

# Environmental Impact Assessment Report

Beinneun 2 Wind Farm

Volume 3

Technical Appendix A7.3: Collision Risk Modelling

Document prepared by Envams Ltd and RPS Tetra Tech for Beinneun 2 Ltd

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# BEINNEUN 2 WIND FARM

## Technical Appendix A7.3: Collision Risk Modelling

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## REPORT

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## Contents

<b>1</b>	<b>COLLISION RISK MODELLING</b> .....	<b>1</b>
1.1	Background .....	1
<b>2</b>	<b>TARGET SPECIES</b> .....	<b>2</b>
<b>3</b>	<b>FIELD SURVEY METHODS</b> .....	<b>3</b>
3.1	Field Surveys.....	3
3.2	Vantage Point Surveys.....	3
	Aims .....	3
	Survey Area and Viewsheds .....	3
	Timing.....	4
	Recording Methods Summary.....	4
	Survey Effort.....	5
<b>4</b>	<b>COLLISION RISK MODELLING METHODS</b> .....	<b>6</b>
4.1	Parameters and Modelling Inputs .....	6
4.2	CRM Step-By-Step Calculation.....	9
<b>5</b>	<b>CRM RESULTS</b> .....	<b>10</b>
<b>6</b>	<b>REFERENCES</b> .....	<b>12</b>

## Tables

Table 1: Summary of Vantage Point flight activity survey effort for the Development (May 2023 to August 2024).....	5
Table 2: Aggregated flight seconds in different height bands of all target species observed across all surveys, within and outside the collision risk area .....	6
Table 3: Aggregated flight seconds per target species, clipped to flights within the collision risk area .....	7
Table 4: VP viewshed areas and extent of overlap with the collision risk area .....	7
Table 5: Turbine parameters used for CRM.....	8
Table 6: Bird parameters and avoidance rates of species in CRM .....	8
Table 7: Breeding seasons of relevant target bird species for CRM .....	9
Table 8: CRM results per species and operational time scenario .....	11

## Appendices

Appendix A Latin Names of species Present in Report

Appendix B Flight Activity Survey Effort

# 1 COLLISION RISK MODELLING

## 1.1 Background

- 1.1.1 RPS were commissioned by Beinneun 2 Ltd, hereafter referred to as “the Applicant”, to produce an ornithology technical report, including the detailing collision risk modelling (CRM), for a proposed onshore wind farm development (“the Development”) located approximately 10 km west of Fort Augustus on Glengarry, Highland, hereafter referred to as “the Site”. The Site is approximately centred on Ordnance Survey (OS) grid reference NH 23398 05392.
- 1.1.2 This Technical Appendix has been produced as a supporting document to Chapter 7 of the Beinneun Wind 2 Farm Environmental Impact Assessment (EIA) Report. This sub-document (Technical Appendix A7.3) includes details of the methods and results of the avian Collision Risk Modelling calculations used to predict the annual number of collisions caused by the Proposed Development, based on data recorded during Vantage Point (VP) surveys completed between 2023 and 2024.
- 1.1.3 The Site location and turbine layout are shown in **Technical Appendix A7.2, Figure 7.1**. The Development comprises the proposed wind energy infrastructure, and associated development, which includes 19 turbines, access tracks and construction compounds. The full description of the Development and an overview of the Site is presented in **Chapter 4: Development Description of the EIA Report**.
- 1.1.4 This report covers the work for data collection up to and including collision risk modelling. It forms a sub-set of wider ornithology works for the Development but is suitably complex that it is best treated as a separate entity.
- 1.1.5 A series of breeding and wintering VP surveys were undertaken between May 2023 and August 2024 to provide data to inform the CRM. Surveys were undertaken following NatureScot (2017) guidance for onshore wind. Full methods for the VP surveys are presented in **Technical Appendix A7.1 Ornithology Baseline Report**.
- 1.1.6 Flight data from the VP surveys were digitised and processed in ArcGIS in preparation for analysis. All flights recorded were loaded into the R environment (R Core Team, 2020) using the sf package (Pebesma, 2018; Pebesma and Bivand, 2023), and the Band *et al.* (2007) model was followed for the analysis. This model is standard across the onshore wind industry and is understood and used by all relevant Statutory Nature Conservation Bodies (SNCBs).
- 1.1.7 In line with NatureScot (2017) guidance, CRM data analysed for the purpose of informing an EIA should not exceed five years of age. Since the data was collected for the Development within the last 2 years, this CRM is deemed suitable for informing an EIA.

## 2 TARGET SPECIES

- 2.1.1 During the early stages of ornithology research for the Development, a list of target species was defined to refine the number of birds recorded and presented in this Technical Appendix, and to help focus the impact assessment. Surveys were not restricted to these species, but they allowed a level of focus for surveyors at the outset, relating to species known to be vulnerable to collision risk within the wind industry and conservation.
- 2.1.2 The target species for the Development were confirmed to be as follows:
- Qualifying species of designated sites in proximity or potentially connected to the Site, including assemblage components;
  - Geese, swans, ducks, grouse, raptors and waders listed on Annex I of the Birds Directive, Schedule 1 of the Wildlife and Countryside Act 1981 (as amended), or the Red and Amber lists of the Birds of Conservation Concern 5 (BoCC 5) (Stanbury, *et al.*, 2021);
  - Target species were also identified with reference to NatureScot guidance (2017; 2018) on target/priority species for assessment.
- 2.1.3 All of the birds recorded, presented, and discussed in this CRM report are target species for collision risk surveys.
- 2.1.4 All bird species names used in this report follow the British List, which is maintained by the British Ornithologists' Union (BOU, 2022), with all species referred to by their British (English) vernacular name. A list of scientific names can be found Error! Reference source not found..

## 3 FIELD SURVEY METHODS

### 3.1 Field Surveys

- 3.1.1 A suite of ornithology field surveys was commissioned by the Applicant to cover the Core Study Area (CSA) together with species-specific buffers (NatureScot, 2017). Field surveys commenced in 2023 and were completed in 2024.
- 3.1.2 The field survey design complied with the guidance in place at the time (NatureScot, 2017) and set out to characterise the distribution, abundance and flight activity of target species. The full methods and results of these are presented in Chapter 7, Technical Appendix A7.1: Ornithology Baseline Report of the EIA Report.
- 3.1.3 The information collected during the baseline surveys (and corresponding desk study) is used to help inform the EIA detailed in Chapter 7: Ornithology of the EIA Report.
- 3.1.4 All field surveyors had extensive ornithological backgrounds with long term experience carrying out the bird survey methods used, estimating flight heights and distances, recording data concisely and correctly, navigation techniques and health and safety.

### 3.2 Vantage Point Surveys

#### Aims

- 3.2.1 The VP surveys were designed to quantify the level of flight activity by each target species and their distribution over the survey area across the seasons.
- 3.2.2 The main aim of the surveys was to provide data for CRM (Band *et al.*, 2024), to help predict annual 'potential mortality' from collision with turbines. However, the VP data were also used to provide an overview of how birds use the Site, to help to inform conclusions on potential disturbance, displacement and barrier effects (assessed in Chapter 7: Ornithology of the EIA Report). The VP survey methods followed the NatureScot guidance at the time (NatureScot, 2017).

#### Survey Area and Viewsheds

- 3.2.3 The VP locations were chosen based on CSA investigation and GIS combining factors such as access and suitability of view in terms of providing sound data for differing height bands. To create the collision risk survey area, a line was drawn around the outermost proposed turbines (as set out at the time of the start of the ornithology surveys) to produce the turbine envelope. This area was then buffered by 500 m (to address inaccuracies of position for flight line observations), and VP viewsheds were created and arranged so that they covered the entire survey area from the minimum possible number of VP locations.
- 3.2.4 This resulted in six VPs being selected:
- VP 1 at OS grid ref. NH 21488 06646;
  - VP 2 at OS grid ref. NH 20645 05531;
  - VP 3 at OS grid ref. NH 20461 04634;
  - VP 4 at OS grid ref. NH 22280 05256;
  - VP 5 at OS grid ref. NH 23040 05465; and
  - VP 6 at OS grid ref. NH 25900 06945.
- 3.2.5 The scanning arc of the VPs was 180°, with a viewing range of 2 km. The VP locations and their viewsheds are presented in **Technical Appendix A7.2, Figure 7.5**.
- 3.2.6 VPs should typically be positioned outside of the survey area to minimise the observer's effect on bird behaviour, however, due to restricted viewshed locations offering adequate coverage, VP2

and VP 3 were located inside the red line boundary survey area. This was necessary to maintain a good viewing area of the turbine envelope.

- 3.2.7 There was some degree of overlap between VPs, however surveys were not carried out simultaneously of one another at these VP survey locations. As a result, this prevented duplicate flight records or any effects due to disturbance by the other surveyor, if surveys had been carried out simultaneously.

### Timing

- 3.2.8 Data were collected during timed watches from the pre-determined VPs. The individual VP watches were spread over the full daylight period available, using local sunrise and sunset times. Some VP watches focussed on dawn and dusk hours to capture any potential presence of specific target species.
- 3.2.9 Each VP watch lasted, a maximum of three hours. Breaks of at least 30 minutes between VP watches were taken to minimise observer fatigue.
- 3.2.10 A total of 414 hours of flight activity survey effort was undertaken across the survey area between May 2023 and August 2024. Consultation was undertaken with NatureScot who confirmed that there was sufficient data to inform the impact assessment from the initial 18 months of surveys. Consequently, 24 hours of flight activity survey effort per season was undertaken despite NatureScot's guidance which recommends 36 hours of flight activity survey effort per season. This was further supplemented with an additional 18 hours of survey effort during the 2024 breeding season.

### Recording Methods Summary

- 3.2.11 During each VP watch, two recording methods were used to record data: focal bird sampling for target species and activity summaries for secondary species.
- 3.2.12 **Focal bird sampling for target species:** the area in view was scanned until a target species was detected, at which point it was followed until it ceased flying or was lost from view. Recording of target species took priority over completion of secondary species activity summaries. The time the target bird was detected, and the flight duration were both recorded. The flight path of the bird was plotted in the field onto OS 1:15,000 scale maps by the surveyor at the time of observation. The bird's flight height was estimated at the time of detection and then at 15 second intervals thereafter. Flight heights were classified into the following height bands:
- **Height band 1:** <20 m;
  - **Height band 2:** 20-40 m;
  - **Height band 3:** 40-100 m;
  - **Height band 4:** 100-150 m;
  - **Height band 5:** 150-250 m;
  - **Height band 6:** 250 m +.
- 3.2.13 **Activity summaries for secondary species:** each watch was sub-divided into 5-minute periods, at the end of which the number and activity of all secondary species observed was recorded. If a target species was being tracked at the end of a 5-minute period, then the activity summary for that period was abandoned and a new one started once observations of the target species had ended.
- 3.2.14 As well as birds in flight, static target species, and those recorded through sound (but not by sight), or those outside the viewshed were recorded. Static birds of non-target species, e.g., perched birds and birds on water bodies were recorded once only on arrival at the VP. Thereafter, only flying birds and newly noticed perched birds were included in the activity summaries. This allowed greater time for focal bird sampling rather than repeated observations of the same static birds.

3.2.15 Each survey was undertaken by a single observer in good conditions (i.e. visibility of at least 2 km). Weather and visibility conditions varied and were recorded on an hourly basis including information on wind strength and direction, precipitation and cloud cover.

### Survey Effort

3.2.16 Due to consultation outcomes with NatureScot (**email dated 12/112024 Beinneun 2 WF – Ornithology Consultation**), 24 hours of survey effort was conducted during the 2023 breeding and non-breeding season and an additional 18 hours of survey effort was undertaken during the 2024 breeding season.

- Breeding season (April to August); and
- Non-breeding season (September to March).

3.2.17 The scheme initially included eight Vantage Points; however, locations 7 and 8 in the east were removed after turbine layout modifications reduced the collision risk area, making these locations unnecessary for further analysis. Data collected at vantage point 7 and 8 was not used within the collision risk modelling.

3.2.18 VP surveys were conducted monthly from May 2023 to December 2023, and for the period between May 2024 and August 2024. This equates to two full breeding seasons and part of one non-breeding season captured across the survey period (2023 – 2024).

3.2.19 A summary of the monthly survey effort at each VP is presented in Table 1, with the full survey schedule breakdown in Appendix B as Appendix Table 1.

3.2.20 Full results from the surveys can be found in Technical Appendix A7.1: Ornithology Baseline Report.

**Table 1: Summary of Vantage Point flight activity survey effort for the Development (May 2023 to August 2024)**

Month	Flight Activity Survey Effort per Vantage Point (hours)						Total Effort
	VP1	VP2	VP3	VP4	VP5	VP6	
<b>2023</b>							
May '23	6	6	6	6	6	6	36
June '23	6	6	6	6	6	6	36
July '23	6	6	6	6	6	6	36
August '23	6	6	6	6	6	6	36
<b>Breeding Season Total</b>	<b>24</b>	<b>24</b>	<b>24</b>	<b>24</b>	<b>24</b>	<b>24</b>	<b>144</b>
September '23	6	6	6	6	6	6	36
October '23	6	6	6	6	6	6	36
November '23	6	6	6	6	6	6	36
December '23	6	6	6	6	6	6	36
<b>Non-Breeding Season Total</b>	<b>24</b>	<b>24</b>	<b>24</b>	<b>24</b>	<b>24</b>	<b>24</b>	<b>144</b>
<b>2024</b>							
May '24				6	6	6	18
June '24	6	6	6	6	6	6	36
July '24	6	6	6	6	6	6	36
August '24	6	6	6	6	6	6	36
<b>Breeding Season Total</b>	<b>18</b>	<b>18</b>	<b>18</b>	<b>24</b>	<b>24</b>	<b>24</b>	<b>126</b>
<b>Total Hours</b>	<b>66</b>	<b>66</b>	<b>66</b>	<b>72</b>	<b>72</b>	<b>72</b>	<b>414</b>

## 4 COLLISION RISK MODELLING METHODS

### 4.1 Parameters and Modelling Inputs

- 4.1.1 Collision Risk Modelling (CRM) was carried out for the Development following NatureScot guidance (NatureScot 2000; 2018; 2024a). The collision risk area (15,386,852m<sup>2</sup>) was calculated in GIS by drawing a concave hull around the 19-turbine layout and adding a 500 m buffer.
- 4.1.2 Only bird flights recorded during the timed VP surveys were taken forward for modelling. Data was loaded into the R coding environment (R Core Team 2020) using the “sf” package (Pebesma, 2018; Pebesma and Bivand, 2023).
- 4.1.3 Details presented in Table 2 refer to the aggregated flight seconds in each different height band, of **each target species observed, both inside and outside the collision risk area** across all VP surveys during the survey period.
- 4.1.4 The ‘number of birds’ is not necessarily the number of different individuals, but may be, for instance the same bird flying through the area several times, or the same individual seen each month.

**Table 2: Aggregated flight seconds in different height bands of all target species observed across all surveys, within and outside the collision risk area**

Species	Flights	No. of birds	<20m	20m to 40m	40m to 100m	100m to 150m	150m to 250m	>250m
Golden Eagle	30	33	465	1740	4035	3165	750	405
White-tailed Eagle	11	12	165	390	780	840	435	105
Golden Plover	6	7	135	165	915	0	0	0
Greenshank	4	5	135	135	0	0	0	0
Osprey	4	4	105	180	345	0	0	0
Common Snipe	3	3	30	465	1845	0	0	0
Teal	3	4	60	360	0	0	0	0
Merlin	2	2	60	0	0	0	0	0
Canada Goose	1	21	0	2835	3150	0	0	0
Hen Harrier	1	1	45	0	0	0	0	0
Mallard	1	2	120	0	0	0	0	0
Pink-footed Goose	1	68	0	0	0	0	5100	0
Red-throated Diver	1	1	0	0	120	0	0	0

- 4.1.5 Only flights or parts of flights that were inside the collision risk area were included in the analysis. If a flight was partially within the collision risk area, it was clipped to the collision risk area, i.e., the proportion that was within the area was calculated and the number of seconds was adjusted assuming the bird was flying at a constant speed. Aggregated flight seconds of each target species, clipped to flights within the collision risk area, are presented in Table 3.

**Table 3: Aggregated flight seconds per target species, clipped to flights within the collision risk area**

Species	Flights	No. of birds	<20m	20m to 40m	40m to 100m	100m to 150m	150m to 250m	>250m
<b>Golden Eagle</b>	24	27	256.3	1110.8	2651	2143.7	581.1	349.9
<b>White-tailed Eagle</b>	10	11	131	312.2	560.4	684.8	406.6	100.6
<b>Common Snipe</b>	3	3	24.6	389.5	1518.9	0	0	0
<b>Greenshank</b>	3	4	120	135	0	0	0	0
<b>Osprey</b>	3	3	105	180	240	0	0	0
<b>Golden Plover</b>	2	2	59.8	148.4	445.2	0	0	0
Merlin	2	2	60	0	0	0	0	0
Teal	2	2	60	0	0	0	0	0
Hen Harrier	1	1	45	0	0	0	0	0
Mallard	1	2	120	0	0	0	0	0
Red-throated Diver	1	1	0	0	89.5	0	0	0

4.1.6 From these preliminary results, some species were excluded from further CRM analysis based on there being only incidental flight records or because flight activity was so low that the species was considered to be at negligible risk of collision. Only target species highlighted in **bold** (in Table 3) had sufficient levels of flight activity, defined as two or more flights (though less flights would be considered if involving large flocks of target species) recorded within the collision risk bands and the collision risk area over the course of the surveys). Hence, the following species were taken forward for further CRM assessments:

- Golden eagle
- White tailed Eagle
- Common Snipe
- Greenshank
- Osprey
- Golden plover

4.1.7 As only flights, or parts of flights, within the collision risk area were included in the CRM, the same treatment was applied to viewsheds. There was substantial variation in which part of the viewshed was within the collision risk area, ranging from 47% to 60%. To be precautionary, only parts of viewsheds that were within the collision risk area were included in the analysis to prevent collision risk from being underestimated. The area of the overlap among each viewshed and the collision risk area was calculated in GIS and is presented in Table 4.

**Table 4: VP viewshed areas and extent of overlap with the collision risk area**

Viewshed	Full area surveyed (m <sup>2</sup> )	Area surveyed which overlapped the collision risk area (m <sup>2</sup> )	Overlap %
1	3,983,150.00	2,688,623.25	67%
2	1,998,935.52	1,324,468.45	66%
3	4,612,200.00	835,155.04	18%
4	5,319,500.00	3,800,827.40	71%
5	5,580,025.00	3,107,962.59	56%
6	5,550,900.00	4,061,022.56	73%

4.1.8 The **turbine parameters** used for the CRM analysis are presented in Table 5, following details specified by the Applicant. **The “collision air space height” was assumed as the worst-case scenario of 172 metres after considering the air gap (28 m) and the turbine tip height (200 m) of the proposed turbine model.**

4.1.9 Given the proposed air gap of these **turbines (28 m)**, a **scenario using data from 20 m banding up is realistic** and sufficient for the proposed turbine layout for this development. Therefore, **data from height bands 2, 3, 4 and 5 (20-250 m)** have been taken forward for modelling purposes. This takes a pragmatic approach and does not enter realms of false precision by trying to split down field survey recorded height bands.

**Table 5: Turbine parameters used for CRM**

Turbine Parameters	Value
Blade diameter (m)	172
Turbine radius (m)	86
Tower height (m)	114
Turbine height (m)	200
Air gap (m)	28
Number of turbines	19
Number of blades	3
Blade depth (m)	4.5
Max chord	5
Rotation period (s)	5.5
Pitch (degrees)	10
Downtime options (%)	15% and 55.2%

4.1.10 Bird biometric parameters used in the CRM are included in Table 6. Most of this data has been gathered from a database of official biometric parameters utilised from NatureScot (2014; 2025) and other sources (Alerstam *et al*, 2007; Provan and Whitfield; Hayman *et al.*, 1986).

4.1.11 Avoidance rates differ per species and a number are applied as standard across the industry (NatureScot, 2025). These factors are crucial and very sensitive in the modelling process, and typically precautionary. An avoidance rate of 98% proposes that out of 100 flight lines through a turbine rotor swept area that only two would collide. For 99.5% avoidance this equates to just five collisions per 1,000 flight lines, or 0.5 collisions per 100. So, the difference between 98% and 99.5% is not simply 1.5%, but is four-fold in terms of modelling results.

**Table 6: Bird parameters and avoidance rates of species in CRM**

Species	Length	Wingspan	Flight speed	Avoidance rate applied
Canada Goose	0.41	1.2	13.4	0.98
Golden Eagle	0.82	2.12	11.9	0.99
Golden Plover	0.28	0.72	13.7	0.98
Greenshank	0.32	0.69	12.3	0.98
Hen Harrier	0.48	1.1	9.1	0.99
Mallard	0.58	0.9	18.5	0.98
Merlin	0.28	0.56	12.1	0.98
Osprey	0.56	1.58	11.4	0.98
Pink-footed Goose	0.68	1.52	17.3	0.998
Red-throated Diver	0.61	1.11	18.6	0.995
Common Snipe	0.26	0.46	17.1	0.98
Eurasian Teal	0.36	0.62	12.5	0.98
White-tailed Eagle	0.8	2.2	11.3	0.95

Sources: NatureScot 2014; NatureScot 2025; Alerstam *et al*, 2007; Provan and Whitfield; Hayman *et al.*, 1986.

## 4.2 CRM Step-By-Step Calculation

- 4.2.1 First, bird and turbine parameters were entered in the standard onshore Band Collision Risk Model (Band *et al.*, 2007) to calculate the chance of collision if a bird passed through a rotor swept area. Next, flight seconds within the collision risk area were aggregated by viewshed and season (breeding or non-breeding) for each species. The same was done for the number of seconds surveyed in each viewshed across species-specific seasons (Table 7).
- 4.2.2 A calculation of effort for each viewshed in each season was calculated by multiplying the number of seconds surveyed by the amount of overlap in m<sup>2</sup> of the viewshed. A weighting of this effort was calculated by dividing the effort of each viewshed in each season by the sum of the total effort across all viewsheds and seasons.

**Table 7: Breeding seasons of relevant target bird species for CRM**

Species	Breeding Season
Canada Goose	April – July
Golden Eagle	February - August
Golden Plover	Mid-April – Mid-July
Greenshank	Mid-April – July
Hen Harrier	April – August
Mallard	April – August
Merlin	March – July
Osprey	April – August
Pink-footed Goose	Mid-May – August
Red-throated Diver	Mid-April - August
Common Snipe	Mid-April – Mid-July
Eurasian Teal	April – August
White-tailed Eagle	February - August

Data from NatureScot (2024b).

- 4.2.3 Flight activity per second surveyed per m<sup>2</sup> was calculated by dividing the flight seconds within the collision risk area by the effort. Weighted flight activity per second was calculated by multiplying the output of this by the respective weighting factor. The sum of weighted flight activity then constituted the flight activity per second per m<sup>2</sup> within the wind farm.
- 4.2.4 The sum of weighted flight activity was then multiplied by the wind farm area to get an estimate of bird activity per second and then multiplied by the number of seconds of daylight in each species-specific breeding and non-breeding season to get an estimate of occupancy in seconds during each of these seasons.
- 4.2.5 Vw was calculated as the planned area of the wind farm multiplied by the rotor diameter. The air gap was excluded because flights from birds within the air gap were also excluded.
- 4.2.6 Vr was calculated as the area in m<sup>3</sup>, the spherical sweep area of a turbine, occupied by the number of turbines with a set rotor radius (e.g., 75m). Vr was divided by Vw and multiplied by occupancy to get an estimate of how many seconds birds spend within rotor swept area.
- 4.2.7 To calculate how many birds are expected to pass through rotors, the Vr occupancy is then divided by the time in seconds it takes a bird to transition through a rotor (t), which is the depth of the sum of the rotor blade depth and bird length in metres, divided by the speed in metres per second. This was multiplied by the collision risk percentage from the Band Model (Band *et al.*, 2007) to get the expected number of collisions without avoidance or turbine downtime.
- 4.2.8 Downtime (Table 5) and avoidance rates (Table 6) were then applied to calculate more realistic collision risk outputs at the end of the process.

## 5 CRM RESULTS

- 5.1.1 CRM was conducted for **six species** identified as being target species (Table 7). Analysis was conducted for the 19-turbine layout over the 40-year lifetime of the Development.
- 5.1.2 It should be noted that the modelling is generic and over precautionary in biological terms. It allows for a scenario where a bird collides with a turbine multiple times. A bird can only die once, but the model works on the assumption that it is replaced instantly in the population, which is not realistic in any circumstances. As such, numbers should be treated as indicators, and not verbatim. They will always be higher than reality scenarios.
- 5.1.3 Inclusion of operational turbine time also provides a more realistic scenario, rather than if turbines run at full speed, all the time, as the basic model assumes. This has been implemented in the modelling presented in this document and the results presented with 15% and 55.2% downtime (i.e., 85% and 44.8% operational time).
- 5.1.4 Raw collision risk modelling makes several highly precautionary assumptions in relation to turbines. These include operating at very fast (maximum) speeds, with no tapering and shutdowns, and no allowance for maintenance downtimes. The UK Government publish load factor numbers which can be used with an implausible turbine output to provide a realistic output, using best scientific evidence. The load factor is calculated by RenewableUK as a rolling average of the past five years using data (on an Unchanged Configuration Basis) from the Digest of UK Energy Statistics published by the Department for Energy Security and Net Zero, using statistics from 2019-2023 (released in July 2024):
- Onshore wind: 26.34%
  - Offshore wind: 40.58%
- 5.1.5 Load factors have been increasing over time due to technological innovation. DESNZ states in its CfD (Standard Terms) Regulations document that the load factor for new build projects (for delivery years 2026-2029) is 62.3% for offshore wind and 44.8% for onshore wind (>5MW).
- 5.1.6 Hence, a load factor of 44.8% (55.2% downtime) was used within the models, which is still regarded as precautionary. This significantly reduces the modelled figures further, but is using the 'best scientific evidence' principal.
- 5.1.7 White-tailed eagle had the largest collision risk probability, with a years per collision rate of 2.68 when considering the 44.8% operational time scenario. Golden eagle was second, with a years per collision rate of 3.86 years. The collision risk of snipe was 8.99 years per collision, followed by golden plover with a rate of 32.89 years per collision and osprey with 43.39 years per collision. Finally, greenshank showed a negligible collision risk with a rate of over 150 years per collision.

**Table 8: CRM results per species and operational time scenario**

Scenario	Species	Total collisions per year			Years per collision	Collisions in 40 years
		Breeding season	Non-breeding season	Total		
19-turbine - 85% Op. Time (15% downtime)	White-tailed Eagle	0.435	0.273	0.708	1.41	28.3
	Golden Eagle	0.386	0.106	0.492	2.03	19.7
	Common Snipe	0.211	0.000	0.211	4.74	8.4
	Golden Plover	0.058	0.000	0.058	17.33	2.3
	Osprey	0.044	0.000	0.044	22.87	1.8
	Greenshank	0.013	0.000	0.013	79.08	0.5
19-turbine - 44.8% Op. Time (55.2% downtime)	White-tailed Eagle	0.229	0.144	0.373	2.68	14.9
	Golden Eagle	0.203	0.056	0.259	3.86	10.4
	Common Snipe	0.111	0.000	0.111	8.99	4.4
	Golden Plover	0.030	0.000	0.030	32.89	1.2
	Osprey	0.023	0.000	0.023	43.39	0.9
	Greenshank	0.007	0.000	0.007	150.05	0.3

## 6 REFERENCES

- 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. DOI:10.1371/journal.pbio.0050197.
- Band, W. 2024. Using a collision risk model to assess bird collision risks for onshore wind farms. NatureScot Research Report 909. [NatureScot Research Report 909 - Using a collision risk model to assess bird collision risks for onshore wind farms | NatureScot](#).
- Band, W., Madders, M. & Whitfield, D. P., 2007. Developing field and analytical methods to assess avian collision risk at wind farms. In: M. de Lucas, G. Janss & M. Ferrer, eds. *Birds and Wind Farms*. Madrid: Quercus, pp. 259-275.
- Bird Survey & Assessment Steering Group, 2023. Bird Survey Guidelines for assessing ecological impacts, v.1.0.0. <https://birdsurveyguidelines.org> (Accessed 15<sup>th</sup> Jan 2025).
- British Ornithologists' Union (2022). The British List: A Checklist of Birds of Britain (10th edition). *Ibis* 164, 860–910.
- CIEEM. 2018. Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater, Coastal and Marine. Chartered Institute of Ecology and Environmental Management, Winchester.
- Cramp, S. & Simmons, K.E.L. 1983. Handbook of the birds of Europe, the Middle East and North Africa: The birds of the Western Palaearctic. Oxford University Press.
- Department for Energy Security & Net Zero <https://assets.publishing.service.gov.uk/media/65e85ee662ff48001a87b243/cfd-ar6-standard-terms-notice.pdf> (accessed Jan 23rd 2025) .
- Furness, R.W. (2019) Avoidance rates of herring gull, great black-backed gull and common gull for use in the assessment of terrestrial wind farms in Scotland. Scottish Natural Heritage Research Report No. 1019.
- Gilbert, C., Gibbons, D. W. & Evans, J., 1998. *Bird Monitoring Methods*. Bedfordshire: RSPB.
- Hardey, J. et al., 2013. *Raptors: A Field Guide to Survey and Monitoring*. Edinburgh: The Stationery Office.
- Hayman, P., Prater, A. & Marchant, J. (1986). *Shorebirds: An Identification Guide to the Waders of the World*. Christopher Helm (Publishers) Ltd. London.
- Nature Scot. 2024a. [Guidance on using an updated collision risk model to assess bird collision risk at onshore wind farms | NatureScot](#).
- NatureScot 2024b. Standing Advice for Planning Consultations – Birds. Available at: <https://www.nature.scot/doc/standing-advice-planning-consultations-birds> Breeding season dates available at: <https://web.archive.org/web/20220613155315/www.nature.scot/sites/default/files/2017-07/A303080%20-%20Bird%20Breeding%20Season%20Dates%20in%20Scotland.pdf>.
- NatureScot, 2016. Environmental Statements and Annexes of Environmentally Sensitive Bird Information, s.l.: NatureScot.
- NatureScot, 2017. Recommended Bird Survey Methods to Inform Impact Assessment of Onshore Wind Farms. Version 2., [Recommended bird survey methods to inform impact assessment of onshore windfarms | NatureScot](#).
- NatureScot. 2000. Windfarms and Birds: Calculating a Theoretical Collision Risk Assuming no Avoidance Action. SNH Guidance Note. SNH.
- NatureScot. 2014. [Wind farm impacts on birds - Flight Speeds and Biometrics for Collision Risk Modelling | NatureScot](#).
- NatureScot. 2016. Guidance – Assessing Connectivity with Special Protection Areas (SPAs). Version 3.

- NatureScot. 2018. Assessing the significance of impacts on bird populations from onshore wind farms that do not affect protected areas, Version 2, s.l.: NatureScot.
- NatureScot. 2022. General Pre-application and Scoping Advice for Onshore Wind Farms.
- NatureScot. 2025. Wind farm impacts on birds - Use of Avoidance Rates in the NatureScot Wind Farm Collision Risk Model. Available online at: <https://www.nature.scot/doc/wind-farm-impacts-birds-use-avoidance-rates-naturescot-wind-farm-collision-risk-model> [Accessed March 2025].
- Pebesma, E. 2018. "Simple Features for R: Standardized Support for Spatial Vector Data." *The R Journal*, 10(1), 439–446. doi:10.32614/RJ-2018-009, Available at: <https://doi.org/10.32614/RJ-2018-009>.
- Pebesma, E., Bivand, R. 2023. *Spatial Data Science: With applications in R*. Chapman and Hall/CRC. doi:10.1201/9780429459016, Available at: <https://r-spatial.org/book/>.
- Provan, S. & Whitfield, D.P. 2006. Avian Flight Speeds and Biometrics for Use in Collision Risk Modelling. Unpublished Report to Scottish Natural Heritage.
- R Core Team. 2020. *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. Available at: <https://www.R-project.org/>.
- Stanbury, A., Eaton, M., Aebischer, N., Balmer, D., Brown, A., Douse, A., Lindley, P., McCulloch, N., Noble, D., and Win I. 2021. The status of our bird populations: the fifth Birds of Conservation Concern in the United Kingdom, Channel Islands and Isle of Man and second IUCN Red List assessment of extinction risk for Great Britain. *British Birds* 114: 723-747. Available online at <https://britishbirds.co.uk/content/status-our-bird-populations>.
- UK wind energy database <https://www.renewableuk.com/energypulse/ukwed/> (Accessed 23<sup>rd</sup> January 2025).

## Appendix A

### Latin Names of species Present in Report

- Canada goose *Branta canadensis*
- Golden eagle *Aquila chrysaetos*
- Golden plover *Pluvialis apricaria*
- Greenshank *Tringa nebularia*
- Hen harrier *Circus cyaneus*
- Mallard *Anas platyrhynchos*
- Merlin *Falco columbarius*
- Osprey *Pandion haliaetus*
- Pink-footed goose *Anser brachyrhynchus*
- Red-throated diver *Gavia stellata*
- Snipe *Gallinago gallinago*
- Teal *Anas crecca*
- White-tailed eagle *Haliaeetus albicilla*

## Appendix B

### Flight Activity Survey Effort

Appendix Table 1: Flight activity survey effort for the Development (2023 – 2024).

Date	Month	VP	Start Time	End Time	Duration (hrs)
<b>2023</b>					
22-May-23	May	2	17:55	20:55	3
22-May-23	May	1	14:10	17:10	3
22-May-23	May	5	14:40	17:40	3
23-May-23	May	3	04:45	07:45	3
23-May-23	May	4	09:00	12:00	3
24-May-23	May	5	09:00	12:00	3
24-May-23	May	6	14:25	17:25	3
26-May-23	May	3	14:00	17:00	3
26-May-23	May	4	17:35	20:35	3
29-May-23	May	1	04:05	07:05	3
30-May-23	May	6	13:10	16:10	3
31-May-23	May	2	13:45	16:45	3
20-Jun-23	Jun	2	11:30	14:30	3
20-Jun-23	Jun	2	08:00	11:00	3
20-Jun-23	Jun	5	07:55	10:55	3
20-Jun-23	Jun	5	11:25	14:25	3
21-Jun-23	Jun	3	14:05	17:05	3
21-Jun-23	Jun	3	10:35	13:35	3
23-Jun-23	Jun	1	10:05	13:05	3
23-Jun-23	Jun	1	06:35	09:35	3
23-Jun-23	Jun	4	10:10	13:10	3
23-Jun-23	Jun	4	06:40	09:40	3
29-Jun-23	Jun	6	04:00	07:00	3
29-Jun-23	Jun	6	07:30	10:30	3
10-Jul-23	Jul	5	16:10	19:10	3
10-Jul-23	Jul	5	19:40	22:40	3
10-Jul-23	Jul	2	19:40	22:40	3
10-Jul-23	Jul	2	16:10	19:10	3
24-Jul-23	Jul	4	11:20	14:20	3
24-Jul-23	Jul	4	14:50	17:50	3
24-Jul-23	Jul	1	14:50	17:50	3
24-Jul-23	Jul	1	11:20	14:20	3
25-Jul-23	Jul	3	09:20	12:20	3
25-Jul-23	Jul	3	12:50	15:50	3
26-Jul-23	Jul	6	13:30	16:30	3
26-Jul-23	Jul	6	10:00	13:00	3
21-Aug-23	Aug	4	14:30	17:30	3

## REPORT

Date	Month	VP	Start Time	End Time	Duration (hrs)
21-Aug-23	Aug	2	10:55	13:55	3
21-Aug-23	Aug	2	14:25	17:25	3
21-Aug-23	Aug	4	11:00	14:00	3
23-Aug-23	Aug	5	08:25	11:25	3
23-Aug-23	Aug	3	11:45	14:45	3
23-Aug-23	Aug	3	08:15	11:15	3
23-Aug-23	Aug	1	11:55	14:55	3
23-Aug-23	Aug	5	15:40	18:40	3
23-Aug-23	Aug	1	15:25	18:25	3
24-Aug-23	Aug	6	11:25	14:25	3
24-Aug-23	Aug	6	07:55	10:55	3
02-Sep-23	Sep	1	11:30	14:30	3
02-Sep-23	Sep	1	15:00	18:00	3
02-Sep-23	Sep	3	11:30	14:30	3
02-Sep-23	Sep	3	15:00	18:00	3
03-Sep-23	Sep	5	09:45	12:45	3
03-Sep-23	Sep	2	09:45	12:45	3
03-Sep-23	Sep	2	13:15	16:15	3
03-Sep-23	Sep	5	13:15	16:15	3
08-Sep-23	Sep	6	15:00	18:00	3
08-Sep-23	Sep	6	11:30	14:30	3
08-Sep-23	Sep	4	11:30	14:30	3
08-Sep-23	Sep	4	15:00	18:00	3
23-Oct-23	Oct	1	11:05	14:05	3
23-Oct-23	Oct	4	11:10	14:10	3
23-Oct-23	Oct	4	14:40	17:40	3
23-Oct-23	Oct	1	14:35	17:35	3
24-Oct-23	Oct	5	09:20	12:20	3
24-Oct-23	Oct	2	09:30	12:30	3
24-Oct-23	Oct	2	13:00	16:00	3
24-Oct-23	Oct	5	12:50	15:50	3
25-Oct-23	Oct	6	14:20	17:20	3
25-Oct-23	Oct	6	10:50	13:50	3
25-Oct-23	Oct	3	13:50	16:50	3
25-Oct-23	Oct	3	10:20	13:20	3
13-Nov-23	Nov	4	13:40	16:40	3
13-Nov-23	Nov	1	10:05	13:05	3
13-Nov-23	Nov	1	13:35	16:35	3
13-Nov-23	Nov	4	10:10	13:10	3
14-Nov-23	Nov	2	09:20	12:20	3
14-Nov-23	Nov	2	12:50	15:50	3
14-Nov-23	Nov	5	09:10	12:10	3
14-Nov-23	Nov	5	12:40	15:40	3
16-Nov-23	Nov	6	10:05	13:05	3
16-Nov-23	Nov	3	09:25	12:25	3

## REPORT

Date	Month	VP	Start Time	End Time	Duration (hrs)
16-Nov-23	Nov	6	13:35	16:35	3
16-Nov-23	Nov	3	12:55	15:55	3
14-Dec-23	Dec	4	09:30	12:30	3
14-Dec-23	Dec	4	13:00	16:00	3
14-Dec-23	Dec	1	13:05	16:05	3
14-Dec-23	Dec	1	09:35	12:35	3
20-Dec-23	Dec	5	09:35	12:35	3
20-Dec-23	Dec	5	13:05	16:05	3
20-Dec-23	Dec	2	09:35	12:35	3
20-Dec-23	Dec	2	13:05	16:05	3
21-Dec-23	Dec	6	08:40	11:40	3
21-Dec-23	Dec	6	12:10	15:10	3
21-Dec-23	Dec	3	08:45	11:45	3
21-Dec-23	Dec	3	12:15	15:15	3
<b>2024</b>					
10-May-24	May	4	09:00	12:00	3
10-May-24	May	4	12:30	15:30	3
27-May-24	May	5	09:00	12:00	3
27-May-24	May	5	12:30	15:30	3
28-May-24	May	6	09:00	12:00	3
28-May-24	May	6	12:30	15:30	3
18-Jun-24	Jun	1	09:00	12:00	3
18-Jun-24	Jun	1	12:30	15:30	3
19-Jun-24	Jun	2	09:00	12:00	3
19-Jun-24	Jun	2	09:00	12:00	3
20-Jun-24	Jun	3	09:00	12:00	3
20-Jun-24	Jun	3	12:30	15:30	3
21-Jun-24	Jun	4	09:00	12:00	3
21-Jun-24	Jun	4	12:30	15:30	3
22-Jun-24	Jun	5	09:00	12:00	3
22-Jun-24	Jun	5	12:30	15:30	3
23-Jun-24	Jun	6	09:00	12:00	3
23-Jun-24	Jun	6	12:30	15:30	3
14-Jul-24	Jul	6	09:00	12:00	3
14-Jul-24	Jul	6	12:30	15:30	3
15-Jul-24	Jul	1	12:30	15:30	3
15-Jul-24	Jul	1	09:00	12:00	3
16-Jul-24	Jul	2	12:30	15:30	3
16-Jul-24	Jul	2	09:00	12:00	3
17-Jul-24	Jul	3	09:00	12:00	3
17-Jul-24	Jul	3	12:30	15:30	3
18-Jul-24	Jul	4	12:30	15:30	3
18-Jul-24	Jul	4	09:00	12:00	3
19-Jul-24	Jul	5	09:00	12:00	3
19-Jul-24	Jul	5	12:30	15:30	3

## REPORT

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Date	Month	VP	Start Time	End Time	Duration (hrs)
07-Aug-24	Aug	6	07:00	10:00	3
07-Aug-24	Aug	6	14:00	17:00	3
08-Aug-24	Aug	5	09:00	12:00	3
08-Aug-24	Aug	5	12:30	15:30	3
09-Aug-24	Aug	4	09:00	12:00	3
09-Aug-24	Aug	4	12:30	15:30	3
10-Aug-24	Aug	3	12:30	15:30	3
10-Aug-24	Aug	3	09:00	12:00	3
11-Aug-24	Aug	2	12:30	15:30	3
11-Aug-24	Aug	2	09:00	12:00	3
12-Aug-24	Aug	1	12:30	15:30	3
12-Aug-24	Aug	1	09:00	12:00	3