The Repowered and Extended Ben Aketil Wind Farm

on behalf of Renantis UK Limited

Technical Appendix 8.2: Collision Mortality Risk Calculations

avianecology

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1 INTRODUCTION

1.1.1 This Technical Appendix has been prepared to accompany **Chapter 8: 'Ornithology'** of the Repowered and Extended Ben Aketil Wind Farm (the Proposed Development) Environmental Impact Assessment (EIA) Report (EIAR).

1.1.2 It presents the details and results of collision mortality risks calculations to inform the design and assessment of the Proposed Development in relation to ornithology features.

2 METHODOLOGY

2.1 Background

2.1.1 The NatureScot Collision Risk Model (CRM) or the Band Model (Band *et al*., 2007[1]) has been used to estimate potential collision mortality risks to target bird species recorded during baseline Vantage Point (VP) flight activity as a result of the Proposed Development.

2.1.2 The NatureScot CRM estimates collision mortality risks in three stages:

- Stage 1: the estimation of the number of birds passing through the rotor swept volume of the wind farm, based on observed flight activity data;
- Stage 2: the estimation of collision likelihood i.e. the probability of a bird flying through a rotor being hit, based on bird and wind farm parameters and whereby all collisions are assumed to be fatal. This provides an estimate of how many fatal collision could occur, in theory, should birds take no avoiding action; and,
- After multiplying Stage 1 and Stage 2 an avoidance factor is then applied i.e. whereby it is assumed birds take action to avoid collision.

2.2 Wind Farm Parameters

2.2.1 The Proposed Development comprises a total of nine turbines, including five repowered turbines (following removal of the existing operational Ben Aketil wind turbines) and four additional turbines. All nine turbines will have a maximum tip height of 200 m, and a maximum rotor diameter of 155 m.

2.2.2 For the purposes of analysis, the flight risk volume (Vw) is based on a buffer constructed around the outer of the nine turbines with a radius of 200 m (area = 399.25 ha) and a height at least equal to the rotor diameter (155 m).

2.2.3 Turbine parameters used in analysis are summarised in **Table 2.1** and are reflective of the preferred candidate turbines tip height, hub height and rotor diameter.

Table 2.1: Wind farm parameters.

Parameter	Value	Unit
Wind Farm Area (200m turbine buffer)	399.25	ha

[1] Band, W., Madders, M., & Whitfield, D.P. (2007). Developing field and analytical methods to assess avian collision risk at wind farms. In: de Lucas, M., Janss, G.F.E. & Ferrer, M. (Eds.) *Birds and Wind Farms: Risk Assessment and Mitigation*, pp. 259- 275. Quercus, Madrid.

Parameter	Value	Unit
No. of rotors	9	-
No. of blades	3	-
Tip height	200	meters
Hub height	122.5	meters
Rotor diameter	155	meters
Rotor radius	77.5	meters
Max chord	5.4	meters
Pitch	15	degrees
Rotation period	6.43[2]	seconds
Downtime	15%	%

2.3 Viewsheds

2.3.1 Target species flight activity data for use in collision mortality risk estimates has been obtained from VP flight activity surveys for the Proposed Development between March 2021 and April 2022, and also from VP flight activity surveys, undertaken as part of post construction ornithological monitoring between January 2022 and December 2022 for the operational Ben Aketil Wind Farm.

2.3.2 Full details are presented in **Technical Appendix 8.1: Technical Ornithology Appendix** of the EIAR.

2.3.3 **Figure 8.3a** and **8.3b** of the EIAR illustrates visible areas for each VP location adopted during surveys using a 2km viewshed radius (detection distance).

2.3.4 Following scheme design revisions, only VP1, VP2 and VP7 (**Figure 8.3a**), and VPA and VPB (**Figure 8.3b**), provide coverage of the wind farm area (200m turbine buffer). As such only target species flight activity data derived from observations at those VPs have been used for the purposes of collision mortality risk estimates.

2.3.5 Areas of visibility for all VPs within the wind farm area (200m turbine buffer) used in collision mortality risk estimates are summarised in **Table 2.2**.

Table 2.2: VP location and viewshed parameters.

VP	Grid Reference	Viewshed Radius (m)	Visible Area (ha) within 200 m turbine buffer[3]
A	NG3021047617	2,000	314.57
B	NG3250446458	2,000	52.49
1	NG3043246750	2,000	106.62
2	NG3266048134	2,000	140.67
7	NG3152848236	2,000	151.95

[2] Based on a possible maximum rotational speed of 11.20 revolutions per minute (r.p.m), with a conservative operating speed estimate derived as 20% of the maximum.
[3] Clipped to remove overlap.

2.4 VP Flight Activity Data

2.4.1 Survey effort (hours) completed at VPA and VPB between March 2021 and March 2022 are summarised in **Table 2.3**.

2.4.2 Survey effort (hours) completed at VP1, VP2, VP7 between January and November 2022 are summarised in **Table 2.4**.

2.4.3 Full details of all target species flights during the VP flight activity surveys are presented in **Technical Appendix 8.1: 'Ornithology'** and **Technical Appendix 8.5** of the EIAR.

Table 2.3: VP flight activity survey effort (hours) summary.

VP	2021										2022		Total No. of hours
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb[4]	
A	9	6	6	6	6	6	9	9	6	6	6	9	84
B	9	6	6	6	6	6	9	9	6	6	6	9	84

VP	2022		Total No. of hours
	Mar	Apr	
A	9	6	15
B	9	6	15

Table 2.4: VP flight activity survey effort.

VP	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	-	18	6	9	12	6	12	12	6	9	9	9	108
2	3	15	9	9	9	3	9	15	6	9	12	9	108
7	6	9	9	12	9	3	12	12	6	9	9	12	108

2.5 'At Collision Risk' Flight Activity

2.5.1 'At collision risk' flight activity for the Proposed Development has been defined as those visible target species flights recorded within the wind farm area (200m buffer around outer turbine locations), with at least part of its flight 'at collision risk height' between 20m and 200 m above the ground.

2.5.2 'At collision risk' flight activity was identified for the following species:

- Pink-footed goose;
- Golden plover;
- Snipe;
- Red-throated diver;
- Grey heron;

[4] Start of breeding (display) season for golden eagle, but non-breeding for most target species.

- Golden eagle;
- Hen harrier;
- White-tailed eagle; and,
- Merlin.

2.5.3 Collision mortality risk estimates have subsequently only been calculated for golden eagle, white-tailed and snipe, as no other target species recorded more than four 'at collision risk' flights. Collision mortality risks for all other target species can therefore be reasonably concluded to be very small (negligible) and not significant at any population level without the requirement for detailed analysis.

2.5.4 Target species flight activity, which occurred "at collision risk" in full or on part, is presented in **Annex 1**.

2.6 Target Species Parameters

2.6.1 Target species parameters used to calculate collision probabilities using the NatureScot approach (SNH, 2000[5]) are presented in **Table 2.5**, with collision probability calculations presented in **Annex 2**.

Table 2.5: Target species parameters.
Parameters are taken from the British Trust for Ornithology (BTO) Birdfacts website[6], Provan and Whitfield (2007[7]) and Bruderer and Boldt (2001[8]).

Species	Length (m)	Wingspan (m)	Flight Speed	Collision Probability (Annex 1)	Avoidance Rate (%)	Occupancy
Snipe	0.26	0.46	15.5	5.0%	98	Breeding April to mid-August
Golden eagle	0.82	2.12	15.0	7.3%	99	All year
White-tailed eagle	0.80	2.20	12.0	8.0%	95	All year

3 COLLISION MORTALITY RISKS

3.1.1 **Table 3.1** and **Table 3.2** provide a summary of annual collision mortality risks estimated for snipe, golden eagle and white-tailed eagle, with further details of analysis presented in **Annex 3**.

3.1.2 Estimates are presented for differing survey periods to capture "at collision risk" flight activity recorded during different survey months and differing VPs adopted for survey.

[5] SNH. (2000). WINDFARMS AND BIRDS: Calculating a theoretical collision risk assuming no avoiding action. Scottish Natural Heritage, Inverness
[6] Available at: https://bto.org/understanding-birds/birdfacts
[7] Provan, S. and Whitfield, P. (2007). Avian flight speeds and biometrics for use in collision risk modelling. A Report to Scottish Natural Heritage (SNH) from Natural Research (Projects) Ltd.
[8] Bruderer, B. and Boldt, A. (2001). Flight characteristics of birds: 1. Radar measurements of speeds. *Ibis*, **143**, pp. 178-204.

Table 3.1: Collision mortality risk estimates March 2021 – April 2022 (VPA and VPB).

Species	Occupancy	Avoidance Rate	Period	Annual Collision Mortality Risk
Snipe	Breeding	98%	Apr 21 – mid-Aug 21[9]	0.054
Golden eagle	All year	99%	Mar 21 – Feb 22	0.100
Golden eagle	All year	99%	Apr 21 – Mar 22	0.129
White-tailed eagle	All year	95%	Mar 21 – Feb 22	0.467
White-tailed eagle	All year	95%	Apr 21 – Mar 22	0.512

Table 3.2: Collision mortality risk estimates January – December 2022 (VP1, 2 and 7).

Species	Occupancy	Avoidance Rate	Period	Annual Collision Mortality Risk
Golden eagle	All year	99%	Jan-Dec 22	0.089
White-tailed eagle	All year	95%	Jan-Dec 22	0.456

3.2 Limitations for Assessment

3.2.1 As illustrated in **Figure 8.3b** following scheme design and for surveys adopting VPA and VPB between March 2021 and April 2022, there are some limitations to the visibility of a single turbine and the wind farm area (200m turbine buffer) in the east and west. The NatureScot collision risk model generally accounts for limitations in viewshed coverage by calculating an average of species flight activity based on that recorded within visible areas, and applying that to the wind farm area (200m turbine buffer).

3.2.2 In review of flight activity for key species including golden eagle, white-tailed eagle and hen harrier recorded from VP1, 2, 3 and 7 during post construction ornithological monitoring for the operational Ben Aketil Wind Farm in 2017 (see **Technical Appendix 8.4**) and 2022 (see **Technical Appendix 8.5**), and which have provided more extensive coverage of the wind farm area (200m turbine buffer), levels of flight activity within areas lacking visibility from VPA and VPB are not considered to be substantially higher or lower than areas of the wind farm area (200m turbine buffer) afforded visual coverage from VPA and VPB, and which have been used to estimate an average of species flight activity to apply to the wind farm area.

3.2.3 Very low levels of other target species flight activity were also recorded from VP1, 2, 3 and 7 during 2022 post construction ornithological monitoring.

3.2.4 Observations from VPA and VPB were undertaken simultaneously during the survey period March 2021 to April 2022. Surveys were commenced following a settling in period and so no potential disturbances to target species are likely to have occurred during observational time, as a result of field surveyors traversing the wind farm. The flight activity recorded from VPA and VPB has been examined for the duplicate recording of flights, of which none occurred. For the purposes of calculating "at collision risk" flights and accounting for viewshed overlap, viewshed areas have therefore been clipped to remove the area overlap from ha/hr calculations. Flight lengths occurring within the retained viewshed areas observed from both VPs have however, been retained for "at risk flight" activity calculations.

[9] To 17th August.

3.2.5 No significant limitations in the estimation of collision mortality risks using flight activity derived from VPA and VPB are therefore considered, with estimates calculated considered valid for the purposes of assessment.

ANNEX 1: "AT COLLISION RISK" FLIGHT ACTIVITY

Table A1.1: "At Collision Risk" Flight Activity March 2021 – April 2022 (VPA and VPB).

Date	VP	Species	No. of Birds	Start Time	Total Flight Duration (s)	Flight Duration (s)			
						HT1	HT2	HT3	HT4
24/03/2021	A	White-tailed eagle	1	12:39	176	146	30	0	0
24/03/2021	B	Golden eagle	0	12:51	20	5	15	0	0
11/05/2021	A	Merlin	1	17:44	42	0	42	0	0
13/05/2021	A	Snipe	2	07:55	762	0	762	0	0
13/05/2021	A	White-tailed eagle	1	09:42	197	45	152	0	0
13/05/2021	A	White-tailed eagle	1	09:43	154	0	154	0	0
13/05/2021	A	Red-throated diver	1	08:23	126	0	0	36	90
13/05/2021	A	White-tailed eagle	1	09:55	298	103	105	90	0
13/05/2021	B	Snipe	1	08:54	59	6	45	0	0
28/06/2021	A	Snipe	1	21:45	30	15	15	0	0
28/06/2021	A	Snipe	1	19:38	45	15	30	0	0
28/06/2021	A	White-tailed eagle	1	17:13	300	0	135	165	0
28/06/2021	A	White-tailed eagle	1	17:31	180	0	180	0	0
14/07/2021	A	Golden eagle	1	14:24	141	96	45	0	0
16/08/2021	A	White-tailed eagle	1	15:57	256	0	256	0	0
13/09/2021	A	Grey heron	1	19:02	165	0	165	0	0
27/10/2021	A	White-tailed eagle	1	16:19	245	90	165	0	0
15/12/2021	A	Golden eagle	1	14:12	150	30	120	0	0
15/12/2021	B	Golden eagle	1	14:12	150	30	120	0	0
15/12/2021	B	Golden eagle	1	11:17	252	56	140	56	0

Date	VP	Species	No. of Birds	Start Time	Total Flight Duration (s)	Flight Duration (s)			
						HT1	HT2	HT3	HT4
19/01/2022	A	Golden eagle	2	13:37	432	0	270	162	0
19/01/2022	A	Golden eagle	1	10:14	372	57	315	0	0
19/01/2022	A	White-tailed eagle	1	09:45	240	70	70	100	0
19/01/2022	A	White-tailed eagle	1	10:11	189	81	108	0	0
19/01/2022	A	Golden eagle	1	12:48	934	0	934	0	0
19/01/2022	B	White-tailed eagle	1	09:45	240	70	70	100	0
19/01/2022	B	Golden eagle	1	10:14	372	57	315	0	0
19/01/2022	B	Golden eagle	2	13:37	432	0	270	162	0
19/01/2022	B	Golden eagle	1	12:48	934	0	934	0	0
22/02/2022	B	White-tailed eagle	1	09:42	250	0	60	30	160
28/03/2022	A	Golden eagle	1	16:02	768	0	300	180	288
28/03/2022	B	Golden eagle	1	13:09	238	0	120	118	0
28/03/2022	B	Golden eagle	1	16:02	768	0	300	180	288
29/03/2022	A	White-tailed eagle	1	11:21	402	15	210	105	72
29/03/2022	A	Common gull	8	11:45	2,008	0	2,008	0	0
19/04/2022	A	Snipe	1	14:55	34	4	30	0	0
19/04/2022	A	Snipe	6	20:02	306	0	306	0	0
19/04/2022	A	Pink-footed goose	4	20:19	632	0	300	332	0

Table A1.2: "At Collision Risk" Flight Activity January – December 2022 (VP1, 2 and 7).

Date	VP	Species	No. of Birds	Time at CRH (HT B)
01/02/2022	2	Golden eagle	1	77
01/02/2022	2	Golden eagle	1	24

21/02/2022	7	White-tailed eagle	1	67
21/02/2022	7	White-tailed eagle	2	188
22/02/2022	1	White-tailed eagle	1	210
23/02/2022	2	Golden eagle	1	196
14/03/2022	7	Golden eagle	1	195
14/03/2022	7	Golden eagle	1	163
23/03/2022	7	Golden eagle	1	48
22/04/2022	2	Golden eagle	1	290
17/05/2022	2	White-tailed eagle	1	126
24/05/2022	7	Golden eagle	1	126
24/05/2022	7	Golden eagle	1	210
17/06/2022	7	White-tailed eagle	1	21
17/06/2022	7	White-tailed eagle	1	74
17/06/2022	7	White-tailed eagle	1	10
17/06/2022	7	White-tailed eagle	1	573
14/07/2022	7	White-tailed eagle	1	149
20/07/2022	7	White-tailed eagle	1	49
13/09/2022	2	White-tailed eagle	3	48
13/09/2022	2	White-tailed eagle	1	91
20/10/2022	7	White-tailed eagle	1	285
24/11/2022	1	Hen harrier	1	70

ANNEX 2: COLLISION PROBABILITY CALCULATIONS

Golden eagle

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA												
K: [1D or [3D	1		Calculation of alpha and p(collision) as a function of radius									
No. Blades	3						Upwind:				Downwind:	
Max Chord	5.4	m	r/R	c/C	α	collide		contribution	collide		contribution	
Pitch (degree	15		radius	chord	alpha	length	p (collision)	from radius r	length	p (collision)	from radius r	
Bird Length	0.82	m	0.025	0.575	7.92	41.36	1.00	0.00125	39.75	1.00	0.00125	
Wingspan	2.12	m	0.075	0.575	2.64	14.32	0.45	0.00334	12.72	0.40	0.00297	
F: Flapping (	0		0.125	0.702	1.58	10.14	0.32	0.00394	8.18	0.25	0.00318	
			0.175	0.860	1.13	8.68	0.27	0.00472	6.28	0.20	0.00342	
Bird speed	15	m/sec	0.225	0.994	0.88	7.82	0.24	0.00547	5.04	0.16	0.00353	
Rotor Diam	155	m	0.275	0.947	0.72	6.41	0.20	0.00548	3.76	0.12	0.00322	
Rotation Peri	6.43	sec	0.325	0.899	0.61	5.41	0.17	0.00546	2.89	0.09	0.00292	
			0.375	0.851	0.53	4.65	0.14	0.00543	2.28	0.07	0.00265	
			0.425	0.804	0.47	4.06	0.13	0.00537	1.82	0.06	0.00240	
			0.475	0.756	0.42	3.58	0.11	0.00530	1.47	0.05	0.00217	
Bird aspect r	0.39		0.525	0.708	0.38	3.20	0.10	0.00523	1.22	0.04	0.00200	
			0.575	0.660	0.34	2.93	0.09	0.00524	1.08	0.03	0.00194	
			0.625	0.613	0.32	2.69	0.08	0.00523	0.98	0.03	0.00190	
			0.675	0.565	0.29	2.47	0.08	0.00520	0.90	0.03	0.00188	
			0.725	0.517	0.27	2.28	0.07	0.00514	0.83	0.03	0.00188	
			0.775	0.470	0.26	2.10	0.07	0.00507	0.85	0.03	0.00205	
			0.825	0.422	0.24	1.94	0.06	0.00497	0.88	0.03	0.00226	
			0.875	0.374	0.23	1.78	0.06	0.00486	0.90	0.03	0.00245	
			0.925	0.327	0.21	1.64	0.05	0.00472	0.91	0.03	0.00262	
			0.975	0.279	0.20	1.51	0.05	0.00456	0.91	0.03	0.00277	
				Overall p(collision) =			Upwind	9.6%		Downwind	4.9%	
								Average	7.3%			

White-tailed eagle

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA												
K: [1D or [3D	1		Calculation of alpha and p(collision) as a function of radius									
No. Blades	3						Upwind:				Downwind:	
Max Chord	5.4	m	r/R	c/C	α	collide		contribution	collide		contribution	
Pitch (degree	15		radius	chord	alpha	length	p (collision)	from radius r	length	p (collision)	from radius r	
Bird Length	0.8	m	0.025	0.575	6.34	33.76	1.00	0.00125	32.15	1.00	0.00125	
Wingspan	2.2	m	0.075	0.575	2.11	11.79	0.46	0.00344	10.18	0.40	0.00297	
F: Flapping (	0		0.125	0.702	1.27	8.41	0.33	0.00409	6.45	0.25	0.00313	
			0.175	0.860	0.91	7.26	0.28	0.00494	4.85	0.19	0.00330	
Bird speed	12	m/sec	0.225	0.994	0.70	6.59	0.26	0.00577	3.81	0.15	0.00333	
Rotor Diam	155	m	0.275	0.947	0.58	5.44	0.21	0.00581	2.79	0.11	0.00298	
Rotation Peri	6.43	sec	0.325	0.899	0.49	4.62	0.18	0.00583	2.10	0.08	0.00266	
			0.375	0.851	0.42	4.00	0.16	0.00583	1.62	0.06	0.00236	
			0.425	0.804	0.37	3.51	0.14	0.00579	1.26	0.05	0.00208	
			0.475	0.756	0.33	3.17	0.12	0.00586	1.06	0.04	0.00196	
Bird aspect r	0.36		0.525	0.708	0.30	2.90	0.11	0.00593	0.93	0.04	0.00189	
			0.575	0.660	0.28	2.67	0.10	0.00597	0.83	0.03	0.00185	
			0.625	0.613	0.25	2.47	0.10	0.00599	0.85	0.03	0.00206	
			0.675	0.565	0.23	2.28	0.09	0.00599	0.90	0.03	0.00236	
			0.725	0.517	0.22	2.11	0.08	0.00596	0.93	0.04	0.00263	
			0.775	0.470	0.20	1.96	0.08	0.00590	0.96	0.04	0.00288	
			0.825	0.422	0.19	1.81	0.07	0.00581	0.97	0.04	0.00310	
			0.875	0.374	0.18	1.68	0.07	0.00570	0.97	0.04	0.00330	
			0.925	0.327	0.17	1.55	0.06	0.00557	0.96	0.04	0.00347	
			0.975	0.279	0.16	1.43	0.06	0.00541	0.95	0.04	0.00361	
				Overall p(collision) =			Upwind	10.7%		Downwind	5.3%	
								Average	8.0%			

Snipe

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA												
K: [1D or [3D	1		Calculation of alpha and p(collision) as a function of radius									
No. Blades	3					Upwind:				Downwind:		
Max Chord	5.4	m	r/R	c/C	α	collide		contribution	collide		contribution	
Pitch (degree	15		radius	chord	alpha	length	p (collision)	from radius r	length	p (collision)	from radius r	
Bird Length	0.26	m	0.025	0.575	8.19	29.12	0.88	0.00110	27.52	0.83	0.00104	
Wingspan	0.46	m	0.075	0.575	2.73	10.24	0.31	0.00231	8.64	0.26	0.00195	
F: Flapping (	0		0.125	0.702	1.64	7.72	0.23	0.00291	5.76	0.17	0.00217	
			0.175	0.860	1.17	6.99	0.21	0.00368	4.58	0.14	0.00241	
Bird speed	15.5	m/sec	0.225	0.994	0.91	6.53	0.20	0.00442	3.75	0.11	0.00254	
Rotor Diam	155	m	0.275	0.947	0.74	5.34	0.16	0.00442	2.69	0.08	0.00223	
Rotation Peri	6.43	sec	0.325	0.899	0.63	4.50	0.14	0.00440	1.99	0.06	0.00194	
			0.375	0.851	0.55	3.87	0.12	0.00437	1.49	0.04	0.00169	
			0.425	0.804	0.48	3.40	0.10	0.00435	1.16	0.03	0.00148	
			0.475	0.756	0.43	3.02	0.09	0.00431	0.90	0.03	0.00129	
Bird aspect r	0.57		0.525	0.708	0.39	2.69	0.08	0.00425	0.71	0.02	0.00112	
			0.575	0.660	0.36	2.41	0.07	0.00417	0.56	0.02	0.00097	
			0.625	0.613	0.33	2.16	0.07	0.00407	0.45	0.01	0.00085	
			0.675	0.565	0.30	1.94	0.06	0.00395	0.36	0.01	0.00074	
			0.725	0.517	0.28	1.74	0.05	0.00381	0.30	0.01	0.00065	
			0.775	0.470	0.26	1.56	0.05	0.00365	0.27	0.01	0.00063	
			0.825	0.422	0.25	1.40	0.04	0.00347	0.30	0.01	0.00075	
			0.875	0.374	0.23	1.24	0.04	0.00327	0.33	0.01	0.00086	
			0.925	0.327	0.22	1.09	0.03	0.00304	0.34	0.01	0.00095	
			0.975	0.279	0.21	0.96	0.03	0.00280	0.34	0.01	0.00101	
				Overall p(collision) =			Upwind	7.3%		Downwind	2.7%	
								Average	5.0%			

ANNEX 3: COLLISION MORTALITY RISK CALCULATIONS

Golden Eagle

Mar 21 – Feb 22

Watch data				**Flying time (s)**	**Flying time hahr-1**	**Weighted flying time ha hr^-1**	
VP	Area (ha)	Time (hrs)	HaHr	Risk height	Risk height	Weighting	Risk height
A	314.6	84.0	26423.9	515.9919720	0.0000054243	0.856998856	0.000004649
B	52.5	84.0	4409.2	157.6017408	0.0000099289	0.143001144	0.000001420
Totals	367.1	168.0	30833.0	673.5937128	0.0000076766	1.000000000	0.000006068
Mean activity hr^-1 in wind farm					**WIND FARM DATA**		
Risk height		0.00242	0.2423%		Wind farm area (ha)	399.25	
Daylight hours		4478					
Downtime		15	0.85		D	155	
Vw =		618837500			L + d	6.22	
Vr =		1056297	No.turbines	9			
Vr/Vw =		0.0017069					
Speed		15					
Vw Occupancy =		10.8495	39058.1				
Vr Occupancy =		0.0185	66.7				
Transit time =		0.4147					
Transits =		160.776					
Collision probability		0.073					
Collisions with no avoidance		11.737					
Collisions with 99% avoidance		0.117					
Collisions with 99% avoidance & downtime		0.100					

Apr 21 – Mar 22

Watch data				**Flying time (s)**	**Flying time hahr-1**	**Weighted flying time ha hr^-1**	
VP	Area (ha)	Time (hrs)	HaHr	Risk height	Risk height	Weighting	Risk height
A	314.6	81.0	25480.2	558.0328053	0.0000060835	0.856998856	0.000005214
B	52.5	81.0	4251.7	282.4912575	0.0000184561	0.143001144	0.000002639
Totals	367.1	162.0	29731.9	840.5240628	0.0000122698	1.000000000	0.000007853
Mean activity hr^-1 in wind farm					**WIND FARM DATA**		
Risk height		0.00314	0.3135%		Wind farm area (ha)	399.25	
Daylight hours		4478					
Downtime		15	0.85		D	155	
Vw =		618837500			L + d	6.22	
Vr =		1056297	No.turbines	9			
Vr/Vw =		0.0017069					
Speed		15					
Vw Occupancy =		14.0396	50542.5				
Vr Occupancy =		0.0240	86.3				
Transit time =		0.4147					
Transits =		208.050					
Collision probability		0.073					
Collisions with no avoidance		15.188					
Collisions with 99% avoidance		0.152					
Collisions with 99% avoidance & downtime		0.129					

Jan 22 – Dec 22

Watch data				**Flying time (s)**	**Flying time hahr-1**	**Weighted flying time ha hr^-1**	
VP	Area (ha)	Time (hrs)	HaHr	Risk height	Risk height	Weighting	Risk height
1	106.6	108.0	11515.0	0.0000000	0.0000000000	0.267057409	0.000000000
2	140.7	108.0	15192.4	305.6282000	0.0000055881	0.352344454	0.000001969
7	152.0	108.0	16410.6	539.0290533	0.0000091240	0.380598136	0.000003473
Totals	399.2	324.0	43117.9	844.6572533	0.0000049040	1.000000000	0.000005442
Mean activity hr^-1 in wind farm					**WIND FARM DATA**		
Risk height		0.00217	0.2173%		Wind farm area (ha)	399.25	
Daylight hours		4478					
Downtime		15	0.85		D	155	
Vw =		618837500			L + d	6.22	
Vr =		1056297	No.turbines	9			
Vr/Vw =		0.0017069					
Speed		15					
Vw Occupancy =		9.7286	50542.5				
Vr Occupancy =		0.0166	86.3				
Transit time =		0.4147					
Transits =		144.166					
Collision probability		0.073					
Collisions with no avoidance		10.524					
Collisions with 99% avoidance		0.105					
Collisions with 99% avoidance & downtime		0.089					

White-tailed Eagle

Mar 21 – Feb 22

Watch data				**Flying time (s)**	**Flying time hahr-1**	**Weighted flying time ha hr^-1**	
VP	Area (ha)	Time (hrs)	HaHr	Risk height	Risk height	Weighting	Risk height
A	314.6	84.0	26423.9	685.3444009	0.0000072046	0.856998856	0.000006174
B	52.5	84.0	4409.2	34.4554396	0.0000021707	0.143001144	0.000000310
Totals	367.1	168.0	30833.0	719.7998405	0.0000046876	1.000000000	0.000006485
Mean activity hr^-1 in wind farm					**WIND FARM DATA**		
Risk height		0.00259	0.2589%		Wind farm area (ha)	399.25	
Daylight hours		4478					
Downtime		15	0.85		D	155	
Vw =		618791000			L + d	6.2	
Vr =		1052901	No.turbines	9			
Vr/Vw =		0.0017015					
Speed		12					
Vw Occupancy =		11.5928	39058.1				
Vr Occupancy =		0.0197	66.7				
Transit time =		0.5167					
Transits =		137.444					
Collision probability		0.08					
Collisions with no avoidance		10.995					
Collisions with 95% avoidance		0.550					
Collisions with 95% avoidance & downtime		0.467					

Apr 21 – Mar 22

Watch data				**Flying time (s)**	**Flying time hahr-1**	**Weighted flying time ha hr^-1**	
VP	Area (ha)	Time (hrs)	HaHr	Risk height	Risk height	Weighting	Risk height
A	314.6	84.0	26423.9	753.4836578	0.0000079209	0.856998856	0.000006788
B	52.5	84.0	4409.2	34.4554396	0.0000021707	0.143001144	0.000000310
Totals	367.1	168.0	30833.0	787.9390974	0.0000050458	1.000000000	0.000007099
Mean activity hr^-1 in wind farm					**WIND FARM DATA**		
Risk height		0.00283	0.2834%		Wind farm area (ha)	399.25	
Daylight hours		4478					
Downtime		15	0.85		D	155	
Vw =		618791000			L + d	6.2	
Vr =		1052901	No.turbines	9			
Vr/Vw =		0.0017015					
Speed		12					
Vw Occupancy =		12.6903	39058.1				
Vr Occupancy =		0.0216	66.7				
Transit time =		0.5167					
Transits =		150.455					
Collision probability		0.08					
Collisions with no avoidance		12.036					
Collisions with 95% avoidance		0.602					
Collisions with 95% avoidance & downtime		0.512					

Jan 22 – Dec 22

Watch data				**Flying time (s)**	**Flying time hahr-1**	**Weighted flying time ha hr^-1**	
VP	Area (ha)	Time (hrs)	HaHr	Risk height	Risk height	Weighting	Risk height
1	106.6	108.0	11515.0	237.7941000	0.0000057364	0.267057409	0.000001532
2	140.7	108.0	15192.4	189.0306667	0.0000034562	0.352344454	0.000001218
7	152.0	108.0	16410.6	555.0103333	0.0000093945	0.380598136	0.000003576
Totals	399.2	324.0	43117.9	981.8351000	0.0000061957	1.000000000	0.000006325
Mean activity hr^-1 in wind farm					**WIND FARM DATA**		
Risk height		0.00253	0.2525%		Wind farm area (ha)	399.25	
Daylight hours		4478					
Downtime		15	0.85		D	155	
Vw =		618791000			L + d	6.2	
Vr =		1052901	No.turbines	9			
Vr/Vw =		0.0017015					
Speed		12					
Vw Occupancy =		11.3077	50542.5				
Vr Occupancy =		0.0192	86.3				
Transit time =		0.5167					
Transits =		134.063					
Collision probability		0.08					
Collisions with no avoidance		10.725					
Collisions with 95% avoidance		0.536					
Collisions with 95% avoidance & downtime		0.456					

Snipe

Apr 21 – mid-Aug 21

Watch data				**Flying time (s)**	**Flying time hahr-1**	**Weighted flying time ha hr^-1**	
VP	Area (ha)	Time (hrs)	HaHr	Risk height	Risk height	Weighting	Risk height
A	314.6	30.0	9437.1	132.4716667	0.0000038993	0.856998856	0.000003342
B	52.5	30.0	1574.7	55.4816293	0.0000097870	0.143001144	0.000001400
Totals	367.1	60.0	11011.8	187.9532960	0.0000068431	1.000000000	0.000004741
Mean activity hr^-1 in wind farm					**WIND FARM DATA**		
Risk height		0.00189	0.1893%		Wind farm area (ha)	399.25	
Daylight hours		2172					
Downtime		15	0.85		D	155	
Vw =		618791000			L + d	5.66	
Vr =		961197	No.turbines	9			
Vr/Vw =		0.0015533					
Speed		**15.5**					
Vw Occupancy =		4.1111	39058.1				
Vr Occupancy =		0.0064	66.7				
Transit time =		0.3652					
Transits =		62.957					
Collision probability		**0.05**					
Collisions with no avoidance		3.148					
Collisions with 98% avoidance		0.063					
Collisions with 98% avoidance & downtime		0.054					