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Rooaunalaghta Green Energy Project

Appendix 7-2

Collision Risk Model Report

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Rooaunalaghta Green Energy Ltd.

Chapter 7 Ornithology

Appendix 7-2: Collision Risk Model Report

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1. OVERVIEW

APEM Group Woodrow was commissioned by Rooaunalaghta Green Energy Ltd, to undertake ornithological surveys of the proposed Rooaunalaghta Wind Farm, hereafter referred to as 'the Project Site'. The wind farm will comprise the installation of 13 wind turbines and associated infrastructure including internal access tracks, underground cabling, crane hardstanding's, turbine foundations, and a control building.

The purpose of this report is to present modelled collision risk estimates based on observed bird usage of the site, in order to provide an indication of the likely collision risk posed by the proposed wind farm to potentially sensitive avian populations. Bird usage data were derived from vantage point (VP) surveys undertaken by suitably experienced ornithological surveyors. The assessment follows the latest NatureScot collision risk guidance (NatureScot 2024), which promotes a standardised and transparent approach to collision risk modelling for onshore wind farms, with the aim of increasing confidence in the robustness and repeatability of results. A detailed technical description of the derivation and underlying assumptions of the model is provided in Band (2024).

Flightline data for selected target species were collected from seven VPs between October 2022 and August 2025. The survey covered three breeding bird seasons and three non-breeding seasons of VP watches. This amounted to 1,516.50 hours of VP watch data (756 hours during the non-breeding seasons and 760.50 hours during breeding seasons). Further information on VP locations and survey effort can be found in the Ornithological Baseline Report and supporting appendices (**Appendix 7-3: Baseline Ornithology Report**, **Appendix 7-6: Viewshed Analysis**, and **Appendix 7-7 Vantage Point Data for Target Species – Maps and Tables**). The target survey effort of 36 hours per VP per season was achieved in all but two instances, with VP6 and VP7 recording 33 and 35.5 hours, respectively, during the Year 1 breeding season. These minor shortfalls were limited to a single season and are not considered to materially affect the overall CRM dataset given the three-year survey programme and total VP effort completed.

One turbine model has been specified for use in the proposed development: the Vestas V136 4.5MW (Model 1). The collision risk zone (CRZ, defined as the height between the minimum and maximum swept height of the turbine rotor, within a 500 m buffer of turbines) is 14 - 150 m for the proposed Model, as detailed in Table 2.

Based on professional judgement, Collision Risk Modelling (CRM) was undertaken for target species that recorded a total aggregate flight time (i.e. number of individuals × flight duration) exceeding 1,000 seconds within the potential CRZ over the study period. For the purposes of this assessment, the potential CRZ was defined as flights occurring at collision risk height and within the turbine envelope (i.e. within a 500 m buffer of turbines). In addition, only species with more than three flight observations over the study period were included in the modelling.

The thresholds of >1,000 seconds of flight activity and >3 flight observations were applied as a screening tool to identify species exhibiting sufficient activity within the CRZ to warrant quantitative collision risk assessment. These thresholds are not prescribed within NatureScot guidance but were adopted as a proportionate, project-specific approach to avoid undertaking CRM for species with only occasional or incidental use of the survey area, where collision risk would be expected to be extremely low.

Target species with an aggregate flight time of less than 1,000 seconds within the potential CRZ were excluded from the CRM, as recorded activity levels were considered insufficient to materially influence

collision risk predictions. Based on the criteria outlined above, CRMs were run for the highlighted 13 target species (refer to Table 1).

Table 1. Target species total flight time within the 500 m turbine buffer over survey period

Species	No. Observations	Min No. individual	Max No. individual	Flight time (seconds) within 500m turbine buffer
Greater white-fronted goose	1	17	17	200
Black-headed gull	**291**	**1**	**150**	**19,408**
Buzzard	**189**	**1**	**4**	**16,494**
Canada goose	1	1	1	60
Common gull	**446**	**1**	**400**	**36,539**
Coot	5	1	23	350
Cormorant	17	1	2	994
Curlew	6	1	8	233
Dunlin	1	2	2	20
Golden plover	**29**	**1**	**95**	**1,945**
Great black-backed gull	**57**	**1**	**8**	**4,324**
Great egret	1	1	1	90
Grey heron	26	1	2	885
Greylag goose	**16**	**1**	**34**	**1,313**
Hen harrier	7	1	1	464
Herring gull	**47**	**1**	**20**	**2,226**
Kestrel	**149**	**1**	**1**	**11,057**
Lapwing	8	1	200	601
Lesser black-backed gull	**428**	**1**	**46**	**28,104**
Little egret	8	1	12	300
Mallard	**43**	**1**	**7**	**1,663**
Merlin	5	1	1	98
Moorhen	1	2	2	-
Mute swan	4	1	7	192
Peregrine	**33**	**1**	**2**	**4,158**
Snipe	**39**	**1**	**23**	**1,557**
Sparrowhawk	**45**	**1**	**2**	**1,561**
Swift	2	2	2	55
Teal	3	4	45	105
Tufted duck	1	2	2	10
Whooper swan	8	1	8	383
Wigeon	1	3	3	12
Woodcock	2	1	1	35

Further information on the species recorded within the study area along with the number of observations per species can be found in the Ornithological Baseline Report - Section 4.1 Vantage Point (VP) watches.

2. METHODOLOGY

Collision risk was assessed using the NatureScot Collision Risk Model (CRM) and associated guidance (Band 2000; Band et al. 2007; NatureScot 2024). The NatureScot CRM provides two alternative modelling approaches depending on the way in which birds use the site. One approach applies to species that make regular flight movements through the wind farm area, while the second applies to species that occupy an area, including the wind farm, as part of a regular territory or activity range. The latter, area-based approach was used in this assessment, as it is considered the most appropriate representation of how the species use the Project Site.

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

- **Stage A** uses bird flight activity data collected during VP surveys (**Appendix 7-7: Vantage Point Data for Target Species – Maps and Tables)** to estimate the density of flying birds within the core study area (defined as within 500 m of turbines) and the proportion of flights occurring at collision risk height, i.e. between the lowest and highest points of the rotor swept area.
- **Stage B** estimates the number of bird passages through the rotor swept area over the relevant period, based on the estimated flight activity density and the proportion of flights occurring at collision risk height.
- **Stage C** calculates the probability of collision for a single bird passage through the rotor swept area.
- **Stage D** estimates the potential collision rate for each species, taking into account levels of site usage and the proportion of time that turbines are not operational.
- **Stage E** applies avoidance rates to account for the proportion of birds that are likely to avoid the wind farm and/or individual turbines, either through large-scale displacement, fine-scale evasive behaviour, or attraction to the site (e.g. in response to habitat change).
- **Stage F** considers sources of uncertainty and provides an indication of the level of error associated with the predicted collision estimates.

2.1. Stage A- Flight activity

Stage A estimates the number of bird flights that may potentially be at risk of collision with turbines in the absence of displacement, avoidance behaviour, or attraction effects.

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

- Areal bird density (D_A); and
- Proportion of birds flying at risk height (Q_{2R})

Areal bird density (D_A) is defined as the number of birds in flight, at any height, at a given time per unit area (typically expressed per square kilometre (km²)). Bird occupancy recorded during VP surveys was converted to areal bird density (expressed per m²) by dividing the total bird flight activity by the area visible from each vantage point (the VP viewshed; **Appendix 7-6: Viewshed Analysis**). Flight activity from VP surveys was recorded in bird-seconds, which is particularly appropriate where numbers of flying birds are low.

D_A was calculated as shown in Equation 1:

$$D_A = b / (t \times A) \text{ birds } m^{-2} \quad \text{(Equation 1)}$$

where:
(b) is the number of target species flight seconds recorded from a VP;
(t) is the duration (in seconds) of all VP watches during either a month, season or year;
(A) is the area of the VP viewshed (km^2) as shown in **Appendix 7-6: Viewshed Analysis**.

D_A was calculated separately for each VP, with the resulting values subsequently combined to derive a mean density. Where there were substantial differences in the duration of VP watches and/or the area of VP viewsheds, the mean was calculated using a weighted approach. The weighting factor reflects the principle that the quantity of flight activity data collected during a VP watch is proportional to both the area observed and the duration of the watch.

The mean density D_A is calculated using Equation 2:

$$Mean\ density\ DA\ =\ \Sigma\ bi\ \sqrt{(ti\ x\ Ai)}\ /\ (ti\ x\ Ai)\ /\ \Sigma\ \sqrt{(ti\ x\ Ai)} \quad \text{(Equation 2)}$$

Where VP viewsheds differ markedly in mean D_A, for example as a result of differences in underlying habitat or patterns of site use, bird density should not be combined into a simple site-wide average. In such circumstances, densities may either be calculated and applied separately for each VP viewshed to estimate collision risk within the corresponding turbine group, or a turbine-weighted mean areal bird density may be used. Under the turbine-weighted approach, the D_A value derived for each VP is weighted according to the number of turbines located within that VP viewshed.

In this case, the average areal bird density ($D_{average}$) was estimated using Equation 3.

The formula for this is:

$$Daverage\ =\ \Sigma\ (Ni\ x\ Di)\ /\ \Sigma\ Ni \quad \text{(Equation 3)}$$

where:
D_i is the areal bird density within the VP viewshed (i);
N_i is the number of turbines to be sited in that VP viewshed; and
$D_{average}$ is the average areal bird density.

The definition of **proportion of birds flying at risk height (Q_{2R})** is the proportion of birds present between the lowest and highest points of a rotor, measured relative to the rotor base. In cases where flights are only recorded in the rotor swept height band, Q_{2R} will be 100%.

2.2. Daylight hours and nocturnal activity

Bird surveys are generally undertaken during daylight hours, and recorded levels of flight activity are assumed to be representative of activity throughout all daylight periods. The duration of daylight varies according to the latitude of the Project Site and the time of year. Within the NatureScot CRM spreadsheet, monthly daylight and night-time hours are automatically calculated once the Project Site latitude is

entered. Site latitude is specified in degrees (with decimal places), and this information is then used by the model to derive the number of daylight hours for each month. The latitude of the wind farm site in question is 53° 31' north (entered in decimals as 53.51°).

Collision risk calculations account for both diurnal and nocturnal flight activity. Diurnal activity is based on observed flight activity for each target species recorded during VP surveys at the Project Site. As nocturnal surveys were not undertaken, nocturnal flight activity was estimated using diurnal activity in combination with professional judgement regarding likely nocturnal behaviour for each species.

Nocturnal activity was approximated on a scale of one to five, where:

- 1 = 0% of diurnal activity,
- 2 = 25% of diurnal activity,
- 3 = 50% of diurnal activity,
- 4 = 75% of diurnal activity, and
- 5 = 100% of diurnal activity.

It should be noted that for species that are primarily nocturnal, this method may underestimate nocturnal flight activity, which could exceed 100% of diurnal activity.

2.3. Stage B- Estimating number of bird flights through rotors

The total **number of bird transit flights through turbine rotors** is proportional to the number of turbines, the cross-sectional area of the turbine rotors, and the density of birds flying at collision risk height, as calculated at Stage A. Transit flights were calculated separately for each month. Consequently, a key output of the collision risk assessment is an estimate of the potential number of bird transits per month, season, or year through the Project Site turbines, assuming no avoidance behaviour. Collision risk is considered to be directly proportional to this potential number of transits.

Stage B incorporates bird density (D_A), the proportion of flights at collision risk height (Q_{2R}), the nocturnal activity factor (f_{night}), and the monthly daylight and night-time hours calculated at Stage A. To estimate the number of birds passing through rotor swept areas, the model accounts for the number of turbines, the turbine rotor radius, and the typical flight speed of each target species. Flight speeds are derived from standard reference literature, acknowledging that actual speed—and therefore collision risk—may vary depending on bird behaviour (e.g. commuting, migration, foraging).

The expected number of bird transits through rotor swept areas was calculated using Equation 4.

$$Number\ of\ transits = v * (D_{average}\ Q_{2R} / 2R) * (T\ \pi R2) * (t_{day} + f_{night}\ t_{night}) \qquad (Equation\ 4)$$

where:
v is bird speed, relative to the ground (m sec^{-1});
$D_{average}$ is the average areal bird density (Birds m^{-2});
Q_{2r} is the proportion of birds flying at risk height (%);
R is the length of the rotor blades, from axis to tip (m);
T is the number of turbines;
f_{night} is the nocturnal activity factor; and

t_{day} and t_{night} the wind farm latitude is used to calculate daylight and night-time hours for each month, and the total for a year.

2.4. Stage C- Probability of collision for a single rotor transit

Stage C calculates the probability of collision for birds flying through an active turbine rotor, using information on turbine dimensions and rotational speed (Table 2), together with physical details on bird size and flight speed (Table 3). It is assumed that birds can avoid stationary infrastructure; therefore, the model estimates the probability of collision only for birds passing through a rotor swept area on a flight path, assuming no avoidance.

The collision probability is calculated for birds passing perpendicular to the rotor plane. Birds approaching at oblique angles are treated as having the same collision probability as perpendicular flights. The model does not account for additional effects from rotor wake turbulence or slipstream effects that might carry a bird clear of a blade.

Due to blade geometry relative to flight direction, upwind flights carry a higher collision risk than downwind flights, even if flight speed relative to the ground is equal. Where upwind and downwind flights are equally likely, the mean collision probability is calculated. In this assessment, a default proportion of 50:50 upwind:downwind flights were applied to weight the respective collision probabilities.

The NatureScot CRM spreadsheet provides a collision risk calculator for a single rotor passage. This calculates the probability of collision for a bird at each rotor radius (r) and angle (ϕ), using increments from r/R=0.05 out to r/R=1, and at 10-degree intervals for ϕ. The probabilities are then averaged over the entire rotor disc to derive the mean collision probability for a single passage.

Turbines operate over a range of wind speeds, typically not below a cut-in speed of 3–4 m/s, and up to a maximum operating wind speed of around 12 m/s. Where turbines operate at multiple rotational speeds, the model uses the mean operational speed, ideally derived from an analysis of wind speed data to determine the likely frequency distribution of turbine speeds. If this information is not available, the mean speed is based on the most likely value provided by the wind farm developer.

At Stage D, the model further accounts for periods when turbines are not operating, either due to low wind speeds or maintenance. The mean turbine speed used in Stage C calculations therefore considers only the time turbines are operational and excludes idle periods.

Table 2. Turbine data

Turbine Data	Unit	Turbine 1
Model name		V136
Hub height	m	82
Rotor Diameter	m	136
Number of blades		3
Rotation speed	rpm	5.6-14
Max blade width	m	4.1
Blade pitch	°	6
Average Rotation speed	rpm	9.8
Average rotational period	s	6.12
Turbine operation time	%	0.85
*Note: Pitch angle varies along the length of the blade, from a high angle close to the hub, to a low pitch angle towards the blade tips, i.e. the blade is twisted. Pitch angle also varies as the pitch is controlled to alter the rotation speed of the turbine. In the model, an average angle is used, representing an average pitch along the blade length. 6-15 degrees is reasonable for a typical large turbine.		

Table 3. Bird data and avoidance rates for target species

Target species *[1]	Bird length (m)	Wingspan (m)	Bird speed (m/s)	% of flight upwind/downwind	Nocturnal activity (From 1 to 5)	Avoidance rate [2]
Black-headed gull	0.4	1.05	11.9	50/50	4	0.992
Buzzard	0.54	1.205	11.6	50/50	2	0.980
Common gull	0.41	1.2	11.9	50/50	3	0.995
Golden plover *	0.275	0.715	17.9	50/50	5	0.980
Great black-backed gull	0.685	1.6	13.7	50/50	4	0.995
Greylag goose	0.825	1.635	19	50/50	3	0.998
Herring gull	0.62	1.475	12.8	50/50	4	0.995
Kestrel	0.34	0.76	10.1	50/50	2	0.950
Lesser black-backed gull	0.58	1.43	13.4	50/50	4	0.995
Mallard	0.58	0.895	18.5	50/50	4	0.980
Peregrine *	0.42	1.03	12.1	50/50	2	0.980
Snipe	0.26	0.455	17.1	50/50	5	0.980
Sparrowhawk	0.33	0.62	11.3	50/50	2	0.980

2.5. Stage D- Multiplying to yield expected collisions per year

2.5.1. Single transit risk

Stage D combines the estimated number of bird transits through turbine rotors across the wind farm (Stage B) with the probability of collision for a single rotor passage (Stage C) to derive an estimate of the total potential collision risk. This calculation was undertaken using Equation 5.

1 Annex I listed species

2 Source SNH 2018, 2024 and Furness 2019

*Single transit risk = (No. of bird transits through rotors * Weighted probability of collision single)/100* (Equation 5)

2.5.2. Non-operational time

The factor Q_{op} accounts for periods when turbines are not operational by representing the proportion of time during which turbines are operating. Wind turbines do not operate continuously and may be idle when wind speeds are below cut-in thresholds or shut down during periods of exceptionally high wind speeds to prevent damage. In addition, turbines are periodically shut down to allow for routine maintenance.

The single-transit collision risk is therefore multiplied by Q_{op} to reflect the proportion of time that turbines are operational. This adjustment is applied prior to the consideration of avoidance behaviour, which is addressed at **Stage E**.

2.6. Stage E- Applying the avoidance rate

2.6.1. Avoidance

The preceding stages of the collision risk model assume that birds do not undertake any avoidance behaviour in response to wind turbines. In practice, however, many bird species exhibit high levels of avoidance, both at the scale of the wind farm and at the level of individual turbines. Evidence from post-construction collision monitoring, including systematic carcass searches and observations of bird behaviour and habitat use in the vicinity of operational wind farms, indicates avoidance rates of 98% or higher for many species. This suggests that actual collision risk is likely to be less than 2% of that predicted by Stages A–D alone.

In accordance with NatureScot guidance (NatureScot 2024), potential collision mortality was therefore calculated for each month and for the annual period using a range of assumed avoidance rates of 95%, 98%, 99% and 99.5%.

2.6.2. Large turbine array correction factor

The large turbine array correction factor is applicable only to large wind farm developments comprising more than 50 turbines. As the proposed development does not meet this threshold, the correction factor is not applicable in this case, and no further consideration is required.

2.7. Stage F- Expressing uncertainty

In estimating collision risk using the methodology described above, there are a number of sources of variability and uncertainty that influence the model outputs. Band (2024) provides a detailed description of the principal sources of uncertainty within the collision risk model, together with guidance on how these should be evaluated and presented.

The purpose of this stage is to reflect the range of uncertainty associated with the collision estimates and the potential implications for target species populations and/or population growth rates. Information considered at this stage includes:

- Uncertainty and variability in flight activity data, including imprecision in flight height estimation and limited information on nocturnal behaviour;
- Uncertainty associated with model assumptions and simplifications, such as variability in bird dimensions and flight speeds, and the simplified representation of bird and turbine blade geometry; and
- Uncertainty arising from turbine parameters, including the number, size, and rotational speed of turbines.

3. RESULTS

3.1. Viewshed spatial coverage

The vantage point (VP) locations remained consistent across all survey periods. A viewshed analysis was undertaken to determine the spatial coverage from each VP using ArcGIS Pro, and the accuracy of the modelled viewsheds was verified in the field by surveyors. The viewshed analysis applied a surface offset of 14 m, corresponding to the lowest rotor swept height of the proposed turbine model, and assumed an observer height of 1.75 m. This approach mapped the airspace visible to surveyors at collision risk height.

Spatial coverage of the VP viewsheds within the 2 km survey arc, and their coverage as a proportion of the 500 m turbine buffer, is presented in Table 4. The locations of the VPs and their associated viewsheds are shown in **Appendix 7-6: Viewshed Analysis**.

Table 4. Viewshed coverage of 500 m buffer of turbines and VP survey effort

Survey period	Vantage Point (VP)	Area of CRZ visible within 500 m turbine buffer (Km^2)	VP effort (hrs)		
			Non-breeding season	Breeding season	Total
YEAR 1	VP1	1.77	36.00	36	72.00
	VP2	1.69	36.00	36	72.00
	VP3	2.58	36.00	36	72.00
	VP4	2.12	36.00	36	72.00
	VP5	0.93	36.00	36	72.00
	VP6	2.37	36.00	33	69.00
	VP7	3.33	36.00	35.5	71.50
YEAR 2	VP1	1.77	36.00	36.5	72.50
	VP2	1.69	36.00	36.5	72.50
	VP3	2.58	36.00	36	72.00
	VP4	2.12	36.00	36.5	72.50
	VP5	0.93	36.00	36	72.00
	VP6	2.37	36.00	39.5	75.50
	VP7	3.33	36.00	39	75.00
YEAR 3	VP1	1.77	36.00	36.00	72.00
	VP2	1.69	36.00	36.00	72.00
	VP3	2.58	36.00	36.00	72.00
	VP4	2.12	36.00	36.00	72.00
	VP5	0.93	36.00	36.00	72.00
	VP6	2.37	36.00	36.00	72.00
	VP7	3.33	36.00	36.00	72.00

3.2. Stage A: Flight activity

3.2.1. Bird density

Vantage point (VP) watches were undertaken over a three-year period, covering three breeding seasons and three non-breeding seasons. Surveys covered the entire Project Site and a 500 m buffer around the proposed turbine locations, providing 99.16% spatial coverage. The Project Site was surveyed from seven VP locations which collectively provided 99.16% coverage of the study area. VP coverage and survey effort are summarised in Table 4, while viewshed analysis is provided in **Appendix 7-6: Viewshed Analysis**.

Each VP was surveyed for a target of 72 hours per survey year, comprising of 36 hours during the breeding season (April–September) and 36 hours during the non-breeding season (October–March), over each of the three survey years, in accordance with NatureScot guidance (SNH 2017, 2018). Watches were divided into sessions each lasting no more than three hours, with breaks between sessions to minimise observer fatigue, and were distributed to provide a representative sample of daylight hours. All flights of target species were recorded during each watch period, yielding total flight activity expressed in bird-seconds. Flight activity was divided by the duration of the watch (in seconds) and the area observed to derive the mean density of birds in flight per square kilometre.

Survey results are summarised in Table 5. Details of the number of VP watches are provided in **Appendix 7-5: Survey Effort and Weather Conditions**, while VP survey data, including flightline tables and maps, are presented in **Appendix 7-7: Vantage Point Data for Target Species**. Flight times recorded within the study area (defined as the 500 m turbine buffer) over the analysis period are provided in Table 5 for the nine target species included in the collision risk model.

In Ireland, golden plover occurs primarily as a winter visitor and may also be present during the passage period (including April); this seasonal pattern was accounted for in the collision risk modelling for this species. Although localised breeding populations of golden plover occur in Ireland, no breeding individuals were recorded within the Project Site during baseline surveys.

Mean D_A values are presented in Table 5 for each target species and were calculated separately for the breeding and non-breeding periods. For golden plover, D_A was derived using flight activity recorded during the non-breeding season and April only.

Table 5. Flight seconds and mean bird density for all target species during the study period

Target species *[3]	Analysis period	Non-breeding: Mean density (birds/km²)	Standard deviation (SD)	Breeding: Mean density (birds/km²)	Standard deviation (SD)
Black-headed gull	Year-round	0.00353	0.00382	0.00075	0.00075
Buzzard	Year-round	0.00241	0.00411	0.00210	0.00213
Common gull	Year-round	0.00886	0.01130	0.00056	0.00084
Golden plover *	Non-breeding (+ April)	0.00061	0.00118		
Great black-backed gull	Non-breeding	0.00100	0.00134		
Greylag goose	Non-breeding	0.00036	0.00051		
Herring gull	Year-round	0.00035	0.00036	0.00013	0.00024
Kestrel	Year-round	0.00211	0.00365	0.00145	0.00253
Lesser black-backed gull	Year-round	0.00274	0.00388	0.00209	0.00209
Mallard	Year-round	0.00017	0.00026	0.00027	0.00027
Peregrine *	Year-round	0.00014	0.00023	0.00240	0.00240
Snipe	Non-breeding	0.00028	0.00040		
Sparrowhawk	Year-round	0.00021	0.00026	0.00022	0.00022

3.2.2. Proportion flying at risk height

The assessment considers a single turbine model, the Vesta V136 4.5 MW turbine, which has rotor swept height of 14–150 m (see Table 2). Bird flight heights were recorded during VP surveys and estimated visually. The proportion of observed flight activity occurring within the rotor swept area, and therefore within the CRZ, was calculated for this turbine specification (%Q2R; see Table 6).

Table 6. Proportion of observed birds flying at rotor risk height at rotor risk height (%Q2R) during all VP watches.

Target species *[4]	Number of birds observed	%Q2R for Model V136
Black-headed gull	334	0.79
Buzzard	223	0.65
Common gull	509	0.82
Golden plover *	40	0.88
Great black-backed gull	81	0.84
Greylag goose	20	1.00
Herring gull	54	0.80
Kestrel	186	0.47
Lesser black-backed gull	498	0.87
Mallard	47	0.66
Peregrine *	36	0.83
Snipe	43	0.67
Sparrowhawk	50	0.34

[3] Annex I listed species
[4] Annex I listed species

3.3. Stage B: Estimating number of flights through rotors

The output from **Stage B** is an estimate of the potential number of bird transits through turbine rotors, presented on a monthly and annual basis (refer to Table 7). The total number of predicted transits is proportional to the number of turbines, the cross-sectional area of the rotor swept area, and the density of birds flying within the CRZ, as defined by flights occurring at collision risk height.

Table 7. Potential number of bird transits through rotors per month and year

Target species *[5]	Number of transits per month												
	1	2	3	4	5	6	7	8	9	10	11	12	YEAR
Black-headed gull	3.18	3.26	4.14	4.55	5.19	5.29	5.35	4.92	4.24	3.84	3.23	3.05	50
Buzzard	1.48	1.58	2.07	2.34	2.72	2.79	2.81	2.55	2.15	1.89	1.53	1.40	25
Common gull	7.61	7.94	10.24	11.38	13.10	13.41	13.54	12.36	10.55	9.40	7.77	7.24	125
Golden plover *	0.99	1.00	1.25	1.36						1.17	1.00	0.95	8
Great black-backed gull	1.10	1.13	1.43							1.32	1.11	1.05	7
Greylag goose	0.60	0.63	0.81							0.74	0.61	0.57	4
Herring gull	0.34	0.35	0.44	0.49	0.55	0.56	0.57	0.53	0.45	0.41	0.34	0.33	5
Kestrel	0.82	0.87	1.14	1.29	1.50	1.54	1.55	1.41	1.19	1.04	0.84	0.77	14
Lesser black-backed gull	3.06	3.14	3.99	4.38	5.00	5.09	5.15	4.73	4.09	3.69	3.11	2.94	48
Mallard	0.20	0.21	0.26	0.29	0.33	0.34	0.34	0.31	0.27	0.24	0.21	0.19	3
Peregrine *	0.12	0.13	0.16	0.18	0.22	0.22	0.22	0.20	0.17	0.15	0.12	0.11	2
Snipe	0.33	0.34	0.42							0.39	0.34	0.32	2
Sparrowhawk	0.07	0.07	0.09	0.10	0.12	0.12	0.12	0.11	0.10	0.08	0.07	0.06	1

3.4. Stage C: Probability of collision for single rotor transit

Data relating to the probability of collision for a bird passing through the rotor swept area were derived from the NatureScot CRM spreadsheet. The resulting collision probabilities for each target species are presented in Table 8.

Table 8. Probability of collision for a single rotor transit for target species

Target species *[6]	Turbine Model
Black-headed gull	3.53%
Buzzard	4.17%
Common gull	3.58%
Golden plover *	2.62%
Great black-backed gull	4.32%
Greylag goose	4.05%
Herring gull	4.26%
Kestrel	3.55%
Lesser black-backed gull	4.01%
Mallard	3.39%
Peregrine *	3.57%
Snipe	2.58%
Sparrowhawk	3.29%

[5] Annex I listed species
[6] Annex I listed species

3.5. Stage D: Multiplying to yield expected collisions per year

Following the application of the preceding stages, the estimated annual number of bird transits through turbine rotors was combined with the probability of collision for a single rotor passage to derive predicted collision rates on a monthly and annual basis, assuming no avoidance behaviour. Avoidance rates were then applied to estimate likely collision and associated mortality rates. This stage also incorporates the proportion of time that turbines are expected to be operational (refer to Table 9).

Predicted collision rates prior to the application of avoidance rates are presented in Table 10.

Table 9. Monthly and year operational time for each turbine model

Turbine operation time[7]	%
January	85%
February	85%
March	85%
April	85%
May	85%
June	85%
July	85%
August	85%
September	85%
October	85%
November	85%
December	85%
Overall	85%

[7] Average historic turbine availability across approximately 20 wind farms across Ireland over a 6-year period. This includes all downtime due to turbine faults, turbine maintenance, grid outages, customer stop/inspections, substation maintenance and shadow flicker.

Table 10. Collision rate before avoidance for target species

Target species *[8]	Collision rate before avoidance												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Black-headed gull	0.0010	0.0010	0.0012	0.0014	0.0016	0.0016	0.0016	0.0015	0.0013	0.0012	0.0010	0.0009	0.0151
Buzzard	0.0005	0.0006	0.0007	0.0008	0.0010	0.0010	0.0010	0.0009	0.0008	0.0007	0.0005	0.0005	0.0090
Common gull	0.0023	0.0024	0.0031	0.0035	0.0040	0.0041	0.0041	0.0038	0.0032	0.0029	0.0024	0.0022	0.0379
Golden plover *	0.0002	0.0002	0.0003	0.0003						0.0003	0.0002	0.0002	0.0017
Great black-backed gull	0.0004	0.0004	0.0005							0.0005	0.0004	0.0004	0.0026
Greylag goose	0.0002	0.0002	0.0003							0.0003	0.0002	0.0002	0.0014
Herring gull	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0001	0.0001	0.0001	0.0019
Kestrel	0.0002	0.0003	0.0003	0.0004	0.0005	0.0005	0.0005	0.0004	0.0004	0.0003	0.0003	0.0002	0.0042
Lesser black-backed gull	0.0010	0.0011	0.0014	0.0015	0.0017	0.0017	0.0018	0.0016	0.0014	0.0013	0.0011	0.0010	0.0165
Mallard	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0009
Peregrine *	0.00004	0.00004	0.00005	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00005	0.00004	0.00003	0.0006
Snipe	0.0001	0.0001	0.0001							0.0001	0.0001	0.0001	0.0005
Sparrowhawk	0.00002	0.00002	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00002	0.00002	0.0000	0.0003

[8] Annex I listed species

3.6. Stage E: Applying the avoidance rate

NatureScot (2018) provides guidance on the application of avoidance rates in collision risk assessments. Collision risk estimates were calculated using avoidance rates of 95%, 98%, 99% and 99.5% for each season (breeding and non-breeding) and for the annual period. The avoidance rates recommended by NatureScot CRM (2018) and Furness (2019) were then applied to derive predicted collision numbers over a decadal period and across the operational lifetime of the Project Site (35 years; see Table 11).

For golden plover, collision estimates for the non-breeding season incorporate all winter months as well as April, reflecting its status in Ireland as a wintering and passage species.

Table 11 presents the predicted collision rates for each target species passing through the rotor swept area, accounting for different assumed avoidance rates for the breeding season, non-breeding season, and annual period.

For the proposed turbine model, the collision risk modelling predicted very low levels of theoretical collision risk (i.e. fewer than one collision per decade when applying the NatureScot-recommended avoidance rates) over the operational lifespan of the proposed development. Predicted collision rates at this level are considered negligible and are not expected to result in population-level effects, as collision-related mortality would not contribute materially (i.e. >1%) to background mortality rates for any of the target species.

Table 11. Collision rate estimated by the non-breeding (NB) and the breeding seasons (B) and year-round, applying different avoidance rates.

Target species *[9]	Collision rate after 95% avoidance			Collision rate after 0.98 avoidance			Collision rate after 0.99 avoidance			Collision rate after 0.995 avoidance			Collisions per decade	Collisions per lifespan of windfarm
	NB	B	Year	NB	B	Year	NB	B	Year	NB	B	Year		
Black-headed gull	0.00031	0.00044	0.00075	0.00012	0.00018	0.00030	0.00006	0.00009	0.00015	0.00003	0.00004	0.00008	0.00121	0.00422
Buzzard	0.00018	0.00027	0.00045	0.00007	0.00011	0.00018	0.00004	0.00005	0.00009	0.00002	0.00003	0.00004	0.00179	0.00628
Common gull	0.00076	0.00113	0.00189	0.00031	0.00045	0.00076	0.00015	0.00023	0.00038	0.00008	0.00011	0.00019	0.00189	0.00663
Golden plover *	0.00007	0.00002	0.00009	0.00003	0.00001	0.00003	0.00001	0.00000	0.00002	0.00001	0.00000	0.00001	0.00034	0.00120
Great black-backed gull	0.00013	0.00000	0.00013	0.00005	0.00000	0.00005	0.00003	0.00000	0.00003	0.00001	0.00000	0.00001	0.00013	0.00046
Greylag goose	0.00007	0.00000	0.00007	0.00003	0.00000	0.00003	0.00001	0.00000	0.00001	0.00001	0.00000	0.00001	0.00003	0.00010
Herring gull	0.00004	0.00006	0.00010	0.00002	0.00002	0.00004	0.00001	0.00001	0.00002	0.00000	0.00001	0.00001	0.00010	0.00034
Kestrel	0.00008	0.00013	0.00021	0.00003	0.00005	0.00008	0.00002	0.00003	0.00004	0.00001	0.00001	0.00002	0.00211	0.00737
Lesser black-backed gull	0.00034	0.00048	0.00082	0.00014	0.00019	0.00033	0.00007	0.00010	0.00016	0.00003	0.00005	0.00008	0.00082	0.00288
Mallard	0.00002	0.00003	0.00005	0.00001	0.00001	0.00002	0.00000	0.00001	0.00001	0.00000	0.00000	0.00000	0.00018	0.00065
Peregrine *	0.00001	0.00002	0.00003	0.00000	0.00001	0.00001	0.00000	0.00000	0.00001	0.00000	0.00000	0.00000	0.00012	0.00043
Snipe	0.00002	0.00000	0.00002	0.00001	0.00000	0.00001	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00009	0.00033
Sparrowhawk	0.00001	0.00001	0.00002	0.00000	0.00000	0.00001	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00006	0.00022

[9] Annex I listed species

3.7. Stage F: Expressing uncertainty

As outlined in NatureScot guidance (2024), uncertainty associated with predicted collision estimates should be quantified where possible when interpreting collision risk modelling results. As described in the methodology, three principal sources of uncertainty are recognised within the CRM process: uncertainty associated with survey data; uncertainty arising from inherent simplifications within the CRM; and uncertainty related to turbine specifications.

Uncertainty may arise during data collection, for example through imprecision in mapping flight locations or categorising flight heights. This source of uncertainty has been minimised through the use of appropriately experienced ornithological surveyors, consistency in survey personnel throughout the survey programme, and data collection over multiple years to increase robustness. Although nocturnal surveys were not undertaken, significant nocturnal activity was only predicted for snipe, which has been explicitly accounted for in the modelling. On this basis, uncertainty associated with survey data is estimated at ±20%.

The NatureScot CRM necessarily incorporates a number of simplifications, including the use of uniform bird dimensions and flight speeds, and simplified representations of turbine blade geometry. While these assumptions do not reflect the full natural variability within and between species, variation in flight behaviour (e.g. commuting, foraging, display), or differing weather conditions, they are required to ensure the model remains transparent and practicable. Uncertainty arising from these model simplifications is also estimated at ±20%.

Turbine specifications used in the CRM were provided by the client and are based on the anticipated turbine models for the proposed development. While some uncertainty exists due to potential turbine micro-siting, any such variation is expected to be minimal and unlikely to materially affect recorded flight activity within the Project Site. Uncertainty arising from turbine specification and layout is also estimated at ±20%.

Overall uncertainty was quantified by combining the three principal sources of uncertainty (survey data, model simplification and turbine models) using the following approach:

$$\sqrt{(〖0.2〗^2+〖0.2〗^2+〖0.2〗^2)}$$

This results in an overall estimated uncertainty of approximately ± 0.35

Although this level of uncertainty appears relatively high, the assessment follows NatureScot CRM guidance (2024) and survey methods consistent with standard practice for onshore wind farm assessments (SNH 2017). Consequently, this level of uncertainty is not considered to undermine the robustness of the modelling approach or the validity of the collision risk estimates presented.

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