Corr Chnoc Wind Farm

Collison Risk Modelling

Technical Appendix 8.4

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Basis of Report

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1.0 Input Data

Delaunay Triangulation[1] from the proposed turbine locations within the two proposed layouts[2] was used to create two wind farm areas[3] and from this two Collision Risk Analysis Areas (CRAAs) were created using a 500 metre (m) buffer (**New Figure AI 8.2**). Using the 500 m area around the turbines accounts for possible inaccuracies in the recording of flightlines and ensures the assessment is precautionary.

As recommended in NatureScot guidance (NS 2025a[i]), the aim of baseline flight activity surveys should be to achieve maximum visual coverage of proposed turbines and associated CRAA from Vantage Point (VP) viewsheds using the minimum number of VPs. However, in practice complete (100%) coverage is often unachievable as a result of the topography of the site, presence of mature forestry and access permissions outwith site boundaries.

However, in this case for the Proposed Development, the visibility of the CRAA at 20 m above ground level was good (**New Figure AI 8.2**). Therefore, the survey data collected over the course of flight activity surveys and subsequently assessed for potential collision mortality risks, is considered to be representative of the whole CRAA and therefore appropriate for the purposes of estimating collision mortality risks using the NatureScot Collision Risk Model (CRM) (Band et al. 2007[ii], Band 2024[iii]).

In the use of the NatureScot CRM, flying time at risk height (secsHahr^{-1}) for each species is calculated as a single mean activity rate within the entirety of the CRAA.

Table 5-3-1, **Table 5-3-2** and **Table 5-3-3** present the parameters which apply to each Collision Risk Model (CRM).

Table 5-3-1: Wind farm parameters

Size of wind farm envelope	671.45	751.27	hectares (ha)
Number of turbines	11	12	turbines
Rotor diameter	162		metres (m)
Hub height	119		m
Max. rotor depth	1.67		m (at 15° pitch angle)
Max. chord	4.20		m
Pitch	15		degrees (°)
Rotation period	7.89		seconds (secs)
Turbine operation time	0.85		percent (%)
Risk height: highest	38		m
Risk height: lowest	200		m
Flight risk volume	1087745400.522	1217056757.919	m^3
Latitude	56.384826		geographic coordinate (decimal)

Table 5-3-2: CRM parameters per species

Species	Length (m)	Wingspan (m)	Assumed flight speed, v (ms^{-1})	Avoidance rate	Probability of collision	Bird transit time (secs)
Black grouse	0.55	0.8	20	0.98	0.042829	0.1111
Golden eagle	0.815	2.12	15	0.99	0.057826	0.1658
Great black-backed gull	0.78	1.65	13.7	0.98	0.05618	0.178978
Hen harrier	0.48	1.1	12	0.99	0.049171	0.179333
Herring gull	0.64	1.5	12.8	0.98	0.053688	0.180625
Snipe	0.27	0.47	17.1	0.98	0.037721	0.113567
White-tailed eagle	0.9	2.4	13.6	0.95 0.975 0.98 0.99	0.062861	0.189118
Whooper swan	1.525	2.305	17.3	0.995	0.068383	0.184798

Table 5-3-3: Visible area within the CRAAs per vantage point[4]

VP	Area (ha)	
	11 turbines	12 turbines
8	149.42	175.75
9	293.92	294.25
10	338.13	356.96
11	261.63	279.06

Birds are assumed to be active during all the daylight hours and this is estimated by calculating the number of hours per day between sunrise and sunset (adjusting for correct latitude) for the survey seasons as defined in **Table 5-3-4** below.

Table 5-3-4: Season definitions per species/species group

Species	Breeding season			Non-breeding season		
	Start date	End date	Hours presumed present	Start date	End date	Hours presumed present
Black grouse	15th May	31st August	2,669	1st September	14th May	1,831

[1] Delaunay triangulation is a form of mathematical/computational geometry where a given set of points (in this case the turbine locations) are all joined to create discrete triangles. Further information is available here: https://uk.mathworks.com/help/matlab/math/delaunay-triangulation.html

[2] An 11-turbine layout (without WTG T18) is now proposed for the AI submission, and the 12-turbine layout is included for comparison with the EIA.

[3] This was adjusted where appropriate depending on the spatial location of the turbines in relation to other turbines.

[4] Numbering of VPs follows sequentially from those used in the 2022-2024 baseline EIA surveys.

Species	Breeding season			Non-breeding season		
	Start date	End date	Hours presumed present	Start date	End date	Hours presumed present
Geese and swans	15th May	31st August	1,812	1st September	14th May	2,688
Golden eagle	1st February	31st August	2,792	1st September	31st January	1,708
Gulls	15th March	31st August	2,669	1st September	14th March	1,831
Raptors (other than eagles)	15th March	31st August	2,669	1st September	14th March	1,831
Waders	1st April	31st July	1,989	1st August	31st March	2,511
White-tailed eagle	1st February	31st August	2,792	1st September	31st January	1,708

2.0 Output Summary

Only flightlines identified to be within the CRAA and recorded within the 2 km viewshed of the associated VP were considered to be 'at-risk' for the purposes of the collision risk modelling.

- 'At-risk' is defined as – a flight having at least part of its duration (i) at Potential Collision Height (PCH)[5]; (ii) within the CRAA; and (iii) recorded within the 2 km viewshed of the associated VP.
- PCH is defined as – the altitude between the minimum and maximum blade height[6] (taken to be from 38 m to 200 m for the Proposed Development).

Golden plover, lapwing, merlin, osprey, pink-footed goose, and red-throated diver were recorded during flight activity surveys, but no flights of these species were considered to be 'at-risk'[7]. Full survey results detailing the findings from each survey visit (including target species' flightlines considered not 'at-risk' and secondary species information) can be found within **AI Technical Appendix 8.1**. Only bird seconds for observations identified as 'at-risk' were then input into a Collision Risk Model (CRM) to calculate the predicted collision rates per season. **Table 5-3-5** and **Table 5-3-6**: Estimated collision rates (12 turbines)

Species	Avoidance rate	2025/2026 non-breeding season	2026 breeding season	Annual	Years per collision
Black grouse	0.98	0.0009	0	0.0009	1134.53
Golden eagle	0.99	0.0574	0.0297	0.0871	11.48
Great black-backed gull	0.98	0	0.0152	0.0152	65.8
Hen harrier	0.99	0.0002	0.0032	0.0034	300.32
Herring gull	0.98	0	0.0120	0.0120	83.27
Snipe	0.98	0	0.0003	0.0003	3187.49
White-tailed eagle	0.95	0.0523	0.2519	0.3042	3.29
	0.975	0.0262	0.1259	0.1521	6.57
	0.98	0.0209	0.1008	0.1217	8.22
	0.99	0.0105	0.0504	0.0609	16.43
Whooper swan	0.995	0.0433	0.0000	0.0433	23.07

provide the estimated collision rates and number of seasons per collision for each species for both the 11-turbine and 12-turbine layouts (i.e. the 11-turbine layout is without WTG T18. The 12-turbine layout is included for comparison with the EIA).

Table 5-3-5: Estimated collision rates (11 turbines)

Species	Avoidance rate	2025/2026 non-breeding season	2026 breeding season	Annual	Years per collision
Black grouse	0.98	0.0009	0	0.0009	1165.73
Golden eagle	0.99	0.0557	0.0289	0.0846	11.82
Great black-backed gull	0.98	0	0.0147	0.0147	67.87
Hen harrier	0.99	0.0002	0.0031	0.0033	309.73
Herring gull	0.98	0	0.0116	0.0116	85.89
Snipe	0.98	0.0009	0	0.0009	3267.07
White-tailed eagle	0.95	0.0508	0.2448	0.2956	3.38
	0.975	0.0254	0.1224	0.1478	6.77
	0.98	0.0203	0.0979	0.1182	8.46
	0.99	0.0102	0.0490	0.0592	16.91
Whooper swan	0.995	0.0422	0	0.0422	23.7

Table 5-3-6: Estimated collision rates (12 turbines)

Species	Avoidance rate	2025/2026 non-breeding season	2026 breeding season	Annual	Years per collision
Black grouse	0.98	0.0009	0	0.0009	1134.53
Golden eagle	0.99	0.0574	0.0297	0.0871	11.48
Great black-backed gull	0.98	0	0.0152	0.0152	65.8
Hen harrier	0.99	0.0002	0.0032	0.0034	300.32

[5] In some cases, only part of a total flight duration was recorded at PCH, and it is assumed that this proportion is applicable for that part of the flight within the CRAA and 2 km viewshed area.

[6] Where the actual rotor blade altitude differs from the pre-defined survey height bands, the collision risk model accounts for this difference on the assumption of an even flight distribution within each particular survey height band, and an adjustment can be made to estimate total flight duration at actual rotor blade altitude.

[7] i.e. the flights were either not within the CRAA and associated viewshed or were only recorded flying above 200 m.

Species	Avoidance rate	2025/2026 non-breeding season	2026 breeding season	Annual	Years per collision
Herring gull	0.98	0	0.0120	0.0120	83.27
Snipe	0.98	0	0.0003	0.0003	3187.49
White-tailed eagle	0.95	0.0523	0.2519	0.3042	3.29
	0.975	0.0262	0.1259	0.1521	6.57
	0.98	0.0209	0.1008	0.1217	8.22
	0.99	0.0105	0.0504	0.0609	16.43
Whooper swan	0.995	0.0433	0.0000	0.0433	23.07

Detailed outputs for the CRM for the following species scoped into the assessment are presented in the following section below: golden eagle and white-tailed eagle. Red-throated diver is not included as no collision risk was found during surveys.

3.0 Detailed Species Outputs

3.1 Golden Eagle (11 turbines)

3.1.1 Non-Breeding Season 2025/2026

Table 5-3-9: Golden eagle flight activity

VP	Seconds at risk height	Observation effort (HaHr)	Flying time at risk height (secsHahr^{-1})
8	197.92	4482.48	2.345E-06
9	8.86	8817.62	1.0497E-07
10	534.01	10143.93	6.3273E-06
11	0	0	0

Table 5-3-10: Golden eagle mortality estimates

Mean activity in wind farm at rotor height	0.0059	hr^{-1}
Total Combined rotor swept volume	563882.1940	m^3
Bird occupancy	10.0636	hrs/season
Bird occupancy of rotor swept volume	18.7808	bird-sec
No. of transits through rotors	113.2741	per season
Estimated collisions	6.5502	per season
Estimated collisions after correction for operation	5.5677	per season
Estimated collisions after avoidance factor	0.0557	per season

3.1.2 Breeding Season 2026

Table 5-3-11: Golden eagle flight activity

VP	Seconds at risk height	Observation effort (HaHr)	Flying time at risk height (secsHahr^{-1})
8	0	6275.47	0
9	342.72	12344.67	2.173E-06
10	0	14201.50	0
11	96.77	10988.36	6.1359E-07

Table 5-3-12: Golden eagle mortality estimates

Mean activity in wind farm at rotor height	0.0019	hr^{-1}
Total Combined rotor swept volume	563882.1940	m^3
Bird occupancy	5.2242	hrs/season
Bird occupancy of rotor swept volume	9.7496	bird-sec
No. of transits through rotors	58.8033	per season
Estimated collisions	3.4004	per season
Estimated collisions after correction for operation	2.8903	per season
Estimated collisions after avoidance factor	0.0289	per season

3.2 Golden Eagle (12 turbines)

3.2.1 Non-Breeding Season 2025/2026

Table 5-3-13: Golden eagle flight activity

VP	Seconds at risk height	Observation effort (HaHr)	Flying time at risk height (secsHahr^{-1})
8	197.92	5272.60	2.216E-06
9	8.86	8827.63	9.9199E-08
10	534.01	10708.72	5.9792E-06
11	0	0	0

Table X-3-14: Golden eagle mortality estimates

Mean activity in wind farm at rotor height	0.0062	hr^{-1}
Total Combined rotor swept volume	615144.2117	m^3
Bird occupancy	10.6404	hrs/season
Bird occupancy of rotor swept volume	19.3610	bird-sec
No. of transits through rotors	116.7732	per season
Estimated collisions	6.7526	per season
Estimated collisions after correction for operation	5.7397	per season
Estimated collisions after avoidance factor	0.0574	per season

3.2.2 Breeding Season 2026

Table 5-3-15: Golden eagle flight activity

VP	Seconds at risk height	Observation effort (HaHr)	Flying time at risk height (secsHahr^{-1})
8	0	7381.64	0
9	342.72	12358.68	2.0494E-06
10	0	14992.21	0
11	96.77	11720.51	5.7868E-07

Table 5-3-6: Golden eagle mortality estimates

Mean activity in wind farm at rotor height	0.0020	hr^{-1}
Total Combined rotor swept volume	615144.2117	m^3
Bird occupancy	5.5127	hrs/season
Bird occupancy of rotor swept volume	10.0308	bird-sec

No. of transits through rotors	60.4991	per season
Estimated collisions	3.4984	per season
Estimated collisions after correction for operation	2.9737	per season
Estimated collisions after avoidance factor	0.0297	per season

3.3 White-Tailed Eagle (11 turbines)

3.3.1 Non-Breeding Season 2025/2026

Table 5-3-17: White-tailed eagle flight activity

VP	Seconds at risk height	Observation effort (HaHr)	Flying time at risk height (secsHahr^{-1})
8	8	122.13	1.447E-06
9	9	0	0
10	10	14.95	1.7716E-07
11	11	0	0

Table 5-3-18: White-tailed eagle mortality estimates

Mean activity in wind farm at rotor height	0.0011	hr^{-1}
Total Combined rotor swept volume	583154.4041	m^3
Bird occupancy	1.8622	hrs/season
Bird occupancy of rotor swept volume	3.5941	bird-sec
No. of transits through rotors	19.0048	per season
Estimated collisions	1.1946	per season
Estimated collisions after correction for operation	1.0155	per season
Estimated collisions after avoidance factor (0.95)	0.0508	per season
Estimated collisions after avoidance factor (0.975)	0.0254	per season
Estimated collisions after avoidance factor (0.98)	0.0203	per season
Estimated collisions after avoidance factor (0.99)	0.0102	per season

3.3.2 Breeding Season 2026

Table 5-3-19: White-tailed eagle flight activity

VP	Seconds at risk height	Observation effort (HaHr)	Flying time at risk height (secsHahr^{-1})
8	244.62	6275.47	1.551E-06
9	0	12344.67	0
10	317.99	14201.50	2.0162E-06
11	192.86	10988.36	1.2228E-06

Table 5-3-20: White-tailed eagle mortality estimates

Mean activity in wind farm at rotor height	0.0032	hr^{-1}
Total Combined rotor swept volume	583154.4041	m^3
Bird occupancy	8.98	hrs/season
Bird occupancy of rotor swept volume	17.3315	bird-sec
No. of transits through rotors	91.6438	per season
Estimated collisions	5.7608	per season
Estimated collisions after correction for operation	4.8967	per season
Estimated collisions after avoidance factor (0.95)	0.2448	per season
Estimated collisions after avoidance factor (0.975)	0.1224	per season
Estimated collisions after avoidance factor (0.98)	0.0979	per season
Estimated collisions after avoidance factor (0.99)	0.0490	per season

3.4 White-Tailed Eagle (12 turbines)

3.4.1 Non-Breeding Season 2025/2026

Table 5-3-21: White-tailed eagle flight activity

VP	Seconds at risk height	Observation effort (HaHr)	Flying time at risk height (secsHahr^{-1})
8	122.13	5272.60	1.3674E-06
9	0	8827.63	0
10	14.95	10708.72	1.6741E-07
11	0	0	0

Table 5-3-22: White-tailed eagle mortality estimates

Mean activity in wind farm at rotor height	0.0012	hr^{-1}
Total Combined rotor swept volume	636168.4408	m^3
Bird occupancy	1.9690	hrs/season
Bird occupancy of rotor swept volume	3.7052	bird-sec
No. of transits through rotors	19.5918	per season
Estimated collisions	1.2316	per season
Estimated collisions after correction for operation	1.0468	per season
Estimated collisions after avoidance factor (0.95)	0.0523	per season
Estimated collisions after avoidance factor (0.975)	0.0262	per season
Estimated collisions after avoidance factor (0.98)	0.0209	per season
Estimated collisions after avoidance factor (0.99)	0.0105	per season

3.4.2 Breeding Season 2026

Table 5-3-23: White-tailed eagle flight activity

VP	Seconds at risk height	Observation effort (HaHr)	Flying time at risk height (secsHahr^{-1})
8	244.62	7381.64	1.4627E-06
9	0	12358.68	0
10	317.99	14992.21	1.9015E-06
11	192.86	11720.51	1.1532E-06

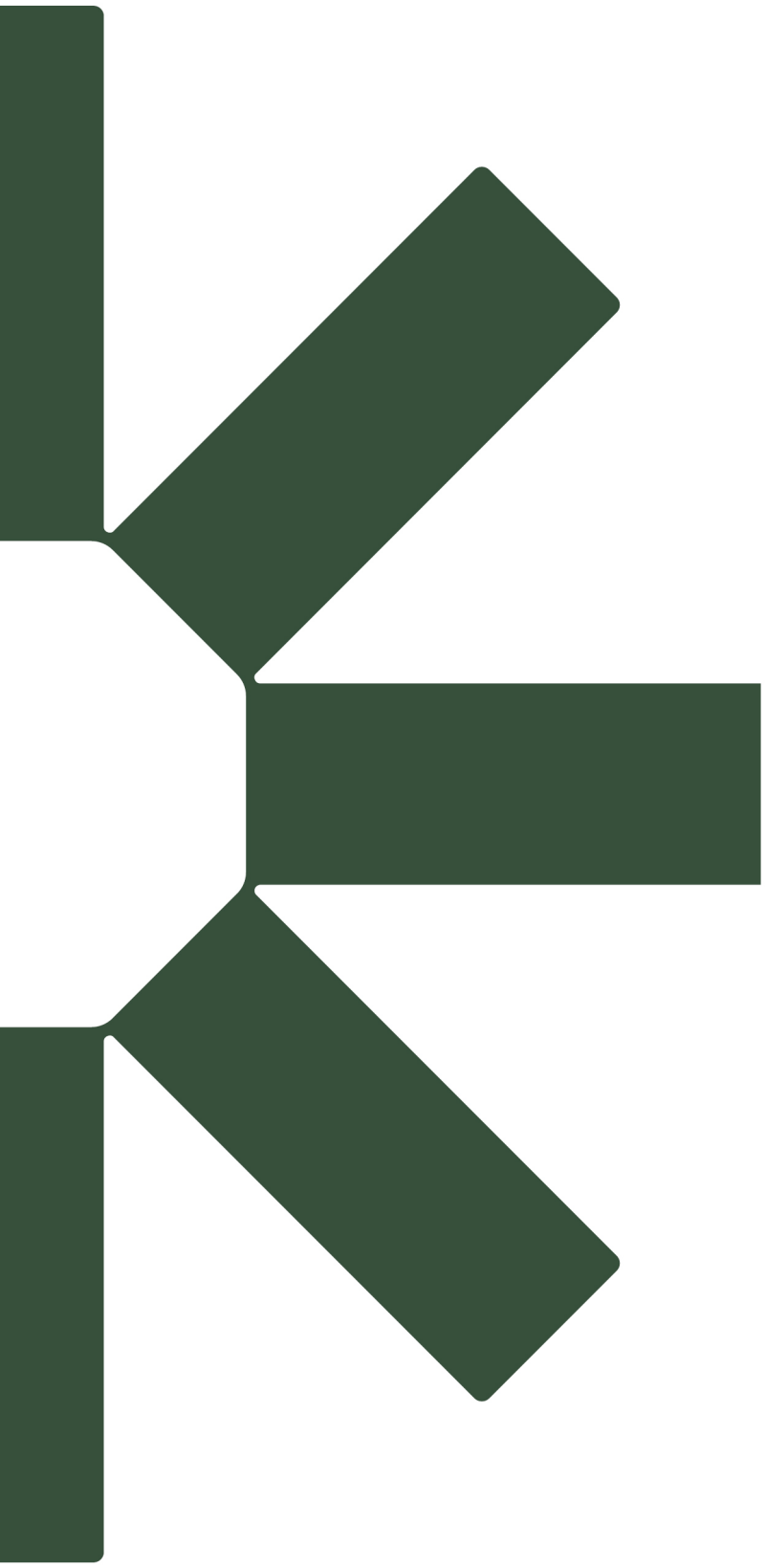
Table 5-3-24: White-tailed eagle mortality estimates

Mean activity in wind farm at rotor height	0.0034	hr^{-1}
Total Combined rotor swept volume	636168.4408	m^3
Bird occupancy	9.4759	hrs/season
Bird occupancy of rotor swept volume	17.8313	bird-sec
No. of transits through rotors	94.2868	per season
Estimated collisions	5.9269	per season
Estimated collisions after correction for operation	5.0379	per season
Estimated collisions after avoidance factor (0.95)	0.2519	per season
Estimated collisions after avoidance factor (0.975)	0.1259	per season
Estimated collisions after avoidance factor (0.98)	0.1008	per season
Estimated collisions after avoidance factor (0.99)	0.0504	per season

[i] NatureScot (2025a) Recommended Bird Survey Methods to inform impact assessment of Onshore Windfarms. Available at: https://www.nature.scot/doc/recommended-bird-survey-methods-inform-impact-assessment-onshore-windfarms

[ii] Band, W., Madders, M., and Whitfield, D.P. (2007). Developing field and analytical methods to assess avian collision risk at wind farms. In: Janss, G., de Lucas, M. & Ferrer, M (eds.) Birds and Wind Farms. Quercus, Madrid. 259-275.

[iii] Band, W. 2024. Using a collision risk model to assess bird collision risks for onshore wind farms. NatureScot Research Report 909. Available at: https://www.nature.scot/doc/naturescot-research-report-909-using-collision-risk-model-assess-bird-collision-risks-onshore-wind



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