APPENDIX 7.8

CRM Report

FEHILY TIMONEY

DESIGNING AND DELIVERING
A SUSTAINABLE FUTURE

COLLISION RISK MODEL REPORT FOR BALLINLA

Ballinla Wind Farm Collision Risk Model

Prepared for:
Statkraft

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1. INTRODUCTION

This report presents the results of the collision risk modelling for the proposed Ballinla Wind Farm, Co. Offaly. This modelling used data from vantage point (VP) surveys carried out in over two summer seasons and four winter seasons between 2021 - 2024. VP surveys were SNH (Scottish Natural Heritage) compliant (SNH 2017a). A total of 19 species (listed below) were recorded within 500m of the turbine layout during VP surveys across the four years. A total of 17 of these species (listed below) proceeded to the modelling stage. Merlin and Short-eared Owl did not proceed to the modelling stage due to absence of flight activity within the 500m buffer/potential collision risk height band.

- Buzzard
- Black-headed Gull
- Golden Plover
- Great Black-backed Gull
- Grey Heron
- Greylag Goose
- Hen Harrier
- Kestrel
- Lapwing
- Lesser Black-backed Gull
- Little Egret
- Mallard
- Mute swan
- Peregrine
- Snipe
- Sparrowhawk
- Whooper Swan

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 2021, 2022, winter 2021/22, 2022/23, 2023/24 and 2024/25 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: Vestas V162		
Hub height (m)	104	Information provided by client
Blade diameter (m)	162	Information provided by client
Blade radius (m)	81	Calculated (blade diameter/2)
Maximum swept height (m)	185	Calculated (hub height + blade radius)
Minimum swept height (m)	23	Calculated (hub height - blade radius)
Number of blades	3	Information provided by client
Maximum blade chord length (m)	4.3	Information provided by client
Fastest rotational speed (r.p.m)	12.1	Information provided by client
Blade pitch (degrees)	9	Typical value
Number of turbines with these dimensions proposed	7	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 100% of the total flight activity survey area (500m radius buffer surrounding the turbine locations) was visible from VP locations (VPs 1-4 and HHVP 1-4). Due to 100% viewshed coverage, no correction factor was required.

Table 3-1: VPs used for Avian Surveys

VP Number	Easting, Northing (ITM)	Area (km2)
1	658330 - 731741	0.685
2	654774 - 732654	1.1746
3	656737 - 728130	2.277
3a	657774 - 729900	1.6147
3b	657350 - 730655	1.5794
4	655554 - 730805	3.1767
4a	655300 - 729778	2.6053
HHVP 1	655973 - 728362	2.3749
HHVP 2	656671 - 729486	1.5728
HHVP 3	655685 - 729862	2.3711
HHVP 4	655717 - 730800	1.9662

The site and the buffer made a total survey area of 4.39 km^2. A total of 100%% of the entire survey area was covered from the 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 All VPs Combined (km2)
4.39	4.39	6.31

3.1.2 VP Survey Effort

VP surveys were carried out at the site monthly from April 2021 - March 2023, from October 2023 - April 2024 and from October - December 2024. The summer season was defined as running from April to September inclusive (six months) for summer 2021 and 2022, while winter was defined as October to March inclusive (six months) for winter 2021/22, 2022/23 and 2023/24. An additional three months of winter season surveys were carried out in winter 2024/25. These surveys included rounds during the spring and autumn migration periods. Watches were 2 * 3 hours = 6 hours per VP per month.

In addition to the main VP survey effort, survey data from hen harrier roost watch VPs undertaken in winter 2023/24 has also been utilised in the CRM. Hen harrier watches were also 2 * 3 hours = 6 hours per VP per month.

The total survey effort over the 5.5 survey seasons covered was 1,003.75 hours/ 3,613,500 seconds. The total survey period exceeded the recommended minimum 2 years of surveys required by SNH guidance (SNH, 2017).

Table 3-3 below details the survey effort for each of the survey seasons covered.

Table 3-3: Survey Effort completed at VPs

Season	VP	Hours	Total Hours
Summer 2021	1	36	144
	2	36	
	3a	24	
	3b	12	
	4a	36	
Winter 2021-2022	1	39	161
	2	42	
	3	41	
	4	39	
Summer 2022	1	42	168
	2	42	
	3	42	
	4	42	
Winter 2022-2023	1	42	168
	2	42	
	3	42	
	4	42	
Winter 2023-2024	1	34	260.75
	2	33.5	
	3	24	
	4	24	

Season	VP	Hours	Total Hours
	HH1	36	
	HH2	36	
	HH3	36	
	HH4	37.25	
Summer 2024	1	3	30
	2	3	
	3	12	
	4	12	
Winter 2024-25	1	18	72
	2	18	
	3	18	
	4	18	

3.1.3 VP Survey Protocol

The VP surveys recorded flight activity of all target species withing fixed visual envelopes, namely: 0-15m, 15-30m, 30-100m, 100-200m and >200m. 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 500m turbine buffer were included for 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 15th August 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	1.2	13.3	98
Black-headed Gull	0.37	1.1	12.5	99.2
Golden Plover	0.28	0.72	17.9	99.8
Great Black-backed gull	0.78	1.65	12	99.56
Grey Heron	0.98	1.6	12.7	98
Greylag Goose	0.81	1.6	19	99.5
Hen Harrier	0.48	1.1	9.1	99
Kestrel	0.34	0.76	10.1	95
Lapwing	0.29	0.69	10	98
Lesser Black-backed Gull	0.58	1.42	11.9	99.56
Little Egret	0.6	0.91	3	98
Mallard	0.58	0.9	18.5	98
Mute Swan	1.5	2.3	17.5	99.5
Peregrine	0.42	1.02	12.1	98
Snipe	0.26	0.46	17.1	98
Sparrowhawk	0.33	0.62	11.3	98
Whooper Swan	1.525	2.305	17.3	99.5

[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.

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	1	0.685	270000
Year 1	2	1.1746	280800
Year 1	3	2.277	147600
Year 1	4	3.1767	140400
Year 1	3a	1.6147	86400
Year 1	3b	1.5794	43200

Years	VPs	A - Area (km2)	t - Total watch time (Seconds)
Year 1	4a	2.6053	129600
Year 2	1	0.685	302400
Year 2	2	1.1746	302400
Year 2	3	2.277	302400
Year 2	4	3.1767	302400
Year 3	1	0.685	133200
Year 3	2	1.1746	131400
Year 3	3	2.277	129600
Year 3	4	3.1767	129600
Year 3	HH1	2.3749	129600
Year 3	HH2	1.5728	129600
Year 3	HH3	2.3711	129600
Year 3	HH4	1.9662	134100
Year 4	1	0.685	64800
Year 4	2	1.1746	64800
Year 4	3	2.277	64800
Year 4	4	3.1767	64800

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

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

Species	Mean bird density (bird-secs/km2)	Standard Deviation
Buzzard	0.003369	0.004435083
Golden Plover	0.213340	0.736734965
Great Black-backed Gull	0.000025	0.000118852
Grey Heron	0.000011	3.93667E-05
Kestrel	0.001593	0.003010768
Lesser Black-backed Gull	0.005496	0.013495315
Peregrine	0.000060	0.00015722
Snipe	0.000141	0.000417121
Sparrowhawk	0.000174	0.00035262
Whooper Swan	0.000096	0.000263624
Little Egret	0.000001	6.05649E-06

Species	Mean bird density (bird-secs/km2)	Standard Deviation
Lapwing	0.026276	0.049621867
Hen Harrier	0.000199	0.000548719
Mallard	0.001337	0.005456424
Mute Swan	0.000008	4.01409E-05
Black-headed Gull	0.000011	5.29943E-05
Greylag Goose	0.000027	0.000128924
Merlin	0.000012	5.12421E-05
Short-eared Owl	0.000039	0.000189247

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 CRM considered the Vestas 6.2 MW turbine with a rotor sweep zone of between 23m and 185m.

The surveys recorded the flight heights of birds, using bands of 0-15m, 15-30m, 30-100m, 100-200m and >200m. Height bands 0-15m and >200m fall outside the rotor sweep zone. All observations of birds flying exclusively within these two 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. Two species - Merlin and Short-eared Owl were not recorded flying at risk height and therefore the Collison Risk for these 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 (23m) falls within the height band 15-30m, 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 < 23m in height. This is also the case for the maximum rotor tip height (185m) which intersects the 30-100m 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, 7m of the rotor height span falls within the 15-30m height range, so 7/15 of the 17.65% of birds flying within that height range would be at rotor risk height. All 91 bird flights which intersected the 30-100m (59.48% of all observations) are fully within the rotor zone. The remaining 85m (100-185m) of the rotor height is within the 100-200m height range, so 85/100 of the 12.42% would also fall within the rotor risk height. Calculation provided below for Buzzard.

Q_{2R} Buzzard

((7/15)* 17.65%)+((70/70)* 59.48%)+((85/100)* 12.42%) = 78.27%

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

Species	Number of birds observed	Number of birds flights observed only in the 15 - 30m band	Proportion observed 15 - 30m height	Number of bird flights observed 30 - 100m	Proportion observed 30 - 100m height	Number of birds flights observed only in the 100 - 200m band	Proportion observed 100 - 200m height	Proportion between 23m and 185 m
Buzzard	153	27	17.64705882	91	59.47712	19	12.4183	0.78268
Golden Plover	1666	5	0.300120048	796	47.77911	605	36.31453	0.787865
Great Black-backed Gull	2	0	0	2	100	0	0	1
Grey Heron	4	2	50	0	0	0	0	0.233333
Kestrel	77	29	37.66233766	35	45.45455	1	1.298701	0.641342
Lesser Black-backed Gull	168	10	5.952380952	86	51.19048	72	42.85714	0.903968
Peregrine	9	2	22.22222222	4	44.44444	3	33.33333	0.831481
Snipe	40	30	75	4	10	0	0	0.45
Sparrowhawk	18	6	33.33333333	6	33.33333	0	0	0.488889
Whooper Swan	21	0	0	18	85.71429	0	0	0.857143
Little Egret	2	2	100	0	0	0	0	0.466667
Lapwing	1103	238	21.57751587	655	59.3835	203	18.40435	0.850967
Hen Harrier	15	4	26.66666667	1	6.666667	0	0	0.190172
Mallard	205	55	26.82926829	147	71.70732	1	0.487805	0.846423
Mute Swan	1	0	0	1	100	0	0	1
Black-headed Gull	4	0	0	3	75	1	25	0.9625
Greylag Goose	1	0	0	0	0	1	100	0.85

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 7-turbine wind farm with a rotor radius of 81m is 144,284 m^2.

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

Species	Predicted number of rotor transits each year[2]
Buzzard	512
Golden Plover	53,589
Great Black-backed Gull	5.39
Grey Heron	0.58
Kestrel	149.3
Lesser Black-backed Gull	955
Peregrine	8.7
Snipe	19.85
Sparrowhawk	13.81
Whooper Swan	25
Little Egret	0.04
Lapwing	3216.83
Hen Harrier	5
Mallard	301
Mute Swan	2.52
Black-headed Gull	2.25
Greylag Goose	7.7

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.

[2] 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.

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.

Table 6-2: Single transit risk

Species	Single transit risk - weighted mean (%)
Buzzard	5.8
Golden Plover	4.34
Great Black-backed Gull	7.4
Grey Heron	8.1
Kestrel	5.5
Lesser Black-backed Gull	6.44
Peregrine	5.5
Snipe	4.2
Sparrowhawk	5.1
Whooper Swan	8.8
Little Egret	19.7
Lapwing	5.3
Hen Harrier	6.8
Mallard	5.2
Mute Swan	8.7
Black-headed Gull	5.3
Greylag Goose	6.1

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 and curtailment 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)[3]
Buzzard	25.18
Golden Plover	1,978.04
Great Black-backed Gull	0.34
Grey Heron	0.4
Kestrel	6.99
Lesser Black-backed Gull	52.24
Peregrine	0.41
Snipe	0.71
Sparrowhawk	0.60
Whooper Swan	1.9
Little Egret	0.01
Lapwing	144.15
Hen Harrier	0.29
Mallard	13.43
Mute Swan	0.19
Black-headed Gull	0.10
Greylag Goose	0.4

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%*".

[3] 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.

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 at operational wind farm 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 wintering 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 500m 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[4]

Species	No. of predicted collisions per year	No. of years between predicted collisions	No. predicted collisions per 35 years	Rate (%)
Buzzard	0.5	2.00	17.5	98
Golden Plover	3.96	0.25	138.6	99.8
Great Black-backed Gull	0.00	0.00	0	99.5
Grey Heron	0.00	0.00	0	98
Kestrel	0.35	2.86	12.25	95
Lesser Black-backed Gull	0.26	3.85	9.1	99.5
Peregrine	0.01	100.00	0.35	98
Snipe	0.01	100.00	0.35	98
Sparrowhawk	0.01	100.00	0.35	98
Whooper Swan	0.01	100.00	0.35	99.5
Little Egret	0.00	0.00	0	98
Lapwing	2.88	0.35	100.8	98
Hen Harrier	0.00	0.00	0	99
Mallard	0.27	3.70	9.45	98
Mute Swan	0.00	0.00	0	99.5

[4] 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.

Species	No. of predicted collisions per year	No. of years between predicted collisions	No. predicted collisions per 35 years	Rate (%)
Black-headed Gull	0.00	0.00	0	99.5
Greylag Goose	0.00	0.00	0	99.5

With the exception of Golden Plover and Lapwing, the predicted collisions per year for the remaining target species are less than one. The proposed wind farm is predicted to result in 3.96 Golden Plover collisions and 2.88 Lapwing collisions per year according to the CRM. While the predicted collision rates for these species are higher due to recorded bird activity and numbers of birds observed, it is noted that the model provides a conservative estimate, and the number of actual collisions is likely to be lower. The majority of Golden Plover and Lapwing activity observed during surveys was focused outside the proposed development over Esker Bog Rathlumber and agricultural land to the north-east of T3.

The numbers of predicted yearly collisions for the remainder of species are either close to or at zero or and are considered negligible.

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 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 development, 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. Therefore, the likely empirical collision mortality figures should be lower than those presented here.

Golden Plover and Lapwing are the only species within measurable predicted collision rates, respectively with 3.96 and 2.88 predicted collisions per year. While the number of predicted collisions for all other species are less than one, Buzzard, Kestrel, Lesser Black-backed Gull, Peregrine, Snipe, Sparrowhawk, Whooper Swan and Mallard 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 Buzzard, Golden Plover, Lapwing, Kestrel, Lesser Black-backed Gull, Peregrine, Snipe, Sparrowhawk, Whooper Swan and Mallard is shown in Table 7-1 to Table 7-3. This indicates that collision mortality would not have a significant impact at either a national or county level for any of these species.

The majority of Golden Plover and Lapwing activity observed during surveys was focused outside the proposed development over Esker Bog Rathlumber and agricultural land to the north-east of T3, reducing the likelihood of these species habitually flying over the proposed development.

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

Parameter	Description	Source / Calculation	Buzzard			Kestrel			Golden Plover				Lapwing			
			National Pop.	County Pop.	Local Pop.	National Pop.	County Pop.	Local Pop.	National Pop.	County Pop.	Local Pop. (Max)	Local Pop. (Avg)	National Pop.	County Pop.	Local Pop. (Max)	Local Pop. (Avg)
pop	Population size	Various sources (see sources/notes row below)	3000	71	15	16470	468.73	23	80707	5613	1000	201	69823	3778	200	19
surv	Annual survival rate	Adult survival rates from www.bto.org/understanding-birds/birdfacts accessed 13/04/23	0.9	0.9	0.9	0.69	0.69	0.69	0.73	0.73	0.73	0.73	0.705	0.705	0.705	0.705
mort(back)	Annual background mortality	pop*(1-surv)	300	7.1	1.5	5105.7	145.3	7.13	21790.89	1515.51	270	54.27	20597.78	1114.5	59	5.605
mort(coll)	Predicted annual collision mortality	Predicted collision rates from CRM	0.5	0.5	0.5	0.35	0.35	0.35	3.96	3.96	3.96	3.96	2.88	2.88	2.88	2.88
%mort(increase)	Percentage increase in annual mortality rate due to collisions		0.017	0.70	3.33	0.007	0.241	4.909	0.018	0.261	1.467	7.297	0.014	0.258	4.881	51.38
	% of population potentially affected by collision mortality		**0.017**	**0.704**	**3.333**	**0.002**	**0.075**	**1.522**	**0.005**	**0.071**	**0.396**	**1.970**	**0.004**	**0.076**	**1.440**	**15.16**

Parameter	Description	Source / Calculation	Buzzard			Kestrel			Golden Plover				Lapwing			
			National Pop.	County Pop.	Local Pop.	National Pop.	County Pop.	Local Pop.	National Pop.	County Pop.	Local Pop. (Max)	Local Pop. (Avg)	National Pop.	County Pop.	Local Pop. (Max)	Local Pop. (Avg)
Magnitude (Percival, 2003)			<1% (Negligible)	<1% (Negligible)	1-5% (Low)	<1% (Negligible)	<1% (Negligible)	1-5% (Low)	<1% (Negligible)	<1% (Negligible)	<1% (Negligible)	1-5% (Low)	<1% (Negligible)	<1% (Negligible)	1-5% (Low)	5-20% (medium)
Sources/Notes:			NPWS (2012) Article 12 Report - Ireland's bird species' status and trends for the period 2008-2012 *** Quality of estimate = Moderate	Estimate based on proportion of national population split by county area, used due to a lack of specific county estimate	Based on VP observations (5x5 km local area)	NPWS (2012) Article 12 Report - Ireland's bird species' status and trends for the period 2008-2012 *** Quality of estimate = Moderate	Estimate based on proportion of national population split by county area, used due to a lack of specific county estimate	Based on county estimate, with wind farm site occupying an approximate local area of 10 km2	IWM 106 (2019) Irish Wetland Bird Survey 2009/10 – 2015/16; Piersma T., Rogers K.G., Boyd H., Bunskoeke E.J. & Jukema J. 2005. Demography of Eurasian Golden Plovers Pluvialis apricaria staging in The Netherlands, 1949–2000. Ardea 93(1): 49–64.	Co. Offaly I-WeBS Counts (sum of 5-year site means for Co. Offaly)	Largest flock size recorded at site	Average flock size across all VP surveys	IWM 106 (2019) Irish Wetland Bird Survey 2009/10 – 2015/16	Co. Offaly I-WeBS Counts (sum of 5-year site means for Co. Offaly)	Largest flock size recorded at site	Average flock size across all VP surveys

Table 7-2: Calculations of potential increases in annual mortality rates due to the predicted collision mortality (Part 2)

Parameter	Description	Source / Calculation	Lesser Black-backed Gull			Peregrine			Snipe		
			National Pop.	County Pop.	Local Pop.	National Pop.	County Pop.	Local Pop.	National Pop.	County Pop.	Local Pop.
pop	Population size	Various sources (see sources/notes row below)	7112	202	32.5	1030	24	2	8550	202	10
surv	Annual survival rate	Adult survival rates from www.bto.org/understanding-birds/birdfacts accessed 13/04/23	0.913	0.913	0.913	0.81	0.81	0.81	0.481	0.481	0.481
mort(back)	Annual background mortality	pop*(1-surv)	618.74	17.57	2.83	195.7	4.56	0.38	4437.45	104.84	5.19
mort(coll)	Predicted annual collision mortality	Predicted collision rates from CRM	0.26	0.26	0.26	0.01	0.01	0.01	0.01	0.01	0.01
%mort(increase)	Percentage increase in annual mortality rate due to collisions		0.004	0.13	0.80	0.001	0.04	0.50	0.000	0.00	0.10
	% of population potentially affected by collision mortality		**0.004**	**0.129**	**0.800**	**0.001**	**0.042**	**0.500**	**0.000**	**0.005**	**0.100**

Parameter	Description	Source / Calculation	Lesser Black-backed Gull			Peregrine			Snipe		
			National Pop.	County Pop.	Local Pop.	National Pop.	County Pop.	Local Pop.	National Pop.	County Pop.	Local Pop.
Magnitude (Percival, 2003)			<1% (Negligible)	<1% (Negligible)	<1% (Negligible)	<1% (Negligible)	<1% (Negligible)	<1% (Negligible)	<1% (Negligible)	<1% (Negligible)	<1% (Negligible)
Sources/Notes:			JNCC website accessed May 2023 - https://jncc.gov.uk/our-work/lesser-black-backed-gull-larus-fuscus/#annual-abundance-and-productivity-by-geographical-area-republic-of-ireland	Estimate based on proportion of national population split by county area, used due to a lack of specific county estimate	50% of largest flock size observed	NPWS (2012) Article 12 Report - Ireland's bird species' status and trends for the period 2008-2012 *** Quality of estimate = Moderate	Estimate based on proportion of national population split by county area, used due to a lack of specific county estimate	Based on county estimate, with wind farm site occupying an approximate local area of 10 km2	NPWS (2012) Article 12 Report - Ireland's bird species' status and trends for the period 2008-2012 *** Quality of estimate = Moderate	Estimate based on proportion of national population split by county area, used due to a lack of specific county estimate	Based on county estimate

Table 7-3: Calculations of potential increases in annual mortality rates due to the predicted collision mortality (Part 3)

Parameter	Description	Source / Calculation	Sparrowhawk			Whooper Swan			Mallard		
			National Pop.	County Pop.	Local Pop.	National Pop.	County Pop.	Local Pop.	National Pop.	County Pop.	Local Pop.
pop	Population size	Various sources (see sources/notes row below)	14830	352	10	10520	407	35	30800	564	30
surv	Annual survival rate	Adult survival rates from www.bto.org/understanding-birds/birdfacts accessed 13/04/23	0.69	0.69	0.69	0.69	0.69	0.69	0.627	0.627	0.627
mort(back)	Annual background mortality	pop*(1-surv)	4597.3	109.12	3.1	3261.2	126.17	10.85	11488.4	210.372	11.19
mort(coll)	Predicted annual collision mortality	Predicted collision rates from CRM	0.01	0.01	0.01	0.01	0.01	0.01	0.27	0.27	0.27
%mort(increase)	Percentage increase in annual mortality rate due to collisions		0.000	0.00	0.10	0.00	0.00	0.03	0.001	0.05	0.90
	% of population potentially affected by collision mortality		**0.000**	**0.003**	**0.100**	**0.000**	**0.002**	**0.029**	**0.001**	**0.048**	**0.900**
Magnitude (Percival, 2003)			<1% (Negligible)	<1% (Negligible)	<1% (Negligible)	<1% (Negligible)	<1% (Negligible)	<1% (Negligible)	<1% (Negligible)	<1% (Negligible)	<1% (Negligible)

Parameter	Description	Source / Calculation	Sparrowhawk			Whooper Swan			Mallard		
			National Pop.	County Pop.	Local Pop.	National Pop.	County Pop.	Local Pop.	National Pop.	County Pop.	Local Pop.
Sources/Notes:			NPWS (2012) Article 12 Report - Ireland's bird species' status and trends for the period 2008-2012 *** Quality of estimate = Moderate	Estimate based on proportion of national population split by county area, used due to a lack of specific county estimate	Based on VP observations (10x10 km local area)	NPWS (2012) Article 12 Report - Ireland's bird species' status and trends for the period 2008-2012 *** Quality of estimate = Moderate	Co. Offaly I-WeBS Counts (sum of 5-year site means for Co. Kildare)	Max observed in vicinity of proposed development during surveys	NPWS (2012) Article 12 Report - Ireland's bird species' status and trends for the period 2008-2012 *** Quality of estimate = Moderate	Estimate based on proportion of national population split by county area, used due to a lack of specific county estimate	Max observed in vicinity of proposed development during surveys

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FEHILY TIMONEY

DESIGNING AND DELIVERING A SUSTAINABLE FUTURE

APPENDIX 1

CRM Species Sheets

Stage A					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Daytime bird density	D_A		birds/km^2		0.003417	0.003417	0.003417	0.003417	0.003417	0.003417	0.003417	0.003417	0.003417	0.003417	0.003417	0.003417	0.0034
Proportion at rotor risk height	Q_{2R}	78.27%															
At latitude 53.3		Daylight hours per month			251.9	273.9	366.4	418.4	491.0	506.8	509.8	458.7	382.5	329.8	261.3	236.1	4486.8
		Nighttime hours per month			492.1	398.1	377.6	301.6	253.0	213.2	234.2	285.3	337.5	414.2	458.7	507.9	4273.2
Stage B																	
No of turbines	T	7															
Rotor radius	R	81	m														
		Total rotor frontal area m^2		144284													
Nocturnal activity factor	f_{night}	0%															
Bird flight speed	v	13.3	m s^{-1}		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
		Projected number of rotor transits			28.7	31.2	41.8	47.7	56.0	57.8	58.1	52.3	43.6	37.6	29.8	26.9	**512**
Stage C																	
No of blades	b	3					Bird length	l	0.52	m							
Rotation speed	Ω	12.1	rpm				Wingspan	w	1.2	m							
Rotor radius	R	81	m				Bird flight speed	v	13.3	m s^{-1}							
Max blade width	C	4.3	m				Flight type		flapping								
Pitch	λ	9	degrees		% of flights upwind/downwind				50%	50%							
Blade profile		see Blade profile sheet															
		Single transit risk		upwind	7.42%												
				downwind	4.16%												
				weighted mean	**5.79%**												
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
					1.41	1.54	2.06	2.35	2.76	2.84	2.86	2.57	2.15	1.85	1.47	1.33	**25**
Stage E																	
Allow for large array correction?		No															
Width of windfarm	w	3	km														
			large array correction		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
					Collision rates allowing for avoidance												
Avoidance rates modelled		95.00%	100.00%		0.07	0.08	0.10	0.12	0.14	0.14	0.14	0.13	0.11	0.09	0.07	0.07	**1.3**
		98.00%	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**
		99.00%	100.00%		0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.02	0.02	0.01	0.01	**0.3**
		99.50%	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**

Stage B	
Projected number of rotor transits	511.67

Stage C	
Single Transit Risk - Weighted Mean	5.8%

Stage D	
Collision Rates before avoidance	25.18

Stage F	
Avoidance Rate	**Number of Fatalities per year**
95.00%	1.26
98.00%	0.50
99.00%	0.25
99.50%	0.13

Buzzard

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		0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016
Proportion at rotor risk height	Q_{2R}	64.13%															
At latitude 53.3		Daylight hours per month			251.9	273.9	366.4	418.4	491.0	506.8	509.8	458.7	382.5	329.8	261.3	236.1	4486.8
		Nighttime hours per month			492.1	398.1	377.6	301.6	253.0	213.2	234.2	285.3	337.5	414.2	458.7	507.9	4273.2
Stage B																	
No of turbines	T	7															
Rotor radius	R	81	m														
		Total rotor frontal area m^2		144284													
Nocturnal activity factor	f_{night}	0%															
Bird flight speed	v	10.1	m s^{-1}		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
		Projected number of rotor transits			8.4	9.1	12.2	13.9	16.3	16.8	16.9	15.2	12.7	11.0	8.7	7.8	**149**
Stage C																	
No of blades	b	3				Bird length	l	0.34	m								
Rotation speed	Ω	12.1	rpm			Wingspan	w	0.76	m								
Rotor radius	R	81	m			Bird flight speed	v	10.1	m s^{-1}								
Max blade width	C	4.3	m			Flight type		flapping									
Pitch	λ	9	degrees		% of flights	upwind/downwind		50%	50%								
Blade profile		see Blade profile sheet															
		Single transit risk		upwind	7.51%												
				downwind	3.53%												
				weighted mean	**5.52%**												
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
					0.39	0.43	0.57	0.65	0.77	0.79	0.79	0.72	0.60	0.51	0.41	0.37	**7**
Stage E																	
Allow for large array correction?		No															
Width of windfarm	w	3	km														
			large array correction		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
Avoidance rates modelled		95.00%	100.00%		Collision rates allowing for avoidance												
		98.00%	100.00%		0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.04	0.03	0.03	0.02	0.02	**0.3**
		99.00%	100.00%		0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	**0.1**
		99.50%	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**
					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**

	A	B
	Stage B	
	Projected number of rotor transits	149.13
	Stage C	
	Single Transit Risk - Weighted Mean	5.5%
	Stage D	
	Collision Rates before avoidance	6.99
	Stage F	
	Avoidance Rate	**Number of Fatalities per year**
	95.00%	0.35
	98.00%	0.14
	99.00%	0.07
	99.50%	0.03

Kestrel

		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		0.21334	0.21334	0.21334	0.21334	0.21334	0.21334	0.21334	0.21334	0.21334	0.21334	0.21334	0.21334	0.2133	
Proportion at rotor risk height	Q_{2R}	78.79%																
At latitude 53.3		Daylight hours per month			251.9	273.9	366.4	418.4	491.1	506.8	509.8	458.7	382.5	329.8	261.3	236.1	4486.8	
		Nighttime hours per month			492.1	398.1	377.6	301.6	252.9	213.2	234.2	285.3	337.5	414.2	458.7	507.9	4273.2	
Stage B																		
No of turbines	T	7																
Rotor radius	R	81	m															
		Total rotor frontal area m^2		144284														
Nocturnal activity factor	f_{night}	25%																
Bird flight speed	v	17.9	m s^{-1}		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total	
		Projected number of rotor transits			3617.1	3602.0	4444.9	4763.8	5347.1	5403.3	5482.5	5113.3	4504.2	4180.6	3627.2	3502.5	**53589**	
Stage C																		
No of blades	b	3				Bird length	l	0.28	m									
Rotation speed	Ω	12.1	rpm			Wingspan	w	0.72	m									
Rotor radius	R	81	m			Bird flight speed	v	17.9	m s^{-1}									
Max blade width	C	4.3	m			Flight type		flapping										
Pitch	λ	9	degrees		% of flights	upwind/downwind		50%	50%									
Blade profile		see Blade profile sheet																
		Single transit risk		upwind	5.57%													
				downwind	3.12%													
				weighted mean	**4.34%**													
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	
					133.51	132.96	164.07	175.84	197.37	199.45	202.37	188.74	166.26	154.31	133.89	129.28	**1978**	
Stage E																		
Allow for large array correction?		No																
Width of windfarm	w	3	km															
			large array correction		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year	
					Collision rates allowing for avoidance													
Avoidance rates modelled		95.00%	100.00%		6.68	6.65	8.20	8.79	9.87	9.97	10.12	9.44	8.31	7.72	6.69	6.46	**98.9**	
		98.00%	100.00%		2.67	2.66	3.28	3.52	3.95	3.99	4.05	3.77	3.33	3.09	2.68	2.59	**39.6**	
		99.00%	100.00%		1.34	1.33	1.64	1.76	1.97	1.99	2.02	1.89	1.66	1.54	1.34	1.29	**19.8**	
		99.80%	100.00%		0.27	0.27	0.33	0.35	0.39	0.40	0.40	0.38	0.33	0.31	0.27	0.26	**4.0**	

A	B
Stage B	
Projected number of rotor transits	53588.67
Stage C	
Single Transit Risk - Weighted Mean	4.34%
Stage D	
Collision Rates before avoidance	1978.04
Stage F	
Avoidance Rate	**Number of Fatalities per year**
0.95	98.90
0.98	39.56
0.99	19.78
1.00	3.96

Golden Plover

Stage A					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Daytime bird density	D_A		birds/km^2		0.026277	0.026277	0.026277	0.026277	0.026277	0.026277	0.026277	0.026277	0.026277	0.026277	0.026277	0.026277	0.0263
Proportion at rotor risk height	Q_{2R}	85.10%															
At latitude 53.3		Daylight hours per month			251.9	273.9	366.4	418.4	491.0	506.8	509.8	458.7	382.5	329.8	261.3	236.1	4486.8
		Nighttime hours per month			492.1	398.1	377.6	301.6	253.0	213.2	234.2	285.3	337.5	414.2	458.7	507.9	4273.2
Stage B																	
No of turbines	T	7															
Rotor radius	R	81	m														
		Total rotor frontal area m^2		144284													
Nocturnal activity factor	f_{night}	0%															
Bird flight speed	v	10	m s^{-1}		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
		Projected number of rotor transits			180.6	196.3	262.7	300.0	352.1	363.4	365.5	328.9	274.3	236.5	187.4	169.3	**3217**
Stage C																	
No of blades	b	3				Bird length	l	0.295	m								
Rotation speed	Ω	12.1	rpm			Wingspan	w	0.695	m								
Rotor radius	R	81	m			Bird flight speed	v	10	m s^{-1}								
Max blade width	C	4.3	m			Flight type		flapping									
Pitch	λ	9	degrees	% of flights upwind/downwind				50%	50%								
Blade profile		see Blade profile sheet															
		Single transit risk		upwind	7.28%												
				downwind	3.27%												
				weighted mean	**5.27%**												
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
					8.09	8.80	11.77	13.44	15.78	16.28	16.38	14.74	12.29	10.60	8.40	7.59	**144**
Stage E																	
Allow for large array correction?		No															
Width of windfarm	w	3	km														
			large array correction		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
					Collision rates allowing for avoidance												
Avoidance rates modelled		95.00%	100.00%		0.40	0.44	0.59	0.67	0.79	0.81	0.82	0.74	0.61	0.53	0.42	0.38	**7.2**
		98.00%	100.00%		0.16	0.18	0.24	0.27	0.32	0.33	0.33	0.29	0.25	0.21	0.17	0.15	**2.9**
		99.00%	100.00%		0.08	0.09	0.12	0.13	0.16	0.16	0.16	0.15	0.12	0.11	0.08	0.08	**1.4**
		99.50%	100.00%		0.04	0.04	0.06	0.07	0.08	0.08	0.08	0.07	0.06	0.05	0.04	0.04	**0.7**

Stage B	
Projected number of rotor transits	3216.83

Stage C	
Single Transit Risk - Weighted Mean	5.3%

Stage D	
Collision Rates before avoidance	144.15

Stage F	
Avoidance Rate	**Number of Fatalities per year**
95.00%	7.21
98.00%	2.88
99.00%	1.44
99.50%	0.72

Lapwing

Stage A					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Daytime bird density	D_A		birds/km^2		0.006171	0.006171	0.006171	0.006171	0.006171	0.006171	0.006171	0.006171	0.006171	0.006171	0.006171	0.006171	0.0062
Proportion at rotor risk height	Q_{2R}	90.40%															
At latitude 53.3		Daylight hours per month			251.9	273.9	366.4	418.4	491.1	506.8	509.8	458.7	382.5	329.8	261.3	236.1	4486.8
		Nighttime hours per month			492.1	398.1	377.6	301.6	252.9	213.2	234.2	285.3	337.5	414.2	458.7	507.9	4273.2
Stage B																	
No of turbines	T	7															
Rotor radius	R	81	m														
		Total rotor frontal area m^2		144284													
Nocturnal activity factor	f_{night}	0%															
Bird flight speed	v	11.9	m s^{-1}		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
		Projected number of rotor transits			53.6	58.3	78.0	89.1	104.5	107.9	108.5	97.6	81.4	70.2	55.6	50.3	**955**
Stage C																	
No of blades	b	3				Bird length	l	0.58	m								
Rotation speed	Ω	12.1	rpm			Wingspan	w	1.42	m								
Rotor radius	R	81	m			Bird flight speed	v	11.9	m s^{-1}								
Max blade width	C	4.3	m			Flight type		flapping									
Pitch	λ	9	degrees		% of flights upwind/downwind			50%	50%								
Blade profile		see Blade profile sheet															
		Single transit risk		upwind	8.21%												
				downwind	4.66%												
				weighted mean	**6.44%**												
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
					2.93	3.19	4.27	4.87	5.72	5.90	5.94	5.34	4.45	3.84	3.04	2.75	**52**
Stage E																	
Allow for large array correction?		No															
Width of windfarm	w	3	km														
			large array correction		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
					Collision rates allowing for avoidance												
Avoidance rates modelled		95.00%	100.00%		0.15	0.16	0.21	0.24	0.29	0.30	0.30	0.27	0.22	0.19	0.15	0.14	**2.6**
		98.00%	100.00%		0.06	0.06	0.09	0.10	0.11	0.12	0.12	0.11	0.09	0.08	0.06	0.05	**1.0**
		99.00%	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**
		99.50%	100.00%		0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.01	**0.3**

Stage B	
Projected number of rotor transits	954.99

Stage C	
Single Transit Risk - Weighted Mean	6.44%

Stage D	
Collision Rates before avoidance	52.24

Stage F	
Avoidance Rate	**Number of Fatalities per year**
0.95	2.61
0.98	1.04
0.99	0.52
1.00	0.26

Lesser Black-backed Gull

Stage A					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Daytime bird density	D_A		birds/km^2		6.01E-05	6.01E-05	6.01E-05	6.01E-05	6.01E-05	6.01E-05	6.01E-05	6.01E-05	6.01E-05	6.01E-05	6.01E-05	6.01E-05	0.0001
Proportion at rotor risk height	Q_{2R}	83.15%															
At latitude 53.3		Daylight hours per month			251.9	273.9	366.4	418.4	491.0	506.8	509.8	458.7	382.5	329.8	261.3	236.1	4486.8
		Nighttime hours per month			492.1	398.1	377.6	301.6	253.0	213.2	234.2	285.3	337.5	414.2	458.7	507.9	4273.2
Stage B																	
No of turbines	T	7															
Rotor radius	R	81	m														
		Total rotor frontal area m^2		144284													
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			0.5	0.5	0.7	0.8	1.0	1.0	1.0	0.9	0.7	0.6	0.5	0.5	**9**
Stage C																	
No of blades	b	3				Bird length	l	0.42	m								
Rotation speed	Ω	12.1	rpm			Wingspan	w	1.02	m								
Rotor radius	R	81	m			Bird flight speed	v	12.1	m s^{-1}								
Max blade width	C	4.3	m			Flight type		flapping									
Pitch	λ	9	degrees	% of flights upwind/downwind				50%	50%								
Blade profile		see Blade profile sheet															
		Single transit risk		upwind	7.28%												
				downwind	3.77%												
				weighted mean	**5.52%**												
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
					0.02	0.02	0.03	0.04	0.04	0.05	0.05	0.04	0.03	0.03	0.02	0.02	**0**
Stage E																	
Allow for large array correction?		No															
Width of windfarm	w	3	km														
			large array correction		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
					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**

Stage B	
Projected number of rotor transits	8.70

Stage C	
Single Transit Risk - Weighted Mean	5.5%

Stage D	
Collision Rates before avoidance	0.41

Stage F	
Avoidance Rate	**Number of Fatalities per year**
95.00%	0.02
98.00%	0.01
99.00%	0.00
99.50%	0.00

Peregrine

Stage A					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Daytime bird density	D_A		birds/km^2		0.000145	0.000145	0.000145	0.000145	0.000145	0.000145	0.000145	0.000145	0.000145	0.000145	0.000145	0.000145	0.0001
Proportion at rotor risk height	Q_{2R}	45.00%															
At latitude 53.3		Daylight hours per month			251.9	273.9	366.4	418.4	491.0	506.8	509.8	458.7	382.5	329.8	261.3	236.1	4486.8
		Nighttime hours per month			492.1	398.1	377.6	301.6	253.0	213.2	234.2	285.3	337.5	414.2	458.7	507.9	4273.2
Stage B																	
No of turbines	T	7															
Rotor radius	R	81	m														
		Total rotor frontal area m^2		144284													
Nocturnal activity factor	f_{night}	25%															
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			1.3	1.3	1.6	1.8	2.0	2.0	2.0	1.9	1.7	1.5	1.3	1.3	**20**
Stage C																	
No of blades	b	3				Bird length	l	0.26	m								
Rotation speed	Ω	12.1	rpm			Wingspan	w	0.46	m								
Rotor radius	R	81	m			Bird flight speed	v	17.1	m s^{-1}								
Max blade width	C	4.3	m			Flight type		flapping									
Pitch	λ	9	degrees	% of flights upwind/downwind				50%	50%								
Blade profile		see Blade profile sheet															
		Single transit risk		upwind	5.49%												
				downwind	2.93%												
				weighted mean	**4.21%**												
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
					0.05	0.05	0.06	0.06	0.07	0.07	0.07	0.07	0.06	0.06	0.05	0.05	**1**
Stage E																	
Allow for large array correction?		No															
Width of windfarm	w	3	km														
			large array correction		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
					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**

	A	B
1	**Stage B**	
2	Projected number of rotor transits	19.85
3		
4	**Stage C**	
5	Single Transit Risk - Weighted Mean	4.2%
6		
7		
8	**Stage D**	
9	Collision Rates before avoidance	0.71
10		
11	**Stage F**	
12	**Avoidance Rate**	**Number of Fatalities per year**
13	95.00%	0.04
14	98.00%	0.01
15	99.00%	0.01
16	99.50%	0.00
17		

Snipe

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	0.000174	0.000174	0.000174	0.000174	0.000174	0.000174	0.000174	0.000174	0.000174	0.000174	0.000174	0.000174	0.0002
Proportion at rotor risk height	Q_{2R}	48.89%														
At latitude 53.3		Daylight hours per month		251.9	273.9	366.4	418.4	491.0	506.8	509.8	458.7	382.5	329.8	261.3	236.1	4486.8
		Nighttime hours per month		492.1	398.1	377.6	301.6	253.0	213.2	234.2	285.3	337.5	414.2	458.7	507.9	4273.2

Stage B																
No of turbines	T	7														
Rotor radius	R	81	m													
		Total rotor frontal area m^2		144284												
Nocturnal activity factor	f_{night}	0%														
Bird flight speed	v	11.3	m s^{-1}	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
		Projected number of rotor transits		0.8	0.8	1.1	1.3	1.5	1.6	1.6	1.4	1.2	1.0	0.8	0.7	**14**

Stage C								
No of blades	b	3		Bird length	l	0.33	m	
Rotation speed	Ω	12.1	rpm	Wingspan	w	0.62	m	
Rotor radius	R	81	m	Bird flight speed	v	11.3	m s^{-1}	
Max blade width	C	4.3	m	Flight type		flapping		
Pitch	λ	9	degrees	% of flights upwind/downwind		50%		50%
Blade profile		see Blade profile sheet						
		Single transit risk	upwind	6.99%				
			downwind	3.29%				
			weighted mean	**5.14%**				

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
		0.03	0.04	0.05	0.06	0.07	0.07	0.07	0.06	0.05	0.04	0.04	0.03	**1**

Stage E																
Allow for large array correction?		No														
Width of windfarm	w	3	km													
			large array correction	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
				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**

Stage B	
Projected number of rotor transits	13.81

Stage C	
Single Transit Risk - Weighted Mean	5.1%

Stage D	
Collision Rates before avoidance	0.60

Stage F	
Avoidance Rate	**Number of Fatalities per year**
95.00%	0.03
98.00%	0.01
99.00%	0.01
99.50%	0.00

Sparrowhawk

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		9.58E-05	9.58E-05	9.58E-05	9.58E-05	9.58E-05	9.58E-05	9.58E-05	9.58E-05	9.58E-05	9.58E-05	9.58E-05	9.58E-05	0.0001
Proportion at rotor risk height	Q_{2R}	85.71%															
At latitude 53.3		Daylight hours per month			251.9	273.9	366.4	418.4	491.0	506.8	509.8	458.7	382.5	329.8	261.3	236.1	4486.8
		Nighttime hours per month			492.1	398.1	377.6	301.6	253.0	213.2	234.2	285.3	337.5	414.2	458.7	507.9	4273.2

Stage B																	
No of turbines	T	7															
Rotor radius	R	81	m														
		Total rotor frontal area m^2		144284													
Nocturnal activity factor	f_{night}	25%															
Bird flight speed	v	17.3	m s^{-1}		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
		Projected number of rotor transits			1.7	1.7	2.1	2.2	2.5	2.5	2.6	2.4	2.1	2.0	1.7	1.7	25

Stage C									
No of blades	b	3			Bird length	l	1.525	m	
Rotation speed	Ω	12.1	rpm		Wingspan	w	2.305	m	
Rotor radius	R	81	m		Bird flight speed	v	17.3	m s^{-1}	
Max blade width	C	4.3	m		Flight type		flapping		
Pitch	λ	9	degrees	% of flights upwind/downwind			50%	50%	
Blade profile		see Blade profile sheet							
		Single transit risk		upwind	10.11%				
				downwind	7.57%				
				weighted mean	**8.84%**				

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
					0.13	0.13	0.16	0.17	0.19	0.19	0.19	0.18	0.16	0.15	0.13	0.12	2

Stage E																	
Allow for large array correction?		No															
Width of windfarm	w	3	km														
			large array correction		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
					Collision rates allowing for avoidance												
Avoidance rates modelled		95.00%	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**
		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**

Stage C	
Single Transit Risk - Weighted Mean	8.8%

Stage D	
Collision Rates before avoidance	1.90

Stage F	
Avoidance Rate	**Number of Fatalities per year**
95.00%	0.10
98.00%	0.04
99.00%	0.02
99.50%	0.01

Whooper Swan

tage A					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Daytime bird density	D_A		birds/km^2		0.001337	0.001337	0.001337	0.001337	0.001337	0.001337	0.001337	0.001337	0.001337	0.001337	0.001337	0.001337	0.0013
Proportion at rotor risk height	Q_{2R}	84.64%															
At latitude 53.3		Daylight hours per month			251.9	273.9	366.4	418.4	491.0	506.8	509.8	458.7	382.5	329.8	261.3	236.1	4486.8
		Nighttime hours per month			492.1	398.1	377.6	301.6	253.0	213.2	234.2	285.3	337.5	414.2	458.7	507.9	4273.2
tage B																	
No of turbines	T	7															
Rotor radius	R	81	m														
		Total rotor frontal area m^2		144284													
Nocturnal activity factor	f_{night}	0%															
Bird flight speed	v	18.5	m s^{-1}		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
		Projected number of rotor transits			16.9	18.4	24.6	28.1	33.0	34.0	34.2	30.8	25.7	22.1	17.5	15.8	**301**
tage C																	
No of blades	b	3				Bird length	l	0.58	m								
Rotation speed	Ω	12.1	rpm			Wingspan	w	0.9	m								
Rotor radius	R	81	m			Bird flight speed	v	18.5	m s^{-1}								
Max blade width	C	4.3	m			Flight type		flapping									
Pitch	λ	9	degrees		% of flights upwind/downwind			50%	50%								
Blade profile		see Blade profile sheet															
		Single transit risk		upwind	6.43%												
				downwind	4.06%												
				weighted mean	**5.25%**												
tage D					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
roportion 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
					0.75	0.82	1.10	1.25	1.47	1.52	1.53	1.37	1.14	0.99	0.78	0.71	**13**
tage E																	
llow for large array correction?		No															
Width of windfarm	w	3	km														
			large array correction		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
					Collision rates allowing for avoidance												
voidance rates modelled		95.00%	100.00%		0.04	0.04	0.05	0.06	0.07	0.08	0.08	0.07	0.06	0.05	0.04	0.04	**0.7**
		98.00%	100.00%		0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.01	**0.3**
		99.00%	100.00%		0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.01	**0.1**
		99.50%	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**

	A	B
	Stage B	
	rojected number of rotor transits	301.07
	Stage C	
	ingle Transit Risk - Weighted Mean	5.2%
	Stage D	
	ollision Rates before avoidance	13.43
	Stage F	
	voidance Rate	**Number of Fatalities per year**
	95.00%	0.67
	98.00%	0.27
	99.00%	0.13
	99.50%	0.07

Mallard

Stage A					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Daytime bird density	D_A		birds/km^2		3.12E-05	3.12E-05	3.12E-05	3.12E-05	3.12E-05	3.12E-05	3.12E-05	3.12E-05	3.12E-05	3.12E-05	3.12E-05	3.12E-05	0.0000
Proportion at rotor risk height	Q_{2R}	100.00%															
At latitude 53.3		Daylight hours per month			251.9	273.9	366.4	418.4	491.0	506.8	509.8	458.7	382.5	329.8	261.3	236.1	4486.8
		Nighttime hours per month			492.1	398.1	377.6	301.6	253.0	213.2	234.2	285.3	337.5	414.2	458.7	507.9	4273.2
Stage B																	
No of turbines	T	7															
Rotor radius	R	81	m														
		Total rotor frontal area m^2		144284													
Nocturnal activity factor	f_{night}	0%															
Bird flight speed	v	12	m s^{-1}		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
		Projected number of rotor transits			0.3	0.3	0.4	0.5	0.6	0.6	0.6	0.6	0.5	0.4	0.3	0.3	5
Stage C																	
No of blades	b	3				Bird length	l	0.78	m								
Rotation speed	Ω	12.1	rpm			Wingspan	w	1.65	m								
Rotor radius	R	81	m			Bird flight speed	v	12	m s^{-1}								
Max blade width	C	4.3	m			Flight type		flapping									
Pitch	λ	9	degrees		% of flights upwind/downwind			50%	50%								
Blade profile		see Blade profile sheet															
		Single transit risk		upwind	9.18%												
				downwind	5.64%												
				weighted mean	**7.41%**												
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
					0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.03	0.03	0.02	0.02	0.02	**0**
Stage E																	
Allow for large array correction?		No															
Width of windfarm	w	3	km														
			large array correction		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
					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**
		99.56%	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**

Stage B	
Projected number of rotor transits	5.39

Stage C	
Single Transit Risk - Weighted Mean	7.4%

Stage D	
Collision Rates before avoidance	0.34

Stage F	
Avoidance Rate	**Number of Fatalities per year**
95.00%	0.02
98.00%	0.01
99.00%	0.00
99.50%	0.00

Great Black-backed Gull

Stage A					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Daytime bird density	D_A		birds/km^2		1.37E-05	1.37E-05	1.37E-05	1.37E-05	1.37E-05	1.37E-05	1.37E-05	1.37E-05	1.37E-05	1.37E-05	1.37E-05	1.37E-05	0.0000
Proportion at rotor risk height	Q_{2R}	23.33%															
At latitude 53.3		Daylight hours per month			251.9	273.9	366.4	418.4	491.0	506.8	509.8	458.7	382.5	329.8	261.3	236.1	4486.8
		Nighttime hours per month			492.1	398.1	377.6	301.6	253.0	213.2	234.2	285.3	337.5	414.2	458.7	507.9	4273.2
Stage B																	
No of turbines	T	7															
Rotor radius	R	81	m														
		Total rotor frontal area m^2		144284													
Nocturnal activity factor	f_{night}	0%															
Bird flight speed	v	12.7	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	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	**1**
Stage C																	
No of blades	b	3				Bird length	l	0.98	m								
Rotation speed	Ω	12.1	rpm			Wingspan	w	1.6	m								
Rotor radius	R	81	m			Bird flight speed	v	12.7	m s^{-1}								
Max blade width	C	4.3	m			Flight type		flapping									
Pitch	λ	9	degrees		% of flights upwind/downwind			50%	50%								
Blade profile		see Blade profile sheet															
		Single transit risk		upwind	9.76%												
				downwind	6.38%												
				weighted mean	**8.07%**												
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	3	km														
			large array correction		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
					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**

Stage B	
Projected number of rotor transits	0.58

Stage C	
Single Transit Risk - Weighted Mean	8.1%

Stage D	
Collision Rates before avoidance	0.04

Stage F	
Avoidance Rate	**Number of Fatalities per year**
95.00%	0.00
98.00%	0.00
99.00%	0.00
99.50%	0.00

Grey Heron

Stage A					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Daytime bird density	D_A		birds/km^2		0.000002	0.000002	0.000002	0.000002	0.000002	0.000002	0.000002	0.000002	0.000002	0.000002	0.000002	0.000002	0.0000
Proportion at rotor risk height	Q_{2R}	46.67%															
At latitude 53.3		Daylight hours per month			251.9	273.9	366.4	418.4	491.0	506.8	509.8	458.7	382.5	329.8	261.3	236.1	4486.8
		Nighttime hours per month			492.1	398.1	377.6	301.6	253.0	213.2	234.2	285.3	337.5	414.2	458.7	507.9	4273.2
Stage B																	
No of turbines	T	7															
Rotor radius	R	81	m														
		Total rotor frontal area m^2		144284													
Nocturnal activity factor	f_{night}	0%															
Bird flight speed	v	3	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	0.6	m								
Rotation speed	Ω	12.1	rpm			Wingspan	w	0.915	m								
Rotor radius	R	81	m			Bird flight speed	v	3	m s^{-1}								
Max blade width	C	4.3	m			Flight type		flapping									
Pitch	λ	9	degrees		% of flights upwind/downwind			50%	50%								
Blade profile		see Blade profile sheet															
		Single transit risk		upwind	22.63%												
				downwind	16.71%												
				weighted mean	**19.67%**												
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	3	km														
			large array correction		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
					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**

Stage B	
Projected number of rotor transits	0.04

Stage C	
Single Transit Risk - Weighted Mean	19.7%

Stage D	
Collision Rates before avoidance	0.01

Stage F	
Avoidance Rate	**Number of Fatalities per year**
95.00%	0.00
98.00%	0.00
99.00%	0.00
99.50%	0.00

Little Egret

				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
D_A		birds/km^2		0.000199	0.000199	0.000199	0.000199	0.000199	0.000199	0.000199	0.000199	0.000199	0.000199	0.000199	0.000199	0.0002
Q_{2R}	19.02%															
	Daylight hours per month			251.9	273.9	366.4	418.4	491.0	506.8	509.8	458.7	382.5	329.8	261.3	236.1	4486.8
	Nighttime hours per month			492.1	398.1	377.6	301.6	253.0	213.2	234.2	285.3	337.5	414.2	458.7	507.9	4273.2
T	7															
R	81	m														
	Total rotor frontal area m^2		144284													
f_{night}	0%															
v	9.1	m s^{-1}		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
	Projected number of rotor transits			0.3	0.3	0.4	0.5	0.5	0.6	0.6	0.5	0.4	0.4	0.3	0.3	**5**
b	3					Bird length	l	0.48	m							
Ω	12.1	rpm				Wingspan	w	1.1	m							
R	81	m				Bird flight speed	v	9.1	m s^{-1}							
C	4.3	m				Flight type		flapping								
λ	9	degrees	% of flights upwind/downwind					50%	50%							
	see Blade profile sheet															
	Single transit risk		upwind	8.93%												
			downwind	4.68%												
			weighted mean	**6.81%**												
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
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
				0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	**0**
	No															
w	3	km														
		large array correction		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
				Collision rates allowing for avoidance												
	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**

	A	B
	Stage B	
	Projected number of rotor transits	4.95
	Stage C	
	Single Transit Risk - Weighted Mean	6.8%
	Stage D	
	Collision Rates before avoidance	0.29
	Stage F	
	Avoidance Rate	**Number of Fatalities per year**
	95.00%	0.01
	98.00%	0.01
	99.00%	0.00
	99.50%	0.00

Hen Harrier

Stage A					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Daytime bird density	D_A		birds/km^2		0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.0000
Proportion at rotor risk height	Q_{2R}	100.00%															
At latitude 53.3		Daylight hours per month			251.9	273.9	366.4	418.4	491.0	506.8	509.8	458.7	382.5	329.8	261.3	236.1	4486.8
		Nighttime hours per month			492.1	398.1	377.6	301.6	253.0	213.2	234.2	285.3	337.5	414.2	458.7	507.9	4273.2
Stage B																	
No of turbines	T	7															
Rotor radius	R	81	m														
		Total rotor frontal area m^2		144284													
Nocturnal activity factor	f_{night}	0%															
Bird flight speed	v	17.5	m s^{-1}		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
		Projected number of rotor transits			0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.2	0.2	0.1	0.1	3
Stage C																	
No of blades	b	3				Bird length	l	1.5	m								
Rotation speed	Ω	12.1	rpm			Wingspan	w	2.3	m								
Rotor radius	R	81	m			Bird flight speed	v	17.5	m s^{-1}								
Max blade width	C	4.3	m			Flight type		flapping									
Pitch	λ	9	degrees		% of flights upwind/downwind			50%	50%								
Blade profile		see Blade profile sheet															
		Single transit risk		upwind	9.95%												
				downwind	7.45%												
				weighted mean	**8.70%**												
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
					0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	**0**
Stage E																	
Allow for large array correction?		No															
Width of windfarm	w	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**

A	B
Stage B	
Projected number of rotor transits	2.52
Stage C	
Single Transit Risk - Weighted Mean	8.7%
Stage D	
Collision Rates before avoidance	0.19
Stage F	
Avoidance Rate	**Number of Fatalities per year**
95.00%	0.01
98.00%	0.00
99.00%	0.00
99.50%	0.00

Mute Swan

Stage A					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Daytime bird density	D_A		birds/km^2		0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.0000
Proportion at rotor risk height	Q_{2R}	96.25%															
At latitude 53.3		Daylight hours per month			251.9	273.9	366.4	418.4	491.0	506.8	509.8	458.7	382.5	329.8	261.3	236.1	4486.8
		Nighttime hours per month			492.1	398.1	377.6	301.6	253.0	213.2	234.2	285.3	337.5	414.2	458.7	507.9	4273.2
Stage B																	
No of turbines	T	7															
Rotor radius	R	81	m														
		Total rotor frontal area m^2		144284													
Nocturnal activity factor	f_{night}	0%															
Bird flight speed	v	12.5	m s^{-1}		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
		Projected number of rotor transits			0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.2	0.2	0.2	0.1	0.1	**2**
Stage C																	
No of blades	b	3				Bird length	l	0.37	m								
Rotation speed	Ω	12.1	rpm			Wingspan	w	1.1	m								
Rotor radius	R	81	m			Bird flight speed	v	12.5	m s^{-1}								
Max blade width	C	4.3	m			Flight type		flapping									
Pitch	λ	9	degrees		% of flights upwind/downwind			50%		50%							
Blade profile		see Blade profile sheet															
		Single transit risk		upwind	6.97%												
				downwind	3.55%												
				weighted mean	**5.26%**												
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
					0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	**0**
Stage E																	
Allow for large array correction?		No															
Width of windfarm	w	3	km														
			large array correction		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
					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**

Stage B	
Projected number of rotor transits	2.25

Stage C	
Single Transit Risk - Weighted Mean	5.3%

Stage D	
Collision Rates before avoidance	0.10

Stage F	
Avoidance Rate	**Number of Fatalities per year**
95.00%	0.01
98.00%	0.00
99.00%	0.00
99.50%	0.00

Black-headed Gull

Stage A					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Daytime bird density	D_A		birds/km^2		0.000033	0.000033	0.000033	0.000033	0.000033	0.000033	0.000033	0.000033	0.000033	0.000033	0.000033	0.000033	0.0000
Proportion at rotor risk height	Q_{2R}	85.00%															
At latitude 53.3		Daylight hours per month			251.9	273.9	366.4	418.4	491.0	506.8	509.8	458.7	382.5	329.8	261.3	236.1	4486.8
		Nighttime hours per month			492.1	398.1	377.6	301.6	253.0	213.2	234.2	285.3	337.5	414.2	458.7	507.9	4273.2
Stage B																	
No of turbines	T	7															
Rotor radius	R	81	m														
		Total rotor frontal area m^2		144284													
Nocturnal activity factor	f_{night}	0%															
Bird flight speed	v	19	m s^{-1}		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
		Projected number of rotor transits			0.4	0.5	0.6	0.7	0.8	0.9	0.9	0.8	0.7	0.6	0.4	0.4	**8**
Stage C																	
No of blades	b	3				Bird length	l	0.81	m								
Rotation speed	Ω	12.1	rpm			Wingspan	w	1.6	m								
Rotor radius	R	81	m			Bird flight speed	v	19	m s^{-1}								
Max blade width	C	4.3	m			Flight type		flapping									
Pitch	λ	9	degrees		% of flights	upwind/downwind		50%	50%								
Blade profile		see Blade profile sheet															
		Single transit risk		upwind	7.26%												
				downwind	4.95%												
				weighted mean	**6.11%**												
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%
																	year total
					Collision rates before avoidance												
					0.02	0.02	0.03	0.04	0.04	0.04	0.05	0.04	0.03	0.03	0.02	0.02	**0**
Stage E																	
Allow for large array correction?		No															
Width of windfarm	w	3	km														
			large array correction		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
					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**

A	B
Stage B	
Projected number of rotor transits	7.67
Stage C	
Single Transit Risk - Weighted Mean	6.1%
Stage D	
Collision Rates before avoidance	0.40
Stage F	
Avoidance Rate	**Number of Fatalities per year**
95.00%	0.02
98.00%	0.01
99.00%	0.00
99.50%	0.00

Greylag Goose

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