ARCUS

TORRANCE WIND FARM EXTENSION II

APPENDIX 11.3:
COLLISION RISK MODELLING

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1 INTRODUCTION

This Technical Appendix has been produced as a supporting document to the Ornithology Chapter of the Environmental Impact Assessment (EIA) Report. It includes details of the avian Collision Risk Modelling (CRM) calculations used to predict the annual number of collisions that may be caused by the proposed Torrance Wind Farm Extension II (the Development), based on data recorded during the 2020-21 Flight Activity Surveys (FAS).

As recommended in NatureScot (NS) guidance[1], the CRM methods were based on Band *et al*. (2007)[2].

2 COLLISION RISK CALCULATIONS

CRM was completed separately for particular seasons (breeding and non-breeding), with each estimate based on the observed occupancy rate (i.e., the proportion of total survey time that flights of a given target species were observed) and the number of potentially active minutes during that period (i.e., the total number of minutes during the relevant season that the bird(s) could be active). Where a species breeds in Scotland, the breeding season was defined in accordance with NS guidance on species-specific breeding seasons[1,3]. For pink-footed goose, the non-breeding season was determined based on FAS records and NS survey guidance for goose species[1].

Flight height was recorded in the following height bands during FAS, which were based on the candidate turbine at the time of surveys:

1. <20 m;
2. 20-40 m;
3. 40-150 m; and
4. >150 m.

The Rotor Swept Height (RSH) of the candidate turbine model is 30–200 m (see

[1] NS (2017). *Recommended bird survey methods to inform impact assessment of onshore wind farms*, Version 2.

[2] Band, W., Madders, M. & Whitfield, D.P. (2007) *Developing field and analytical methods to assess avian collision risk at wind farms*. In de Lucas, M., Janss, G. & Ferrer, M. (eds.) *Birds and Wind Power*. Quercus, Madrid.

[3] NS (2009) *Breeding season dates for key breeding species in Scotland* [Online] Available at: https://www.nature.scot/bird-breeding-season-dates-scotland (Accessed 15/11/22)

Table 4). Therefore, height bands 2, 3 and 4 fall within or partially within the RSH. A 'worst-case scenario' approach was adopted and all target species flights within these height bands were considered to be at Potential Collision Height (PCH). Species with ≥3 flights or ≥10 individuals recorded within a single season passing through the Collision Risk Zone (CRZ [as defined below]) were included in the CRM. For species where flight activity was lower than this, it was considered that collision risk was negligible, and these species/seasons were scoped out of CRM.

The CRZ for the Random models was defined as PCH within the area of the Vantage Point (VP) viewsheds visible during FAS (viewsheds are shown on Figure 11.2, while full details of FAS are presented within Appendices 11.1 'Baseline Ornithology Report 2020-21' and 11.2 'Baseline Ornithology Report 2020-21 – Confidential Annex). Where the Regular model was used, the CRZ was defined as the area within 500 m of the proposed turbine locations (the Turbine Envelope).

A single year of FAS was completed to inform CRM, which was confirmed in consultation with NS who agreed that a single year of surveys was sufficient to appropriately and robustly inform an Ecological Impact Assessment (EcIA; see Section 11.3 of Chapter 11 for further details).

For each species, the risk of collision for an individual was calculated by estimating the likelihood of collision based on the characteristics of the birds and of the turbines, using the Band *et al*. (2007) model[2]. The model runs as a two-stage process:

- **Stage 1**: calculate the number of birds flying through the rotors; and
- **Stage 2**: estimate the probability of a bird flying through the rotors being hit.

The estimated number of bird movements through the CRZ (stage 1) is then multiplied by the probability of collision (stage 2) to estimate the theoretical number of birds at risk of collision.

This produces a theoretical collision mortality rate that assumes birds take no action to avoid collision when, in practice, most birds do take avoiding action, which dramatically lowers predicted mortality. Therefore, the predicted collision mortality is multiplied by a percentage representing avoidance behaviour likely to be displayed by birds flying towards turbine blades. This involves the use of species-specific avoidance rates recommended by NS[4].

During Stage 1, the model varies dependent on whether the species in question exhibits random or regular flight behaviour. A Random model is used where species flights show no discernible pattern, such as raptors foraging widely over a Site. A Direct model is used where flights are regular, such as well-used goose commuting routes between roosting and foraging locations, or divers commuting between breeding lochs and the coast.

Species with sufficient flight activity to be modelled were as follows: pink-footed goose (non-breeding season) and peregrine (breeding season). Details of the individual target species flights included are presented in Appendices 11.1 and 11.2.

Curlew was scoped out of CRM despite seven flights being recorded during the breeding season. Although curlew was recorded in flight occasionally during the breeding season FAS, all seven flights were within open ground to the north of the Turbine Envelope, indicating that flight behaviour was associated with the breeding territories, rather than being randomly distributed across the VP viewsheds. Use of the Site by curlew is not expected to increase post-construction All five flights recorded at RSH were further than 500 m from the nearest turbine and therefore there is very low risk of collision.

[4] NS (2018) Avoidance Rates for the onshore NS Wind Farm Collision Risk Model [Online] Available at: https://www.nature.scot/wind-farm-impacts-birds-use-avoidance-rates-naturescot-wind-farm-collision-risk-model (Accessed 15/11/22)

2.1 Stage 1: Calculating Numbers of Birds Flying Through the Rotors

2.1.1 Available Hours for Flight Activity

The total amount of time that a species was potentially active was determined by calculating the minutes of available daylight for each species during the months of interest. For pink-footed goose, which could be active nocturnally, an additional 25% of night hours were added to the daylight hours to give a more accurate representation of the available hours for this species. Potential collisions were calculated for the breeding and/or non-breeding seasons separately, to account for potential seasonal variation in flight activity.

The total available hours for flight activity for each species are included in Tables 1-2 below.

2.1.2 Input Variables for CRM

2.1.2.1 Pink-footed goose

Based on the regular and predictable flight behaviour of pink-footed goose, the Regular model was used for this species during CRM. Input variables for Stage 1 are presented in Table 1.

Table 1: Input Variables for Pink-footed Goose CRM (Regular Model)

Species	Season	Observation effort (hours)	No. of birds observed in CRZ	No. of birds observed in CRZ per hour of effort	Available hours for flight activity	Potential no. of birds at risk during season
Pink-footed Goose	Non-breeding Season (September to April)	96	634	6.60	3310.125*	21860.62
*Includes additional 25% of night hours.						

2.1.2.2 Peregrine

Based on the flight behaviour of peregrine, and the unpredictability of their flights within the CRZ, for this species the Random model was used. The CRZ (i.e. the area within the VP viewsheds) for all species was 1191.37 ha. Input variables for Stage 1 are presented in Table 2.

Table 2: Input Variables for Peregrine CRM (Random Model)

Species	Season[3]	Total observation time (seconds)	Available hours for flight activity	Time at RSH (seconds)
Peregrine	Breeding (March to mid-August)	237600	2581.25	778

2.2 Stage 2: Estimating the Probability of Collision

2.2.1 Bird Biometrics and Avoidance Rates

The relevant biometrics and species-specific avoidance rates used in Stage 2 of the CRM are presented in Table 3. Both target species were considered to use flapping flight.

Table 3: Target Species Biometrics and Avoidance Rates Used in the CRM

Species	Body length*,** (m)	Wingspan*,** (m)	Assumed flight speed (m/s)**	Avoidance rate*** (%)
Pink-footed goose	0.675	1.525	19.30	99.8
Peregrine	0.420	1.020	12.10	98.0

*Values taken from Robinson, R.A. (2005) *BirdFacts: profiles of birds occurring in Britain & Ireland. BTO, Thetford* www.bto.org/about-birds/birdfacts (accessed 15/11/2022)

**Values taken from Bruderer, B. & Boldt, A. 2001. Flight characteristics of birds: I. Radar measurements of speeds. *Ibis*, 143, 178-204 and Provan, S. & Whitfield, D.P. (2007). *Avian flight speeds and biometrics for use in collision risk modelling*. Report from Natural Research to Scottish Natural Heritage. Natural Research Ltd, Banchory.

*** Values taken from NS (2018) *Avoidance Rates for the onshore NatureScot Wind Farm Collision Risk Model*.

2.2.2 Turbine Parameters

The candidate turbine model for the Development is the Siemens Gamesta 170. Technical specifications of this model and the values used in the CRM are presented in

Table 4.

Table 4: Candidate Turbine Parameters

Parameter	Siemans Gamesta 170 (used for CRM)
Hub height	115 m
Rotor diameter	170 m
Rotor swept height	30-200 m
No. of turbines	4
No. of rotor blades	3
Risk window area	2595450 m^2
Risk volume	441226500 m^3
Maximum chord width	4.5
Rotation period	5.17 seconds**
Average pitch	6
Estimated maximum operation*	85%
* Taken from British Wind Energy Association (BWEA). 2007. *Factsheet: Can We Rely on Wind?* BWEA, London ** Value used is for Siemens Gamesta 155	

2.3 Calculation of Collision Probability

Collision risk for birds passing through the rotors was calculated using the NS example spreadsheet for calculating the probability of collision[5]. The results are presented in

Table 5.

Table 5: Probability of Collision for Birds Passing through Rotors

Species (and flight type)	p(collision)* Upwind	p(collision)* Downwind	Mean
Pink-footed goose (flapping)	6.3%	4.7%	5.5%
Peregrine (flapping)	6.6%	4.1%	5.3%
*Where p = probability; the probability is calculated for both upwind and downwind flights, with a higher collision risk in upwind conditions; the mean was then used to estimate collision risk			

The final collision rates calculated for both species are listed in Table 6.

Table 6: Estimated Seasonal Collision Risk and Number of Years Per Collision for Species for which CRM was Completed

Species	Period*	Annual collision risk (no. of birds killed)		No. of years per collision	
		Assuming no avoidance	Using species-specific avoidance rates**	Assuming no avoidance	Using species-specific avoidance rates**
Pink-footed goose	Non-breeding season	155.285	0.311	0.006	3.220

[5] Available at: https://www.nature.scot/professional-advice/planning-and-development/advice-planners-and-developers/renewable-energy-development/onshore-wind-energy/wind-farm-impacts-birds (last accessed 15/11/2022).

Species	Period*	Annual collision risk (no. of birds killed)		No. of years per collision	
		Assuming no avoidance	Using species-specific avoidance rates**	Assuming no avoidance	Using species-specific avoidance rates**
Peregrine	Breeding season	0.746	0.015	1.340	67.020

*****Both species were recorded during FAS in a single season only, and therefore these values also represent the predicted annual collisions for each species.

******Avoidance rates taken from NS guidance[4]

3 CONCLUSION

CRM was completed for two target species: pink-footed goose and peregrine. Using species specific avoidance rates, mean collision risk based on a single year of FAS data was predicted to be as follows:

- Pink-footed goose: 0.311 collisions per year (during the non-breeding season), or one collision every 3.220 years;
- Peregrine: 0.015 collisions per year (during the breeding season), or one collision every 67.020 years.