



Carrigeen Renewable Energy Development

Collision Risk Modelling

DEC Ltd.

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1 INTRODUCTION

Collision Risk Modelling has been completed for the Carrigeen Renewable Energy Development to inform the impact assessment to key ornithological receptors identified for the proposed Project.

During more than 3 years of baseline flight activity vantage point survey monitoring for the Wind Farm Site a total of 14 no. species were identified as key ornithological receptors. The location of the four no. vantage points and the associated viewshed from these four vantage points are shown on **Figure 1**. The 14 no. species are as follows:

Buzzard; Cormorant; Greater Black-Backed Gull; Grey Heron; Hen Harrier; Kestrel; Lesser Black-backed Gull; Mallard; Merlin; Sparrowhawk; Short-eared Owl; Snipe; Teal; and Whooper Swan.

As per NatureScot 2025 Guidelines it is the data gathered during the flight activity vantage point surveys that is to be used for the Collision Risk Model (CRM) to predict mortalities from collision with the Wind Turbines. The NatureScot (2025) guidelines go on to state that the area of the flight activity survey should extend to 500m beyond the outermost Wind Turbines. As such all flight activity associated with target species occurring within 500m buffer of the Wind Turbines (i.e. the Flight Survey Area (FSA)) are included in the model. The extent of the FSA is shown on **Figure 1**.

Of the 14 target species observed during the flight activity vantage point surveys, flight activity for all species was recorded within the FSA.

Of the 14 no. species recorded in flight within the FSA, 13 have been recorded flying within the potential collision height (PCH) of the rotor swept area (RSA).

No flight associated with Short-eared Owl was recorded flying within the potential collision height of the RSA and as such this species is excluded from the model. Therefore collision risk modelling has been undertaken for the remaining 13 no. species that have been recorded at PCH within the FSA.

The CRM has been completed in line with NatureScot (Band, 2024) guidelines.

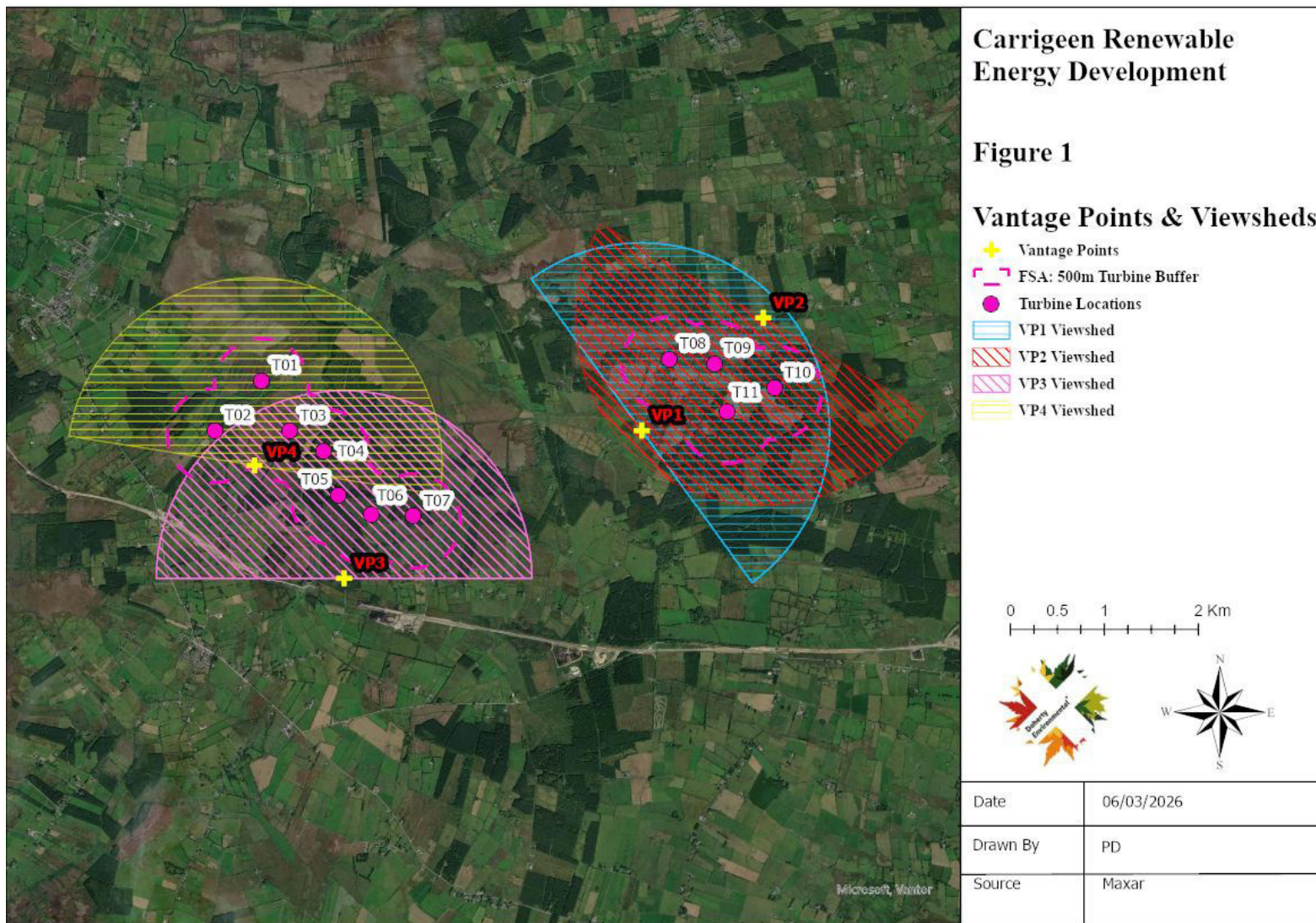


Figure 1 Vantage Points and Viewsheds

1.1 BAND 2024 MODEL NORMAL APPROACH

The current CRM recommended by NatureScot, as published by Band (2024) comprises 5 no. stages that ultimately provide an estimate of the number of collisions for the subject species with a Wind Turbine. The 5 no. stages are:

Stage A: Bird survey data recorded during the flight activity surveys are used to establish the density of flying birds in the vicinity of the Wind Turbines, and the proportion flying at PCH.

Stage B: Uses the bird density and proportion at risk height outputs from Stage A to estimate the potential number of bird passages through rotors in the period in question.

Stage C: Calculates the probability of collision during a single bird rotor transit.

Stage D: Estimates the potential collision rate for a bird species, assuming current levels of bird use of the site, allowing for the proportion of time that Wind Turbines are not operational.

Stage E: Estimates the potential collision rate for a bird species taking into account the proportion of birds likely to avoid the wind farm or its Wind Turbines, either because they have been displaced from the site or because they evasive action or are attracted to the wind farm, e.g. in response to changing habitats. The rate of avoidance for bird species is provided by NatureScot (2025) and these rates are used in the model.

2 BASELINE DATA

The primary input data used for the completion of the model has been derived from the following:

- Wind farm vantage point surveys completed for the proposed Wind Farm Site over a 3.5-year period, spanning 3 no. non-breeding seasons (2022/2023; 2023/2024; and 2024/2025) and 4 no. breeding seasons, spanning 2022; 2023; 2024; and 2025.
- Area of wind farm vantage point viewshed at 22m height and greater.
- Bird metrics for key ornithological receptors for which CRM has been completed, sourced from BTO Bird Facts website;
- Turbine specifications for Nordex N163 with a blade pitch of 6 applied for the model;
- The percentage at which time the Wind Turbines will be operational during the operation phase of the Project; and
- Nocturnal flight activity factor based on the following:
 - **Buzzards, Hen Harrier, Kestrel, Merlin & Sparrowhawk** are diurnal raptors, with activity largely confined to daylight hours. These species rely on visual cues, which limits its effectiveness at night. In view of this a nocturnal activity factor of 1 has been applied for the raptor species collision modelling.

- **Cormorant** are generally inactive at night and a nocturnal activity factor of 1 has been applied for the Cormorant collision modelling.
- **Grey Heron** night time activity is considered to be low with this species generally occupying roosts at night. Van Vesseem & Draulans (1987) recorded low levels of night time flight activity by Grey Heron. In view of this a nocturnal activity factor of 2 has been applied for Grey Heron.
- **Mallard** and **Teal** are known to be active during night time, with Korner *et al.* (2016) showing nocturnal activity to be c. 50% of overall daytime activity during their investigation of Mallard diel activity patterns. In view of this finding a nocturnal activity factor of 3 has been applied for Mallard with the same rate being applied to Teal.
- **Snipe** are active during crepuscular and nocturnal periods of the day and as such a nocturnal activity factor of 5 has been applied when modelling the impact to snipe
- **Whooper Swan** activity during the non-breeding season in Ireland is largely confined to daylight hours. These species rely on visual cues, which limits its effectiveness at night. In view of this a nocturnal activity factor of 1 has been applied for the raptor species collision modelling.
- **Gulls** are generally considered diurnal, but several species particularly larger gulls like lesser black-backed and Greater Black-Backed Gull, exhibit notable nocturnal activity, especially in coastal and urban environments. Garthe & Huppop (2004) assigned a nocturnal activity factor of 3 for both Lesser Black-backed Gull and Greater Black-Backed Gull. Whilst this factor was assigned with respect to the marine environment, it is used for the purpose of this CRM.

2.1.1 Wind Farm Vantage Point Survey Flight Data

The flight data gathered during the vantage point survey for inclusion within the CRM is the flight activity for the 13 species observed in the FSA at potential collision height of the RSA. This flight activity data was collected over 7 seasons from the 2022 breeding season to the 2205 breeding season inclusive. The RSA of the Project Wind Turbines is 22m to 185m. During the flight activity vantage point survey flight activity was assigned to the following three no. height bands: 1 = <20m; 2 = 20m to 200m; and 3 = >200m. As such only flights recorded within the height band 2 (20m to 200m) fall within the RSA and in accordance with the NatureScot guidelines it is these observations that are only required to be incorporated into the CRM. However, given the approach set out above with regard to flightlines (i.e. where the entirety of individual flightlines that includes sections of the flight outside as well as inside the 500m buffer, the entire flight has been included in the model) a similar approach has been adopted for flight line inclusion within the RSA, with the entirety (i.e. all seconds) of any flight where a portion of that flight was recorded at RSA being included in the model. This represents a worst-case scenario approach as it over-estimates the actual time of flight within the FSA observed at RSA height.

It is further noted that all flight activity within the 20m to 200m band, which includes a 15m band above the RSA has been included for modelling. This approach again leads to some minor over-estimation of the duration of flight activity included in the model.

2.1.2 Area of Wind Farm Viewshed

The area of the wind farm vantage point VP1 to VP4 viewsheds at a height of 20m are as follows:

VP1: 2.2km²

VP2: 2.2km²

VP3: 2.6km²

VP4: 2.1km²

2.1.3 Flight Activity Vantage Point Watch Time

The watch time for the flight activity vantage point surveys provided in **Table 1** below.

Table 1: Monthly Watch Time (in Seconds) from Vantage Points

VP1 Monthly VP Watch Time (Seconds)											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
75,600	75,600	75,600	75,600	75,600	75,600	75,600	75,600	75,600	75,600	75,600	75,600
VP2 Monthly VP Watch Time (Seconds)											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
75,600	75,600	75,600	75,600	75,600	75,600	75,600	75,600	75,600	75,600	75,600	75,600
VP3 Monthly VP Watch Time (Seconds)											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
75,600	75,600	75,600	75,600	75,600	75,600	75,600	75,600	75,600	75,600	75,600	75,600
VP4 Monthly VP Watch Time (Seconds)											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
75,600	75,600	75,600	75,600	75,600	75,600	75,600	75,600	75,600	75,600	75,600	75,600

2.1.4 Bird Metrics & Nocturnal Flight Activity Factor

The bird metrics and nocturnal flight activity factor for each of the 4 no. species are set out in **Table 2** below.

Table 2: Bird Metrics

Species	Length [m]	Wingspan [m]	Speed [m/s]	Flight Type	Nocturnal Factor
Buzzard	0.54	1.2	11.6	Flapping	0%
Cormorant	0.9	1.45	15.2	Flapping	0%
Greater Black-Backed Gull	0.64	1.59	13.7	Flapping	50%
Grey Heron	0.94	1.85	11.2	Flapping	25%
Hen Harrier	0.48	1.1	9.1	Flapping	0%
Kestrel	0.34	0.76	10.10	Flapping	25%

Species	Length [m]	Wingspan [m]	Speed [m/s]	Flight Type	Nocturnal Factor
Lesser Black-backed Gull	0.58	1.43	13.4	Flapping	50%
Mallard	0.58	0.9	18.5	Flapping	50%
Merlin	0.28	0.56	10.1	Flapping	0%
Sparrowhawk	0.33	0.62	11.3	Flapping	0%
Snipe	0.26	0.46	17.1	Flapping	100%
Teal	0.36	0.61	19.7	Flapping	50%
Whooper Swan	1.52	2.3	17.3	Flapping	0%

2.1.5 Turbine Specifications

The turbine specifications for the Nordex 5.7 MW N163 model are set out in **Table 3** below.

Table 3: Turbine Specifications

Turbine Parameter	Value
Hub height	103.5m
Rotor Radius	81.5m
No. of Blades	3
Rotation Speeds	15.89rpm ¹
Max. Blade Width	4m
Blade Pitch	6 degrees

2.1.6 Operating Turbines

For the purposes of the CRM the percentage time at which the Wind Turbines will be operation is set at 85%.

3 RESULTS

3.1.1 Stage A: Flight Activity

This stage estimates the number of flights that would be potentially at risk from the proposed Wind Turbines in the absence of the birds being displaced or taking other avoiding action.

¹ A rotation speed of 15.89 has been used in the model but the actual rotation speed of the turbines is predicted to be less within the range of 6 to 11.8rpm. As such the use of the 15.89rpm speed represents a worst-case scenario

Two key parameters derived from survey observations are required to describe the degree of flight activity. These are:

Areal Bird Density D_A ; and

Proportion of birds flying at risk height (Q_{2R}).

Areal Bird Density D_A is calculated by dividing the number of flight seconds recorded for the species within the FSA (denoted as **b**) by a combination of the duration of the vantage point survey effort (denoted as **t**) and the area of the viewshed in km^2 (denoted as **A**).

The equation is $D_A = b/(t \times A) \text{ birds m}^{-2}$

Proportion of birds flying at risk height (Q_{2R}) is the proportion of flight activity recorded in the RSA. Given the approach to identifying flight activity within the RSA as set out in Section 2 above, Q_{2R} represents the percentage ratio between flight activity observed in the FSA and flight activity assigned to the RSA.

The density of key ornithological receptors subject to Collision Risk Modelling and their proportion of flight at rotor risk height is provided in **Table 4** below.

Table 4: Bird Density & Proportion of Flight at Rotor Risk Height

Species	Density (D_A) (Birds/ KM_2)	Proportion of Flight at Risk Height (Q_{2R}) (%)
Buzzard	0.0004	96.32
Cormorant	0.0000044	100
Greater Black-Backed Gull	0.0000054	100
Grey Heron	0.0000206	47.6
Hen Harrier	0.0000009	20
Kestrel	0.0003285	84.5
Lesser Black-backed Gull	0.0000182	80
Mallard	0.0000782	65.8
Merlin	0.0000009	33.3
Sparrowhawk	0.0000023	25
Snipe	0.0000015	14.3
Teal	0.0000028	50
Whooper Swan	0.0000233	100

3.1.2 Stage B: Estimating No. of Rotor Transits

The estimated no. of transits predicted annual transits for each species through the rotor swept area is provided in **Table 5** below.

Table 5: Projected No. of Rotor Transits

Species	No. of Transits
Buzzard	140
Cormorant	1
Greater Black-Backed Gull	3
Grey Heron	4
Hen Harrier	0.05
Kestrel	85.6
Lesser Black-backed Gull	6.7
Mallard	38.1
Merlin	0.06
Sparrowhawk	0.2
Snipe	0.16
Teal	0.5
Whooper Swan	9.1

3.1.3 Stage C: Probability of Collision for a Single Rotor Transit

The likelihood of a bird colliding with a rotor whilst flying through the rotor swept area is set out for each of the 13 no. species below.

Table 6: Probability of Collision for a Single Rotor Transit

Species	No. of Transits (%)
Buzzard	6.77
Cormorant	7.76
Greater Black-Backed Gull	8.26
Grey Heron	9.18
Hen Harrier	7.38
Kestrel	5.76
Lesser Black-backed Gull	6.97

Species	No. of Transits (%)
Mallard	5.52
Merlin	6.16
Sparrowhawk	5.34
Snipe	4.19
Teal	4.64
Whooper Swan	10.03

3.1.4 Stage D: Predicted Collisions with No Avoidance

Assuming an operational ratio of the turbines of 85% the results of Stage B and Stage C can be combined to provide a predicted annual average collision rate. **Table 7** sets out the predicted average annual no. collisions for each species.

Table 7: Predicted Average Annual No. of Collision

Species	No. Predicted Collisions before Avoidance (%)
Buzzard	8
Cormorant	0
Greater Black-Backed Gull	0
Grey Heron	0
Hen Harrier	0.003
Kestrel	4.19
Lesser Black-backed Gull	0.4
Mallard	1.79
Merlin	0.003
Sparrowhawk	0.009
Snipe	0.006
Teal	0.02
Whooper Swan	0.78

3.1.5 Stage E: Predicted Collision with Avoidance

NatureScot guidelines (NatureScot, 2018; 2025) provide guidance on the use of avoidance rates for collision risk assessment. The recommended NatureScot avoidance rate for each of the 13 no. species subject to the CRM are listed in **Table 8** below.

Table 8: NatureScot Recommended Avoidance Rates

Species	NatureScot Recommend Avoidance Rate
Buzzard	98%
Cormorant	98%
Greater Black-Backed Gull	99.5%
Grey Heron	98%
Hen Harrier	99%
Kestrel	95%
Lesser Black-backed Gull	99.5%
Mallard	98%
Merlin	98%
Sparrowhawk	98%
Snipe	98%
Teal	98%
Whooper Swan	99.5%

*NatureScot guidelines do not provide a recommended avoidance rate for all species. The NatureScot guidelines state that for species for which no recommended avoidance rate is assigned "we recommend a default value of 98%".

Collision risk has been completed for avoidance rates at 95%; 98%; and 99% for each of the 13 no. species. Collision risk has been completed at the recommended avoidance rates of 95%, 98%, 99%, & 99.5%.

Table 9 sets out the predicted no. of collisions per year with respect to each of the relevant avoidance rates listed above.

Table 9: Predict No. of Collision per Year with Avoidance

Species & Collision/Year	95%	98%	99%	99.5%
Buzzard	0.4	0.16	0.081	0.04
Cormorant	0.005	0.002	0.001	0.000
Greater Black-Backed Gull	0.0089	0.0035	0.0018	0.0009

Species & Collision/Year	95%	98%	99%	99.5%
Grey Heron	0.0143	0.0057	0.0029	0.0014
Hen Harrier	0.0002	0.0001	0.0000	0.0000
Kestrel	0.2096	0.0839	0.0419	0.0210
Lesser Black-backed Gull	0.0199	0.0080	0.0040	0.0020
Mallard	0.0894	0.0357	0.0179	0.0089
Merlin	0.0002	0.0001	0.0000	0.0000
Sparrowhawk	0.0004	0.0002	0.0001	0.0000
Snipe	0.0003	0.0001	0.0001	0.0000
Teal	0.0011	0.0004	0.0002	0.0001
Whooper Swan	0.0389	0.156	0.0078	0.0039

Table 10 sets out the predicted no. of collisions for each species over a 35-year life span of the proposed Project. The rates set out in **Table 10** are derived from the annual collision risk based upon the recommended avoidance rates as highlighted in bold text in **Table 9** above.

Table 10: Predict No. of Collision based on 35-year Operational Lifetime

Species & Collision/Year	Annual Collision Risk	Collision over Lifetime of Wind Farm
Buzzard	0.16	5.6
Cormorant	0.002	0.07
Greater Black-Backed Gull	0.0009	0.0315
Grey Heron	0.0057	0.2
Hen Harrier	0.0000	0

Species & Collision/Year	Annual Collision Risk	Collision over Lifetime of Wind Farm
Kestrel	0.0839	2.94
Lesser Black-backed Gull	0.002	0.07
Mallard	0.0357	1.25
Merlin	0.0001	0.0035
Sparrowhawk	0.0002	0.007
Snipe	0.0001	0.0035
Teal	0.0004	0.014
Whooper Swan	0.0039	0.1365

3.1.6 Stage F: Expressing Uncertainty

The updated Band Guidelines (NatureScot, 2024) include this stage as the last stage in the CRM. The guidelines noted that collision risk modelling, as per the method set out therein and used for this CRM, are underpinned by sources of variability or uncertainty. Uncertainty within the CRM arises from multiple sources, including variability in input parameters, limitations in empirical data, and simplified structural assumptions underpinning the model. Key parameters contributing to uncertainty typically include site-specific bird activity levels, bird flight height distributions, avoidance rates and Wind Turbine specifications.

Uncertainty relating to bird activity and populations has been minimised by collecting data over multiple years, well in excess of the minimum recommended requirement of 2 years or 4 seasons. The collection of this data by experienced surveyors provides a robust dataset for site-specific bird activity. Throughout the vantage point surveys, the recording of flight height data has also been stream-lined into three height bands in order to maximise the accuracy of the flight heights recorded. The use of this robust dataset is considered to be minimise the level of uncertainty associated with the models predicted annual species-specific activity. It is noted that due to current practical limitations nocturnal vantage point surveys have not been completed and as such there is uncertainty with regard to nocturnal activity across the site, particularly with regard to those species (e.g. snipe) that are known to be active at night. It is noted that the recommended nocturnal activity flight factor, which has been introduced as part of the updated 2024 model, have been used to minimise uncertainty relating to nocturnal flight activity. With the above in mind, it is considered that any uncertainty relating to the dataset used for the collision risk modelling is of $\pm 20\%$.

The CRM is based on a simplified oblique approach that assumes probability of collision for any bird passing through a Wind Turbine rotor is the same regardless of the direction of flight. As noted in the guidelines, the actual risk of collision depends to some extent on a bird's angle of approach, determined by the direction of flight and the orientation of the Wind Turbine blades. However, the model assumes that all bird flights make a perpendicular approach to the Wind Turbine rotor. The guidelines note that this simplification leads to some underestimation of collision risk, which may be as much as 10% for large birds. The guidelines also provide an example of uncertainty expression for the model, where an uncertainty range of $\pm 20\%$ is applied. In view of the above the range of uncertainty due to simplifications in the collision model is representative of $\pm 20\%$.

The Wind Turbine model and associated dimensions that are proposed as part of the Project have been provided by the Applicant. It is assumed that in the event of receipt of planning permission for the Project this permission will be conditioned with respect to the Wind Turbine specifications set out in the planning application. With this in mind no uncertainty regarding the Wind Turbine model is considered to arise (uncertainty = 0%).

The range of uncertainty due to each of these three sources can be combined to give an overall uncertainty of $\sqrt{(u_1^2 + u_2^2 + u_3^2)}$, where u_1 , u_2 and u_3 are respectively the percentage uncertainties from uncertainty relating to bird activity; simplification of the model; and turbine design options. Using this equation an overall collision risk uncertainty range of $\pm 30\%$ is calculated: i.e. $\sqrt{(0.2^2 + 0.2^2 + 0.0^2)} = 28\%$.

4 REFERENCES

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APPENDIX 1: CRM SPECIES OUTPUTS

