Appendix 7.4

Bat Mitigation Plan

SCOTTISHPOWER RENEWABLES

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1 Introduction

1. The assessment of bat activity at Proposed Development concluded that pipistrelle bats (both common pipistrelle *Pipistrellus pipistrellus* and soprano pipistrelle *Pipistrellus pygmaeus,* hereafter referred to as “pipistrelle bats”) and *Nyctalus* bats are present in sufficient abundance that the Proposed Development is considered to pose a High risk to these bat populations (see **Chapter 7: Ecology and Biodiversity** and **Appendix 7.3 Bat Survey Report** of the EIAR).

2. As such mitigation measures are required to reduce the risk to bats during operation of the Proposed Development. This document describes the mitigation measures, method of implementation, auditing and monitoring programme which would be implemented during the operational phase of the Proposed Development. It also describes the process by which any changes to mitigation measures would be made as part of feedback from monitoring data.

2 Mitigation Measures

3. Although the relationship between recorded bat activity and fatalities at windfarm sites in the United Kingdom (UK) remains unclear (Mathews et al., 2016), ScottishPower Renewables (hereafter referred to as ‘the Applicant’) are able to infer this relationship to some extent by comparing activity data recorded at the Proposed Development to that collected from operational projects in the same region (i.e. south west Scotland) which have a known rate of bat fatalities.

4. The Applicant has conducted detailed acoustic and fatality monitoring of bats at ten operational windfarms and acoustic monitoring aligned to the 2019 Scottish Natural Heritage[1] (SNH) guidance (SNH et al, 2019) at three development phase projects. This combined dataset comprises data collected at 71 unique locations with static bat detectors deployed for a total of 1710 nights, providing a total sample size of 9367 detector nights of bat activity (sample unit = 1 detector/night) after some samples were removed due to equipment failure. Of these, 7269 samples are from nine projects in south west Scotland and were used for the analysis.

5. Carcass surveys have been undertaken at all ten of the operational windfarms using methods consistent with the Department for Environment, Food and Rural Affairs (DEFRA) study (Mathews et al., 2016). Of these, six were found to have zero bat fatalities, two had an “incidental” rate of fatality (considered to be <2 bat fatalities/wind turbine/year) and two had fatality rates greater than two bat fatalities/wind turbine/year.

6. The data collected at the ten operational windfarms indicates a relationship between bat activity and the rate of fatality. **Plate 7.4.1** shows the ten operational sites ranked by bat activity and colour coded by the category of fatality rate. Sites with higher activity tended to have higher rates of fatality.

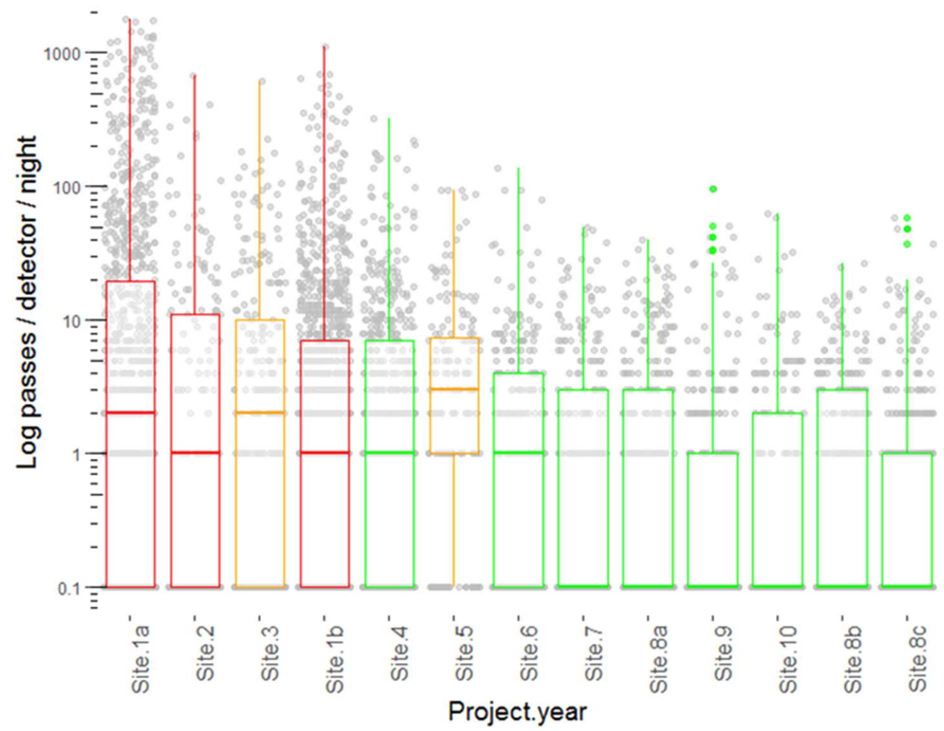

Plate 7.4.1 Operational windfarm sites ranked left to right in descending order of bat activity (recorded July – September), shown both as box plots of the overall dataset and individual samples as grey points. Red sites had >2 fatalities/wind turbine/year; amber sites had <2 fatalities/wind turbine/year; green sites had zero fatalities detected. The data only includes Pipistrelle and Nyctalus species

7. This dataset can be used as a reference for new projects by providing a comparison of bat activity within a region in a similar manner to Ecobat, but in addition it can benchmark activity rates for new projects against activity rates of sites with a known rate of bat fatality.

8. **Plate 7.4.2** and **Plate 7.4.3** show the number of pipistrelle and Nyctalus bat passes respectively per location per night at different percentiles compared to the same values derived from operational projects with different categories of bat fatality. From these data it is predicted that without mitigation, the bat activity at Proposed Development would generate fatality rates classified as per **Table 7.4.1**.

[1] Now known as NatureScot.

Detector Location	Pipistrelle Fatality Rate	Nyctalus Fatality Rate
21	Incidental-High	None
22	Incidental-High	None
23	None	None
24	Incidental-High	None
25	None	Incidental-High
26	Incidental-High	None
27	Incidental-High	None
28	None	None
29	Incidental-High	None
30	None	None
31	None	None
32	Incidental-High	None-High
33	None	None
34	Incidental-High	None

Table 7.4.1 Predicted Bat Fatality Rates for Each Detector Location in the Absence of Mitigation

9. Since the predicted bat fatality rate at most locations has the potential to be high for either one or both key bat genus, the mitigation measures would comprise curtailment of the operation of all wind turbines during certain weather conditions.

10. Based on work done at other operational windfarms in upland forested sites in south west Scotland, 90% of Pipistrelle bat activity occurs when wind speeds are below 5.5 m/s and temperatures are above 11 degrees Celsius at nacelle height (**Plate 7.4.4**). The curtailment would apply between 30 minutes post-sunset and 40 minutes pre-sunrise and would be activated once the weather condition parameters specified above are met. As such they would be used as the starting parameters for curtailing wind turbines at the Proposed Development. The mitigation measures would be implemented at each wind turbine between 1 April – 31 October each year for the lifetime of the Proposed Development unless monitoring results necessitate a change.

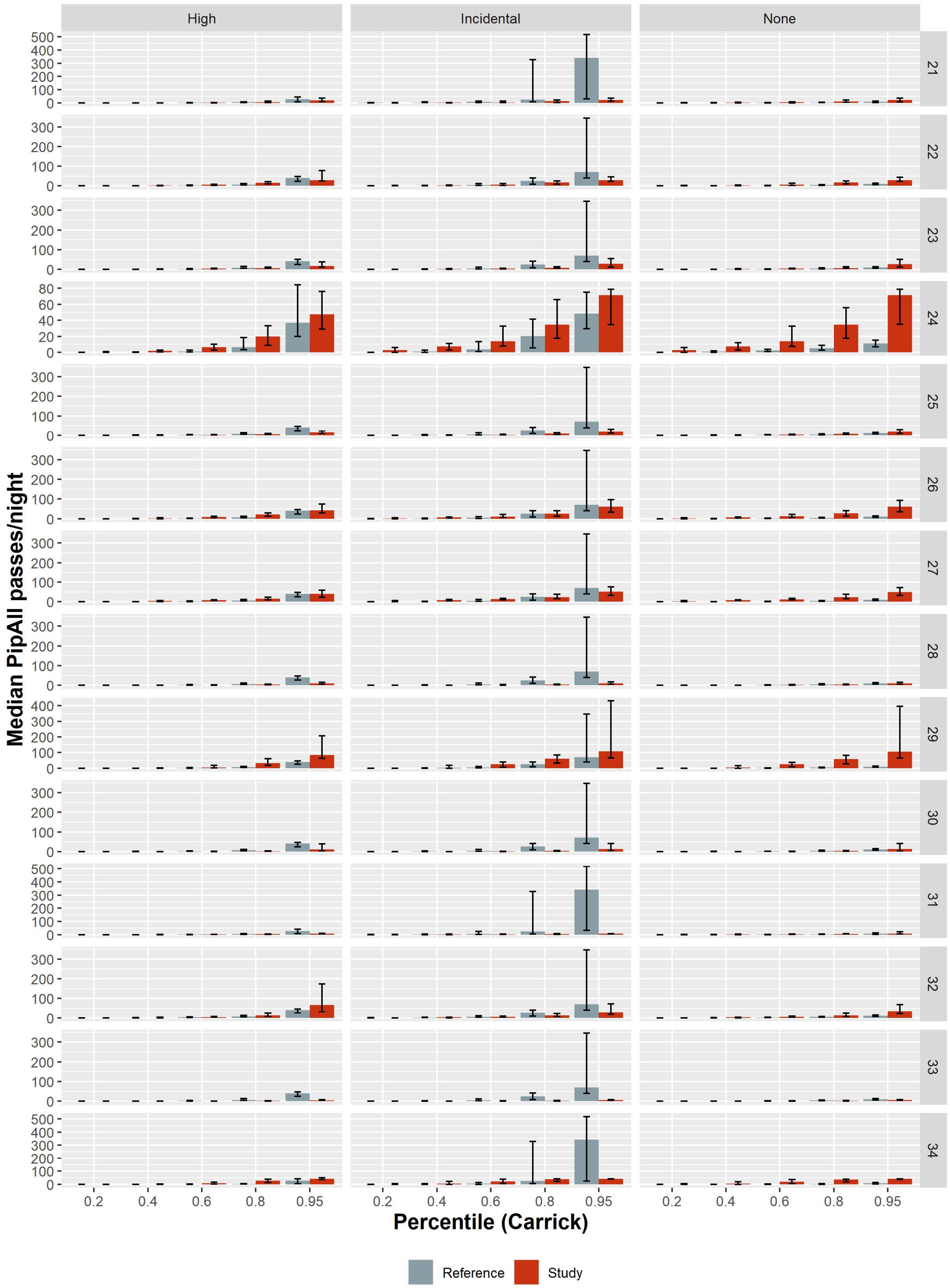

Plate 7.4.2 Number of pipistrelle bat passes per night per location at different percentiles compared to operational projects with a known category of bat fatality. Error bars are 95% Confidence Intervals derived using bootstrap methods due to non-normal distribution of the datasets

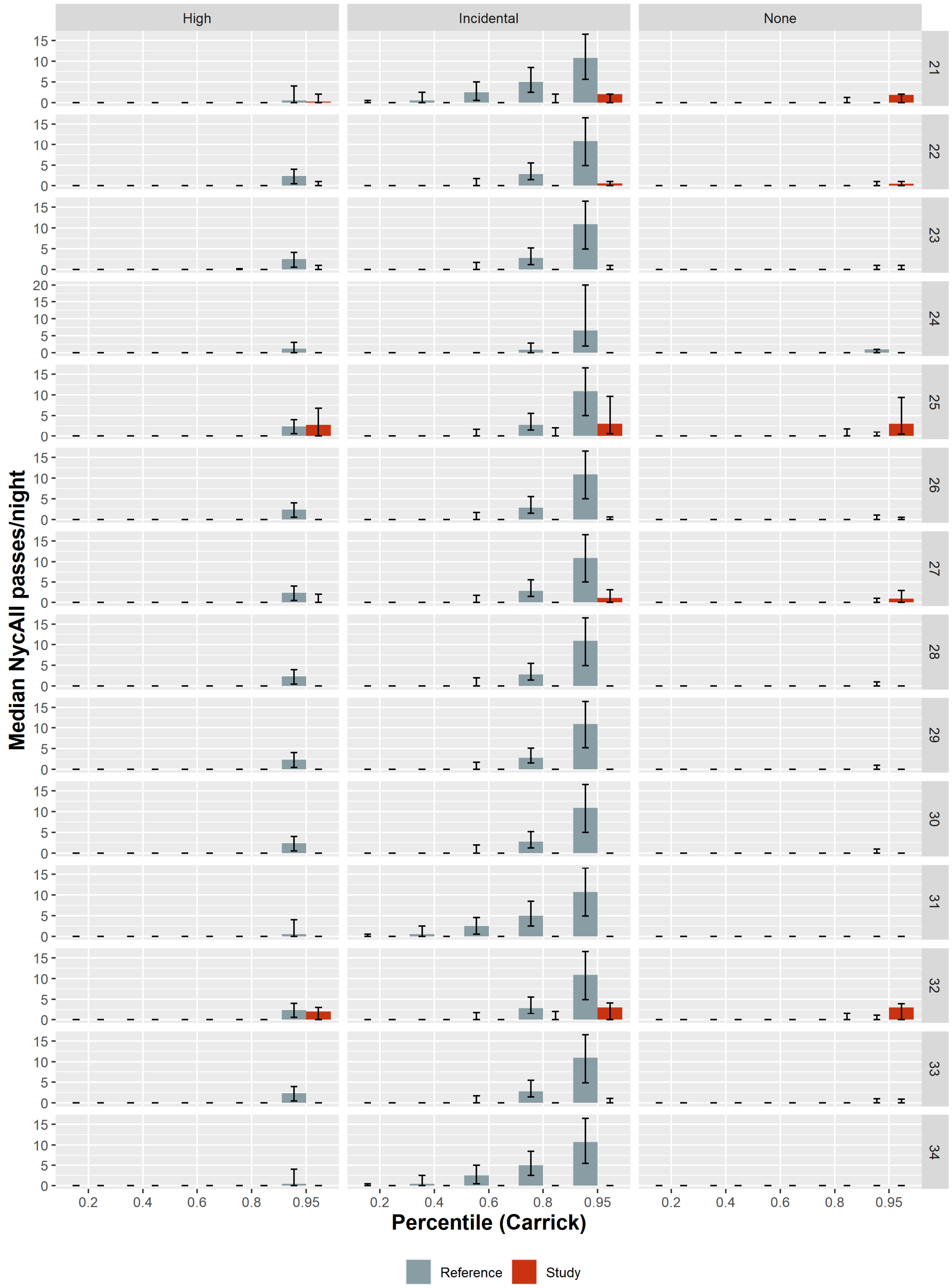

Plate 7.4.3 Number of Nyctalus bat passes per night per location at different percentiles compared to operational projects with a known category of bat fatality. Error bars are 95% CIs derived using bootstrap methods due to non-normal distribution of the datasets

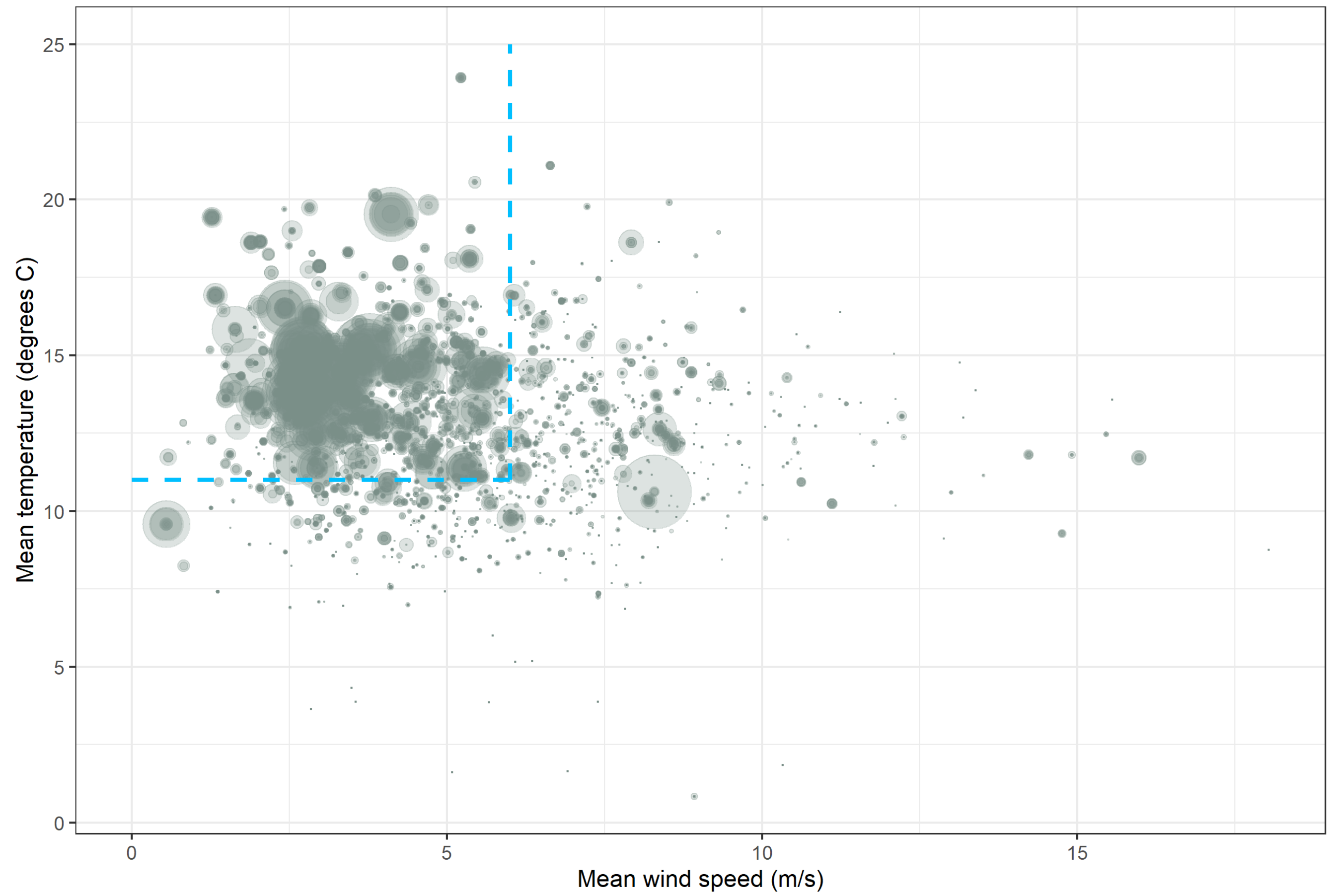

Plate 7.4.4 Typical pattern of bat Pipistrelle activity compared to wind speed and temperature parameters measured at upland operational windfarms in south west Scotland. The dashed lines indicate the 5.5m/s windspeed and 11 degrees Celsius thresholds which correspond with circa. 90% of all activity

3 Implementation

11. The implementation of the mitigation would be via software which would automatically send a “pause” command to the relevant wind turbine when the parameters are met, initiating a feathering of the blades to the fully open position using the pitch controls and disengagement of the generator. This would slow the rotation speed of the blades to below one revolutions per minute (RPM) (i.e. slower than the second hand of a clock). The emergency braking system shall not be used.

12. The wind speed would be obtained from each wind turbine anemometry apparatus (on the nacelle) via the Supervisory Control and Data Acquisition (SCADA) interface. The control software will run within the proprietary SPR Centre of Operation of Renewable Energy (CORE) system.

13. This method of control has already been established and is used for another SPR windfarm, **Image 5** is a screenshot of the parameter input window for this project within CORE. Note that the example includes a parameter for temperature which can be used if curtailment is required, as well as offsets for sunset and sunrise if required.

14. Note that in the example of **Image 7.4.1** there is a “Speed Lo limit” of 5.5 m/s, below which the wind turbine would enter a “pause” state, and a “Speed Hi Limit” of 5.6 m/s above which the wind turbine would “run”. The reason for this is to stop the wind turbine rapid cycling between “pause” and “run” when the wind speed is averaging 5.5 m/s.

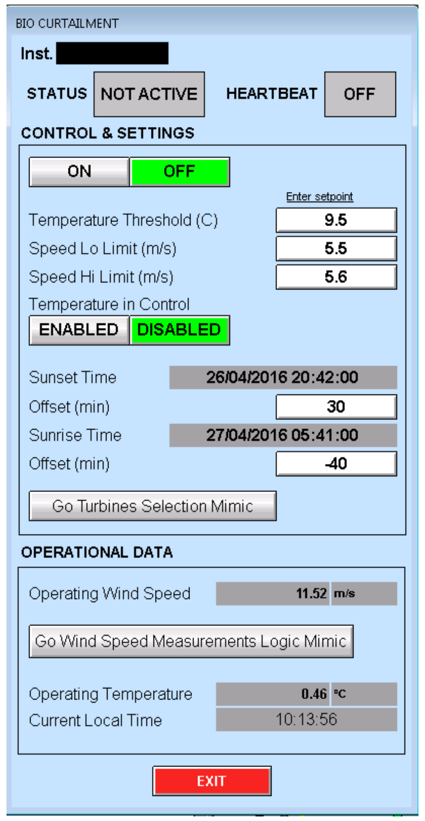

Image 7.4.1 Screenshot of the curtailment parameter input window within CORE in use for another SPR windfarm

4 Auditing

15. All wind turbine sensor data reported via SCADA is logged in a PI database[2]. This includes the wind speed and temperature data recorded at each wind turbine anemometry, as well as a TRUE/FALSE flag as to whether the mitigation system was in operation. As such it is a simple process to download the data over any period to validate that the system was operating according to the chosen parameters. An example of this output for another SPR windfarm is displayed in a graphical format in **Plate 7.4.5**. A similar output would be included in the annual report of the system operation for the Proposed Development.

[2] PI is a commercial product of OSISoft: https://www.osisoft.com/pi-system/.

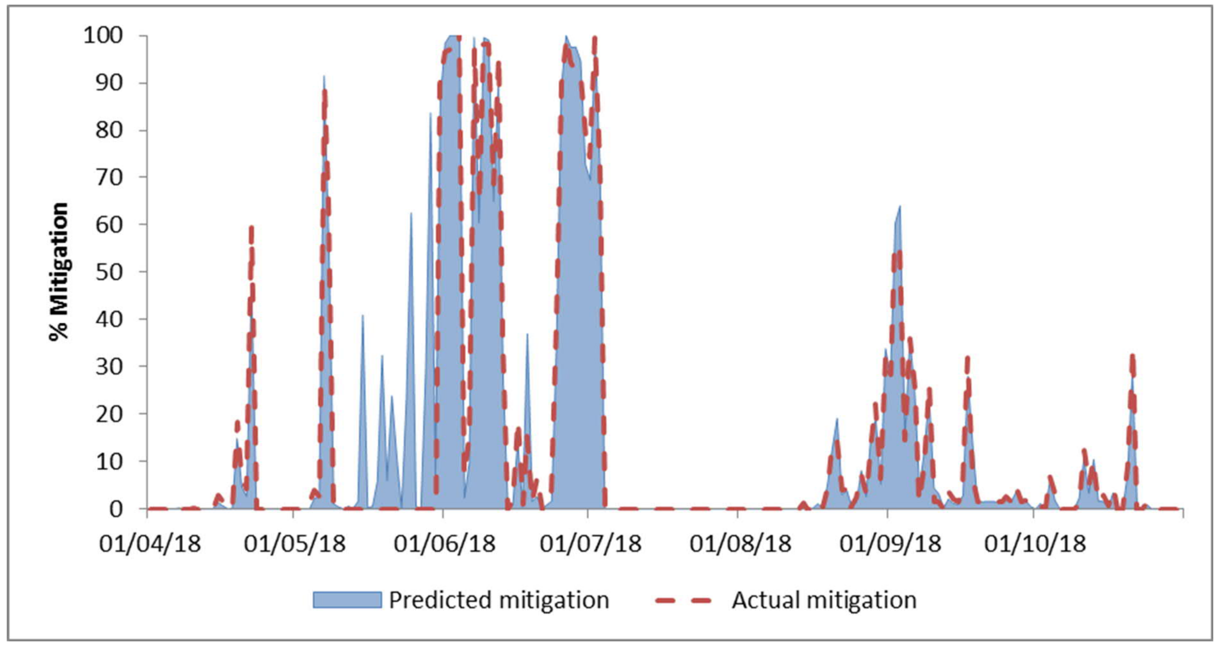

Plate 7.4.5 Example output of the auditing available from wind turbine SCADA data for another SPR windfarm in 2018. The blue shaded areas show the predicted mitigation (based on weather data) and the red dashed line shows the actual mitigation implemented during each night automatically by the CORE software. Data not available during two periods of site outage 9 – 29 May and 5 July – 12 August, when wind turbines were non-operational

5 Monitoring

5.1 Rationale and Objective

16. Monitoring would comprise measurement of bat activity and fatality rates and would be undertaken annually until validation of the initial parameters and any amendments are established in consultation with NatureScot.

17. The maximum increase to natural mortality due to bat fatalities which is considered unlikely to have a significant impact on bat populations, and therefore deemed 'incidental', is considered to be two bat fatalities per wind turbine per year. This is based on fatality thresholds applied at German windfarm sites (irrespective of species present) and is achievable without excessive losses in power production (yield) (Behr, 2015 and Wind Bat website[3]). Due to the limited data available on bat populations and bat ecology in Scotland it is not possible to predict exact impacts on bat populations, therefore applying a fatality value from within a European context is the best currently available method of establishing a threshold.

18. The basis of "incidental" levels of bat mortality arising from windfarm operation being criminal was considered in RWE vs Eaton 2012 in England, which ruled that a threshold of bat fatalities must exist to enable legitimate activities to take place.

19. The objective of the monitoring is to provide a robust estimate of the total number of bat fatalities, which would be used to determine whether the mitigation is effective. There is no specific objective to determine the specific weather conditions under which a fatality may have occurred, since the hypothesis at Year One is that the mitigation would

[3] http://www.windbat.techfak.fau.de/tools/index_en.shtml ProBat tool used in Germany to help select curtailment parameters to achieve <2 fatalities / wind turbine / year.

be effective. As such the proposed sampling approach varies from that suggested in Appendix 4 of the guidance (SNH et al, 2019).

5.2 Overview

20. The survey methodology would comprise static bat detectors at six randomly selected wind turbines during July – September inclusive which is when most fatalities are found to occur. This represents a precautionary approach in that if bat fatality rates are sufficiently low during this period, they are highly unlikely to be greater at other times of year. Therefore, if the mitigation is effective during this period, it would be effective during periods of lower levels of activity. The use of six wind turbines is considered to provide a representative sample (46% of wind turbines sampled) and is coincident with the number of wind turbines which can reliably be searched for bat carcasses by a dog team in a single day.

21. Microphones would be mounted at 2m above ground level and positioned horizontally facing away from wind turbine towers.

22. Carcass searching would be undertaken within a 50m radius at the same six wind turbines every two weeks from 1 July until end of September i.e. seven searches in total. An example search schedule, which was used for the worked example below, is shown in **Table 7.4.2**. The search schedule will be adapted, should wind turbines be non-operational or not revolving during the night prior to the scheduled search.

23. A worked example of the expected parameter estimation and resulting precision of estimates is described below.

Search Date	T1	T2	T3	T4	T5	T6
1 July	1	1	1	1	1	1
15 July	1	1	1	1	1	1
29 July	1	1	1	1	1	1
13 August	1	1	1	1	1	1
27 August	1	1	1	1	1	1
10 September	1	1	1	1	1	1
24 September	1	1	1	1	1	1

Table 7.4.2 Example Search Schedule Using 14 Day Search Interval

5.3 Estimates and Precision

24. All sampling methods are a pragmatic compromise, and an acceptable threshold for the precision of the estimates must be made. The precision of fatality estimates is based on four key factors: carcass persistence rate; observer efficiency rate; search interval and proportion of area searched.

25. The median carcass persistence rate for bat carcasses at other SPR sites from n=111 trials has been estimated at 15.41 days[4]. This may vary at the Proposed Development, and as such would be estimated across each monitoring period by placing n=5 bat carcasses distributed randomly below each of the n=6 wind turbines to be searched during each survey (i.e. n=30 bat carcasses trials in total). Each carcass would also be paired with a motion activated camera-trap, which would provide the exact timing as to when a carcass is removed. The carcasses will then be checked manually on the following survey and left in-situ if remains are still visible for a maximum of four weeks (i.e. two survey periods) then retrieved.

26. The search methodology would aim to achieve an observer efficiency rate of >80% (i.e. 80% of carcasses which are present are detected) and would calculate this using integrated trials of the n=30 carcasses placed to determine carcass persistence. Previous work at SPR sites using trained dog teams (and for the DEFRA study) has demonstrated that an observer efficiency rate of >0.81 is achievable. It is assumed that 95% of the area under the wind turbines would be searched since there are no ground conditions at the Proposed Development which would restrict access, although this would be checked during surveys. Based on these parameters and a 14 day search interval (i.e. every two weeks), a median estimate of 63.1% (95% CI 56-68.7%)[5] of carcasses which exist would be detected.

27. Based on the above parameters, if n=4 carcasses were found the adjusted median total fatality estimate would be 14.11, with a 90% confidence interval between 4.5 and 24.76[6] (**Plate 7.4.6**).

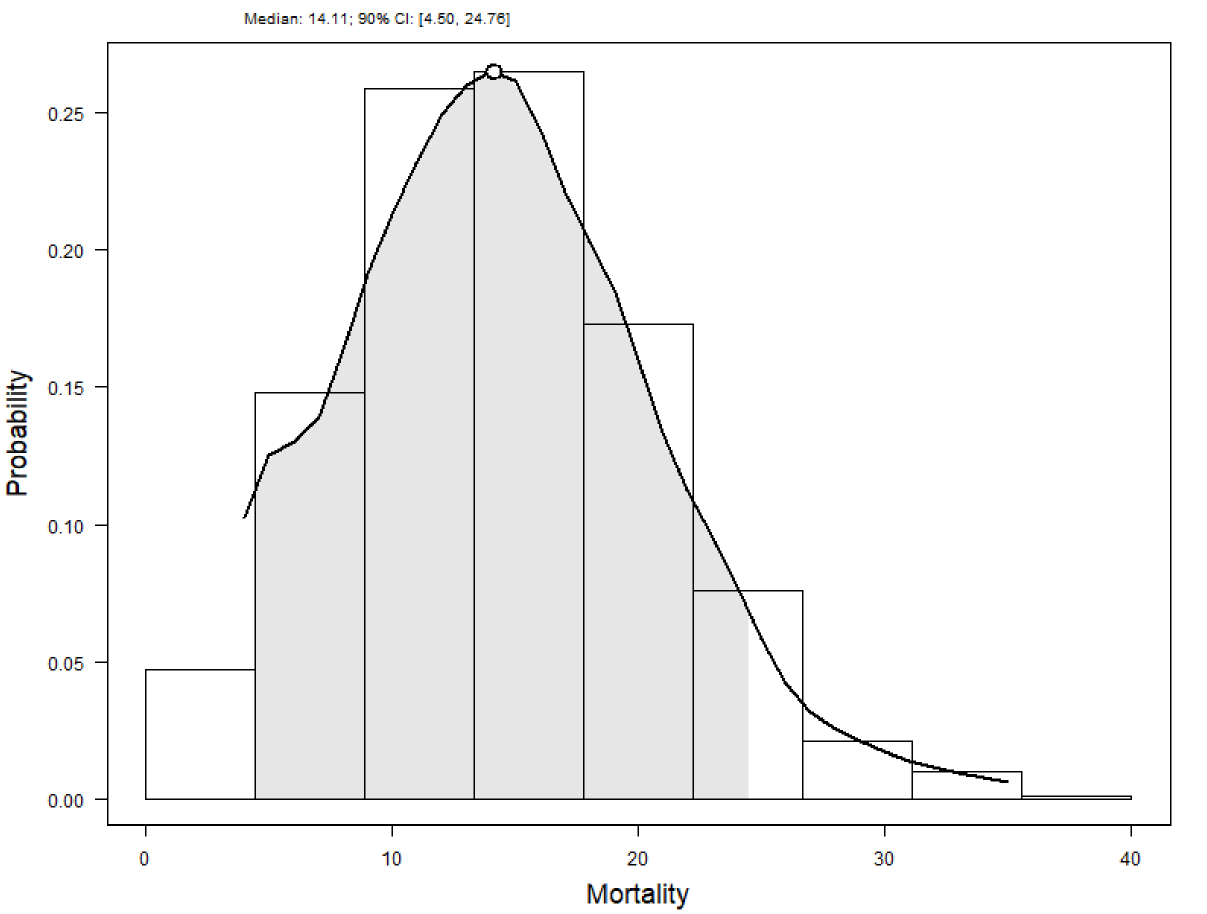

Plate 7.4.6 Probability distribution of estimates of true fatality rate based on the monitoring design described and a scenario where 4 carcasses are found

28. Therefore, in order to be 95% confident that the true fatality rate is less than two bats per wind turbine per year (i.e. n=26 fatalities), four or fewer bat carcasses must be detected within the total search area using the survey methodology outlined above.

[4] Calculated using GenEst "Carcass persistence" package, lognormal model.
[5] Calculated using GenEst "Detection Probability" package.
[6] Calculated using GenEst "Mortality Estimation" package.

5.4 Analysis

29. Detailed analysis of the results would be undertaken using the USGS developed Generalised Mortality Estimator software[7], which combines different accepted methods of calculating fatalities into a single tool and allows different models to be fitted to datasets depending on their distribution. It also combines the calculation of different sources of error around each parameter into an estimate of uncertainty around the final estimate.

5.5 Change Management

30. Following each annual monitoring period, if the number of bat fatalities is less than two bats per wind turbine per year, the operator shall be entitled to propose amendments to the curtailment parameters. If the number of bat fatalities is greater than two bats per wind turbine per year, the operator shall be obligated to propose amendments to the mitigation. Any changes proposed would be consulted on with NatureScot and implemented the following year with repeated monitoring using the methods described above unless otherwise varied (e.g. to investigate conditions in which fatalities are occurring).

6 References

Behr, O. (2015). 'Bat-friendly' operation of wind turbines – the current status of knowledge and planning procedures in Germany. Presentation at Wind Power and Wildlife Symposium, Stirling University.

Mathews, F., S. Richardson, P. Lintott and D. Hosken (2016). Understanding the Risk to European Protected Species (bats) at Onshore Wind Turbine Sites to inform Risk Management. Final Report. University of Exeter.

SNH, Natural England, Natural Resources Wales, Renewable UK, ScottishPower Renewables, Ecotricity Ltd, the University of Exeter & Bat Conservation Trust (BCT) (2019). Bats and Onshore Wind Turbines: Survey Assessment and Mitigation.

Windbat 2016, Federal Ministry for Economic Affairs and Energy Germany, accessed 8th May 2019, www.windbat.techfak.fau.de/tools/index_en.shtml.

[7] https://www.usgs.gov/software/genest-a-generalized-estimator-mortality.

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