ARCUS

CARRICK WINDFARM

APPENDIX 8.5: COLLISION RISK MODELLING

DECEMBER 2021

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1 INTRODUCTION

This Appendix has been produced as a supporting document to Chapter 8: Ornithology of the Environmental Impact Assessment Report (EIAR). It includes details of the avian Collision Risk Modelling (CRM) calculations used to predict collision risk to target species recorded during the 2018/19 and 2019/20 Flight Activity Surveys. As recommended in NatureScot[1] guidance, the CRM methods were based on Band *et al*. (2007)[2].

For the Flight Activity Surveys, height bands 2 and 3 (30-175mmetres (m)and >175m) fall within the Rotor Swept Height (RSH) of the candidate wind turbine model (30-200m). Therefore, 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). Flights that passed within the Collision Risk Zone (CRZ) at PCH were included in the CRM (where sufficient flight activity was recorded, defined as ≥ 3 flights or ≥ 10 individuals within the CRZ at PCH). Professional judgement was used to scope in or out additional flights, for example peregrine flights were scoped out where there was no risk of collision as flights were associated with a territory, rather than randomly distributed within the CRZ, and flights did not enter the CRZ.

A random model was used for peregrine, as this was considered to be most applicable for this species. Although the flight lines indicated that birds made some direct (regular) foraging flights along woodland edge, the random model was considered to be a more representative approach to account for future habitat changes within the Site, as keyholing will create additional areas of woodland edge which peregrine may favour for foraging in future. A direct model would assume that peregrine will only be at risk of collision close to the existing territory, whereas using the random model will account for the collision risk associated with potential foraging in keyholed areas in future and is considered to be a more conservative approach to assessing collision risk.

An adapted direct model was used for osprey, with two CRZs identified due to two distinct, direct (regular) flight patterns. Firstly CRZ 1 was defined as the area within 500m of the proposed wind turbines 8-13, associated with an obvious east-west flight path through the Site to the east of Linfern Loch. Additionally, CRZ 2 was identified, covering an area of flights associated with the osprey nest (the location of which is provided in Appendix 8.4, Figure CA2 of the EIAR). This was defined as the area within 500m of the proposed wind turbines 8 and 11. Both CRZs are shown on Figure CA5, Appendix 8.4 of the EIAR.

Flights associated with CRZ 1 were recorded in the 2019 and 2020 osprey breeding season, while flights associated with CRZ 2 were only recorded during the 2019 osprey breeding season. A single random flight was also recorded during 2020, therefore a random model was used for this flight.

Where the random model was used, the CRZ was defined as the visible area within the Vantage Point (VP) Viewsheds used for the Flight Activity Surveys.

2 COLLISION RISK CALCULATIONS

CRM was completed separately for particular seasons (breeding and non-breeding), with the estimate based on the observed occupancy rate and the number of potentially active minutes in that period. Seasons were defined in accordance with NatureScot guidance on species-specific breeding seasons[3].

Species that met these criteria during 2018/19 were: osprey (breeding season[4]), goshawk (breeding and non-breeding seasons) and peregrine (breeding season).

[1] Formerly known as Scottish Natural Heritage (SNH).

[2] Band, W., Madders, M. & Whitfield, D.P. (2007) Develo*ping 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 11/10/21)

[4] As osprey is a migratory species that does not overwinter in the UK, the breeding season risk equates to annual risk

Species that met these criteria during 2019/20 were: osprey (breeding season[4]), goshawk (breeding and non-breeding seasons) and peregrine (breeding and non-breeding seasons).

Details of target species flights included in the CRM are presented within the following Appendices:

- Table A4.1, Appendix 8.1;
- Table A2-1, Appendix 8.2;
- Table A4.1, Appendix A8.3, and;
- Table A2.1, Appendix 8.4.

All flights at PCH within the CRZ were included in CRM, with the exception of those listed in Table A8.5.1. Explanations of why particular flights were excluded from the CRM are included in Table 8.5.1.

Table 8.5.1 Details of Flights Not Included in Collision Risk Modelling

Species*	Season	Key no.**	Reasons for excluding flights from CRM
Peregrine	2019/20 non-breeding season	291	Flight not random - associated with a north/south flight path that was not within 500m of wind turbines.
	2019/20 breeding season	361	Flights not random - associated with a north/south flight path that was not within 500m of wind turbines.
		408	
		370	Flights not random – Short flights associated with a breeding territory, outwith the CRZ.
		374	
		396	
		408	Flight not random - associated with a north/south flight path that was not within 500m of wind turbines.
		444	Flights not random – Short flights associated with a breeding territory, outwith the CRZ.
		460	

* Species names and order follow the British List maintained by the British Ornithologists' Union (BOU)[5];

** Key numbers allow identification of individual flights, and correspond with the numbers shown on Figure CA3, Appendix 8.4.

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 wind turbines, using the Band *et al*. (2007) model[2]. The model runs as a two-stage process:

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

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 hours of available daylight for each species during the months of interest. The total available hours for flight activity for each species are included in Tables 8.5.2-8.5.5 below.

2.1.2 Input Variables for the 2018/19 CRM

The input variables for Stage 1 of the CRM for osprey using 2018/19 data (for which a direct model was used) are presented in Table 8.5.2.

[5] British Ornithologists' Union. (2017). The British List: A Checklist of Birds of Britain (9th edition). Ibis 160: 190-240.

Table 8.5.2 Input Variables for Osprey Direct CRM Model: 2019

Season[3]	CRZ	Observation effort (hours)	No. of birds observed in CRZ	No. of birds per hour of effort	Available hours for flight activity	Potential no. of birds at risk during season
Breeding Season (April to August)	CRZ 1 – East of Linfern Loch	90*	4	0.044	2442.5	108.56
	CRZ 2 Flights around the breeding territory	60**	4	0.25	2442.5	610.63
*Hours from VP1, VP3 and VP4 used as the CRZ falls within these viewsheds. ** Hours from VP1 and VP4 used as the CRZ falls within these viewsheds. ***Although only four birds were observed, during these four flights the CRZ was crossed 15 times, which was accounted for during modelling to produce the "number of birds per hour of effort"						

2.1.2.1 Random Models

The random model was used for all other species for which collision risk was estimated using 2018/19 data (goshawk and peregrine). The CRZ (i.e. the area within the VP viewsheds) was 2657.22 ha. Species-specific input variables are presented in Table 8.5.3.

Table 8.5.3 Input Variables for Random CRM Models: 2018/19

Species	Season[3]	Total observation time	Available hours for flight activity	Time at RSH (seconds)
Goshawk	Breeding (mid-March to mid-August)	540000 seconds	2394.5	255
	Non-breeding (mid-August to mid-March)	540000 seconds	2112	225
Peregrine	Breeding (March to mid-August)	540000 seconds	2578.25	438

2.1.3 Input Variables for the 2019/20 CRM

2.1.3.1 Direct Models

The input variables for Stage 1 of the CRM for osprey in CRZ 1, using 2019/20 data (for which a direct model was used), are presented in Table 8.5.4.

Table 8.5.4 Input Variables for Osprey Direct CRM Model: 2020

Season[3]	CRZ	Observation effort (hours)	No. of birds observed in CRZ	No. of birds per hour of effort	Available hours for flight activity	Potential no. of birds at risk during season
Breeding season (April to August)	CRZ 1 – East of Linfern Loch	90*	13	0.144	2442.5	352.81
*Hours from VP1, VP3 and VP4 used as the CRZ falls within these viewsheds.						

2.1.3.2 Random Models

The random model was used all other species for which collision risk was estimated using 2019/20 data (osprey flights around the breeding territory, goshawk and peregrine). The CRZ (i.e. the area within the VP viewsheds) differed between breeding and non-breeding seasons for goshawk and peregrine. This is because an additional VP was added from September 2019 onwards, when the non-breeding seasons for these species commenced. To account for this an average CRZ area was calculated across the season. Species-specific input variables are presented in Table 8.5.5.

Table 8.5.5 Input Variables for Random CRM Model: 2019/20

Species (and season)	CRZ Area (ha)	Season[3]	Total observation time	Available hours for flight activity	Time at RSH (seconds)
Osprey (flights around the breeding territory)	3189.86	Breeding (April to August)	648000 seconds	2442.5	202
Goshawk	3189.86	Breeding (mid-March to mid-August)	648000 seconds	2394.5	222
	3123.28	Non-breeding (mid-August to mid-March)	1015000 seconds	2112	237
Peregrine	3189.86	Breeding (March to mid-August)	777600 seconds	2578.25	864
	3113.77	Non-breeding (mid-August to February))	885600 seconds	1928.25	240

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 for each species used in Stage 1 of the CRM are presented in Table 8.5.6. All target species were considered to use flapping (rather than gliding) flight.

Table 8.5.6 Target Species Biometrics and Avoidance Rates Used in the CRM

Species	Body length* (m)	Wingspan* (m)	Assumed flight speed (m/s)**	Avoidance rate*** (%)
Osprey	0.560	1.580	12.00	98.00
Goshawk	0.565	1.05	10.00	98.00
Peregrine	0.420	1.020	12.10	98.00

Species	Body length* (m)	Wingspan* (m)	Assumed flight speed (m/s)**	Avoidance rate*** (%)

* Values taken from Robinson, R.A. (2005) *BirdFacts: profiles of birds occurring in Britain & Ireland. BTO, Thetford* www.bto.org/about-birds/birdfacts (accessed 05/10/2020) and Mullarney, K, Svensson, L, Zetterström, D, and Grant, P J. (2000). Collins Bird Guide. HarperCollins, London

** Values taken from a range of literature which includes:

- Alerstam T., Rosén M., Bäckman J., Ericson P.G.P., Hellgren O. 2007. Flight speeds among bird species: allometric and phylogenetic effects. *PLoS Biol*, 5, 1656-1662;
- Provan, S. & Whitfield, D.P. 2006. *Avian Flight Speeds and Biometrics for Use in Collision Risk Modelling*. Unpublished Report to Scottish Natural Heritage (SNH); and
- Bruderer, B. & Bolt, A. 2001. Flight characteristics of birds: I. Radar measurements of speeds. *Ibis*, 143, 178-204.

*** SNH (2018) *Avoidance Rates for the onshore SNH Wind Farm CRM*

2.2.2 Wind Turbine Parameters

The candidate wind turbine model used for the CRM was the Siemens Gamesa SGRE170. Specifications of this wind turbine model are presented in Table 8.5.7.

Table 8.5.7 Wind Turbine Dimensions Used in the CRM

Parameter	Value
Hub height	115.00m
Rotor radius	85.00 m
No. of wind turbines	13
No. of rotor blades	3
Risk window area	8,082,692.09m^2
Risk volume	1,374,057,655m^3
Maximum chord width	4.50m
Rotation period	6.82 seconds
Average pitch	6.00 degrees
Estimated maximum operation*	85%

* Taken from British Wind Energy Association (BWEA). 2007. Factsheet: *Can We Rely on Wind?* BWEA, London

2.3 Calculation of Collision Probability

Collision risk for birds passing through the rotors was calculated using the NatureScot example spreadsheet for calculating the probability of collision[6]. The results are presented in Table 8.5.8.

Table 8.5.8 Probability of Collision for Birds Passing Through Rotors

Species	p(collision)* Upwind	p(collision)* Downwind	Mean
Osprey (flapping)	6.5%	4.6%	5.6%
Goshawk (flapping)	6.8%	4.5%	5.7%
Peregrine (flapping)	5.7%	3.8%	4.7%

[6] 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 11/10/2021).

Species	p(collision)* Upwind	p(collision)* Downwind	Mean
*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 each species are listed in Table 8.5.9 below.

Table 8.5.9 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*
Osprey	2019 breeding season CRZ 1	1.482	0.030	0.675	33.726
	2019 breeding season CRZ 2	3.765	0.075	0.266	13.279
	2019 breeding season total	5.248	0.105	0.191	9.527
	2020 breeding season CRZ 1	4.818	0.096	0.208	10.377
	2020 breeding season – Random model	0.080	0.002	12.432	621.599
	2020 breeding season total	4.899	0.098	0.204	10.207
	Breeding season/Annual mean	5.073	0.101	0.2	9.9
Goshawk	2018/19 non-breeding season	0.100	0.002	10.029	501.428
	2019 breeding season	0.128	0.003	7.805	390.240
	2018/19 whole year	0.228	0.005	4.389	219.451
	2019/20 non-breeding season	0.048	0.001	21.034	1051.719
	2020 breeding season	0.077	0.002	12.914	645.719
	2019/20 whole year	0.125	0.002	8.002	400.082
	Annual mean	0.176	0.004	5.7	283.4
Peregrine	2019 breeding season/ whole year	0.239	0.005	4.184	209.191

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*
	2019/20 non-breeding season	0.051	0.001	19.618	980.907
	2020 breeding season	0.273	0.005	3.666	183.302
	2020 whole year	0.324	0.006	3.089	154.442
	Annual mean	0.9	0.006	3.6	177.7