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COLLISION RISK MODEL REPORT FOR GORTLOUGHRA

Gortloughra Wind Farm Collision Risk Model

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Collision Risk Model Gortloughra Wind Farm

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Abstract: This report details the collision risk modelling approach and results for the eight target bird species recorded at the proposed Gortloughra Wind Farm between October 2019 and September 2024.

TABLE OF CONTENTS

1. INTRODUCTION 1
2. DATA SOURCES 2
   - 2.1.1 Data Sources 2
   - 2.1.2 Wind Turbine Parameters 2
3. REVIEW AND ANALYSIS OF THE VP SURVEY COVERAGE AND RESULTS 3
   - 3.1.1 VP Locations and Viewshed Coverage 3
   - 3.1.2 VP Survey Effort 3
   - 3.1.3 VP Survey Protocol 5
   - 3.1.4 Post-hoc correction of flight activity data 5
   - 3.1.5 Avian Biometrics 5
4. STAGES OF THE COLLISON RISK MODEL 7
5. STAGE A - FLIGHT ACTIVITY 8
   - 5.1 Areal bird density (D_A) 8
   - 5.2 Proportion of birds flying at risk height (Q_{2R}) 10
6. RESULTS 11
   - 6.1 Stage B - Projected number of rotor transits 11
   - 6.2 Stage C - Probability of collision for a single rotor transit (assuming no avoidance) 11
   - 6.3 Stage D - Multiplying to yield expected collisions per year (considering operational time of proposed wind farm) 12
   - 6.4 Stage E - Applying the avoidance rate 13
7. DISCUSSION 16
8. REFERENCES 20

LIST OF TABLES

Page

Table 2-1: Wind Farm and Wind Turbine Parameters 2
Table 3-1: VPs used for Avian Surveys 3
Table 3-2: Survey Areas 3
Table 3-3: Survey Effort completed at VPs 4
Table 3-4: Biometrics of Target Species 5
Table 5-1: The time that the vantage point was watched (t) and vantage point viewshed (A) 8
Table 5-2: Areal bird density (D_A) of species at the proposed Gortloughra Wind Farm site 9
Table 5-3: Proportion of birds flying at risk height 10
Table 6-1: Projected number of rotor transits (assuming no avoidance) 11
Table 6-2: Single transit risk 12
Table 6-3: Collision rate per year before avoidance 12
Table 6-4: Results of CRM assuming avoidance 14
Table 7-1: Calculations of potential increases in annual mortality rates due to the predicted collision mortality 18

LIST OF FIGURES

Page

Figure 6-1: Kestrel Observation recorded on 16th August 2022. 15

1. INTRODUCTION

This report presents the results of the collision risk modelling for the proposed Gortloughra Wind Farm, Co. Cork. This modelling used data from vantage point (VP) surveys carried out in over a five year period between 2019 - 2024. VP surveys were SNH (Scottish Natural Heritage) compliant (SNH 2017a). A total of 16 species were recorded within 500m of the turbine layout during VP surveys across the five years: Buzzard, Chough, Cormorant, Dunlin, Golden Plover, Great Black-backed Gull, Grey Heron, Hen Harrier, Kestrel, Lesser Black-backed Gull, Peregrine, Red Grouse, Snipe, Sparrowhawk, Swift and Teal. Of these, a total of 14 species were recorded within the potential collision height (PCH)/ rotor swept zone and thus the following species proceeded into the modelling stage:

- Buzzard
- Chough
- Cormorant
- Dunlin
- Golden Plover
- Great Black-backed Gull
- Grey Heron
- Hen Harrier
- Kestrel
- Lesser Black-backed Gull
- Peregrine
- Sparrowhawk
- Snipe
- Swift

The modelling was carried out using the NatureScot Collision Risk Model (CRM) (also known as the Band model (Band, 2024; NatureScot, 2024)). The CRM provides a method based on vantage point data to estimate the number of birds likely to collide with turbines at a proposed wind farm. This allows pre-construction assessment of collision impacts on local and national populations. As birds may avoid a wind farm (for example some may be displaced from the area, while others may avoid turbines or take other evasive action to prevent a collision), the CRM accounts for this by applying an avoidance rate.

2. DATA SOURCES

2.1.1 Data Sources

The following data and information were provided for this assessment:

- Spreadsheet data listing all observations of flight activity recorded during the VP surveys.
- GIS mapping of flight lines recorded during the summer 2020, 2021, 2022, 2023 and 2024, winter 2019/20, 2020/21, 2021/22, 2022/23 and 2024 VP surveys.
- Mapping of the VP locations.
- Mapping of the proposed turbine locations.
- Technical specifications for the proposed turbines.

2.1.2 Wind Turbine Parameters

Details of the turbine parameters are show including data on blade chord length, and rotational speed were provided by Statkraft.

Table 2-1: Wind Farm and Wind Turbine Parameters

Parameter	Value	Notes
Model: Vesta V162 6.2 MW		
Hub height (m)	100	Information provided by client
Blade diameter (m)	150	Information provided by client
Blade radius (m)	75	Calculated (blade diameter/2)
Maximum swept height (m)	175	Calculated (hub height + blade radius)
Minimum swept height (m)	25	Calculated (hub height - blade radius)
Number of blades	3	Information provided by client
Maximum blade chord length (m)	4.2	Information provided by client
Fastest rotational speed (r.p.m)	12.6	Information provided by client
Blade pitch (degrees)	6	Typical value
Number of turbines with these dimensions proposed	8	Information provided by client
Wind farm operation (%)	85	Typical value

3. REVIEW AND ANALYSIS OF THE VP SURVEY COVERAGE AND RESULTS

3.1.1 VP Locations and Viewshed Coverage

Three VP locations were selected to cover the site (VP1 – VP3).

For the purposes of collision risk modelling, a 500 m radius buffer was drawn around each of the proposed turbine locations. This buffer was used as the flight activity survey area, following SNH (2017a) guidance.

A total of 95.15% of the total flight activity survey area (500m radius buffer surrounding the turbine locations) was visible from VP locations (VPs 1-3). For the purposes of collision risk analysis, a correction factor of 1.05 has been applied to the flight durations recorded to achieve 100% viewshed coverage. This provides a more conservative estimate of collision risk at the site.

Table 3-1: VPs used for Avian Surveys

VP Number	Easting, Northing (ITM)	Area (km2)
1	515146, 559917	2.5825
2	513367, 560477	1.3974
3	515854, 561125	0.8002

The site and the buffer made a total survey area of around 4.48 km^2. A total of 95.15% of the entire survey area was covered from three vantage point viewpoints. These three VP viewshed overlapped for just under 12% of the survey area.

Table 3-2: Survey Areas

Area of survey area (km2)	Area survey area covered by viewsheds (km2)	Total Area of the three VPs Area (km2)
4.49	4.27	4.78

3.1.2 VP Survey Effort

VP surveys were carried out at the site monthly from October 2019 - September 2024. The summer season was defined as running from April to September inclusive (six months) for summer 2020, 2021, 2022, 2023 and 2024 while winter was defined as October to March inclusive (six months) for winter 2019/20, 2020/21, 2021/22, 2022/23 and 2024. In addition, rounds of spring migration were carried out in April 2022 and March 2024 along with an autumn migration round in October 2024.

Watches were 2 * 3 hours = 6 hours per VP per month. The total survey effort over the 5.25 year survey period was 1,147.15 hours/ 4,129,740 seconds. The total survey period was also greater than the recommended 2 years of surveys required by SNH guidance (SNH, 2017).

Table 3-3 below details the survey effort for each of the ten seasons (five years of surveys).

Table 3-3: Survey Effort completed at VPs

Season	VP	Hours	Total Hours
Winter 2019/20	1	36	108
	2	36	
	3	36	
Summer 2020	1	36	108
	2	36	
	3	36	
Winter 2020/21	1	36	108
	2	36	
	3	36	
Summer 2021	1	36	108
	2	36	
	3	36	
Winter 2021-22	1	36	108
	2	36	
	3	36	
Summer 2022	1	42	126
	2	42	
	3	42	
Winter 2022-23	1	36	108
	2	36	
	3	36	
Summer 2023	1	38.3	114.4
	2	39.1	
	3	37	
Winter 2023/24	1	48	143.75
	2	47.75	
	3	48	
Summer 2024	1	36	108
	2	36	
	3	36	

3.1.3 VP Survey Protocol

The VP surveys recorded flight activity of all target species withing fixed visual envelopes, namely: 0-10m, 20-20m, 20-30m, 30-50m, 50-100m, 100-185m and >185m. Flight durations were not classified in the field as inside and outside of the 500 m buffer boundary surrounding the turbines. Following a more conservative approach, the total duration of any flightline which intersects the boundary of the site is included in full regardless of the percentage time the flightline was outside the site i.e., all time inside and outside the site are included in the model for flightlines that intersect the site at some point.

3.1.4 Post-hoc correction of flight activity data

Flight lines that intersected the 500 m turbine buffer were included for collision risk modelling (CRM) in alignment with SNH (2017) guidance. This is a conservative approach in relation to flightlines that pass both within and outside the 500 m turbine buffer. For flightlines of this nature, the full observation time both inside and outside the buffer has been included for modelling, rather than splitting the observation time retrospectively i.e., all time inside and outside the site are included in the model for flightlines that intersect the site at some point.

3.1.5 Avian Biometrics

The biometrics and flight speed values used in the calculations for each of the target species is shown in Table 3-4. The bird body lengths and wingspans were sourced from the BTO bird facts website (https://www.bto.org/understanding-birds/birdfacts/find-a-species; last accessed 11th February 2025). The flight speeds used come from Alerstam et al., 2007. Birds are assumed to be active for 8 hours a day in winter and 12 hours a day in summer.

Table 3-4: Biometrics of Target Species

Species	Length (m)	Wingspan (m)	Average speed (m/s)	Avoidance rates1 (%)
Buzzard	0.52	1.20	13.3	98
Cormorant	0.80	1.60	14.60	98
Chough	0.40	0.82	12.50	98
Dunlin	0.20	0.40	16.1	98
Golden Plover	0.28	0.72	17.9	99.8[2]
Great Black-backed gull	0.78	1.65	12	98
Grey Heron	0.98	1.60	12.7	98
Hen Harrier	0.48	1.1	9.1	99
Kestrel	0.34	0.76	10.10	95

[1] Avoidance rates refer to the frequency at which birds may avoid a wind farm. SNH (2018) guidance states that this may be due to displacement from the area, avoidance of turbines or evasive action to prevent a collision. Avoidance rates may be different for different bird species and SNH (2018) guidance provides a list of recommended avoidance rates that should be applied to raw collision risk probabilities.
[2] Based on study of avoidance rates of golden plover from Gittings (2022) – see section 6 for further details.

Species	Length (m)	Wingspan (m)	Average speed (m/s)	Avoidance rates1 (%)
Lesser Black-backed Gull	0.58	1.42	11.9	98
Peregrine	0.42	1.02	12.1	98
Snipe	0.26	0.46	17.1	98
Sparrowhawk	0.33	0.62	11.3	98
Swift	0.16	0.45	10.5	98

4. STAGES OF THE COLLISON RISK MODEL

The model estimates the number of collisions through a process of five stages:

Stage A uses bird survey data to establish the density of flying birds in the vicinity of the turbines, and the proportion flying at a risk height, between the lowest and highest points of the rotors.

Stage B provides an estimate, based on the bird density and proportion at risk height, of the potential number of bird passages through rotors in the period in question.

Stage C calculates the probability of collision during a single bird rotor transit.

Stage D estimates the potential collision rate for a bird species, assuming current levels of bird use of the site, allowing for the proportion of time that turbines are not operational.

Stage E takes account of the proportion of birds likely to avoid the wind farm or its turbines, either because they have been displaced from the site or because they take evasive action or are attracted to the wind farm, e.g. in response to changing habitats.

Further details of Stage A calculations are provided in Section 5. Details of the results of calculations for Stages B to E are provided for each species in Appendix 1 and summarised in Section 6.

5. STAGE A - FLIGHT ACTIVITY

This stage estimates the number of flights which, in the absence of birds being displaced, taking other avoiding action or being attracted to the wind farm, would potentially be at risk from the turbines. It requires field data to determine levels of flight activity within the proposed wind farm.

For non-directional flights, two key parameters derived from survey observations are needed to describe the magnitude of flight activity:

i. Areal bird density (D_A) and
ii. Proportion of birds flying at risk height (Q_{2R})

5.1 Areal bird density (D_A)

Areal bird density (D_A) is the number of birds, in flight at any height at a given point in time, per unit area. D_A is most often recorded in bird seconds, which is particularly appropriate where bird numbers are low, and is usually expressed per square kilometre (km^2).

To calculate the Areal bird density the study area was defined as a 500m buffer of the wind farm site. As a precautionary measure all flightlines which interested this area were included in full in the calculate of Areal bird density.

D_A is calculated as follows:

DA = b / (t x A) bird-seconds m-2

where:

(b) is the number of flight seconds from a vantage point;

(t) is the time (in seconds) that the vantage point is watched;

(A) is the area of the vantage point view-shed (km^2).

The latter two parameters for this calculation are provided below in Table 5-1.

Table 5-1: The time that the vantage point was watched (t) and vantage point viewshed (A)

Years	VPs	A - Area (km2)	t - Total watch time (Seconds)
Year 1	VP1	2.5825	259200
Year 1	VP2	1.3974	259200
Year 1	VP3	0.8002	259200
Year 2	VP1	2.5825	259200
Year 2	VP2	1.3974	259200
Year 2	VP3	0.8002	259200

Years	VPs	A - Area (km2)	t - Total watch time (Seconds)
Year 3	VP1	2.5825	280800
Year 3	VP2	1.3974	280800
Year 3	VP3	0.8002	280800
Year 4	VP1	2.5825	267480
Year 4	VP2	1.3974	270360
Year 4	VP3	0.8002	262800
Year 5	VP1	2.5825	302400
Year 5	VP2	1.3974	301500
Year 5	VP3	0.8002	302400

Table 5-2 below provides the Areal bird density (D_A) of species recorded within the proposed Gortloughra Wind Farm study area over the five years of Vantage Point Surveys.

Table 5-2: Areal bird density (D_A) of species at the proposed Gortloughra Wind Farm site

Species	Mean bird density (bird-secs/km2)	Standard Deviation
Buzzard	0.00107	0.0009
Cormorant	0.000013	0.0001
Chough	0.00070	0.0019
Dunlin	0.000003	0.00001
Golden Plover	0.037409	0.0868
Great Black-backed gull	0.00008	0.0002
Grey Heron	0.000020	0.0001
Hen Harrier	0.00014	0.0004
Kestrel	0.008160	0.0223
Lesser Black-backed Gull	0.000121	0.0002
Peregrine	0.00021	0.0003
Snipe	0.0000016	0.00001
Sparrowhawk	0.00015	0.0003
Swift	0.000120	0.0005
Red Grouse	0.000006	0.00002

5.2 Proportion of birds flying at risk height (Q_{2R})

Proportion of birds flying at risk height (Q_{2R}) is the proportion of birds recorded flying between the lowest and highest points of the proposed rotor, measured relative to the rotor base. The Collision Risk Model considered the Vesta 6.2 MW turbine with a rotor sweep zone of between 25m and 175m.

The surveys recorded the flight heights of birds, using bands of 0-10m, 10-20m, 20-30m, 30-50m, 50-100m, 100-185m and >185m. Height bands 0-10m 10-20m, and >185m fall outside the rotor sweep zone. All observations of birds flying exclusively within these three bands are not flying at risk height and are therefore omitted from the model. In instances where a bird was recorded flying both outside and inside the risk height this observation is included in the model. One species Red Grouse was not recorded flying at risk height and therefore the Collison Risk for this species is considered to be zero. Table 5-3 provides the proportion of birds flying at risk height for each species

The minimum rotor tip height (25m) falls within the height band 20-30m, therefore including all observations which were flying only within this height band would overestimate the proportion of birds flying at risk height as it would also include birds that were flying < 25m in height. This is also the case for the maximum rotor tip height (175m) which intersects the 100-185m flight band. The Band (2024) includes a calculation to refine the proportion of birds flying at risk height in instances where this occurs. Taking Buzzard as an example, 5 m of the rotor height span falls within the 20-30 m height range, so 5/10 of the 8.57% of birds flying within that height range would be at rotor risk height. All 29 birds which intersected the 30-100m (82.86% of all observations) are fully within the rotor zone. The remaining 75 m (100-175m) of the rotor height is within the 100-180 m height range, so 75/80 of the 5.71% would also fall within the rotor risk height. Calculation provided below for Buzzard.

Q_{2R} Buzzard

((5/10)*8.57%)+((70/70)* 82.86%)+((75/80)*5.71%) = 92.50%

Table 5-3: Proportion of birds flying at risk height

Species	Total number of individual bird flights observed	Number of flights observed only in the 20 - 30m band	Proportion observed 20 - 30m height (%)	Number of flights observed 30 - 100m	Proportion observed 30m-100 m height (%)	Number of flights observed only in the 100 - 180m band	Proportion observed 100 - 180m height (%)	Proportion between 25 m and 175 m (%)
Buzzard	35	3	8.57	29	82.86	2	5.71	92.50%
Cormorant	2	0	0.00	2	100.00	0	0.00	100.00%
Chough	32	11	34.38	11	34.38	0	0.00	51.56%
Dunlin	3	0	0.00	3	100.00	0	0.00	100.00%
Golden Plover	776	43	5.54	651	83.89	16	2.06	88.60%
Great Black-backed Gull	4	0	0.00	4	100.00	0	0.00	100.00%
Grey Heron	2	0	0.00	2	100.00	0	0.00	100.00%
Hen Harrier	6	0	0.00	2	33.33	0	0.00	33.33%
Kestrel	80	12	15.00	58	72.50	0	0.00	80.00%
Lesser Black-backed Gull	9	1	11.11	3	33.33	5	55.56	90.97%
Peregrine	18	5	27.78	11	61.11	1	5.56	80.21%
Snipe	2	0	0.00	1	50.00	0	0.00	50.00%
Sparrowhawk	12	3	25.00	7	58.33	0	0.00	70.83%
Swift	2	0	0.00	2	100.00	0	0.00	100.00%

6. RESULTS

6.1 Stage B - Projected number of rotor transits

Table 6-1 provides the predicted number of rotor transits per year for each species assuming birds take no avoiding action. The total number of bird transits expected through rotors is proportional to the number and cross-sectional area of the rotors, and to the density of birds in the airspace at risk height. The total rotor frontal area for the 8 turbine wind farm with a rotor radius of 75m is 141,372 m^2.

Table 6-1: Projected number of rotor transits (assuming no avoidance)

Species	Predicted number of rotar transits each year[3]
Buzzard	200.16
Cormorant	2.89
Chough	68.60
Dunlin	0.70
Golden Plover	6763.32
Great Black-backed gull	14.60
Grey Heron	3.86
Hen Harrier	6.46
Kestrel	1002.53
Lesser Black-backed Gull	19.92
Peregrine	30.99
Snipe	0.21
Sparrowhawk	18.26
Swift	19.16

6.2 Stage C - Probability of collision for a single rotor transit (assuming no avoidance)

This stage uses information on the size and speed of the turbines and physical details on the size and speed of the bird to compute the risk of collision for a bird flying through a rotating rotor.

It is assumed that birds can avoid stationary infrastructure, so no account is taken of the turbine towers or the blades when stationary. The model evaluates the probability of a bird colliding if it passes at random at any point through the rotor disk on a flight path perpendicular to the rotor plane.

[3] Number of rotor transits provided to 2 decimal places to provide more accurate figure than the nearest whole number in the CRM model data sheets in Appendix 1.

Table 6-2: Single transit risk

Species	Single transit risk - weighted mean (%)
Buzzard	6.09
Cormorant	7.13
Chough	5.55
Dunlin	4.28
Golden Plover	4.60
Great Black-backed gull	7.74
Grey Heron	8.45
Hen Harrier	6.87
Kestrel	5.64
Lesser Black-backed Gull	6.72
Peregrine	5.78
Snipe	4.46
Sparrowhawk	5.33
Swift	4.46

6.3 Stage D - Multiplying to yield expected collisions per year (considering operational time of proposed wind farm)

Stage B estimated the likely number of flights through rotors across the wind farm; Stage C calculated the risk of collision for each single bird transit through a rotor. Stage D multiplies these together to yield an estimate of total potential collision risk, including a factor to allow for the proportion of time that the wind turbines are operational. This is before considering avoidance behaviour, which is stage E.

The proportion of time turbines are operational Q_{op} for the proposed wind farm is 85% (year average for all 12 months). This includes down-time for maintenance as well as time inactive because of low-wind or storm conditions.

Table 6-3: Collision rate per year before avoidance

Species	Collision rates / year (before avoidance)[4]
Buzzard	10.36
Cormorant	0.17
Chough	3.24
Dunlin	0.03

[4] Collision rates / year provided to 2 decimal places to provide more accurate figure than the nearest whole number in the NatureScot CRM model data sheets in Appendix 1. This limitation in the NatureScot model data sheet does not provide the exact number of results < 1.

Species	Collision rates / year (before avoidance)[4]
Golden Plover	264.67
Great Black-backed gull	0.96
Grey Heron	0.28
Hen Harrier	0.38
Kestrel	48.03
Lesser Black-backed Gull	1.14
Peregrine	1.52
Snipe	0.01
Sparrowhawk	0.83
Swift	0.73

6.4 Stage E - Applying the avoidance rate

The preceding stages of the model assume that birds take no avoiding action in response to wind turbines. In reality, birds mostly take action to avoid collision with wind turbines.

The avoidance rate factors used are as recommended by Scottish Natural Heritage (SNH, 2010; SNH 2018).

Golden plover have been recorded in low numbers as collision fatalities at wind farms (Hoetker et al., 2006; Grunkorn 2011). The SNH guidance (SNH, 2018) does not provide a specific avoidance rate for Golden Plover, but states that for species not covered by the guidance "*we recommend a default value of 98%*".

However, a review (Gittings, 2022) of the development of the SNH avoidance rate guidance shows that the default avoidance rate of 98% is not based on any published empirical evidence, the trend is for avoidance rates to increase as more data becomes available, and the guidance does not always reflect the latest evidence on species specific avoidance rates. Therefore, the lack of a species-specific avoidance rate for Golden Plover in the SNH avoidance rate guidance does not necessarily mean that there is not any robust data available that could be used to develop a species-specific avoidance rate for Golden Plover.

However, 3 years of post-construction monitoring sites (Gittings, 2022) indicates a much higher avoidance rate should be applied for non-breeding Golden Plover populations. The studies had robust survey methodologies and were carried out at wind farm sites with high levels of Golden Plover flight activity. The review considers that an avoidance rate of 99.8% is a suitable precautionary estimate for winter Golden Plover.

In further support of a high micro-avoidance rate, a study in the Netherlands of three operational wind farms where Golden Plovers were both diurnally and nocturnally active found no fatalities (Krijgsveld et al., 2009). Golden plovers were not recorded breeding within the 500 m turbine envelope during the survey period which reduces magnitude. The 99.8% avoidance rate reflects the high micro-avoidance rate of the species.

Table 6-4: Results of CRM assuming avoidance[5]

Species	No. of predicted collisions per year	No. of years between predicted collisions	No. predicted collisions per 40 years	Rate (%)
Buzzard	0.21	4.83	8.29	98
Cormorant	0.00	285.87	0.14	98
Chough	0.06	15.44	2.59	98
Dunlin	0.00	1952.14	0.02	98
Golden Plover	0.50	2.00	52.00	99.8
Great Black-backed gull	0.02	52.06	0.77	98
Grey Heron	0.01	180.17	0.22	98
Hen Harrier	0.00	282.09	0.14	99
Kestrel	2.40	0.42	96.00	95
Lesser Black-backed Gull	0.02	43.95	0.91	98
Peregrine	0.03	32.87	1.22	98
Snipe	0.02	60.42	0.66	98
Sparrowhawk	0.00	6329.11	0.01	98
Swift	0.01	68.86	0.58	98

With the exception of Kestrel, the predicted collisions per year for the remaining target species were less than one. The proposed wind farm is however predicted to result in 2.40 Kestrel collisions per year according to the CRM. However, this is a conservative estimate and consideration should be given to the outlier observation of 18,900s on the 16th of August 2022. This observation on one day in five years of surveys accounted for 62.37% of the total Kestrel time spent in study area (30,303s). This one observation has inflated the overall outcome of the CRM model. If this one observation was excluded in the model, the sum of time within the study area with the correction factor applied is, 11,403s over the five years of surveys and the bird density would be reduced to 0.002552 bird-secs/km^2. In this case, the number of predicted collisions per year equates to 0.74 / year. In addition, the observation recorded Kestrel flying in an area covering 60.29ha. Of this, only 5.66ha (9.38%) is within the NE of the 500m buffered study area, as shown in Figure 6-1. As such, taking this as percentage of time spent inside the study area, of this 18,900s observation only 1,772.8s would be attributed as time within the study area (18,900s*9.38%). In this case, the bird density would be reduced to 0.003078 bird-secs/km^2 and the number of predicted collisions per year equates to 0.91 / year.

Golden Plover were the second highest with a predicted collision rate of 0.5 per year. The remainder are close to zero and are considered negligible.

[5] With correction factors applied for the following: avoidance rates, operating time, and the fact that 95.24% and not 100% of the study area was visible during surveys. Where the number of predicted collisions is shown as 0.00, it means the number of predicted collisions are <0.01 per year. Species with >1 predicted collisions per year (assuming avoidance) are emboldened.

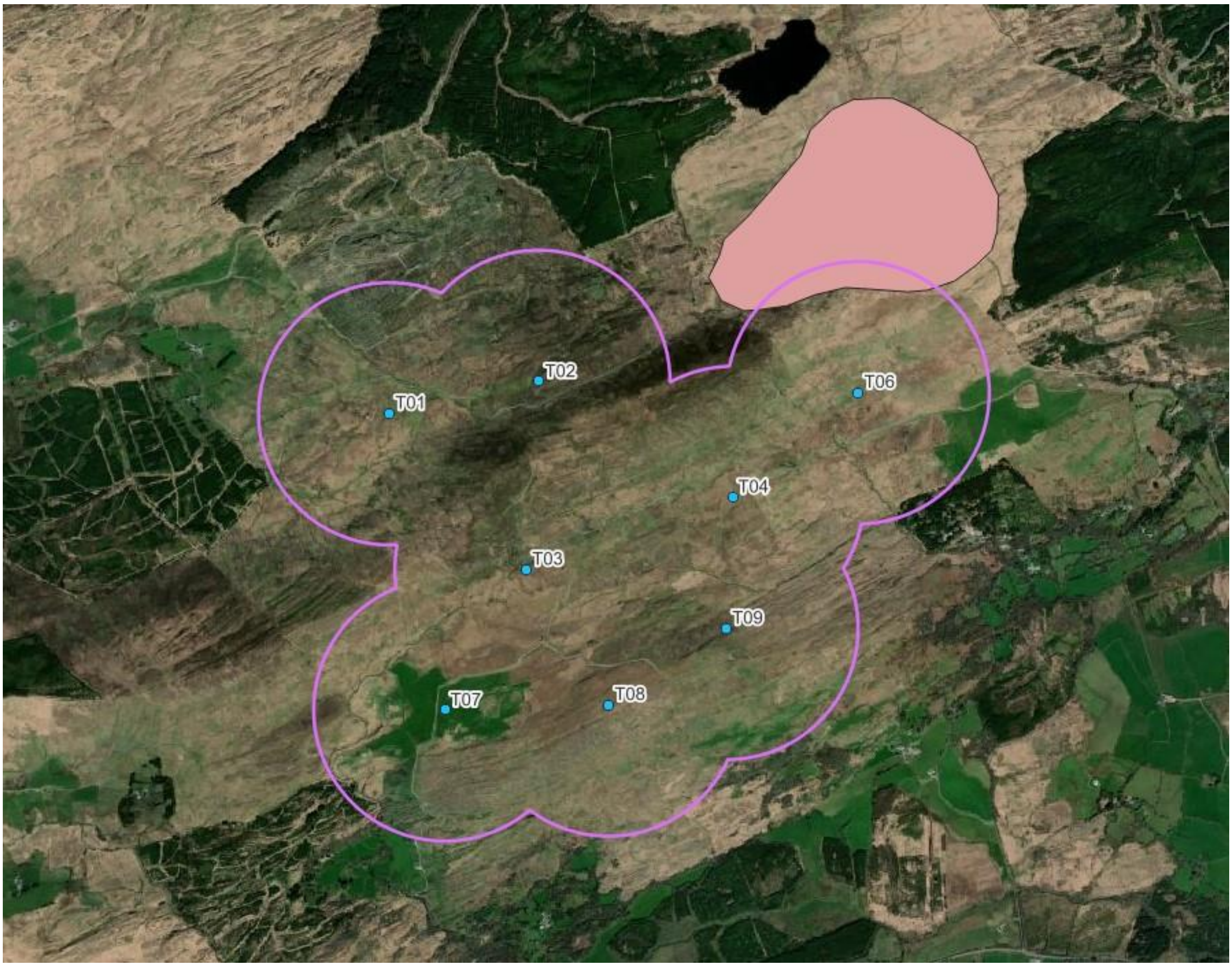

Figure 6-1: Kestrel Observation recorded on 16th August 2022.

7. DISCUSSION

The Band CRM model involves making a number of assumptions. The amount of time that a species may be active within the site is also required for the model and must be estimated with respect to the bird species' known behaviour and observations of its occurrence at the study area.

The model assumes that no action is taken by a bird to avoid collision, so that the unadjusted collision risk figures derived are purely theoretical and represent worst case estimates. In reality, birds are able to perceive potential obstacles while in flight and actively take avoiding action. Given the general absence of empirically derived avoidance estimates for individual species, additional assumptions about likely levels of active avoidance on the part of birds are generally made in order to draw conclusions. Available evidence to date (SNH, 2010; SNH, 2017; Fernley *et al.*, 2006; Whitfield & Madders, 2006; Whitfield, 2009; Whitfield & Urquhart, 2015) suggests that avoidance rates are well in excess of 95%. Accordingly, outputs from collision risk analysis where precautionary avoidance rates are used must be interpreted with care.

The main influence on the final result of collision risk analysis is the avoidance rate that is applied to the model; and without accurate avoidance rates, the usefulness of the model as a predictor of impact can be badly impaired. The avoidance rate factors used are those that are currently recommended by SNH (SNH, 2010; SNH, 2018). These avoidance rates are widely considered to be highly precautionary in nature. It should be remembered that the difference between an avoidance factor of 98% and 99% will have the effect of doubling the calculated annual collision rate. In many cases where collision mortality has been monitored for operating wind farms, observed mortality has been below that which was predicted by modelling pre-construction bird survey data.

In the case of the calculations for the proposed Gortloughra Wind Farm site, a conservative approach was taken in the choice of which bird flights to include in the collision risk calculations. In addition, a worst-case scenario i.e., shortest rotation time (top turbine rotating speed) and birds flapping, rather than gliding has been used. Other studies use the mean of the worst-case scenario and best-case scenario (longest rotation period and bird gliding rather than flapping) probabilities. Finally, the calculations have used the conservative downtime estimate (15%, or turbines rotating 85% of the time), but in reality, this level of downtime may be greater. A conservative correction factor was also applied to the recorded flight durations based on the assumption that 95.15 of the study area was visible during surveys. Therefore, the likely empirical collision mortality figures should be lower than those presented here.

Kestrel is the only species within measurable predicted collision rates, with 2.4 predicted collisions per year. While the number of predicted collisions for all other species are less than one, Golden Plover, Chough and Hen Harrier are also considered further. The population-level consequences of predicted collision risks can be assessed by considering the additional mortality that would be caused (assuming that the collision risk is non-additive) relative to the population at a national and county level.

The potential increase in annual mortality rates for Golden Plover, Kestrel, Buzzard, Chough, Hen Harrier and Peregrine is shown in Table 7-1. This indicates that collision mortality would not have a significant impact at either a national or local (county population or SPA in the case of Hen Harrier) level for any of these species.

Significant impacts are also not envisaged for Kestrel at a national or county level. As mentioned in section 6, the predicted number of collisions per was inflated by on observation outlier of 18,900s accounting for 62.37% of total flight time in the Study Area. In addition to this, it should also be noted that there is a known high degree of uncertainty to the predicted collision rate of Kestrel due to their behaviour. Most Kestrel flight activity is usually of birds that are mainly hovering. The collision risk modelling methodology does not account for this type of flight activity, and, as hovering flight is usually stationary, inclusion of this flight activity will result in a significant overestimation of the collision risk. However, Pearce-Higgins et al. (2009) noted that previous studies have found that Kestrel are “known to continue foraging activity close to turbines and to be susceptible to collision”. Therefore, while it is clear that Kestrels are regularly utilising the proposed site, the no. of predicted collisions per year should be considered with caution.

Table 7-1: Calculations of potential increases in annual mortality rates due to the predicted collision mortality

Parameter	Description	Source / Calculation	Golden Plover		Kestrel		Buzzard		Chough		Hen Harrier		Peregrine	
			National Population	County Population	National Population	County Population	National Population	County Population	National Population	County Population	National Population	SPA/Local Population	National Population	County Population
pop	Population size	Various sources (see sources/notes row below)	80707	9237	16470	1759.7	3000	320.5	536	288	95.5	2	1030	110
surv	Annual survival rate	Adult survival rates from www.bto.org/understanding-birds/birdfacts accessed 13/04/23	0.73	0.73	0.69	0.69	0.9	0.9	0.8	0.8	0.81	0.81	0.81	0.81
mort(back)	Annual background mortality	pop*(1-surv)	21790.89	2493.99	5105.7	545.507	300	32.05	107.2	57.6	18.145	0.38	195.7	20.9
mort(coll)	Predicted annual collision mortality	Predicted collision rates from CRM	0.5	0.5	2.4	2.4	0.21	0.21	0.06	0.06	0.004	0.004	0.03	0.03
%mort (increase)	Percentage increase in annual mortality rate due to collisions		0.002	0.020	0.047	0.440	0.069	0.647	0.060	0.112	0.020	0.933	0.016	0.146
	Percentage of population potetnially affected by collision mortality		0.0006	0.0054	0.0146	0.1364	0.0069	0.0647	0.0121	0.0225	0.0037	0.1773	0.0030	0.0277
Magnitude (Percival, 2003)			<1% (Negligible)	<1% (Negligible)	<1% (Negligible)	<1% (Negligible)	<1% (Negligible)	<1% (Negligible)	<1% (Negligible)	<1% (Negligible)	<1% (Negligible)	<1% (Negligible)	<1% (Negligible)	<1% (Negligible)
Sources/Notes:			IWM 106 (2019) Irish Wetland Bird Survey 2009/10 – 2015/16	Sum of 5-year mean counts of Golden Plover from all Co. Cork I-WeBS sites	NPWS (2012) Article 12 Report - Ireland's bird species' status and trends for the period	Estimate based on proportion of population split by county area, used due to a lack of a county	NPWS (2012) Article 12 Report - Ireland's bird species' status and trends for the period 2008-	Estimate based on proportion of population split by county area, used due to a lack of a county	NPWS (2021) Status and Distribution of Chough in Ireland: Results of the National Survey 2021	NPWS (2021) Status and Distribution of Chough in Ireland: Results of the National Survey 2021	NPWS (2024)+L1:M10 The 2022 National Survey of breeding Hen Harrier in Ireland (number	NPWS (2024) The 2022 National Survey of breeding Hen Harrier in Ireland (number of pairs x2)	NPWS (2012) Article 12 Report - Ireland's bird species' status and trends for the period 2008-	Estimate based on proportion of population split by county area, used due to a lack of a county

Parameter	Description	Source / Calculation	Golden Plover National Population	Golden Plover County Population	Kestrel National Population	Kestrel County Population	Buzzard National Population	Buzzard County Population	Chough National Population	Chough County Population	Hen Harrier National Population	Hen Harrier SPA/Local Population	Peregrine National Population	Peregrine County Population
					2008-2012	estimate	2012 (est number of pairs x2)	estimate	(confirmed pairs x2)	(confirmed pairs x2)	of pairs x2)		2012 (est number of pairs x2)	estimate

8. REFERENCES

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FEHILY TIMONEY

DESIGNING AND DELIVERING
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APPENDIX 1

CRM Species Sheets

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
18	**Stage A**					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		year avge	
19	Daytime bird density	D_A		birds/km^2		0.00107	0.00107	0.00107	0.00107	0.00107	0.00107	0.00107	0.00107	0.00107	0.00107	0.00107	0.00107		0.0011	
20	Proportion at rotor risk height	Q_{2R}	92.50%																	
21	At latitude 51.8		Daylight hours per month			259.1	277.4	366.8	415.3	484.2	497.9	501.6	454.0	381.4	332.2	267.1	244.4		4481.5	
22			Nighttime hours per month			484.9	394.6	377.2	304.7	259.8	222.1	242.4	290.0	338.6	411.8	452.9	499.6		4278.5	
23	**Stage B**																			
24	No of turbines	T	8																	
25	Rotor radius	R	75	m																
26			Total rotor frontal area m^2		141372															
27	Nocturnal activity factor	f_{night}	0%																	
28	Bird flight speed	v	13.3	$m\ s^{-1}$		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		year total	
29			Projected number of rotor transits			11.6	12.4	16.4	18.5	21.6	22.2	22.4	20.3	17.0	14.8	11.9	10.9		**200**	
30	**Stage C**																			
31	No of blades	b	3				Bird length	l	0.52	m										
32	Rotation speed	Ω	12.6	rpm			Wingspan	w	1.2	m										
33	Rotor radius	R	75	m			Bird flight speed	v	13.3	$m\ s^{-1}$										
34	Max blade width	C	4.2	m			Flight type		flapping											
35	Pitch	λ	6	degrees			% of flights upwind/downwind		50%	50%										
36	Blade profile		see Blade profile sheet																	
37			Single transit risk		upwind	7.21%														
38					downwind	4.97%														
39					weighted mean	**6.09%**														
40	**Stage D**					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		year avge	
41	Proportion of time operational	Q_{op}				85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%		85.0%	
42																				
43						Collision rates before avoidance													year total	
44						0.60	0.64	0.85	0.96	1.12	1.15	1.16	1.05	0.88	0.77	0.62	0.57		**10**	
45	**Stage E**																			
46	Allow for large array correction?		No																	
47	Width of windfarm	w	1.3	km																
48				large array		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		per year	
49				correction		Collision rates allowing for avoidance														
50	Avoidance rates modelled		95.00%	100.00%		0.03	0.03	0.04	0.05	0.06	0.06	0.06	0.05	0.04	0.04	0.03	0.03		**0.5**	
51			98.00%	100.00%		0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01		**0.2**	
52			99.00%	100.00%		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01		**0.1**	
53			99.50%	100.00%		0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00		**0.1**	
54																				

Buzzard

18	**Stage A**					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		year avge
19	Daytime bird density	D_A		birds/km^2		0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013		0.0000
20	Proportion at rotor risk height	Q_{2R}	100.00%																
21	At latitude 51.8		Daylight hours per month			259.1	277.4	366.8	415.3	484.2	497.9	501.6	454.0	381.4	332.2	267.1	244.4		4481.5
22			Nighttime hours per month			484.9	394.6	377.2	304.7	259.8	222.1	242.4	290.0	338.6	411.8	452.9	499.6		4278.5
23	**Stage B**																		
24	No of turbines	T	8																
25	Rotor radius	R	75	m															
26			Total rotor frontal area m^2		141372														
27	Nocturnal activity factor	f_{night}	0%																
28	Bird flight speed	v	14.6	$m\ s^{-1}$		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		year total
29			Projected number of rotor transits			0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2		**3**
30	**Stage C**																		
31	No of blades	b	3				Bird length	l	0.8	m									
32	Rotation speed	Ω	12.6	rpm			Wingspan	w	1.6	m									
33	Rotor radius	R	75	m			Bird flight speed	v	14.6	$m\ s^{-1}$									
34	Max blade width	C	4.2	m			Flight type		flapping										
35	Pitch	λ	6	degrees			% of flights upwind/downwind		50%	50%									
36	Blade profile		see Blade profile sheet																
37			Single transit risk		upwind	8.15%													
38					downwind	6.11%													
39					weighted mean	**7.13%**													
40	**Stage D**					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		year avge
41	Proportion of time operational	Q_{op}				85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%		85.0%
42																			
43						Collision rates before avoidance													year total
44						0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01		**0**
45	**Stage E**																		
46	Allow for large array correction?		No																
47	Width of windfarm	w	1.3	km															
48				large array		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		per year
49				correction		Collision rates allowing for avoidance													
50	Avoidance rates modelled		95.00%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		**0.0**
51			98.00%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		**0.0**
52			99.00%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		**0.0**
53			99.50%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		**0.0**
54																			
55																			

Cormorant

18	**Stage A**					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
19	Daytime bird density	D_A		birds/km^2		0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007
20	Proportion at rotor risk height	Q_{2R}	51.56%															
21	At latitude 51.8		Daylight hours per month			259.1	277.4	366.8	415.3	484.2	497.9	501.6	454.0	381.4	332.2	267.1	244.4	4481.5
22			Nighttime hours per month			484.9	394.6	377.2	304.7	259.8	222.1	242.4	290.0	338.6	411.8	452.9	499.6	4278.5
23	**Stage B**																	
24	No of turbines	T	8															
25	Rotor radius	R	75	m														
26			Total rotor frontal area m^2		141372													
27	Nocturnal activity factor	f_{night}	0%															
28	Bird flight speed	v	12.5	m s^{-1}		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
29			Projected number of rotor transits			4.0	4.2	5.6	6.4	7.4	7.6	7.7	6.9	5.8	5.1	4.1	3.7	**69**
30	**Stage C**																	
31	No of blades	b	3				Bird length	l	0.4	m								
32	Rotation speed	Ω	12.6	rpm			Wingspan	w	0.82	m								
33	Rotor radius	R	75	m			Bird flight speed	v	12.5	m s^{-1}								
34	Max blade width	C	4.2	m			Flight type		flapping									
35	Pitch	λ	6	degrees			% of flights upwind/downwind		50%	50%								
36	Blade profile			see Blade profile sheet														
37			Single transit risk		upwind	6.74%												
38					downwind	4.36%												
39					weighted mean	**5.55%**												
40	**Stage D**					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
41	Proportion of time operational	Q_{op}				85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%
42																		
43						Collision rates before avoidance												year total
44						0.19	0.20	0.27	0.30	0.35	0.36	0.36	0.33	0.28	0.24	0.19	0.18	**3**
45	**Stage E**																	
46	Allow for large array correction?		No															
47	Width of windfarm	w	1.3	km														
48				large array		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
49				correction		Collision rates allowing for avoidance												
50	Avoidance rates modelled		95.00%	100.00%		0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	**0.2**
51			98.00%	100.00%		0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	**0.1**
52			99.00%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**
53			99.50%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**
54																		

Chough

18	**Stage A**					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
19	Daytime bird density	D_A		birds/km^2		3.00E-06	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.0000
20	Proportion at rotor risk height	Q_{2R}	100.00%															
21	At latitude 51.8		Daylight hours per month			259.1	277.4	366.8	415.3	484.2	497.9	501.6	454.0	381.4	332.2	267.1	244.4	4481.5
22			Nighttime hours per month			484.9	394.6	377.2	304.7	259.8	222.1	242.4	290.0	338.6	411.8	452.9	499.6	4278.5
23	**Stage B**																	
24	No of turbines	T	8															
25	Rotor radius	R	75	m														
26			Total rotor frontal area m^2		141372													
27	Nocturnal activity factor	f_{night}	0%															
28	Bird flight speed	v	16.1	m s^{-1}		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
29			Projected number of rotor transits			0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	**1**
30	**Stage C**																	
31	No of blades	b	3				Bird length	l	0.2	m								
32	Rotation speed	Ω	12.6	rpm			Wingspan	w	0.4	m								
33	Rotor radius	R	75	m			Bird flight speed	v	16.1	m s^{-1}								
34	Max blade width	C	4.2	m			Flight type		flapping									
35	Pitch	λ	6	degrees			% of flights upwind/downwind		50%	50%								
36	Blade profile			see Blade profile sheet														
37			Single transit risk		upwind	5.21%												
38					downwind	3.36%												
39					weighted mean	**4.28%**												
40	**Stage D**					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
41	Proportion of time operational	Q_{op}				85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%
42																		
43						Collision rates before avoidance												year total
44						0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0**
45	**Stage E**																	
46	Allow for large array correction?		No															
47	Width of windfarm	w	1.3	km														
48				large array		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
49				correction		Collision rates allowing for avoidance												
50	Avoidance rates modelled		95.00%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**
51			98.00%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**
52			99.00%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**
53			99.50%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**
54																		

Dunlin

17			Set to 'birds on migration' to use 'Migrant collision risk' sheet in place of Stage A															
18	**Stage A**					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
19	Daytime bird density	D_A		birds/km^2		0.037409	0.037409	0.037409	0.037409	0	0	0	0	0.037409	0.037409	0.037409	0.037409	0.0249
20	Proportion at rotor risk height	Q_{2R}	88.60%															
21	At latitude 51.8		Daylight hours per month			259.1	277.4	366.8	415.3	484.2	497.9	501.6	454.0	381.4	332.2	267.1	244.4	4481.5
22			Nighttime hours per month			484.9	394.6	377.2	304.7	259.8	222.1	242.4	290.0	338.6	411.8	452.9	499.6	4278.5
23	**Stage B**																	
24	No of turbines	T	8															
25	Rotor radius	R	75	m														
26			Total rotor frontal area m^2		141372													
27	Nocturnal activity factor	f_{night}	25%															
28	Bird flight speed	v	17.9	m s^{-1}		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
29			Projected number of rotor transits			765.6	757.0	928.1	989.3	0.0	0.0	0.0	0.0	938.2	876.0	765.6	743.4	**6763**
30	**Stage C**																	
31	No of blades	b	3				Bird length	l	0.28	m								
32	Rotation speed	Ω	12.6	rpm			Wingspan	w	0.72	m								
33	Rotor radius	R	75	m			Bird flight speed	v	17.9	m s^{-1}								
34	Max blade width	C	4.2	m			Flight type		flapping									
35	Pitch	λ	6	degrees			% of flights upwind/downwind		50%	50%								
36	Blade profile		see Blade profile sheet															
37			Single transit risk		upwind	5.44%												
38					downwind	3.77%												
39					weighted mean	**4.60%**												
40	**Stage D**					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
41	Proportion of time operational	Q_{op}				85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%
42																		
43						Collision rates before avoidance												year total
44						29.96	29.62	36.32	38.72	0.00	0.00	0.00	0.00	36.71	34.28	29.96	29.09	**265**
45	**Stage E**																	
46	Allow for large array correction?		No															
47	Width of windfarm	w	1.3	km														
48				large array		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
49				correction		Collision rates allowing for avoidance												
50	Avoidance rates modelled		95.00%	100.00%		1.50	1.48	1.82	1.94	0.00	0.00	0.00	0.00	1.84	1.71	1.50	1.45	**13.2**
51			98.00%	100.00%		0.60	0.59	0.73	0.77	0.00	0.00	0.00	0.00	0.73	0.69	0.60	0.58	**5.3**
52			99.00%	100.00%		0.30	0.30	0.36	0.39	0.00	0.00	0.00	0.00	0.37	0.34	0.30	0.29	**2.6**
53			99.80%	100.00%		0.06	0.06	0.07	0.08	0.00	0.00	0.00	0.00	0.07	0.07	0.06	0.06	**0.5**
54																		

Golden Plover

17			Set to 'birds on migration' to use 'Migrant collision risk' sheet in place of Stage A															
18	**Stage A**					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
19	Daytime bird density	D_A		birds/km^2		0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.0001
20	Proportion at rotor risk height	Q_{2R}	100.00%															
21	At latitude 51.8		Daylight hours per month			259.1	277.4	366.8	415.3	484.2	497.9	501.6	454.0	381.4	332.2	267.1	244.4	4481.5
22			Nighttime hours per month			484.9	394.6	377.2	304.7	259.8	222.1	242.4	290.0	338.6	411.8	452.9	499.6	4278.5
23	**Stage B**																	
24	No of turbines	T	8															
25	Rotor radius	R	75	m														
26			Total rotor frontal area m^2		141372													
27	Nocturnal activity factor	f_{night}	0%															
28	Bird flight speed	v	12	m s^{-1}		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
29			Projected number of rotor transits			0.8	0.9	1.2	1.4	1.6	1.6	1.6	1.5	1.2	1.1	0.9	0.8	**15**
30	**Stage C**																	
31	No of blades	b	3				Bird length	l	0.78	m								
32	Rotation speed	Ω	12.6	rpm			Wingspan	w	1.65	m								
33	Rotor radius	R	75	m			Bird flight speed	v	12	m s^{-1}								
34	Max blade width	C	4.2	m			Flight type		flapping									
35	Pitch	λ	6	degrees			% of flights upwind/downwind		50%	50%								
36	Blade profile		see Blade profile sheet															
37			Single transit risk		upwind	8.98%												
38					downwind	6.50%												
39					weighted mean	**7.74%**												
40	**Stage D**					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
41	Proportion of time operational	Q_{op}				85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%
42																		
43						Collision rates before avoidance												year total
44						0.06	0.06	0.08	0.09	0.10	0.11	0.11	0.10	0.08	0.07	0.06	0.05	**1**
45	**Stage E**																	
46	Allow for large array correction?		No															
47	Width of windfarm	w	1.3	km														
48				large array		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
49				correction		Collision rates allowing for avoidance												
50	Avoidance rates modelled		95.00%	100.00%		0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	**0.0**
51			98.00%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**
52			99.00%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**
53			99.50%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**
54																		
55																		

Great Black-backed Gull

18	**Stage A**					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
19	Daytime bird density	D_A		birds/km^2		0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.0000
20	Proportion at rotor risk height	Q_{2R}	100.00%															
21	At latitude 51.8		Daylight hours per month			259.1	277.4	366.8	415.3	484.2	497.9	501.6	454.0	381.4	332.2	267.1	244.4	4481.5
22			Nighttime hours per month			484.9	394.6	377.2	304.7	259.8	222.1	242.4	290.0	338.6	411.8	452.9	499.6	4278.5
23	**Stage B**																	
24	No of turbines	T	8															
25	Rotor radius	R	75	m														
26			Total rotor frontal area m^2		141372													
27	Nocturnal activity factor	f_{night}	0%															
28	Bird flight speed	v	12.7	m s^{-1}		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
29			Projected number of rotor transits			0.2	0.2	0.3	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.2	0.2	**4**
30	**Stage C**																	
31	No of blades	b	3				Bird length	l	0.98	m								
32	Rotation speed	Ω	12.6	rpm			Wingspan	w	1.6	m								
33	Rotor radius	R	75	m			Bird flight speed	v	12.7	m s^{-1}								
34	Max blade width	c	4.2	m			Flight type		flapping									
35	Pitch	λ	6	degrees			% of flights upwind/downwind		50%	50%								
36	Blade profile		see Blade profile sheet															
37			Single transit risk		upwind	9.63%												
38					downwind	7.28%												
39					weighted mean	**8.45%**												
40	**Stage D**					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
41	Proportion of time operational	Q_{op}				85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%
42																		
43						Collision rates before avoidance												year total
44						0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	**0**
45	**Stage E**																	
46	Allow for large array correction?		No															
47	Width of windfarm	w	1.3	km														
48				large array		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
49				correction		Collision rates allowing for avoidance												
50	Avoidance rates modelled		95.00%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**
51			98.00%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**
52			99.00%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**
53			99.50%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**
54																		

Grey Heron

18	**Stage A**					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
19	Daytime bird density	D_A		birds/km^2		0.00014	0.00014	0.00014	0.00014	0.00014	0.00014	0.00014	0.00014	0.00014	0.00014	0.00014	0.00014	0.0001
20	Proportion at rotor risk height	Q_{2R}	33.33%															
21	At latitude 51.8		Daylight hours per month			259.1	277.4	366.8	415.3	484.2	497.9	501.6	454.0	381.4	332.2	267.1	244.4	4481.5
22			Nighttime hours per month			484.9	394.6	377.2	304.7	259.8	222.1	242.4	290.0	338.6	411.8	452.9	499.6	4278.5
23	**Stage B**																	
24	No of turbines	T	8															
25	Rotor radius	R	75	m														
26			Total rotor frontal area m^2		141372													
27	Nocturnal activity factor	f_{night}	0%															
28	Bird flight speed	v	9.1	m s^{-1}		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
29			Projected number of rotor transits			0.4	0.4	0.5	0.6	0.7	0.7	0.7	0.7	0.5	0.5	0.4	0.4	**6**
30	**Stage C**																	
31	No of blades	b	3				Bird length	l	0.48	m								
32	Rotation speed	Ω	12.6	rpm			Wingspan	w	1.1	m								
33	Rotor radius	R	75	m			Bird flight speed	v	9.1	m s^{-1}								
34	Max blade width	c	4.2	m			Flight type		flapping									
35	Pitch	λ	6	degrees			% of flights upwind/downwind		50%	50%								
36	Blade profile		see Blade profile sheet															
37			Single transit risk		upwind	8.50%												
38					downwind	5.24%												
39					weighted mean	**6.87%**												
40	**Stage D**					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
41	Proportion of time operational	Q_{op}				85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%
42																		
43						Collision rates before avoidance												year total
44						0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.04	0.03	0.03	0.02	0.02	**0**
45	**Stage E**																	
46	Allow for large array correction?		No															
47	Width of windfarm	w	1.3	km														
48				large array		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
49				correction		Collision rates allowing for avoidance												
50	Avoidance rates modelled		95.00%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**
51			98.00%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**
52			99.00%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**
53			99.50%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**
54																		

Hen Harrier

17			Set to 'birds on migration' to use 'Migrant collision risk' sheet in place of Stage A															
18	**Stage A**					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
19	Daytime bird density	D_A		birds/km^2		0.00816	0.00816	0.00816	0.00816	0.00816	0.00816	0.00816	0.00816	0.00816	0.00816	0.00816	0.00816	0.0082
20	Proportion at rotor risk height	Q_{2R}	80.00%															
21	At latitude 51.8		Daylight hours per month			259.1	277.4	366.8	415.3	484.2	497.9	501.6	454.0	381.4	332.2	267.1	244.4	4481.5
22			Nighttime hours per month			484.9	394.6	377.2	304.7	259.8	222.1	242.4	290.0	338.6	411.8	452.9	499.6	4278.5
23	**Stage B**																	
24	No of turbines	T	8															
25	Rotor radius	R	75	m														
26			Total rotor frontal area m^2		141372													
27	Nocturnal activity factor	f_{night}	0%															
28	Bird flight speed	v	10.1	m s^{-1}		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
29			Projected number of rotor transits			58.0	62.1	82.0	92.9	108.3	111.4	112.2	101.6	85.3	74.3	59.8	54.7	**1003**
30	**Stage C**																	
31	No of blades	b	3				Bird length	l	0.34	m								
32	Rotation speed	Ω	12.6	rpm			Wingspan	w	0.76	m								
33	Rotor radius	R	75	m			Bird flight speed	v	10.1	m s^{-1}								
34	Max blade width	C	4.2	m			Flight type		flapping									
35	Pitch	λ	6	degrees			% of flights upwind/downwind		50%	50%								
36	Blade profile		see Blade profile sheet															
37			Single transit risk		upwind	7.11%												
38					downwind	4.16%												
39					weighted mean	**5.64%**												
40	**Stage D**					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
41	Proportion of time operational	Q_{op}				85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%
42																		
43						Collision rates before avoidance												year total
44						2.78	2.97	3.93	4.45	5.19	5.34	5.38	4.86	4.09	3.56	2.86	2.62	**48**
45	**Stage E**																	
46	Allow for large array correction?		No															
47	Width of windfarm	w	1.3	km														
48				large array		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
49				correction		Collision rates allowing for avoidance												
50	Avoidance rates modelled		95.00%	100.00%		0.14	0.15	0.20	0.22	0.26	0.27	0.27	0.24	0.20	0.18	0.14	0.13	**2.4**
51			98.00%	100.00%		0.06	0.06	0.08	0.09	0.10	0.11	0.11	0.10	0.08	0.07	0.06	0.05	**1.0**
52			99.00%	100.00%		0.03	0.03	0.04	0.04	0.05	0.05	0.05	0.05	0.04	0.04	0.03	0.03	**0.5**
53			99.50%	100.00%		0.01	0.01	0.02	0.02	0.03	0.03	0.03	0.02	0.02	0.02	0.01	0.01	**0.2**
54																		
55																		

Kestrel

18	**Stage A**					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
19	Daytime bird density	D_A		birds/km^2		0.000121	0.000121	0.000121	0.000121	0.000121	0.000121	0.000121	0.000121	0.000121	0.000121	0.000121	0.000121	0.0001
20	Proportion at rotor risk height	Q_{2R}	90.97%															
21	At latitude 51.8		Daylight hours per month			259.1	277.4	366.8	415.3	484.2	497.9	501.6	454.0	381.4	332.2	267.1	244.4	4481.5
22			Nighttime hours per month			484.9	394.6	377.2	304.7	259.8	222.1	242.4	290.0	338.6	411.8	452.9	499.6	4278.5
23	**Stage B**																	
24	No of turbines	T	8															
25	Rotor radius	R	75	m														
26			Total rotor frontal area m^2		141372													
27	Nocturnal activity factor	f_{night}	0%															
28	Bird flight speed	v	11.9	m s^{-1}		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
29			Projected number of rotor transits			1.2	1.2	1.6	1.8	2.2	2.2	2.2	2.0	1.7	1.5	1.2	1.1	**20**
30	**Stage C**																	
31	No of blades	b	3				Bird length	l	0.58	m								
32	Rotation speed	Ω	12.6	rpm			Wingspan	w	1.42	m								
33	Rotor radius	R	75	m			Bird flight speed	v	11.9	m s^{-1}								
34	Max blade width	C	4.2	m			Flight type		flapping									
35	Pitch	λ	6	degrees			% of flights upwind/downwind		50%	50%								
36	Blade profile		see Blade profile sheet															
37			Single transit risk		upwind	7.97%												
38					downwind	5.47%												
39					weighted mean	**6.72%**												
40	**Stage D**					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
41	Proportion of time operational	Q_{op}				85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%
42																		
43						Collision rates before avoidance												year total
44						0.07	0.07	0.09	0.11	0.12	0.13	0.13	0.12	0.10	0.08	0.07	0.06	**1**
45	**Stage E**																	
46	Allow for large array correction?		No															
47	Width of windfarm	w	1.3	km														
48				large array		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
49				correction		Collision rates allowing for avoidance												
50	Avoidance rates modelled		95.00%	100.00%		0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	**0.1**
51			98.00%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**
52			99.00%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**
53			99.50%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**
54																		

Lesser Black-backed Gull

					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
		Set to 'birds on migration' to use 'Migrant collision risk' sheet in place of Stage A															
Stage A					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Daytime bird density	D_A		birds/km^2		0.00021	0.00021	0.00021	0.00021	0.00021	0.00021	0.00021	0.00021	0.00021	0.00021	0.00021	0.00021	0.0002
Proportion at rotor risk height	Q_{2R}	80.21%															
At latitude 51.8		Daylight hours per month			259.1	277.4	366.8	415.3	484.2	497.9	501.6	454.0	381.4	332.2	267.1	244.4	4481.5
		Nighttime hours per month			484.9	394.6	377.2	304.7	259.8	222.1	242.4	290.0	338.6	411.8	452.9	499.6	4278.5
Stage B																	
No of turbines	T	8															
Rotor radius	R	75	m														
		Total rotor frontal area m^2		141372													
Nocturnal activity factor	f_{night}	0%															
Bird flight speed	v	12.1	m s^{-1}		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
		Projected number of rotor transits			1.8	1.9	2.5	2.9	3.3	3.4	3.5	3.1	2.6	2.3	1.8	1.7	**31**
Stage C																	
No of blades	b	3				Bird length	l	0.42	m								
Rotation speed	Ω	12.6	rpm			Wingspan	w	1.02	m								
Rotor radius	R	75	m			Bird flight speed	v	12.1	m s^{-1}								
Max blade width	C	4.2	m			Flight type		flapping									
Pitch	λ	6	degrees			% of flights upwind/downwind		50%	50%								
Blade profile		see Blade profile sheet															
		Single transit risk		upwind	7.01%												
				downwind	4.54%												
				weighted mean	**5.78%**												
Stage D					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Proportion of time operational	Q_{op}				85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%
					Collision rates before avoidance												year total
					0.09	0.09	0.12	0.14	0.16	0.17	0.17	0.15	0.13	0.11	0.09	0.08	**2**
Stage E																	
Allow for large array correction?		No															
Width of windfarm	w	1.3	km														
			large array		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
			correction		Collision rates allowing for avoidance												
Avoidance rates modelled		95.00%	100.00%		0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	**0.1**
		98.00%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**
		99.00%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**
		99.50%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**

Peregrine

					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
		Set to 'birds on migration' to use 'Migrant collision risk' sheet in place of Stage A															
Stage A					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Daytime bird density	D_A		birds/km^2		0.0000016	1.6E-06	1.6E-06	1.6E-06	1.6E-06	1.6E-06	1.6E-06	1.6E-06	1.6E-06	1.6E-06	1.6E-06	1.6E-06	0.0000
Proportion at rotor risk height	Q_{2R}	50.00%															
At latitude 51.8		Daylight hours per month			259.1	277.4	366.8	415.3	484.2	497.9	501.6	454.0	381.4	332.2	267.1	244.4	4481.5
		Nighttime hours per month			484.9	394.6	377.2	304.7	259.8	222.1	242.4	290.0	338.6	411.8	452.9	499.6	4278.5
Stage B																	
No of turbines	T	8															
Rotor radius	R	75	m														
		Total rotor frontal area m^2		141372													
Nocturnal activity factor	f_{night}	0%															
Bird flight speed	v	17.1	m s^{-1}		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
		Projected number of rotor transits			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0**
Stage C																	
No of blades	b	3				Bird length	l	0.26	m								
Rotation speed	Ω	12.6	rpm			Wingspan	w	0.46	m								
Rotor radius	R	75	m			Bird flight speed	v	17.1	m s^{-1}								
Max blade width	C	4.2	m			Flight type		flapping									
Pitch	λ	6	degrees			% of flights upwind/downwind		50%	50%								
Blade profile		see Blade profile sheet															
		Single transit risk		upwind	5.33%												
				downwind	3.59%												
				weighted mean	**4.46%**												
Stage D					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Proportion of time operational	Q_{op}				85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%
					Collision rates before avoidance												year total
					0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0**
Stage E																	
Allow for large array correction?		No															
Width of windfarm	w	1.3	km														
			large array		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
			correction		Collision rates allowing for avoidance												
Avoidance rates modelled		95.00%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**
		98.00%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**
		99.00%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**
		99.50%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**

Snipe

17			Set to 'birds on migration' to use 'Migrant collision risk' sheet in place of Stage A															
18	**Stage A**					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
19	Daytime bird density	D_A		birds/km^2		0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.0002
20	Proportion at rotor risk height	Q_{2R}	70.83%															
21	At latitude 51.8		Daylight hours per month			259.1	277.4	366.8	415.3	484.2	497.9	501.6	454.0	381.4	332.2	267.1	244.4	4481.5
22			Nighttime hours per month			484.9	394.6	377.2	304.7	259.8	222.1	242.4	290.0	338.6	411.8	452.9	499.6	4278.5
23	**Stage B**																	
24	No of turbines	T	8															
25	Rotor radius	R	75	m														
26			Total rotor frontal area m^2		141372													
27	Nocturnal activity factor	f_{night}	0%															
28	Bird flight speed	v	11.3	m s^{-1}		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
29			Projected number of rotor transits			1.1	1.1	1.5	1.7	2.0	2.0	2.0	1.8	1.6	1.4	1.1	1.0	**18**
30	**Stage C**																	
31	No of blades	b	3				Bird length	l	0.33	m								
32	Rotation speed	Ω	12.6	rpm			Wingspan	w	0.62	m								
33	Rotor radius	R	75	m			Bird flight speed	v	11.3	m s^{-1}								
34	Max blade width	C	4.2	m			Flight type		flapping									
35	Pitch	λ	6	degrees			% of flights upwind/downwind		50%	50%								
36	Blade profile		see Blade profile sheet															
37			Single transit risk		upwind	6.65%												
38					downwind	4.02%												
39					weighted mean	**5.33%**												
40	**Stage D**					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
41	Proportion of time operational	Q_{op}				85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%
42																		
43						Collision rates before avoidance												year total
44						0.05	0.05	0.07	0.08	0.09	0.09	0.09	0.08	0.07	0.06	0.05	0.05	**1**
45	**Stage E**																	
46	Allow for large array correction?		No															
47	Width of windfarm	w	1.3	km														
48				large array		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
49				correction		Collision rates allowing for avoidance												
50	Avoidance rates modelled		95.00%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**
51			98.00%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**
52			99.00%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**
53			99.50%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**
54																		

Sparrowhawk

17			Set to 'birds on migration' to use 'Migrant collision risk' sheet in place of Stage A															
18	**Stage A**					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
19	Daytime bird density	D_A		birds/km^2		0.00012	0.00012	0.00012	0.00012	0.00012	0.00012	0.00012	0.00012	0.00012	0.00012	0.00012	0.00012	0.0001
20	Proportion at rotor risk height	Q_{2R}	100.00%															
21	At latitude 51.8		Daylight hours per month			259.1	277.4	366.8	415.3	484.2	497.9	501.6	454.0	381.4	332.2	267.1	244.4	4481.5
22			Nighttime hours per month			484.9	394.6	377.2	304.7	259.8	222.1	242.4	290.0	338.6	411.8	452.9	499.6	4278.5
23	**Stage B**																	
24	No of turbines	T	8															
25	Rotor radius	R	75	m														
26			Total rotor frontal area m^2		141372													
27	Nocturnal activity factor	f_{night}	0%															
28	Bird flight speed	v	10.5	m s^{-1}		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
29			Projected number of rotor transits			1.1	1.2	1.6	1.8	2.1	2.1	2.1	1.9	1.6	1.4	1.1	1.0	**19**
30	**Stage C**																	
31	No of blades	b	3				Bird length	l	0.16	m								
32	Rotation speed	Ω	12.6	rpm			Wingspan	w	0.45	m								
33	Rotor radius	R	75	m			Bird flight speed	v	10.5	m s^{-1}								
34	Max blade width	C	4.2	m			Flight type		flapping									
35	Pitch	λ	6	degrees			% of flights upwind/downwind		50%	50%								
36	Blade profile		see Blade profile sheet															
37			Single transit risk		upwind	5.88%												
38					downwind	3.04%												
39					weighted mean	**4.46%**												
40	**Stage D**					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
41	Proportion of time operational	Q_{op}				85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%
42																		
43						Collision rates before avoidance												year total
44						0.04	0.04	0.06	0.07	0.08	0.08	0.08	0.07	0.06	0.05	0.04	0.04	**1**
45	**Stage E**																	
46	Allow for large array correction?		No															
47	Width of windfarm	w	1.3	km														
48				large array		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
49				correction		Collision rates allowing for avoidance												
50	Avoidance rates modelled		95.00%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**
51			98.00%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**
52			99.00%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**
53			99.50%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0**
54																		

Swift

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