Appendix 7-6
Collision Risk Assessment

Proposed Ardderroo Wind Farm,
Co. Galway

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Table of Contents

1 INTRODUCTION

This document has been prepared by McCarthy Keville O'Sullivan Ltd. to assess the collision risk for birds at the proposed Ardderroo Wind Farm, Co. Galway. The collision risk assessment, prepared by Mr. David Naughton (BSc), is based on vantage point (VP) surveys undertaken at the site of the proposed development from March 2016 to March 2018 from ten fixed vantage point locations.

Collision risk is calculated using a mathematical model to predict the numbers of individual birds, of a particular species, that may be killed by collision with moving wind turbine rotor blades. The modelling method used in this collision risk calculation follows Scottish Natural Heritage (SNH) guidance which is sometimes referred to as the Band Model (Band *et al*. (2007).

Two stages are involved in the model:

- Stage 1: Determination of the number of birds or flights passing through the air space swept by the rotor blades of the wind turbines

- Stage 2: Calculation of the probability of a bird strike occurring.

The product of Stage 1 and Stage 2 gives a theoretical annual collision mortality rate on the assumption that birds make no attempt to avoid colliding with turbines.

The Band model has been the subject of academic assessment (e.g. Chamberlain et al., 2005 & 2006, Madders & Whitfield 2006, Drewitt & Langston 2006, Fernley, Lowther & Whitfield 2006) and its results must be interpreted with a degree of caution.

For a number of years, SNH advocated a highly precautionary approach, recommending a value of 95% as an avoidance rate (Band et al., 2007). However, based on empirical evidence precautionary rates have now been increased to 98-99% or higher in most cases.

2 METHODOLOGY

The steps used to derive the collision risk for the proposed development according to the Band Model are outlined below:

(1) Stage 1 (Band): the model uses observations of birds flying through the study area during vantage point surveys to calculate the number of birds estimated to fly through the proposed turbines blade swept areas.

(2) Stage 2 (Band): the model calculates the collision risk for an individual bird flying through a rotating turbine blade. The collision risk depends of the species biometrics and flight behaviour. Bird biometrics are available from the British Trust of Ornithology (BTO) online bird collision risk guidance, while flight speeds have been referenced from Alerstam et al. (2007).

(3) The product of the number of birds calculated to fly through the turbines in a year and the risk that a bird doing so will collide with the moving blades gives the worst case scenario for collision mortality. The worst case scenario assumes that birds flying towards the turbines make no attempt to avoid them.

(4) An avoidance factor is applied to the results to account for avoidance of the turbines by birds in flight. This corrects for the ability of the birds to detect and manoeuvre around the turbines. Avoidance rates are available from SNH online bird collision risk guidance (SNH 2018).

(5) Finally, a figure for the average downtime of the turbines is applied. This accounts for wind speeds unsuitable for turbine rotation and maintenance downtime (in the case of the subject site, maintenance downtime has been taken at 85%. The final output is a real-world estimation of the number of collisions that may occur at the wind farm.

The Band Method makes a number of assumptions on the biometrics of birds and the turbine design. These are:

- Birds are assumed to be of a simple cruciform shape
- Turbine blades are assumed to have width and pitch angle, but no thickness
- Birds fly through turbines in straight lines
- 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 and represent worst case estimates.

A number of assumptions were made in the calculation of collision risk at Ardderroo Wind Farm. These assumptions are tailored specifically to Ardderroo Wind Farm and are as follows:

- Birds in flight within the study area at heights between 25m and 175m are assumed to be in danger of collision with the rotating turbine blades. This is a precautionary approach as the lower extent of the swept area of the turbine blades will be greater than 25m.

- Avoidance factors of individual species are those currently recommended by SNH 2018. An avoidance factor is applied to the results to account for avoidance of the turbines by birds in flight. This corrects for the ability of the birds to detect and manoeuvre around the turbines.

- No preference was taken for birds using flapping or gliding flight through the study area. In the calculation of the percentage risk of collision for a bird flying through a rotating turbine, the mean of the worst case scenario (*i.e.* a bird flying upwind through a turbine using flapping flight whilst the turbine is at its fastest rotation speed) and the best case scenario (*i.e.* a bird flying downwind through a rotating turbine using a gliding flight whilst the turbine at its slowest rotation speed) has been used.

The Collision Risk Assessment (CRA) also makes assumptions on the turbine specifications, such as rotor diameter and rotational speed. Because the final choice of turbine will not be known until a competitive tendering process is completed, the worst-case scenario is assumed. The worst-case scenario is a combination of the maximum collision risk area (affected by hub height and rotor blade length), maximum number of turbines proposed and minimum turbine downtime. The turbine and wind farm characteristics at Ardderroo Wind Farm are presented in Table 2.1.

Table 2.1 Turbine and wind farm characteristics

Wind Farm Component	Scenario Modelled
Assumed turbine model	Vestas V150-4.0/4.2 MW
Number of turbines	25
Blades per turbine rotor (3d model used)	3
Rotor diameter (m)	150
Rotor radius (m)	75
Hub height (m)	103.5
Swept height (m)	28.5 – 178.5
Mean pitch of blade (degrees)	45
Maximum chord (m)	4.2
Minimum Rotor Speed (RPM)	4.9
Maximum Rotor Speed (RPM)	12.0
Average Rotor Speed (RPM)	8.45
Average rotational period (Seconds) [60/Average RPM]	7.10
Turbine operational time (%)	85%

3 RESULTS

Collison risks were calculated using flight data recorded during vantage point watches at ten vantage point locations within the study area between March 2016 and March 2018. The target species recorded within the potential collision risk zone included Buzzard, Common Gull, Cormorant, Hen Harrier, Kestrel, Sparrowhawk, White-tailed Eagle and Whooper Swan.

The calculation parameters are outlined in Tables 3.1 - 3.6 below. A worked example of the calculation of collision risk for Cormorant is available in Appendix 1.

Table 3.1 Ardderroo Windfarm VP Survey Effort and Viewshed Coverage

Vantage Point	Visible Area (ha)	Risk Area (ha)	Turbines	Total Survey Effort (hrs)	Survey Effort Migratory Birds (hrs)
VP01a	268.2	242.6	5	158	85
VP02	215.3	191.6	4	154	81
VP04	633.7	405.7	10	148.5	76
VP05	277.1	272.8	7	150.67	81
VP06	341.8	290.1	6	152.98	77.17
VP07	584.8	384.6	9	150	77
VP08	613.6	224.7	3	151.58	77.58
VP09	625.9	505.1	8	149	78
VP10	641.3	285.1	5	158.58	79.83
VP11	269.5	47.56	1	141.17	72

Survey Effort Migratory Birds is the amount of the time (in hours) surveyed during the winter period (October – March) to account for Whooper Swan Availability.

Table 3.2 Bird Biometrics (Taken from BTO BirdFacts) and Recorded PCH during VP Surveys

Species	Length (m)	Wingspan (m)	Ave. speed (m/s)	Seconds in flight at PCH 25>175 m
Buzzard	0.54	1.2	13.3	200
Common Gull	0.41	1.2	13.4	340
Cormorant	0.90	1.45	15.2	2,119
Hen Harrier	0.48	1.1	9.1	36
Kestrel	0.34	0.76	10.1	6,701
Sparrowhawk	0.33	0.62	10	574
White-tailed Eagle	0.8	2.2	13.6	504
Whooper Swan	1.52	2.3	17.3	420

Seconds in flight at PCH is calculated by multiplying the number of birds observed per flight by the duration of the flight spent within the height band 25-175m.

Table 3.3 Number of Transits per Turbine within the Viewshed of each VP in one year (TnT = TnY/x)

Species	VP01a	VP02	VP04	VP05	VP06	VP07	VP08	VP09	VP10	VP11
Buzzard	0	0	0	0	**2.66**	0	0	0	0	0
Common Gull	**1.16**	0	0	**0.17**	0	0	0	**0.93**	**0.94**	0
Cormorant	**1.18**	**0.96**	**3.08**	**2.76**	**1.23**	**1.27**	**0.72**	**7.06**	**1.7**	**3.57**
Hen Harrier	0	0	0	**0.41**	0	0	0	0	0	0
Kestrel	**3.93**	**2.33**	**5.05**	**1.9**	**7.58**	**7.5**	0	**4.41**	**8.41**	**4.76**
Sparrowhawk	**1.19**	**0.95**	**0.95**	0	**0.67**	**1.08**	0	0	0	0
White-tailed Eagle	0	0	**0.34**	**1.7**	**0.82**	0	0	0	0	**6.08**
Whooper Swan	0	0	0	0	**7.73**	0	0	0	0	0

Table 3.4 Number of Transits across site (Averages from Table 3.4 Above

Species	Average Transits	Transits Across Entire Site (All 25 Turbines) (Average Transits*25)
Buzzard	0.27	6.66
Common Gull	0.32	7.99
Cormorant	2.35	58.82
Hen Harrier	0.04	1.03
Kestrel	4.59	114.65
Sparrowhawk	0.48	12.07
White-tailed Eagle	0.89	22.35
Whooper Swan	0.77	19.33

Table 3.5 Collision Risk Workings (Both Flapping and Gliding Flight Collision Risk took the average between upwind and downwind)

Species	Flapping Flight	Gliding Flight	Collision Risk [(Flapping + Gliding)/2]
Buzzard	7.48%	7.24%	7.4%
Common Gull	7.13%	6.81%	7.0%
Cormorant	7.63%	7.41%	7.5%
Hen Harrier	10.23%	10.09%	10.2%
Kestrel	8.63%	8.52%	8.6%
Sparrowhawk	8.62%	8.54%	8.6%
White-tailed Eagle	N/A	8.00%	N/A
Whooper Swan	8.54%	8.15%	8.3%

Table 3.6 Collision Probability assuming no Avoidance (Transits*Collision Risk)

Species	Collision Risk	Transits Across Entire Site	Collisions/year (No Avoidance)
Buzzard	7.4%	6.66	0.4898
Common Gull	7.0%	7.99	0.5570
Cormorant	7.5%	58.82	4.4234
Hen Harrier	10.2%	1.03	0.1043
Kestrel	8.6%	114.65	9.8316
Sparrowhawk	8.6%	12.07	1.0356
White-tailed Eagle	8.0%	22.35	1.7925
Whooper Swan	8.3%	19.33	1.6132

Table 3.7 Collision Probability using Avoidance Rates outlined in SNH September 2018 V2

Species	Collisions /year	Collisions / 30 years	Avoidance factor (%)	Note
Buzzard	0.010	0.294	98	All year
Common Gull	0.011	0.334	98	All year
Cormorant	0.088	2.654	98	All year
Hen Harrier	0.001	0.031	99	All year
Kestrel	0.492	14.747	95	All year
Sparrowhawk	0.021	0.621	98	All year
White-tailed Eagle	0.093	2.778	95	All year
#White-tailed Eagle	0.036	1.075	98	All year
Whooper Swan *	0.008	0.242	99.5	Winter/passage (Oct-Mar)

*** Whooper Swan and are assumed to be active 25% of the night as well as daylight hours per SNH guidance. This is calculated as a portion of the length of night for the survey period provided by www.timeanddate.com and is added to available hours for activity of the species per year.**

#White-tailed Eagle collision probability was also calculated using an Avoidance Rate of 98% as outlined in May et al (2011)

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British Trust of Ornithology (BTO) online BirdFacts.
Available at https://www.bto.org/about-birds/birdfacts

Appendix 1

WORKED EXAMPLE OF COLLISION RISK CALCULATION – Cormorant (VP1a)

Stage 1 (Transits through rotors per year at VP1a)

Survey area visible of Vantage Point viewshed in hectares (Avp)

268.2

Survey Time (secs) / Bird observation time at 25-175m (secs)

568,800	63

Proportion of time between 25 – 175m (t1)
(obs time/survey time) = 0.00011

Flight activity of Cormorant per visible unit of area (F) is given by the proportion of observed time at potential collision height (t1) divided by the survey area visible of VP01a (Avp)
F=t1/Avp

4.13E-07

The 500m buffer of the turbines located within the viewshed of the vantage point give the area of risk in ha (Arisk)

242.6

Proportion of time in risk area (Trisk) is given by the flight activity per ha (F) multiplied by the risk area (Arisk)
Trisk = F*Arisk

0.000100

Availability of species activity throughout the two year survey period in hours (BA)

10,887.13

The bird occupancy of the risk area (n) is given by the proportion of time in risk area (Trisk) multiplied by the hours available for the bird in a year (Ba)
n=Trisk*Ba

1.09075

The risk volume (Vw) is given by the area of risk multiplied by the diameter of the swept area of the rotors
Vw= Arisk*rotor diameter

363900000

Max chord width (d)	No. of turbines (x)	Bird length in m (l)
4.2	5	0.9

The actual volume of air swept by rotors (o) is provided by
o= x*(piR^2(d+l))

450622.2

The bird occupancy of the rotor swept area (b) is provided by the bird occupancy of the risk area (n) multiplied by the actual volume of air swept by rotors (o) divided by the risk volume (Vw)) in units of seconds/year)
b= 3600(n((o/Vw))

4.862497808

Time for bird to pass through rotors (t2) is provided by (the maximum chord width (d) plus the legth of the bird (l)) divided the typical flight speed of the bird (v)

t2= (d+Bl)/v

0.3355

The number of bird passes through rotor per year (N) is calculated as the bird occupancy of the rotor swept area (b) divided by the time for the bird to pass through the rotors (t2)

N= b/t2

14.49215033

Total transits adjusted for maximum operation of the turbines in a year (Tn) is then calculated in this case it will be given as 85%.

Tn= N*0.85

12.32

Total transits in a year is calculated by dividing the total transits adjusted for maximum operation of the turbine (Tn) by the number of months surveyed (M) and multiplying the result by 12 to give a standard year's transits (TnY)

(Tn/M)*12=TnY

5.91

The number of transits per turbine within the viewshed of a vantage point is calculated by dividing the total transits in a year (TnY) by the number of turbines within the viewshed (x) to give (TnT).

TnY/x=TnT

1.18

Average transits per turbine (ATnT) is calculated by averaging the number of transits per turbine (TnT) within the viewshed of each vantage point.

$(TnT_1+TnT_2+TnT_3+\ldots\ldots)/10$

2.35

To then calculate the number of transits across the windfarm (T) the average number of transits per turbine (ATnT) is multiplied by the total number of turbines present within the windfarm (Tx).

T=ATnT*Tx

58.8218

Transits through rotors for the species in a one year period across the site

58.82

Stage 2 (Collision probability)

Calculation of the probability of the birds colliding with the turbine rotors

The probability of a bird colliding with the turbine blades when making a transit through a rotor depends on a number of estimated factors. These factors include the avoidance factor 98% – the ability of birds to take evasive action when coming close to wind turbine blades.

In the calculations, the length of a Cormorant was taken to be 0.9 metres and the wingspan 1.45 metres. The flight velocity of the bird is assumed to be 15.2 metres per second. The maximum chord of the blades is taken to be 4.0 metres, variable pitch is assumed to be 45 degrees and the average rotation cycle is taken to be 6.03 seconds per rotation, depending on wind conditions.

A probability, ρ (r, φ), of collision for a bird at radius r from the hub and at a position along a radial line that is at angle φ from the vertical is calculated. This probability is then integrated over the entire rotor disc, assuming that the bird transit may be anywhere at random within the area of the disc. Scottish Natural Heritage (SNH) have made available a spreadsheet to aid the calculation of these probabilities. For a full explanation of the calculation methods see Band *et al*. (2007). The results of the calculations are shown in Table 1.3.

This is calculated using the SNH collision risk probability model at http://www.snh.gov.uk/planning-and-development/renewable-energy/onshore-wind/bird-collision-risks-guidance/

Collision probability

7.5%

Collisions per year

The annual theoretical collision rate assuming no avoidance = T*Collision probability

4.423

The annual theoretical collision rate assuming 98% avoidance

0.09

Theoretical collision rate assuming 98% avoidance across the 30 year duration of the windfarm

2.65