APPENDIX 7-6

COLLISION RISK ASSESSMENT

Collision Risk Assessment

Laurclavagh Renewable Energy Development

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1. INTRODUCTION

This document outlines the methodology used to assess the predicted rate of collisions for birds at the Proposed Wind Farm site. The collision risk assessment is based on vantage point surveys undertaken at the Proposed Wind Farm site from April 2020 to March 2022 and April 2023 to September 2023. This represents a 30-month survey period, consisting of three breeding seasons and two winter seasons, which is in full compliance with Scottish Natural Heritage guidance (SNH, 2017). Surveys were undertaken from two fixed vantage points.

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 turbine on birds.

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 turbine. 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 turbine will be 103.5m at hub height, with 3 blades of a diameter of 163m, giving a maximum rotor height of 185m and a minimum rotor height of 22m. The model makes a number of assumptions on the turbine design and on biometrics of birds:

- Birds are assumed to be of a simple cruciform shape.
- Turbine blades are assumed to have length, depth 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.

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 a 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. 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.

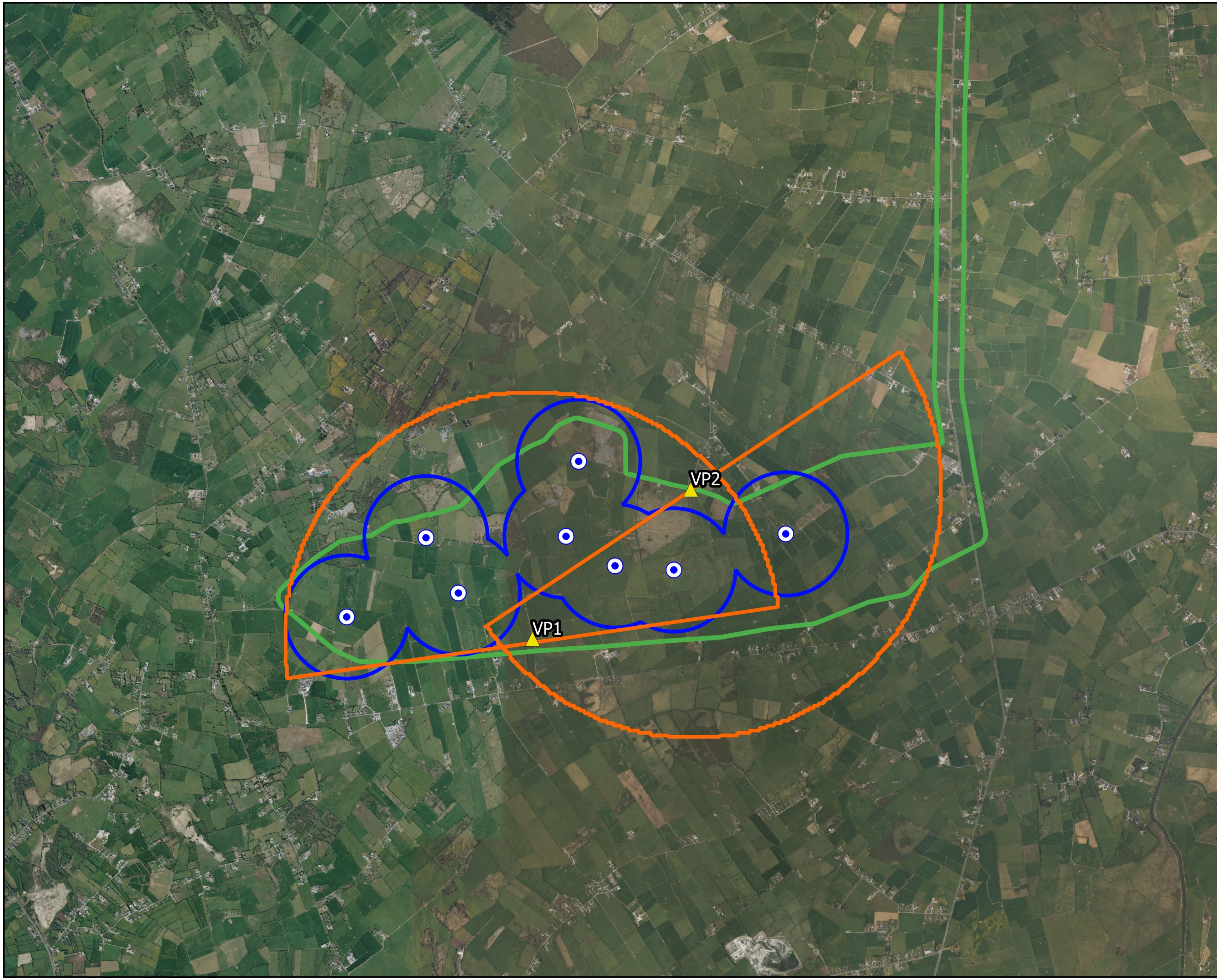
The Regular Flight Model predicts the number of transits through a cross-sectional area of a wind farm which represents the width of the commuting corridor. A "risk window" is identified: a 2-dimensional line the width of a wind farm to a 500m buffer of the turbines, multiplied by the rotor diameter. 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 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 a wind farm while assuming that all flights within the vantage point viewshed are randomly occurring, i.e., any observed flight could just as easily occur within a 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 the Proposed Wind Farm site, the 12 species recorded in flight in the study area were randomly distributed. Therefore, a Random Flight Model was conducted for these species. The viewsheds used for the viewshed area described above are presented in Figure 7-6-1 below. These viewsheds represent the lowest swept rotor height of 22m.



Map Legend

- EIAR Site Boundary
- Proposed Turbine Locations
- 500m Radius of Turbines
- Vantage Point Locations
- Viewshed

Drawing Title: Viewshed Coverage at 22m	
Project Title: Laurclavagh Renewable Energy Development	
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2.2 Modelling Process

The steps used in the Band Model to derive the collision mortality rate for each species observed at a 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 birds transits per year multiplied by the collision risk provides an annual collision mortality rate. There is an assumption that birds flying towards the turbines make no attempt to avoid them.

- To account for birds attempting to avoid 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 a wind farm, based on observed bird activity during the vantage point survey period.

2.3 Turbine specifications

Birds in flight within the viewshed at heights in bands 15-25m and 25-200m above ground level have been included in the collision risk model. The turbine specifications used in the model are available in Table 7-6-1.

Table 7–6–1 Turbine specifications

Turbine Component	Scenario Modelled
Turbine model	Nordex N163
Number of turbines	8
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)	6.75
Turbine operational time[1]	30 years

2.4 Ornithological Receptors

The species of conservation concern recorded during surveys at the Proposed Wind Farm site were:

- Black-headed Gull
- Common Gull
- Golden Plover
- Hen Harrier
- Lesser Black-backed Gull
- Peregrine Falcon
- Whooper Swan
- Kestrel
- Lapwing
- Snipe
- Buzzard
- Sparrowhawk

A collision risk model (CRM) was conducted for each of these species. It is assumed that waterbirds are active for 25% of the night along with daylight hours (as per SNH guidance) and this is accounted for in the model.

2.5 Calculation Parameters

The calculation parameters for the vantage point are outlined in Table 7-6-2. Bird biometrics are presented in Table 7-6-3. Table 7-6-4 presents the model input values for the random model: bird seconds in flight at PCH observed from the vantage points during the relevant survey period. Bird seconds in flight at

[1] 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%.

PCH is calculated by multiplying the number of birds observed per flight by the duration of the flight spent within PCH.

Table 7-6-2 Survey effort and viewshed coverage

Vantage Point	Visible Area at 22m (ha)	Risk Area (ha)	No. Turbines visible	Total Survey Effort (hr)
VP1	644	439	7	174
VP2	639	184	3	174

Table 7–6–3 Bird biometrics

Species	Body Length(m)	Wingspan(m)	Flight Speed(m/s)
Golden Plover	0.275	0.715	17.9
Hen Harrier	0.48	1.1	9.1
Peregrine Falcon	0.445	1.05	12.1
Whooper Swan	1.5	2.2	17.3
Black-headed Gull	0.355	1.05	11.9
Common Gull	0.41	1.2	13.4
Lesser Black-backed Gull	0.58	1.425	11.9
Kestrel	0.335	0.755	10.1
Lapwing	0.295	0.845	12.8
Snipe	0.255	0.42	17.1
Buzzard	0.54	1.205	11.6
Sparrowhawk	0.33	0.625	10

Table 7–6–4 Model input values

Species	Model	Period	Bird seconds at PCH
Golden Plover	Random	October to April	49,783
Hen Harrier	Random	September to March	30
Peregrine Falcon	Random	All	536
Whooper Swan	Random	Winter	1,555
Black-headed Gull	Random	Winter	19,408
Black-headed Gull	Random	Breeding	6,743
Common Gull	Random	Winter	89,800
Lesser Black-backed Gull	Random	Winter	2,953
Lesser Black-backed Gull	Random	Breeding	30,741
Kestrel	Random	All	7,737
Lapwing	Random	Winter	4,029
Snipe	Random	Winter	534
Buzzard	Random	All	8,817
Sparrowhawk	Random	All	192

The avoidance rates applied to the collision risk were: 99.8-99.6% for golden plover[2], 99.5% for whooper swan, 99% for hen harrier, 95% for kestrel and 98% for the remaining species.

[2] *See Appendix 7-6-1 of this report for further details.*

3. RESULTS AND DISCUSSION

A “Random” collision risk model has been conducted for birds observed during vantage points surveys at the Proposed Wind Farm using the Band Model, following best practice guidance from NatureScot. Collision risk models provide theoretical predictions of the probability of bird collision with wind turbine rotor blades. The results are affected by sources of uncertainty including the representativeness of the survey data, natural variability in bird populations, model assumptions and estimates on bird attraction and avoidance rates. As such, the results are considered to be a best estimate of collision risk, rather than a precise figure. The predicted number of transits per year and the estimated collision risk is presented in Table 7-6-5, 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 7-6-5 Collision rate predictions. For each species, the survey period and model type are specified, along with the predicted number of transits through the risk area and the collision risk (for flapping flight, gliding flight and the average of both). Two values for collision rate are presented: the initial collision rate without avoidance and a final estimated collision rate (with an avoidance factor). Finally, the estimated number of collisions over the lifetime of the turbines in presented, along with the corresponding estimated number of years of operation for one collision to occur.

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		
Black-headed Gull	Winter	random	1151.1	4.89%	4.7%	4.79%	55.16	98%	1.103	33.09 birds	1 year
Black-headed Gull	Breeding	random	522.9	4.89%	4.7%	4.79%	25.05	98%	0.501	15.03 birds	2 years
Common Gull	Winter	random	5989.7	4.99%	4.75%	4.87%	291.85	98%	5.837	175.11 birds	<1 year
Golden Plover	October to April	random	4656.1	4.22%	no gliding flight	4.22%	196.71	99.6%	0.787	23.61 birds	1 year
								99.8%	0.393	11.8 birds	3 years
Hen Harrier	September to March	random	1.1	5.79%	5.69%	5.74%	0.06	99%	0.001	0.02 birds	1653 years
Lesser Black-backed Gull	Winter	random	175.8	5.75%	5.52%	5.64%	9.91	98%	0.198	5.95 birds	5 years
Lesser Black-backed Gull	Breeding	random	2377.3	5.75%	5.52%	5.64%	134.03	98%	2.681	80.42 birds	<1 year
Peregrine Falcon	All	random	33.3	5.14%	4.97%	5.06%	1.68	98%	0.034	1.01 birds	30 years
Whooper Swan	Winter	random	134.9	7.51%	no gliding flight	7.51%	10.13	99.5%	0.051	1.52 birds	20 years
Kestrel	All	random	399.6	4.89%	4.8%	4.85%	19.37	95%	0.968	29.05 birds	1 year
Lapwing	Winter	random	257.5	4.54%	no gliding flight	4.54%	11.7	98%	0.234	7.02 birds	4 years
Snipe	Winter	random	45.5	4.05%	no gliding flight	4.05%	1.84	98%	0.037	1.1 birds	27 years
Buzzard	All	random	522.8	5.58%	5.41%	5.5%	28.74	98%	0.575	17.24 birds	2 years
Sparrowhawk	All	random	9.8	4.85%	4.79%	4.82%	0.47	98%	0.009	0.28 birds	106 years

Taking into account the uncertainties associated with the model, the predicted collision risk is negligible for hen harrier and sparrowhawk. At least one collision over the lifetime of the wind farm is predicted for black-headed gull, common gull, golden plover, lesser black-backed gull, peregrine falcon, whooper swan, kestrel, lapwing, snipe and buzzard.

The collision risk for common gull (winter) is estimated at 5.8 birds per year (or 175 birds over the lifetime of the wind farm), collision risk for lesser black-backed gull (winter) is estimated at 0.2 birds per year (or six birds over the lifetime of the wind farm) and the collision risk for lesser black-backed gull (breeding) is estimated at 2.7 birds per year (or 81 birds over the lifetime of the wind farm). Additional mortality caused by collisions relative to background mortality rate should be assessed to evaluate the population level consequences for these species. Following the magnitude of effects outlined in Percival (2003), a <1% increase in background mortality corresponds with a negligible effect and a 1-5% increase in background mortality corresponds with a low effect.

For golden plover, hen harrier, peregrine falcon, whooper swan, black-headed gull (all seasons), kestrel, lapwing, snipe, buzzard and sparrowhawk there is a <1% increase in background mortality rate (negligible effect). For common gull and lesser black-backed gull (all seasons) there is a 2.3-3.9% increase in background mortality rates (low effect). Further assessment of these species is conducted in Chapter 7 of this Environmental Impact Assessment Report.

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