APPENDIX 7-6

COLLISION RISK ASSESSMENT

Collision Risk Assessment

Knockshanvo Wind Farm

Table of Contents

TABLE OF TABLES

1. INTRODUCTION

This document outlines the methodology used to assess the collision risk for birds at the proposed Knockshanvo Wind Farm, located in County Clare. The collision risk assessment is based on vantage point surveys undertaken at the wind farm site from April 2018 to September 2023 inclusive. This represents a 66-month survey period, consisting of six breeding seasons and five winter seasons, which is in full compliance with Scottish Natural Heritage guidance (SNH, 2017). Surveys were undertaken from five fixed Vantage Point (VP) Locations. VP1, VP2, VP3, VP4 and VP5 were surveyed from April 2018 to March 2023. In April 2023, VP2 was discontinued and surveys at VP6 commenced, to ensure as comprehensive as possible coverage of the updated viable area/turbine layout.

Collision risk is calculated using a mathematical model to predict the number of birds that may be killed by collision with moving wind turbine rotor blades. The modelling method used in this collision risk calculation is known as the Band Model (Band *et al.,* 2007) and has been used in a number of studies on bird collision with wind turbines (e.g. Chamberlain *et al.,* 2006; Drewitt and Langston, 2006; Fernley *et al.,* 2006; Madders and Whitfield, 2006). Note that these are theoretical predictions, therefore results must be interpreted with a degree of caution.

Two stages are involved in the Band Model. First, the number of bird transits through the air space swept by the rotor blades of the wind turbines per year is estimated. Then the collision risk for a bird passing through the rotor blades is calculated using a mathematical formula. The product of these provides a theoretical annual collision mortality rate. Finally, a bird avoidance rate is applied to the collision mortality rate to account for birds attempting to avoid collision. This final collision mortality rate informs the assessment of impacts of the wind farm development on key ornithological receptors (KORs) in the EIAR.

While the majority of the Wind Farm Site is visible, as provided in Figure 7.3/7.4 of the EIAR, there is a gap in the viewshed. At the Wind Farm Site, it proved very difficult to achieve full visibility of the entire proposed turbine layout (at the lowest swept height (21m)) given the topography and land use (commercial forestry) of the Wind Farm Site. There is one turbine (T4) that is not covered by a vantage point survey at the lowest swept height. Additionally, between April 2018 and March 2023, before the addition of VP6, there was an additional turbine that was not covered by the vantage point surveys (T7). The Band Model (Band *et al.*, 2007) can account for gaps in the viewshed, therefore this is not a significant limitation on the collision risk model. Furthermore, the habitats throughout the Wind Farm Site are predominantly commercial forestry and therefore, significant differences in the avian distribution and abundance is not anticipated within the viewshed gaps.

2. METHODOLOGY

2.1 The Band Model

The Band Model is used to predict the number of bird collisions that might be caused by a wind farm development. It uses species-specific information on bird biometrics, flight characteristics and the expected amount of flight activity, along with turbine-specific information on hub height, rotor diameter, pitch and rotational speed. The 9 No. turbines will be 102.5m at hub height, with 3 blades with a diameter of 163m, giving a maximum rotor height of 184m and a minimum rotor height of 21m. The model makes a number of assumptions on the turbine design and on biometrics of birds:

1. Birds are assumed to be of a simple cruciform shape.
2. Turbine blades are assumed to have length, depth and pitch angle, but no thickness.
3. Birds fly through turbines in straight lines.
4. Bird flight is not affected by the slipstream of the turbine blade.

- Because the model assumes that no action is taken by a bird to avoid collision, it is recognised that the collision risk figures derived are purely theoretical (before an avoidance factor is applied)[1].

Two forms of collision risk modelling are outlined by Band *et al.* (2007): a **"Regular Flight Model"** and the **"Random Flight Model"**. A Regular Flight Model is generally applied to situations where flightlines form a regular pattern. This may occur, for example, when birds are using the wind farm site as a commuting corridor between roosting and feeding grounds or migratory routes, as is often observed in geese and swans. The Random Flight Model generally applied to situations where flightlines form no discernible patterns or routes. This is often observed, for example when raptors are in foraging or hunting flights.

The Regular Flight Model predicts the number of transits through a cross-sectional area of the wind farm which represents the width of the commuting corridor. A "risk window" is identified: a 2-dimensional line the width of the wind farm to a 500m buffer of the turbines, multiplied by the rotor diameter. All commuting flights which pass through this risk window within the rotor swept height (potential collision height; PCH) are included in collision risk modelling. Any regular flights more than 500m from the turbine layout can be excluded from the analysis. There are a number of key assumptions and limitations:

- The turbine rotor swept area is 2-dimensional, i.e. there is a single row of turbines in the windfarm. This represents all turbines within the commuting corridor accounted for by a single straight-line.
- Bird activity is spatially explicit.
- Birds in an observed flight only cross the turbine area once and do not pass through the cross-section a second time (or multiple times).
- Habitat and bird activity will remain the same over time and be unchanged during the operational stage of the windfarm.
- All flight activity used in the model occurred within the viewshed area calculated at the lowest swept rotor height.

The Random Flight Model predicts the number of transits through the wind farm while assuming that all flights within the vantage point viewshed are randomly occurring, i.e., any observed flight could just as easily

[1] *As previously outlined, a bird avoidance rate is applied to the collision mortality rate predicted by the model to account for birds attempting to avoid collision*

occur within the Wind Farm Site as outside it. All flights within PCH inside the viewshed are included in the model. There are a number of key assumptions and limitations:

- Bird activity is not spatially explicit, i.e., activity is equal throughout the viewshed area and this is equal to activity in the windfarm area.
- Habitat and bird activity will remain the same over time and be unchanged during the operational stage of the windfarm.
- All flight activity used in the model occurred within the viewshed area calculated at the lowest swept rotor height.

More detail on both the Random and Regular Flight Model calculations are available from SNH: https://www.nature.scot/wind-farm-impacts-birds-calculating-theoretical-collision-risk-assuming-no-avoiding-action. In the case of Knockshanvo Wind Farm, for all species recorded in flight in the wind farm study area, flights were randomly distributed. Therefore, a Random Flight Model was conducted for these species.

2.2 Modelling Process

The steps used in the Band Model to derive the collision mortality rate for each species observed at the wind farm site are outlined below.

- Stage 1: Estimate the number of bird transits through the air space swept by the rotor blades of the wind turbines. Transits are calculated using either the "Regular" or "Random" flight model (Band *et al.,* 2007), depending on flight distribution and behaviour.
- Stage 2: Calculate the collision risk for an individual bird flying through a rotating turbine blade. Collision risk is calculated using a formula which incorporates the number of bird transits (Stage 1), individual species' biometrics, individual species' flight speed and style, and the proposed turbine parameters. This formula is publicly available on the SNH website: https://www.nature.scot/wind-farm-impacts-birds-calculating-probability-collision. Biometrics are available from the British Trust of Ornithology (BTO, 2021) and flight speeds are available from Alerstam *et al.* (2007). For species that can both flap and glide, the mean of the collision risk for flapping and for gliding flight is taken.
- The product of the number of bird transits per year multiplied by the collision risk provides an annual collision mortality rate. Note that this is the worst-case scenario for collision mortality, as it assumes that birds flying towards the turbines make no attempt to avoid them.
- To account for birds attempting to avoid a collision, an avoidance factor is applied to the annual collision mortality rate. This corrects for the ability of the birds to detect and manoeuvre around the turbines. Avoidance rates are available from SNH (2018). Bird avoidance rates are generally 98-99% or higher for most species, based on empirical evidence, targeted studies and literature reviews, and continue to be updated following further studies of bird behaviour and mortality rates at wind farm sites.

The final annual collision risk corrected for avoidance is a "real-world" estimation of the number of collisions that may occur at the wind farm, based on observed bird activity during the vantage point survey period.

2.3 Turbine specifications

For this collision risk model, birds in flight within the viewshed at height band 10-25m, 25-175 and >175m above ground level were included for surveys conducted between April 2018 and September 2021, and height bands 10-25m and 25-200m above ground level were included for surveys conducted between October 2021 and September 2023. However, only a proportion of height band 10-25m overlaps with the proposed rotor swept area. Only a proportion of height band 10-25m was included as the low swept height of the proposed turbine only marginally overlaps with this height band. A total of 25%[2] of the flight activity from this height was included in the CRM to mirror the proportion of overlap between the turbine and this height band. The turbine specifications are available in Table 1.

Table 1 Turbine specifications at Knockshanvo wind farm

Wind Farm Component	Scenario Modelled
Number of turbines	9
Blades per turbine rotor	3
Rotor diameter (m)	163
Rotor radius (m)	81.5
Hub height (m)	102.5
Swept height (m)	21 – 184
Pitch of blade (degrees)	6
Maximum chord (m) (i.e. depth of blade)	4.5
Rotational period (s)[3]	6.75
*Turbine operational time	85%

***This operational period of 85% is referenced from a report by the British Wind Energy Association (BWEA) (2007) which identifies the standard operational period of the wind turbines in the UK to be roughly 85%.**

It was necessary to run three collision risk models to assess the full range of turbine dimensions in this application. The second model assesses the swept path between 22-185m and the third model assess the swept path between 30.5-179.5m. Appendix 1 shows the collision risk assessment based these two alternative turbine dimension. These three collision risk assessments allow for the full range of possible turbine dimensions to be assessed (21-185m). Taking a precautionary approach, the highest predicted collision risk for each species was then presented in Section 7.6.2 in Chapter 7 of the EIAR.

2.3.1 Key Ornithological Receptors

The key ornithological receptors (KORs) recorded within PCH during surveys at Knockshanvo were:

- Hen Harrier
- Peregrine
- Kestrel
- Snipe
- Woodcock
- Buzzard
- Sparrowhawk

A CRM was conducted for each of these species. It is acknowledged that the predicted number of transits, and hence predicted rate of collision, for snipe may be largely underestimated, as flight activity for this species is largely crepuscular in nature (during twilight) while the VP survey sample predominantly consists of hours during daylight period when visibility is not an issue. It is assumed that waterbirds (i.e., snipe and woodcock) are active for 25% of the night along with daylight hours (as per SNH guidance) and this is accounted for in the model.

[2] *It is assumed that there is an even distribution of flight activity within the height band.*
[3] *The assumed turbine model was Nordex 163 Turbine for the following parameters: maximum chord and rotational period.*

2.4 Calculation Parameters

The calculation parameters for the vantage point are outlined in Table 2. Bird biometrics are presented in Table 3. Table 4 presents the model input values: bird seconds in flight at PCH (random model) observed from the vantage point during the relevant survey period. Bird seconds in flight at PCH is calculated by multiplying the number of birds observed per flight by the duration of the flight spent within PCH.

*Table 2 Knockshanvo Wind Farm survey effort and viewshed coverage**

Vantage Point	Visible Area at 21m (ha)	Risk Area (ha)	Turbines visible	Total Survey Effort (hr)
VP1	360	72	1	399
VP3	256	112	3	399
VP4	227	102	2	399
VP5	459	124	2	399
VP6	393	146	3	36

**VP2 was omitted from this analysis as the visible area of the vantage point does not cover any of the proposed turbines.*

Table 3 Bird biometrics

Species	Body Length(m)	Wingspan(m)	Flight Speed(m/s)
Hen Harrier	0.48	1.1	9.1
Peregrine Falcon	0.42	1.02	20.7
Kestrel	0.34	0.76	10.1
Snipe	0.26	0.46	17.1
Woodcock	0.34	0.6	17.1
Buzzard	0.54	1.2	13.3
Sparrowhawk	0.33	0.62	10

Table 4 Model input values

Species	Model	Period	PCH sec. (Total)
Hen Harrier[4]	random	All	2,814
Peregrine	random	All	35.5
Kestrel	random	All	15,686.75
Snipe	random	All	1,536.25
Woodcock	random	All	30
Buzzard	random	All	13,130.5
Sparrowhawk	random	All	2,175.5

The avoidance rates applied to the collision risk were: 99% for hen harrier, 95% for kestrel and 98% for the remaining species.

[4] All flight activity at PCH is included in this model with the following exception. Flight activity that is associated with foraging behaviour exclusively within the Gortacullin Bog NHA has not been included in the collision risk modelling. Rationale: this flight activity is limited to the areas of open habitat surrounding the Wind Farm Site and does not accurately represent hen harrier activity within the Wind Farm Site and specifically around the proposed turbine layout which is exclusively within forestry habitats. Furthermore, the flight activity within the NHA is not randomly distributed and is predictably associated with the open habitat of the NHA where no turbines are proposed.

3. RESULTS

The predicted number of transits per year and the collision risk is presented in Table 5, along with the final predicted number of collisions per year. Note that for birds that both flap and glide, the average collision risk percentage between flapping and gliding is taken.

Table 5 Results of CRM

Species	Survey Period	Model	Transits	Collision Risk			Collision Rate			Estimated Collisions Over Lifetime of Wind Farm	One Bird Collision
				flapping	gliding	overall	without avoidance	avoidance factor	with avoidance		
Hen Harrier	All	random	135.3	5.79%	5.69%	5.74%	7.77	99%	0.078	2.33 birds	13 years
Peregrine Falcon	All	random	1.4	5.14%	4.97%	5.06%	0.07	98%	0.001	0.04 birds	693 years
Kestrel	All	random	768.3	4.89%	4.8%	4.85%	37.24	95%	1.862	55.86 birds	1 year
Snipe	All	random	144.6	4.05%	no gliding flight	4.05%	5.85	98%	0.117	3.51 birds	9 years
Woodcock	All	random	2.9	4.31%	no gliding flight	4.31%	0.13	98%	0.003	0.08 birds	398 years
Buzzard	All	random	739	5.58%	5.41%	5.5%	40.62	98%	0.812	24.37 birds	1 year
Sparrowhawk	All	random	100.6	4.85%	4.79%	4.82%	4.85	98%	0.097	2.91 birds	10 years

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https://www.timeanddate.com/sun/

APPENDIX 1

ALTERNATIVE TURBINE DIMENSIONS

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4. TURBINE DIMENSIONS

4.1 Scenario 2

4.1.1 Calculation Specifications

Table 6 Scenario 2 specifications

Wind Farm Component	Scenario Modelled
Number of turbines	9
Blades per turbine rotor	3
Rotor diameter (m)	163
Rotor radius (m)	81.5
Hub height (m)	103.5
Swept height (m)	22 – 185
Pitch of blade (degrees)	6
Maximum chord (m) (i.e., depth of blade)	4.5
Rotational period (s)[5]	6.75
*Turbine operational time	85%

[5] *The assumed turbine model was Nordex 163 Turbine for the following parameters: maximum chord and rotational period.*

4.1.2 Results

The predicted number of transits per year and the collision risk is presented in Table 7 along with the final predicted number of collisions per year. Note that for birds that both flap and glide, the average collision risk percentage between flapping and gliding is taken.

Table 7 Results of CRM for Scenario 2

Species	Survey Period	Model	Transits	Collision Risk			Collision Rate			Estimated Collisions Over Lifetime of Wind Farm	One Bird Collision
				flapping	gliding	overall	without avoidance	avoidance factor	with avoidance		
Hen Harrier	All	random	132.3	5.79%	5.69%	5.74%	7.6	99%	0.076	2.28 birds	13 years
Peregrine Falcon	All	random	1.4	5.14%	4.97%	5.06%	0.07	98%	0.001	0.04 birds	703 years
Kestrel	All	random	751.4	4.89%	4.8%	4.85%	36.42	95%	1.821	54.63 birds	1 year
Snipe	All	random	141.2	4.05%	no gliding flight	4.05%	5.71	98%	0.114	3.43 birds	9 years
Woodcock	All	random	2.9	4.31%	no gliding flight	4.31%	0.12	98%	0.002	0.07 birds	405 years
Buzzard	All	random	725.8	5.58%	5.41%	5.5%	39.9	98%	0.798	23.94 birds	1 year
Sparrowhawk	All	random	99.1	4.85%	4.79%	4.82%	4.77	98%	0.095	2.86 birds	10 years

4.2 Scenario 3

4.2.1 Calculation Specifications

Table 8 Scenario 3 specifications

Wind Farm Component	Scenario Modelled
Number of turbines	9
Blades per turbine rotor	3
Rotor diameter (m)	149
Rotor radius (m)	74.5
Hub height (m)	105
Swept height (m)	30.5 – 179.5
Pitch of blade (degrees)	6
Maximum chord (m) (i.e., depth of blade)	4.5
Rotational period (s)[6]	6.417
*Turbine operational time	85%

For the alternative turbine 2 collision risk model, birds in flight within the viewshed at height band 25-175 and >175m above ground level were included for surveys conducted between April 2018 and September 2021, and height band 25-200m above ground level were included for surveys conducted between October 2021 and September 2023. The input values for model are outlined in Table 9 below.

Table 9 Model input values

Species	Model	Period	PCH sec. (Total)
Hen Harrier	random	All	2,232
Peregrine	random	All	30
Kestrel	random	All	12,476
Snipe	random	All	1,085
Woodcock	random	All	0
Buzzard	random	All	12,527
Sparrowhawk	random	All	1,892

[6] *The assumed turbine model was Nordex 149 Turbine for the following parameters: maximum chord and rotational period.*

4.2.2 Results

The predicted number of transits per year and the collision risk is presented in Table 10, along with the final predicted number of collisions per year. Note that for birds that both flap and glide, the average collision risk percentage between flapping and gliding is taken.

Table 10 Results of CRM for Scenario 3

Species	Survey Period	Model	Transits	Collision Risk			Collision Rate			Estimated Collisions Over Lifetime of Wind Farm	One Bird Collision
				flapping	gliding	overall	without avoidance	avoidance factor	with avoidance		
Hen Harrier	All	random	77.9	6.25%	6.11%	6.18%	4.81	99%	0.048	1.44 birds	21 years
Peregrine Falcon	All	random	0.9	5.57%	5.38%	5.47%	0.05	98%	0.001	0.03 birds	1016 years
Kestrel	All	random	449.2	5.29%	5.2%	5.25%	23.56	95%	1.178	35.35 birds	1 year
Snipe	All	random	79	4.4%	no gliding flight	4.4%	3.48	98%	0.07	2.09 birds	14 years
Buzzard	All	random	553.4	6.03%	5.85%	5.94%	32.86	98%	0.657	19.72 birds	2 years
Sparrowhawk	All	random	71.7	5.24%	5.18%	5.21%	3.74	98%	0.075	2.24 birds	13 years

4.3 Comparison

Species	Collisons Risk Per Year (Scenario 1)	Collisons Risk Per Year (Scenario 2)	Collisons Risk Per Year (Scenario 3)
Hen Harrier	0.078	0.076	0.048
Peregrine Falcon	0.001	0.001	0.001
Kestrel	1.862	1.821	1.178
Snipe	0.117	0.114	0.07
Woodcock	0.003	0.002	n/a
Buzzard	0.812	0.798	0.657
Sparrowhawk	0.097	0.095	0.075