendix 2**.

In addition, all detectors must be appropriately calibrated to account for variation between detector units and to allow a valid comparison of recorded bat activity across a suite of detectors (Larson & Hayes 2000). Specialists must be aware of specific microphone capabilities and limitations and must take this into account when setting the location and angle of the microphone. This may be within the developable areas, or at proposed turbine locations if they are known, or along linear features. Specialists must be aware of the constraints of bat detectors (e.g. microphone sensitivity and area of coverage) and must take these into consideration when designing the pre-constructions methodology. Constraints/limitations must also be listed in the report.

Microphone(s) sensitivity must be monitored in the field during every site visit using an appropriate calibrator. The aim is to ensure correct bat detector and microphone performance. This will enable more accurate comparisons between results from different sites. If sensitivity has been lost, the gain and sensitivity settings on the bat detector can be adjusted to compensate. Microphones must be replaced if the loss in sensitivity is significant - this will depend on the specific capability for each manufacturer.

3.2.3 Monitoring heights

There is a strong likelihood that the proportion and composition of species presence at height will differ from ground level, which could have significant impacts in relation to assessing impacts at sites with a high proportion of high-risk species (e.g. species commuting, migrating and foraging within the rotor swept area). Kunz et al. (2007) have shown that the correlation between bat activity estimates from pre-construction acoustic monitoring and post-construction bat fatality estimates is stronger as the bat detector is deployed at greater heights.

In order to capture the call recordings of different bat species that fly and forage at different heights, it is important that monitoring is conducted both near ground level and within the rotor swept zone. It is also important to try, as far as possible, to capture calls across the full rotor swept height range, therefore, multiple microphone heights are required on tall meteorological masts. There must be one microphone between 7 m and 10 m to account for species that forage near the ground and for the data to be comparable to call data recorded on smaller 10 m masts in other biotopes across the study area. Additional microphones must also be added on the meteorological mast to cover as much of the rotor swept zone as possible, without producing too much overlap in the call data between the different heights. For masts that are 80 m tall or less, two microphones per mast is sufficient (one at 7-10 m and one at 50 – 80 m). For masts greater than 80 m tall, three microphones must be installed at a lower height (7-10 m), middle height (height will depend on the total height of the mast) and top height (as close to the top of the meteorological mast as possible).

There are several available techniques that can be used to fix static detectors at height. Appropriate methods will depend largely on the type of equipment available. Lattice meteorological masts are useful for installing detectors at height because they are easy to climb for installation and maintenance purposes.

In South Africa, developers are erecting meteorological masts on most sites that can be used to erect bat monitoring equipment. Ideally, such masts are climbable lattice structures; however, some developers use pole structures that provide more of a challenge in terms of erecting equipment and maintaining microphones. Such challenges could be overcome through pulley systems or guy wire climbing systems. Other methods do exist and, if proven to be effective, can be used. Early engagement between specialists and developers can assist in overcoming some of these challenges.

Certain detectors will have limitations in their range depending on the methods employed and these must always be considered when designing a survey. New equipment and techniques are being developed and the choice of methods must be reviewed in the light of new developments.

3.3 Control Sites

There is much debate around the true value of control sites. Whilst data collected at a control site could add value to a bat monitoring assessment, there are too many uncertainties around the true value of this extra monitoring effort to justify control sites as a minimum requirement. It is an option that can be recommended for a particular site, if the specialist feels it is appropriate. The concerns regarding making the use of a control site for bat monitoring a minimum requirement are as follows:

- Finding a control site that is truly comparable to the study site, with a similar composition of biotopes will be very difficult, especially for very large sites.
- Most of the WEF sites are extremely large. Hence, to cover double or one and a half of the bat monitoring equipment and survey effort required, will make these studies unfeasibly expensive and time consuming.
- Whilst there are various potential impacts on bats due to wind energy, such as roost disturbance, displacement from or loss of foraging habitat, fragmentation of migration routes, etc., the most severe impact identified to date, is large-scale bat fatalities. A control site may inform on whether bat activity has decreased on site for natural reasons or as a result of the WEF, however, it does not add value in terms of mitigating for fatalities. This can only be done through a combination of activity monitoring on site before and after construction and carcass searches in the operational phase.

It is suggested, that where the entire study area is monitored pre-construction, yet only a certain area of the site is developed, the remaining area that is monitored both pre- and post-construction be used as the control. However, if a bat specialist does see value in a control site for a particular WEF site, this can be included in their study proposal with the correct motivation.

3.4 Other Survey Methods

3.4.1 Cameras and Radar

Other methods for monitoring bats, such as infrared or thermal cameras and radar, have been suggested. For logistical and financial reasons, it may be impractical to use these at most WEF sites, however, such methods can be used in addition to acoustic monitoring where the budget and suitability of the site allows.

3.4.2 Capture of bats

The capture of bats (mist-netting/harp-trapping)[1] may be considered where call identification requires clarification and/ or other standard techniques (roost surveys and activity surveys) cannot deliver a robust impact assessment. For species with overlapping echolocation call parameters, particularly in certain species rich and diverse regions, live capture and release for identification

[1] **Capture and handling of bats must only be conducted by appropriately trained and experienced people with the requisite rabies pre-exposure inoculations.**

purposes may be necessary. Trapping will also help assist in identifying non-echolocating fruit bats on site, as well as species that use calls of low intensity that are difficult to detect using acoustic monitoring techniques (e.g. *Nycteris thebaica*). Please see the Section 3.5 for more information on fruit bats. Live capture and release may also be necessary to obtain echolocation calls from released bats which can be used as reference calls for the acoustic monitoring. However, caution must be used when using calls from caught and then released bats as reference calls, as the calls from stressed animals flying in cluttered habitat will often not reflect the parameters of open flying bats (non-stressed, non-clutter flying bats) (Fukui et al. 2004; Law et al. 2002)

These capture methods are not a minimum requirement for pre-construction monitoring (except for sites where fruit bats are likely), but can be used *in addition* to the above-mentioned methods (roost surveys, activity surveys and acoustic monitoring) and cannot be used in isolation. Furthermore, whenever these techniques are used, it is important to remember that the sampling of bats will not be at the height of the turbine blades. Individuals using these methods must have training and/or experience in the safe, ethical and effective capture of bats **and possess the appropriate provincial permits to catch and handle bats in the area[1].**

3.4.3 Radio tracking

Radio-tracking may provide additional information on what areas of a particular site the bat is using and how it commutes or migrates between various areas (e.g. roost and foraging sites). However, radio-telemetry is expensive and may not be appropriate in certain habitats and for many species (e.g. many landscape features that will obscure the signal, resulting in very little data being collected because the bat cannot be 'located' and many bats are too small to put sensors on to). This is not a minimum requirement of the guideline, but can be used in addition to the recommended techniques.

3.5 Fruit Bats

Fruit bats (Family: Pteropodidae) in South Africa are susceptible to fatality by wind turbines (MacEwan 2016). In areas where the Scoping study indicates the likely presence of fruit bats, intensive roost surveys must be undertaken to determine the presence of both cave-dwelling and tree roosting species. For *Epomophorus* species, nocturnal surveys involving listening for calling males must be undertaken, especially in the months of May and June (although calling can be heard throughout the year). These fruit bats can also be located by finding feeding spit-out under fruiting or feeding perch trees and can often be seen flying at night. Because *Rousettus aegyptiacus* echolocates, albeit it a primitive form of tongue-clicking, it may be picked up by acoustic recording equipment. *Rousettus aegyptiacus* is a cave dweller; hence, roost surveys are also important for this species. In areas where fruit bats are likely to occur, capture techniques[1], such as mist-netting[2] should be used to confirm their presence and to identify the species in the area.

3.6 Weather Conditions

General guidance for carrying out manual bat surveys (i.e. walked and driven transects and mist-netting[2] where appropriate) suggests that surveys must only take place in optimum weather conditions, to maximise the likelihood of recording bats. It is advised to avoid heavy rain, strong winds and low temperatures, because bats are least likely to fly in these conditions and activity levels will be low. However, where static detectors are deployed for a number of days at a time, the selection of survey nights with ideal weather conditions is unlikely to be achieved for all survey nights. Data from windy or wet nights may also prove useful in determining how bat activity changes with weather conditions.

3.6.1 Measuring environmental parameters

During static monitoring, weather information must be recorded on site throughout the monitoring period. Data on wind speed, rainfall and temperature that are gathered over the entire year must be compared with the bat data (i.e. bat activity) of the site. This information is useful for data interpretation, impact assessment and mitigation recommendation purposes. Basic weather conditions must also be recorded on nights when transects or if live-capturing is conducted.

4. INTERPRETING RESULTS

Survey information must always be collected, recorded and analysed to meet the objectives set out in Section 0.

One important component in meeting these objectives is the relative bat activity for the site. Static detectors provide the raw data to estimate relative bat activity. There are a number of ways in which this can be determined but consideration must be made to the end results which is to achieve a robust impact assessment.

BAT ACTIVITY INDEX = BAT PASSES (or similar)/ UNIT TIME

A single bat pass is defined as a sequence of ≥1 echolocation calls where the duration of each pulse is ≥2 ms. Single call fragments do not apply, only completed single pulses. Where there is a gap between pulses of >500 ms in one file, this then represents a new bat pass. If it is thought that the bat passes are multiple recordings of the same individual, this must be noted.

Furthermore, it is recommended that surveys also calculate a relative abundance index, to address the potential skewing of the data by a single bat making several passes at the recording site as opposed to multiple bats flying by. It is possible to estimate relative abundance by

[2] **Capture and handling of bats must only be conducted by appropriately trained and experienced people with the requisite rabies pre-exposure inoculations.**

adjusting the activity by the survey times (unit effort) (Miller 2001), i.e. the number of minutes per night (time interval) having recorded passes.

Different detectors and different microphones produce different quantities of data and various conversion software may produce a different number of bat activity units; hence, detector type, microphone type and conversion software used on site must remain consistent throughout the monitoring period and must be described in the monitoring reports. Bat activity data must be corrected for gaps in recording due to technical and/or other problems that may have been experienced during the monitoring period. An explanation of these corrections must be detailed in reports. Data must be normalised from sunset to sunrise so that activity levels can be compared across microphones and sites and analysed within site to provide:

- Median bat passes per hour per microphone per month and per annum. See **Appendix 3**.
- An indication of seasonal variation in species activity and composition across the site. Site-wide information on bat distributions may provide useful information on which species are using which parts of the site.
- Relative levels of bat activity recorded between 7 m and 10 m and within the proposed turbine swept path area.
- Variations in activity and species composition at different wind speeds and other environmental parameters (temperature, barometric pressure and humidity) where these are available. This can be used to inform any future mitigation.

5. PRE-CONSTRUCTION MONITORING REPORTS

The following Section provides guidance on assessing the standard of pre-construction monitoring reports for onshore WEFs. As a minimum, each pre-construction monitoring report written for an EA process must meet the requirements of the applicable Environmental Impact Assessment Regulations and must include, but not be limited to the following:

- **Expertise of specialist overseeing the work and expertise of other surveyors.** The lead specialist/ the person who signs off on the report must be registered as a Zoological or Ecological Scientist with the SACNASP, according to the Natural Scientific Professions Act of 2003 and must have at least 5 years of bat scientific experience. Where people other than the specialists are involved in the monitoring (e.g. walking manual transects, analysing recordings etc.), they must be listed and their relevant experience and knowledge described.
- **Introduction to the project development and the background environmental conditions,** including but not limited to a description and map of the monitoring area, the proposed infrastructure development and the background habitat relevant to bats – vegetation, climate, geology, hydrology, land use, etc.

- **Pre-construction monitoring methods used,** including the dates, times and duration of monitoring and equipment used. Acknowledgement and rationale must be provided if the methods have deviated from the guidance provided in this document.
- **Technical or other limitations** of the survey and how this could have restricted the quantity and quality of information collected.
- **Results and discussions** must provide answers that meet the objectives in Section 2 of these guidelines. The results must provide information on, but not be limited to:
  - Bat species composition and activity levels near the ground and within rotor sweep height.
  - A description of the biology and conservation status of the species on site.
  - Bat distribution across the site in relation to various habitats or biotopes.
  - Bat activity levels must be calculated per unit time and described for different species or species groups where species or groups can be reliably separated from recordings. This would normally be done for both manual activity transects and static activity surveys separately.
  - Bat activity in rotor weep height compared to climatic variables such temperature, wind speed, humidity and barometric pressure.
  - A description and map of bat sensitive features, including roosting and foraging potential and confirmed areas and appropriate buffers on sensitive features.
  - Results must be presented scientifically in text, graphs and tables but must not be too complex that the public, developers and authorities cannot understand what is presented.
- **Identification and assessment of impacts** (based on monitoring results and up-to-date published research) that links back to:
  - The identified species, their conservation status and likely impacts and assessment of the impact.
  - Bat activity in relation to habitat, height, wind speed and other environmental parameters.
  - Daily and seasonal variations in bat activity.
  - Consideration of the likely changes in land-use over the lifetime of the WEF and consideration of other WEF proposals that may have a cumulative impact on the proposal under consideration (where data are available to facilitate cumulative assessment within a reasonable timescale, it must be included in the assessment, but this must be already determined at proposal phase, so that the specialist can budget for the analysis of these data).
  - Cumulative impacts must also be assessed – see Section 6 below.
  - A description of fatal flaws, rendering the project as “No-Go” must be provided if the scientific evidence supports this.
- **Recommendations for potential mitigation** (see Section 7 below). Assuming there are no fatal flaws, mitigation and management measures to reduce or prevent impacts on bats, based on scientific evidence, must be included in the report.

6. CUMULATIVE IMPACTS

In considering cumulative impacts, specialists must take into consideration cumulative impacts on bats from mainly other renewable energy developments, but other activities or developments or agricultural practises can also be considered within a minimum of a 30 km radius from the proposed project (in line with the radius used in the national web-based environmental screening tool in terms of section 24(5)(h) of the NEMA, 1998 (Act No 107 of 1998) and regulation 16(1)(b)(v) of the EIA regulations, 2014, as amended). **However, a more biologically relevant larger radius is preferable due to the nightly and seasonal distances that some bats fly exceeding 30 km.** When assessing cumulative impacts, information from, but not limited to the following must be considered:

- Information on other renewable energy developments in the area can be obtained from various sources, including but not limited to https://egis.environment.gov.za/. The specialist must use this database with caution, and only consider developments in the cumulative impact assessment that are developed or likely to be developed.
- Specialists must try and obtain data from other preconstruction or operational bat monitoring studies within the cumulative assessment radius.
- The South African Bat Fatality Threshold Guidelines (MacEwan et al. 2020) describe how to determine thresholds for single sites and larger cumulative areas. It is important to note, that whilst thresholds can be determined for larger areas, the onus on every development is not to exceed their site specific threshold. If all development or land use areas remain below their bat fatality threshold, the cumulative area should not exceed the larger threshold.

7. MITIGATION MEASURES

Because of the environmental principles for sustainable development that are set out in Chapter 1 of the National Environmental Management Act (NEMA) Act 107 of 1998 (Section 1.5)**,** the duty of care that each developer has to the environment and the fact that bat fatalities are a reality at all operational WEFs in South Africa (Doty & Martin 2012; Aronson et al. 2013; MacEwan 2016 and Kate MacEwan pers. comm. 15 March 2020), it is important that where pre-construction monitoring surveys show medium to high levels of bat activity relative to the terrestrial ecoregion that the site is situated in (**Table 5**) and/or where SCC are confirmed and/or critical habitats are present, fatality minimization measures are recommended. Recommending fatality minimization measures upfront in the planning stages is advantageous because it can feed into the financial models and technical planning of a project. It is more difficult to apply adaptive mitigation after commercial operation has commenced. In terms of the South Africa Environmental legislation, mitigation and management measures are only enforceable if they are written into the EA and the auditable EMPr and thus, **important bat fatality minimization measures must be written into the EA and EMPr and the wording must leave no doubt that these measures must be applied.** Some guidance on recommending mitigation measures is provided below and in Aronson et al. (2018), however, the specialist must keep up to date with the latest and most effective mitigation measures being researched in South Africa and worldwide.

7.1 Buffer Zones

The aim of the pre-construction monitoring phase must be to place turbines in lower risk and lower sensitive locations to bats. This can be achieved by the use of appropriate buffer zones. These must be considered no-go areas for wind turbine development, i.e. no part of the wind turbine, including the blade tips must encroach into these buffers zones. This is a horizontal distance that can be measured on a map and on the ground. It applies from the ground through the full length of the turbine sweep, i.e. all parts of the turbine, tower and rotor sweep must remain outside of this zone at ground level and in the airspace.

SABAA has recommended a set of nationally applicable wind turbine buffer zones for bats at proposed wind energy development as described below.

For wind turbine developments, including all parts of the blades and towers, SABAA recommends, as an absolute minimum, a buffer of 200 m around all potentially bat important features, e.g. delineated watercourses, i.e. from the edge of the riparian zone or from the edge of the outer wetland zone, woodland vegetation (any trees or bush clumps considered important on site, including alien vegetation), outbuildings (all structures considered as potentially important for bats – water towers, farm buildings, bridges, artificial roosts, etc.), rocky outcrops, topographical ridges and Protected Areas (as described in NEMA: Protected Areas Act 57 of 2003).

The exception to the above minimum distance is for confirmed roosts (permanent or seasonal roosts) or potential roosts that were not safe to survey. When considering roost size, the following has been defined: small roost = 1 - 49 bats; medium roost = 50 – 499 bats; large roost = 500 – 1999 bats; extra-large roost =/>2000 bats. The following buffers must apply:

- A buffer of 500 m for a small roost of Least Concern (LC) bats and/or Low Fatality Risk bats.
- A buffer of 1 km for a medium roost of LC bats and/or Low Fatality Risk bats.
- A buffer of 2.5 km for a large roost of LC bats and/or Low Fatality Risk bats.
- A buffer of 1 km for a small roost of SCC bats and/or Medium, Medium-High and High Turbine Fatality Risk.
- A buffer of 2.5 km for a medium roost of SCC bats and/or Medium, Medium-High and High Turbine Fatality Risk.
- A buffer of 5 km for a large roost of SCC bats with a Low Fatality Risk.
- A buffer of 10 km for a large roost of SCC bats with a Medium, Medium-High and High Turbine Fatality Risk.
- A buffer of 20 km for an extra-large roost of bats with any conservation status and/or risk level.

Important Notes:

- Where a roost of bats may fall into more than one buffer zone category above, the greater of the two distances apply.
- Where roosts are mixed with different species, the buffer must be assigned according to the species requiring the greater distance.
- These are minimum values and they do not exempt the developer from implementing additional mitigation measures outside of the buffer zones where bat activity levels dictate.
- Roost buffers should be radial, unless the specialist has good scientific evidence of specific flights paths of bats leaving and entering the roost.
- A buffer of 500m around all known movement corridors with a use of >50 individuals per season.
- For other associated WEF developments, such as buildings, sub-stations, roads and powerlines, developers must:
  - For roads: A 200 m minimum buffer applies to bat roosts, and disturbances to foraging areas by roads must be considered in the assessment.
  - For power lines: A 500 m powerline buffer applies to bat roosts, with the exception of very large roosts (=/>2000 bats), where 2 km buffer applies. Powerlines can cross bat important foraging areas area, as long as all the other water use license mitigation measures are in place in the case of wetlands and rivers.
  - For buildings and sub-station infrastructure: A 500 m minimum buffer applies to bat roosts, and disturbances to foraging areas by roads must be considered in the assessment. Light pollution and noise from such building must also be considered in the assessment and a larger buffer may be required to prevent impacts on large or extra large roosts.

7.2 Recommending Proactive Fatality Minimization Measures

Biodiversity is not spread evenly across the Earth but follows complex patterns determined by climate, geology and the evolutionary history of the planet. These patterns are called "ecoregions" - https://www.worldwildlife.org/biomes. The World Wildlife Fund (WWF) defines an ecoregion as a "large unit of land or water containing a geographically distinct assemblage of species, natural communities, and environmental conditions".

Very little published data on relative bat activity levels in South Africa exists. However, acoustic bat activity data gathered from 30 completed long-term pre-construction monitoring surveys conducted by Inkululelko Wildlife Services (Pty) in South Africa was collated and analysed for publication (MacEwan et al. 2020). The data were obtained from 156 microphones the 3-11 m above ground level height range (2716 - 152358 recording hours in each ecoregion) and 55 microphones in the 50-110 m above ground level height range (992 - 36873 recording hours in each ecoregion). These data were used to develop an initial table of bat fatality risk for some of the terrestrial ecoregions in South Africa. Whilst the Dinerstein et al. (2017) ecoregions were considered as a more recent publication, the ecoregions delineated according to Olson et al. (2001) were a better fit for the data.

Based on the assumption that bat activity is positively correlated with bat fatality risk at turbines, the information presented in **Table 5** can be used in two ways:

- **Between ecoregions.** Bat fatality risk is expected to be greater in ecoregions with higher bat activity.
- **Within ecoregions.** Bat fatality risk is expected to be greater at sites where bat activity is high for the relevant ecoregion.

Where possible, high risk ecoregions and sites should be avoided and developers must understand the risk level of and to their projects. However, with variable bat activity between and within ecoregions, bat fatality risk should be evaluated on a case-by-case basis in the context of the relevant ecoregion(s). For example, while 1.5 bat passes per hour near ground level is indicative of high bat activity and fatality risk in the Nama Karoo Ecoregion, it is considered to represent low activity and fatality risk in the Lowland Fynbos and Renosterveld Ecoregion.

Table 5 Height-specific bat activity and fatality risk in different South African terrestrial ecoregions

Ecoregion	Height category*	Low Risk (Median bat passes/ hour)	Medium Risk (Median bat passes/ hour)	High Risk (Median bat passes/ hour)
Succulent Karoo	Near ground	0.00	> 0.00 - 0.20	> 0.20
	Rotor sweep	0.00	> 0.00 - 0.03	> 0.03
Nama Karoo	Near ground	< 0.18	0.18 - 1.01	> 1.01
	Rotor sweep	< 0.03	0.03 - 0.42	> 0.42
Montane Fynbos and Renosterveld	Near ground	0.00	> 0.00 - 0.33	> 0.33
	Rotor sweep	0.00	> 0.00 - 0.21	> 0.21
Lowland Fynbos and Renosterveld	Near ground	< 2.20	2.20 – 5.27	> 5.27
	Rotor sweep	0.00	> 0.00 – 0.37	> 0.37
Albany Thickets	Near ground	< 1.58	1.58 – 4.27	> 4.27
	Rotor sweep	< 0.24	0.24 – 1.52	> 1.52
Drakensberg Grasslands, Woodlands and Forest	Near ground	< 0.23	0.23 – 1.76	> 1.76
	Rotor sweep	< 0.04	0.04 - 0.39	> 0.39
Kwazulu-Cape Coastal Forest Mosaic	Near ground	< 8.31	8.31 - 40.39	> 40.39
	Rotor sweep	< 3.46	3.46 - 13.85	> 13.85
Maputaland Coastal Forest Mosaic	Near ground	< 6.88	6.88 - 20.87	> 20.87
	Rotor sweep	< 27.45	27.45 - 139.68	> 139.68

***Height category:** Near ground = 3-11 m above ground level; Rotor sweep = 50 – 110 m above ground level

Fatality minimization measures should be recommended in pre-construction monitoring reports and applied from the commencement of turbine rotation where greater than medium or high risk levels occur, as per **Table 5**. Environmental and weather parameters must be used to determine turbine specific, seasonal specific and hourly specific mitigation measures. A proportional approach must be applied. These measures must be carried through to the EA and EMPr for each project.

Whilst all bats are considered important from an ecosystem services perspective and all bats must be protected, special attention must be given to assessing impacts on SCC and operational mitigation may be required. Residual impacts occurring during the operational phase must be addressed to protect especially these species (but all species at risk) during the operation of WEFs.

8. OPERATIONAL MONITORING

In accordance with the South African Good Practice Guidelines for Operational Monitoring for Bats at Wind Energy Facilities (Aronson et al. 2020 or subsequent editions), operational monitoring is required for all projects. Every WEF in South Africa, no matter what size must conduct operational bat monitoring according to the Aronson et al. 2020 (or subsequent editions) guidelines. Such a condition must be written into the EA and EMPr for the WEF.

9. BASELINE DATA COLLECTION AND STORAGE

To better inform future pre-construction monitoring methodology and mitigation measures, it is important that the current limited knowledge of the biology and ecology of many South African bat species, as well as the interaction between bats and WEFs is addressed within the South African context. To this end, data collected during pre-construction (e.g. acoustic monitoring and roost surveys) and operational monitoring (e.g. acoustic monitoring and carcass searches) at WEFs, must be deposited with a designated coordinator at the end of the relevant data collection campaigns. The development of such a repository is in progress. Until such time as one is available, all monitoring reports must be submitted to SABAA on completion of the monitoring as part of the environmental assessment process. Once a designated and agreed repository is available, SABAA will send a notice to their members and advise of the repository.

This information is critical for our understanding of WEFs and their impacts on bats in South Africa and, in addition to informing future guidelines, will inform future avenues of research.

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APPENDIX 1: MONITORING MINIMUM REQUIRMENTS

Recommendations of minimum requirements of pre-construction monitoring effort are provided below, with further methodological detail on each survey aspect provided in Section 3.

Any deviations from the guidelines must be scientifically or practically (not economically or logistically) justified. Financial or capacity constraints are not acceptable reasons for deviating from the minimum requirements.

Monitoring periods

- 12 months for =/>20 MW WEFs, both inside and outside of REDZ.
- 6 months for <20 MW WEFs, both inside and outside of REDZ.

Survey Area

- The area of influence (AOI)/ study area must be supplied to the specialist by the developer. If the turbine layout is unknown, the full AOI must be surveyed. If the developer supplies the specialist with a specific turbine development area as the AOI and requests the monitoring to cover that area only, then the assessment is only applicable to that area. Any development outside of the provided AOI would constitute a new study or an extension to a study.
- Whilst the intensive monitoring must occur within the AOI of the wind turbines, the assessment should consider the potential impacts of ancillary developments, like access roads, powerlines, etc. (if known) and account for any light pollution, removal of vegetation, etc.

Roost Surveys

- Daytime inspection in summer and winter of potential and known roosts within the AOI.
- Known medium, large or extra-large roosts and all caves within a 20km radius must be surveyed at least once during the preconstruction monitoring period.

Manual Surveys

- Eight nights of manual surveys through transects or point sampling in various biotopes, spread evenly across all four seasons. Surveys must begin at evening civil twilight when conducted in the evening and last for at least two and a half hours.

Static Surveys

- A minimum of one >50 m fixed monitoring station per 10 000 ha or part thereof.
- For masts that are 80 m tall or less, two microphones per mast is sufficient (one at 7-10 m and one at 50 – 80 m). For masts greater than 80 m tall, three microphones must be installed at a lower height (7-10 m), middle height (height will depend on the total height of the mast) and top height (as close to the top of the meteorological mast as possible).
- A minimum of one 7-10 m fixed monitoring station per 5000 ha or per biotope.

- The survey period when data are collected must strive to be 100% (especially in autumn and spring to collect data during the migration and peak foraging and breeding times) but a minimum of 75% of one year of successful recording data for each site, covering all four seasons is acceptable. This is calculated as the average % recording time over all static monitoring stations deployed on the site over one year.
- Nightly monitoring periods must begin at sunset and end at sunrise and must record the entire night. These times can be obtained relatively accurately from appropriate software programs such as Wildlife Acoustic's Songmeter Configuration Utility or Chris Corben's Anasun Application.

Data analysis and Reporting

- Survey information must always be collected, recorded and analysed to meet the objectives set out in Section 2. All data collected must be analysed, rather than a subset of the data. As a minimum the following must be analysed and reported on:
- Median bat passes per hour per microphone per month and per annum.
- An indication of seasonal variation in species activity and composition across the site. Site-wide information on bat distributions may provide useful information on which species are using which parts of the site.
- Relative levels of bat activity recorded between 7-10 m and within the proposed turbine swept path area.
- Variations in activity and species composition at different wind speeds and other environmental parameters (e.g. temperature, barometric pressure and humidity) where these are available. This can be used to inform any future mitigation.

APPENDIX 2: How to determine the number of bat monitoring stations to install at a pre-construction WEF site

To determine the number of bat monitoring stations and microphones to use for a project, the developer must supply the specialist with a set AOI/ study area. The developer must ensure and understand that the bat monitoring and bat impact assessment in relation to turbine development only applies to that area, hence if the turbine layout is not certain, the largest possible area must be provided for the monitoring and assessment. Any turbine development outside of the provided AOI would constitute a new study or an extension to a study.

Whilst the intensive monitoring must occur within the AOI of the wind turbines, the assessment should consider the potential impacts of ancillary developments, like access roads, powerlines, etc. (if known) and account for any light pollution, removal of vegetation, etc.

A non-negotiable requirement of these guidelines is that at a pre-construction WEF site, bat activity must be monitored "at height" (i.e. within the rotor swept zone of proposed turbines). This should be augmented with monitoring of bat activity near (i.e. 7-10 m above) ground level, to also ensure that all "biotopes" (i.e. unique combinations of vegetation, land-use and topography) on site are adequately monitored. Microphones will, therefore, generally need to be installed on both "tall" (e.g. meteorological) and "short" masts. On tall masts, one or two microphones must be installed at height (depending on the height of the meteorological mast) and an additional microphone should also be installed near ground level. This will allow for paired recording on tall masts of bat activity at height and near ground level, and comparison of such data with that from any other tall and short masts on site.

At least one microphone must be installed at height for every 1-10 000 ha comprising a site. For sites with highly heterogeneous vegetation and/or terrain, additional microphones must be installed at height. Therefore, a homogenous 4 000 ha site will require one microphone at height, a homogenous 13 000 ha site will require two microphones at height, and a highly heterogenous 13 000 ha site will require three or more microphones at height.

In addition to the minimum number of microphones installed at height, at least one microphone must be installed near ground level (on a tall or short mast) for every 1-5 000 ha comprising a site or, for every significant biotope on site – whichever is greatest. To determine the number of biotopes on site, vegetation, land-use and terrain must be considered. Vegetation types should be sourced from Mucina and Rutherford (2006). Land-use types should be considered when significant portions of a site have been transformed by e.g. crop cultivation, livestock farming, or alien plant invasion. Vegetation and land-use will often be correlated with topography, and low-lying areas (e.g. ravines and floodplains) will often be associated with water. Empty buildings and human settlements can be assessed using roost surveys, mist-netting and acoustic spot surveys.

The following example demonstrates that when determining the number of monitoring stations to install at a pre-construction WEF site, both site size and habitat diversity must be considered.

Example

For a hypothetical 31 500 ha WEF site in the Karoo, bat activity should be monitored:

- At height, at a minimum of four stations, based on the following calculation: 31 500 ha / 10 000 ha per station = 3.15, which translates to 4 stations.
- Near ground level, at a minimum of seven stations, based on the following calculation: 31 500 ha / 5 000 ha per station = 6.3, which translates to 7 stations.
- At a minimum of 7 stations, IF monitoring is performed both at height and near ground level on a tall mast at four stations, and near ground level on a short mast at three stations, AND if monitoring is performed (at least near ground level) in each of the (five) biotopes on site (identified as shown in the table below). If not, additional stations will be required to ensure that monitoring is performed (at least near ground level) in each biotope.

Biotopes in a hypothetical Karoo WEF site

Vegetation / Land-use	**Terrain**		
	Rivers and wetlands	Undulating plains	Ridges
Tanqua Wash	1		
Riviere	1		
Tanqua Karoo		1	1
Cultivated fields		1	

APPENDIX 3: How to Calculate Comparable and Standardised Median Average Bat Passes per Hour Values per Month and per Annum

To start with, download Power Pivot for Excel at: https://www.microsoft.com/en-us/download/details.aspx?id=43348 (because median values are not provided by standard Excel PivotTables). Then, set up your data as follows:

- In Sheet1 of a blank Excel file, collate the following raw detector data in separate columns:
  - microphone height category (ground level or rotor sweep).
  - microphone ID (e.g. AL1 10m).
  - night (e.g. 2020/03/25).* See Appendix 3.1 for instruction how to obtain "night" dates from your original "day/date" column if you are not already working in a programme like Kaleidoscope that does it for you.
  - month (e.g. Mar, Aug, etc.) – by extracting this from the night using the formula =TEXT(C2;"mmm").
  - total bat passes per night.
  - total recording hours. * See Appendix 3.2 for instruction how to obtain the number of recording hours per night.
- In the last column, calculate the **average/ mean** bat passes per hour (bp/h) for the night by dividing total bat passes per night by total recording hours per night, you will get an bat passes per hour for each recording night.

Note: Sheet 1 MUST include all nights when recording occurred successfully, including nights when zero bat passes were recorded. It is recommended to also include nights when recording did not occur successfully, for the possible need to depict or assess the gaps in a monitoring study, and for the sake of consistency between different studies and consultants.

Most of the time, acoustic bat activity data are not normally distributed. Therefore, it is more appropriate to calculate **median** (as opposed to mean) bat passes per hour per month and/ or per annum. To do this:

- Select all the raw data and create a PivotTable with the data by choosing Insert>PivotTable>New Worksheet (Sheet2) and check: "Add this data to the Data Model."
- Go to Power Pivot>Measures>New Measure> then for Measure name type "Median" and under Formula, type and select =MEDIAN(BP/H) >OK.
- In the PivotTable Fields panel, check (tick) *fx* Median (so Median appears under Values), and drag and drop fields as follows:
- Columns: month
- Rows: height category, then microphone
- In the PivotTable, you will see for each height category: the median number of bat passes per hour recorded through each microphone during each calendar month.
- Copy and paste the PivotTable (EXCLUDING all Grand Total values) into a blank Sheet3 by selecting Paste Special>Values and number formats. (Grand Total values are automatically calculated for a specific microphone, or all microphones combined, represents the overall

median bp / h calculated from the raw data – NOT from the 12 (or fewer) month-specific median bp / h values – which is more accurate, especially if there are no data for certain months, or data for the same month from more than one year.

- Calculate separately for each height category, for all microphones combined, the median number of bat passes per hour for each calendar month, and for all calendar months combined, the median number of bat passes per hour for the full annual cycle, using the formula =MEDIAN().

Appendix 3.1 - How to Convert per "Date" data to per "Night" data

This only needs to be done if your software programme does not do it automatically for you.

- Take the output text file data (e.g. 10min outputs) from your software analysis programme (e.g. Analook or Kaleidoscope) and paste this into an excel spreadsheet. The four columns should be automatically be labelled: ''Day'; 'Time'; 'Label'; 'Number'.
- Add a new fifth column and label it 'Night'.
- Add the Filter function to all of the columns.
- With all data in the 'Time' column still selected, click 'conditional formatting' in the 'Home' tab, > 'highlight cell rules if', > 'Between', then change the times to '00:00' and any time after sunrise, e.g. '10:00', > select the colour you want those times to be highlighted then click ok. The times between midnight and 10am should now be highlighted.
- Click the 'Filter' icon in the 'Time' column, > 'Filter by colour', > 'No fill'. You should now only see times from sunset to 23:59.
- In the 'Night' column in the first cell below the column title, write the formula =B2 (B2 is the first cell in the 'Date' column) and press enter. (You don't want to change the dates from sunset to 23:59) Do this for all the rest of the cells below it.
- Click the 'Filter' icon in the 'Time' column, > 'Filter by colour', > select the cell colour that you used to highlight the times between '00:00 and 10:00', you should now only see times between 00:00 and 10:00. In the first cell in the 'Night' column type =XXX-1 (XXX is the 'Date' cell with a corresponding coloured time minus one). This changes the date to the same date as the start of that night. Do the same for the rest of the highlighted cells only.
- Click the 'Filter' icon in the 'Time' column, > 'Filter by colour', then uncheck the cell colour that you used to highlight the times between '00:00 and 10:00', you will now have per night data under the Night column.

Appendix 3.2 How to Calculate the Number of Recording Hours in the Night

- Assuming your detector is set to record constantly from sunset to sunrise, you can get the nightly hours for your site location from https://www.timeanddate.com/sun/@1020592 (this example is for Bedford, EC).
- The website table provides you with 'Daylength'. Change the daylength from hours, minutes seconds to decimal hours by multiplying the time by 24 and formatting the cell from time to number. Then, to get night hours, minus that figure from 24 (24 hrs). This will result in the decimal night hours between sunset and sunrise, assuming your detector was set to record constantly from sunset to sunrise.

- Important to note:
- You MUST minus any down time due to battery and mic problems.
- Furthermore, the detector location (GPS location) must have been set up correctly in the detector program for the times to be accurate.