Chleansaid Wind Farm
ESB Asset Development UK Limited
Appendix 9.3: Collision Risk Model Analysis

avianecology

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1 INTRODUCTION

1.1.1 This Technical Appendix has been prepared to accompany **Chapter 9: Ornithology** of the Environmental Impact Assessment Report (EIAR) for the proposed Chleansaid Wind Farm (hereafter 'Proposed Development').

1.1.2 It presents the details and results of collision mortality risk calculations, completed to inform the assessment for the Proposed Development upon ornithological interests.

1.1.3 This Technical Appendix is supplementary to **Appendix 9.1** in Volume 2 of the EIAR, and full details of the methodology, including the desk study and consultation, study areas and field surveys is provided within the **Appendix 9.1**.

2 METHODOLOGY

2.1 Background

2.1.1 The Band collision risk model (CRM) (Band *et al*., 2007) has been used to estimate the collision mortality risk to target species.

2.1.2 The Band CRM calculates 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 Vantage Point (VP) 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 16 turbines, with 12 turbines of 200 m maximum tip height, 118.5 m hub height, and four turbines of 180 m maximum tip height, 98.5 m hub height, and for all 16 turbines, 163 m maximum rotor diameter.

2.2.2 For the purposes of analysis, the flight risk volume (Vw) is based on a buffer constructed around the individual turbine locations with a radius of 290 m (area = 397.60 ha) and a height at least equal to the rotor diameter (163 m).

2.2.3 Turbine parameters are summarised in **Table 9.3.1.** The proposed turbine is the 'N163 – Nordex', but given the lack of available specification for all parameters for the turbine type, specification for a comparable candidate turbine (the 'Vestas V164-8.0') is used where parameters for the proposed turbine are not available.

Table 9.3.1: Turbine parameters.

Parameter	Value	Unit
Size of Wind Farm *(290m turbine buffer)*	397.60	ha

Parameter	Value	Unit
No. of rotors	16	-
No. of blades	3	-
Height to tip	180 - 200	metres
Hub height	98.5 – 118.5	metres
Rotor diameter	163	metres
Rotor radius	81.5	metres
Max chord	5.4	metres
Pitch	15	degrees
Rotation period	5.7	seconds
Downtime	15	%

2.3 Viewsheds

2.3.1 Target species flight activity data for use in CRM Analysis calculations has been obtained from two VPs during VP flight activity surveys between September 2019 and August 2021.

2.3.2 Visible areas for each VP location have been calculated using an observer height of 1.5 m and a 10 m vertical offset above the ground. The extent of the visible area that could be seen from each VP location was confirmed during a reconnaissance visit.

2.3.3 **Table 9.3.2** presents the visible areas of each viewshed and that which falls within the "study area" constructed using a 290 m buffer around the turbines for the purpose of analysis.

Table 9.3.2: VP locations and viewshed visible areas.

VP	Grid Reference	Viewshed Radius (m)	Visible Area (ha)
			Within 290 m turbine buffer
1	NC 62736 16611	2,000	215.84
2	NC 60367 17854	2,000	202.91

2.4 VP Flight Activity Data

2.4.1 Survey effort (hours) completed at each VP location between September 2019 and August 2021 is summarised in **Table 9.3.3**. Full details of all target species flights during the VP flight activity surveys are presented in **Appendix 9.1** in Volume 2 of the EIAR, and are shown in **Figures 9.5a-c** in Volume 3 of the EIAR.

Table 9.3.3: VP flight activity survey effort summary.

VP	2019				2020								Year 1 Total
	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	
1	6	9	9	9	9	6	9	0	0	9	9	6	81
2	6	9	9	9	9	6	9	0	0	9	9	6	81
VP	**2020**				**2021**								**Year 2 Total**
	Sep	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	
1	9	9	6	6	6	6	9	9	6	9	9	6	90
2	9	9	6	6	6	6	9	9	6	9	9	6	90

2.5 'At risk' Flights

2.5.1 The flights of the species, golden eagle, hen harrier, red kite, white-tailed eagle, lapwing, snipe, grey heron, whooper swan, black-throated diver, short-toed eagle, wood sandpiper, greylag goose and curlew were recorded as 'at risk', identified as those flights recorded within 290 m of the turbines and flying at collision risk height (e.g. between 17-200 m). Given the two different sizes of turbines used (180 m and 200 m tip height), the highest tip height (200 m) is used as the upper limit of the collision risk height, while the lower limit of the collision risk height (17 m) is derived from the lower rotor sweep of the shorter turbine height (180 m). As a precaution, bird flights at height bands 1-5 (thus 0-200 m) are regarded as 'at risk' given height band 1 is <30 m, and thus the lower sweep of the 180 m tip height turbine falls into this band.

2.5.2 CRM Analysis was only undertaken on those species with four, or more, at risk flights, over the 2-year survey period, and accordingly the flights of golden eagle and hen harrier were analysed.

2.5.3 CRM Analysis was not undertaken on wader species, unless they were qualifying species for designated sites with potential connectivity to the turbine area (defined by core foraging range in SNH, 2016).

2.5.4 Six greylag goose flights were also recorded 'at risk' during the two years of survey, although this species is discounted for CRM Analysis, given only two flights were recorded on the same day in October 2020, with all other flights recorded outside the non-breeding season (in April-June 2021) and so representative of resident/feral species[1], rather than migratory birds of the Icelandic population that may be connected to designated sites (Dornoch Firth and Loch Fleet Special Protection Area (SPA) and Ramsar 19.3 km from the site).

2.5.5 Details of VP flight activity surveys of those target species flying 'at risk' are provided in **Technical Annex 1**.

2.5.6 'At risk' flight activity recorded during the survey period for those species which were analysed using CRM is summarised in **Table 9.3.4**. Note, CRM Analysis was undertaken for both Year 1 and Year 2.

Table 9.3.4: "At collision risk" flight activity.

Species	Total No. of Flights	Total No. of Birds	Total Time at Collision Risk Height (secs) as Derived from CRM Analysis (secs) [2]

[1] Given greylag geese are highly territorial, geese recorded 8.3 km from the Caithness and Sutherland Peatlands Ramsar are not considered to be breeding geese from the Ramsar, but instead resident/feral birds.

[2] Total time multiplied by the number of birds.

Species	Total No. of Flights	Total No. of Birds	Total Time at Collision Risk Height (secs) as Derived from CRM Analysis (secs) [2]
Golden eagle	31	35	15,881
Hen harrier	9	10	2,847

2.6 Target Species Parameters

2.6.1 The target species parameters used to calculate the collision probability calculations for the species in **Table 9.3.4** is presented in **Table 9.3.5**. The results of the collision probability calculations are given in **Technical Annex 2**.

Table 9.3.5: Target species parameters.
Parameters are taken from the British Trust for Ornithology (BTO) Birdfacts website[3] in accordance with Urquhart & Whitfield (2016), which is the recommended source of this information as stated in NatureScot guidance (SNH, 2018).

Species	Length (m)	Wingspan (m)	Flight Speed (m/s)	Collision Probability (%)[4]	Avoidance Rate (%)	Occupancy
Golden eagle	0.82	2.12	15.0	7.4	99	All year.
Hen harrier	0.48	1.10	11.50	6.9	99	All year.

[3] https://www.bto.org/understanding-birds/birdfacts (Accessed 16/11/2021).
[4] See **Technical Annex 2**.

3 COLLISION RISK ANALYSIS

3.1 Approach

3.1.1 Only those species with ≥4 flights at collision risk, over the 2-year survey period, were chosen for CRM Analysis, as flights below this number would be inconsequential at any population level (see also **Section 2.5 - 'At risk' Flights** of **Technical Appendix 9.3)**

3.1.2). As such, flights of golden eagle and hen harrier were subjected to CRM Analysis.

3.1.3 The following important information is used in the CRM Analysis:

- Wind farm area (290m): 397.60 ha;
- Assumed daylight flying hours (potential): 3575.6 and 4491.1[5] respectively in Year 1 and 2 (based on all year occupancy);
- Downtime: 15 %;
- Latitude for centre of the Site: 58.129577; and
- Lifespan of wind farm is 35 years.

3.1.4 **Table 9.3.6** presents the output from the CRM Analysis for the assessed species, with details of results in **Technical Annex 3**. Note, given the classification of at-risk flights (all flights in HT1-5, thus 0 – 200m) due to the two different sized turbines to be used in the Proposed Development, these CRM Analysis results are considered to be highly precautionary (and represent a worst-case scenario).

Table 9.3.6: CRM Analysis results.

Species	Avoidance Rate (%)	Annual Collision Mortality			35 year Collision Mortality		
		Year 1	Year 2	Average	Year 1	Year 2	Average
Golden eagle	99	0.03[6]	0.83	0.43	0.99	28.90	14.95
Hen harrier	99	0.08[7]	0.10	0.09	2.80	3.59	3.20

[5] Potentially active hours have been calculated using latitude of 58.129577 as per Forsythe *et al.* (1995) and based on annual occupancy for raptors. Reduced potential daylight flight hours in Year 1 due to the omission of April and May 2020 surveys due to Covid-19 restrictions on travel.

[6] Only based on two at-risk flights.

[7] Only based on two at-risk flights.

4 REFERENCES

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ANNEX 1 – "AT RISK" FLIGHT ACTIVITY

Table A1-1 present "at risk" flight activity for target species recorded during the survey period (September 2019 – August 2021; the number of birds, total flight duration and time spent at (HT1 – HT5) and above (HT6) collision risk height is presented. Note, of these, golden eagle and hen harrier were recorded in sufficient number "at collision risk" height and considered appropriate for CRM Analysis to be carried out.

Table A1-1: Target species "at risk" flight activity (Wind Farm Area: 290m).

Survey Year	Date	VP	Species	No. of Birds	Start Time (24hrs)	Total Flight Duration (secs) [8]	Total Time Spent (secs)[9]					
							HT1	HT2	HT3	HT4	HT5	HT6
1	14/10/2019	2	Golden eagle	1	13:46	315	0	15	135	165	0	0
1	25/03/2020	2	Hen harrier	1	08:39	312	15	72	225	0	0	0
1	17/06/2020	1	Golden eagle	1	16:02	641	26	45	270	180	120	0
1	24/06/2020	2	Snipe	1	09:29	53	23	30	0	0	0	0
1	24/06/2020	2	Snipe	1	11:23	213	3	150	60	0	0	0
1	24/06/2020	2	Snipe	1	09:42	130	10	120	0	0	0	0
1	24/06/2020	2	Snipe	2	10:37	642	12	360	270	0	0	0
1	24/06/2020	2	Snipe	1	10:51	612	12	285	315	0	0	0
1	24/06/2020	2	Snipe	1	11:33	310	10	120	180	0	0	0
1	29/06/2020	2	Snipe	1	15:24	221	11	195	15	0	0	0
1	29/06/2020	2	Snipe	1	15:38	522	12	300	210	0	0	0
1	01/07/2020	1	Hen harrier	2	15:23	802	0	0	652	150	0	0
1	13/08/2020	2	Grey heron	1	12:14	58	13	45	0	0	0	0
2	23/09/2020	2	Golden eagle	3	13:01	900	0	0	0	0	180	720
2	12/10/2020	1	Whooper swan	2	13:56	148	58	90	0	0	0	0

[8] Total time multiplied by the number of birds.

Survey Year	Date	VP	Species	No. of Birds	Start Time (24hrs)	Total Flight Duration (secs) [8]	Total Time Spent (secs)[9]					
							HT1	HT2	HT3	HT4	HT5	HT6
2	22/10/2020	1	Greylag goose	2	12:19	234	0	0	114	120	0	0
2	22/10/2020	2	Golden eagle	1	15:38	35	0	35	0	0	0	0
2	22/10/2020	2	Golden eagle	1	14:56	697	0	0	75	60	285	277
2	22/10/2020	2	Golden eagle	1	15:09	312	0	0	0	75	60	177
2	22/10/2020	2	Greylag goose	24	16:36	5,208	0	0	5,208	0	0	0
2	04/11/2020	2	Golden eagle	3	12:11	1,830	75	45	945	180	495	90
2	04/11/2020	2	Hen harrier	1	13:14	158	83	75	0	0	0	0
2	04/11/2020	2	Hen harrier	1	13:21	502	180	255	67	0	0	0
2	04/11/2020	2	Hen harrier	1	15:13	137	77	60	0	0	0	0
2	12/11/2020	1	Golden eagle	1	09:58	637	0	7	390	180	60	0
2	01/12/2020	2	Whooper swan	5	12:29	620	0	0	0	0	620	0
2	17/12/2020	1	White-tailed eagle	1	15:09	277	82	75	120	0	0	0
2	16/02/2021	1	Golden eagle	1	10:42	600	120	150	225	105	0	0
2	16/02/2021	1	Hen harrier	1	12:02	247	0	142	15	90	0	0
2	16/02/2021	1	Golden eagle	1	12:08	776	45	105	416	105	30	75
2	16/02/2021	1	Golden eagle	1	15:08	1073	105	120	323	180	90	255
2	16/02/2021	1	Golden eagle	1	15:10	941	0	0	416	300	75	150
2	10/03/2021	2	White-tailed eagle	1	11:04	343	0	75	268	0	0	0
2	10/03/2021	2	Golden eagle	1	11:05	292	7	30	90	165	0	0
2	10/03/2021	2	Golden eagle	1	11:25	149	15	30	104	0	0	0
2	10/03/2021	2	Golden eagle	1	12:02	394	0	0	394	0	0	0
2	10/03/2021	2	Golden eagle	1	09:59	422	45	75	122	105	75	0

Survey Year	Date	VP	Species	No. of Birds	Start Time (24hrs)	Total Flight Duration (secs) [8]	Total Time Spent (secs)[9]					
							HT1	HT2	HT3	HT4	HT5	HT6
2	10/03/2021	2	Golden eagle	1	10:46	998	143	195	570	90	0	0
2	10/03/2021	2	Hen harrier	1	10:59	259	109	75	75	0	0	0
2	10/03/2021	2	Golden eagle	1	11:07	1026	6	195	780	45	0	0
2	10/03/2021	2	Golden eagle	1	12:47	387	0	45	135	90	60	57
2	10/03/2021	2	Golden eagle	1	12:50	778	0	30	360	148	60	180
2	12/04/2021	1	Black-throated diver	2	15:35	364	0	0	364	0	0	0
2	16/04/2021	1	Curlew	1	10:37	54	9	45	0	0	0	0
2	16/04/2021	1	Greylag goose	6	07:41	984	0	0	0	540	444	0
2	16/04/2021	1	Red kite	1	11:18	190	0	190	0	0	0	0
2	16/04/2021	1	Red kite	2	11:16	200	150	50	0	0	0	0
2	16/04/2021	1	Red kite	1	11:18	336	0	45	180	111	0	0
2	16/04/2021	1	Greylag goose	2	06:54	440	0	60	380	0	0	0
2	27/04/2021	2	Lapwing	1	10:13	60	15	45	0	0	0	0
2	27/04/2021	2	Golden eagle	1	10:35	180	90	45	45	0	0	0
2	16/05/2021	2	Greylag goose	4	11:03	480	0	0	0	0	480	0
2	16/05/2021	2	Golden eagle	1	14:11	540	0	0	240	195	45	60
2	08/06/2021	2	Golden eagle	1	14:24	1309	4	120	595	320	195	75
2	08/06/2021	2	Golden eagle	1	15:09	891	0	0	141	165	165	420
2	08/06/2021	2	Golden eagle	1	16:01	1062	0	0	75	90	135	762
2	16/06/2021	1	Snipe	2	07:37	56	0	56	0	0	0	0
2	16/06/2021	1	Snipe	1	07:43	133	0	133	0	0	0	0
2	16/06/2021	1	Lapwing	1	07:32	38	15	23	0	0	0	0

Survey Year	Date	VP	Species	No. of Birds	Start Time (24hrs)	Total Flight Duration (secs) [8]	Total Time Spent (secs)[9]					
							HT1	HT2	HT3	HT4	HT5	HT6
2	20/06/2021	1	Snipe	1	10:40	5	0	5	0	0	0	0
2	20/06/2021	1	Hen harrier	1	14:19	60	45	15	0	0	0	0
2	20/06/2021	1	Lapwing	2	11:50	376	76	150	150	0	0	0
2	20/06/2021	1	Lapwing	1	12:02	190	15	175	0	0	0	0
2	20/06/2021	1	Snipe	1	11:25	240	0	105	135	0	0	0
2	20/06/2021	1	Snipe	1	14:41	81	0	81	0	0	0	0
2	20/06/2021	1	Lapwing	1	13:21	120	120	0	0	0	0	0
2	20/06/2021	1	Lapwing	1	14:11	75	0	75	0	0	0	0
2	20/06/2021	1	Lapwing	2	14:58	240	30	210	0	0	0	0
2	20/06/2021	1	Short-toed eagle	1	12:05	1200	60	120	675	345	0	0
2	20/06/2021	1	Lapwing	1	16:26	107	107	0	0	0	0	0
2	20/06/2021	1	Lapwing	1	16:37	104	104	0	0	0	0	0
2	20/06/2021	1	Golden eagle	1	16:52	164	0	0	164	0	0	0
2	25/06/2021	2	Wood sandpiper	1	09:08	192	162	30	0	0	0	0
2	25/06/2021	2	Greylag goose	7	11:39	56	0	0	56	0	0	0
2	25/06/2021	2	White-tailed eagle	1	11:37	342	57	105	105	75	0	0
2	25/06/2021	2	Snipe	1	10:21	260	0	120	140	0	0	0
2	06/07/2021	1	Lapwing	1	09:03	127	52	75	0	0	0	0
2	06/07/2021	1	Hen harrier	1	10:40	370	0	220	150	0	0	0
2	06/07/2021	1	Golden eagle	1	11:49	423	0	0	78	345	0	0
2	05/08/2021	2	Golden eagle	1	14:35	216	0	0	216	0	0	0
2	05/08/2021	2	Golden eagle	1	15:25	777	0	60	135	162	270	150

Survey Year	Date	VP	Species	No. of Birds	Start Time (24hrs)	Total Flight Duration (secs) [8]	Total Time Spent (secs)[9]					
							HT1	HT2	HT3	HT4	HT5	HT6
2	05/08/2021	2	Golden eagle	1	14:34	243	0	45	135	63	0	0
2	05/08/2021	2	Golden eagle	1	15:21	426	0	0	90	75	156	105

ANNEX 2 – COLLISION PROBABILITY CALCULATIONS

Golden eagle

K: [1D or [3D] (0 or 1)	**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		collide		contribution	collide		contribution
Pitch (degrees)	**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	6.70	35.08	1.00	0.00125	33.47	1.00	0.00125
Wingspan	**2.12**	m	0.075	0.575	2.23	12.23	0.43	0.00321	10.62	0.37	0.00279
F: Flapping (0) or gliding (+1)	**0**		0.125	0.702	1.34	8.72	0.31	0.00381	6.76	0.24	0.00296
			0.175	0.860	0.96	7.52	0.26	0.00461	5.12	0.18	0.00313
Bird speed	**15**	m/sec	0.225	0.994	0.74	6.83	0.24	0.00537	4.05	0.14	0.00319
Rotor Diam	**163**	m	0.275	0.947	0.61	5.62	0.20	0.00541	2.97	0.10	0.00286
Rotation Period	**5.71**	sec	0.325	0.899	0.52	4.76	0.17	0.00542	2.25	0.08	0.00256
			0.375	0.851	0.45	4.12	0.14	0.00540	1.74	0.06	0.00228
			0.425	0.804	0.39	3.61	0.13	0.00537	1.36	0.05	0.00203
			0.475	0.756	0.35	3.27	0.11	0.00543	1.15	0.04	0.00192
Bird aspect ratio:	0.39		0.525	0.708	0.32	2.99	0.10	0.00549	1.01	0.04	0.00185
			0.575	0.660	0.29	2.75	0.10	0.00553	0.90	0.03	0.00181
			0.625	0.613	0.27	2.53	0.09	0.00554	0.82	0.03	0.00179
			0.675	0.565	0.25	2.34	0.08	0.00553	0.88	0.03	0.00208
			0.725	0.517	0.23	2.17	0.08	0.00550	0.92	0.03	0.00233
			0.775	0.470	0.22	2.01	0.07	0.00544	0.95	0.03	0.00257
			0.825	0.422	0.20	1.86	0.06	0.00536	0.96	0.03	0.00278
			0.875	0.374	0.19	1.72	0.06	0.00526	0.97	0.03	0.00297
			0.925	0.327	0.18	1.58	0.06	0.00513	0.97	0.03	0.00313
			0.975	0.279	0.17	1.46	0.05	0.00498	0.96	0.03	0.00328
			Overall p(collision) =			**Upwind**		**9.9%**		**Downwind**	**5.0%**
								Average	**7.4%**		

Hen harrier

K: [1D or [3D] (0 or 1)	**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		collide		contribution	collide		contribution
Pitch (degrees)	**15**		radius	chord	alpha	length	p (collision)	from radius r	length	p (collision)	from radius r
Bird Length	**0.48**	m	0.025	0.575	5.13	21.84	1.00	0.00125	20.24	0.92	0.00115
Wingspan	**1.1**	m	0.075	0.575	1.71	7.82	0.36	0.00268	6.21	0.28	0.00213
F: Flapping (0) or gliding (+1)	**0**		0.125	0.702	1.03	5.87	0.27	0.00335	3.91	0.18	0.00223
			0.175	0.860	0.73	5.30	0.24	0.00423	2.89	0.13	0.00231
Bird speed	**11.5**	m/sec	0.225	0.994	0.57	4.98	0.23	0.00511	2.20	0.10	0.00226
Rotor Diam	**163**	m	0.275	0.947	0.47	4.14	0.19	0.00520	1.49	0.07	0.00188
Rotation Period	**5.71**	sec	0.325	0.899	0.39	3.59	0.16	0.00532	1.07	0.05	0.00159
			0.375	0.851	0.34	3.19	0.15	0.00546	0.81	0.04	0.00139
			0.425	0.804	0.30	2.87	0.13	0.00557	0.62	0.03	0.00121
			0.475	0.756	0.27	2.60	0.12	0.00564	0.49	0.02	0.00106
Bird aspect ratio:	0.44		0.525	0.708	0.24	2.37	0.11	0.00569	0.57	0.03	0.00136
			0.575	0.660	0.22	2.17	0.10	0.00570	0.63	0.03	0.00167
			0.625	0.613	0.21	1.99	0.09	0.00569	0.68	0.03	0.00194
			0.675	0.565	0.19	1.83	0.08	0.00564	0.71	0.03	0.00219
			0.725	0.517	0.18	1.68	0.08	0.00556	0.73	0.03	0.00240
			0.775	0.470	0.17	1.54	0.07	0.00546	0.73	0.03	0.00259
			0.825	0.422	0.16	1.41	0.06	0.00532	0.73	0.03	0.00274
			0.875	0.374	0.15	1.29	0.06	0.00515	0.72	0.03	0.00286
			0.925	0.327	0.14	1.17	0.05	0.00495	0.70	0.03	0.00296
			0.975	0.279	0.13	1.06	0.05	0.00472	0.68	0.03	0.00302
			Overall p(collision) =			**Upwind**		**9.8%**		**Downwind**	**4.1%**
								Average	**6.9%**		

ANNEX 3 – COLLISION RISK MODEL ANALYSIS

Golden eagle (Year 1)

VP	Watch data			Flying time (s)	Flying time hahr-1	Weighted flying time ha hr^-1	
	Area (ha)	Time (hrs)	HaHr	Risk height	Risk height	Weighting	Risk height
1	215.84	81.0	17483.04	17.37	0.0000002760	0.515438806	0.0000001423
2	202.91	81.0	16435.71	121.70	0.0000020568	0.484561194	0.0000009966
Totals	418.75	162.0	33918.75	139.07	0.0000023328	1.0000000000	0.0000011389

Mean activity hr^-1 in wind farm				WIND FARM DATA			
Risk height	0.00045	0.0453%		Wind farm area (ha)	397.60		
Daylight hours			3575.6				
Downtime			15	0.85		D	163.0
Vw =			648088000			L + d	6.22
Vr =			2075655	No. of turbines	16	R	81.5
Vr/Vw =			0.0032027				
Speed			15				
Vw Occupancy =			1.619	5828.9			
Vr Occupancy =			0.005	18.7			
Transit time =			0.415				
Transits =			45.021				
Collision probability from SNH sheet			0.074				
Collisions with no avoidance			3.332				
Collisions with 99% avoidance			0.033				
Collisions with 99% avoidance & downtime			0.028				

35 year mortality	1.166				
35 year mortality with 15% downtime etc	0.991				
Years for 1 death	35.313				

Golden eagle (Year 2)

VP	Watch data			Flying time (s)	Flying time hahr-1	Weighted flying time ha hr^-1	
	Area (ha)	Time (hrs)	HaHr	Risk height	Risk height	Weighting	Risk height
1	215.84	90.0	19425.60	1354.64	0.0000193707	0.515438806	0.0000099844
2	202.91	90.0	18261.90	2231.96	0.0000339498	0.484561194	0.0000164508
Totals	418.75	180.0	37687.50	3586.59	0.0000533205	1.0000000000	0.0000264352

Mean activity hr^-1 in wind farm				**WIND FARM DATA**	
Risk height	0.01051	1.0511%		**Wind farm area (ha)**	397.60

Daylight hours	4491.1				
Downtime	15	0.85		**D**	163.0
Vw =	648088000			**L + d**	6.22
Vr =	2075655	**No. of turbines**	16	**R**	81.5
Vr/Vw =	0.0032027				
Speed	15				
Vw Occupancy =	47.204	169935.5			
Vr Occupancy =	0.151	544.3			
Transit time =	0.415				
Transits =	1312.521				

Collision probability from SNH sheet	0.074				
Collisions with no avoidance	97.127				
Collisions with 99% avoidance	0.971				
Collisions with 99% avoidance & downtime	0.826				
35 year mortality	33.994				
35 year mortality with 15% downtime etc	28.895				
Years for 1 death	1.211				

Hen harrier (Year 1)

VP	Watch data			Flying time (s)	Flying time hahr-1	Weighted flying time ha hr^-1	
	Area (ha)	Time (hrs)	HaHr	Risk height	Risk height	Weighting	Risk height
1	215.84	81.0	17483.04	414.06	0.0000065788	0.515438806	0.0000033910
2	202.91	81.0	16435.71	136.16	0.0000023012	0.484561194	0.0000011151
Totals	418.75	162.0	33918.75	550.22	0.0000088800	1.0000000000	0.0000045060

Mean activity hr^-1 in wind farm				**WIND FARM DATA**			
Risk height	0.00179	0.1792%		**Wind farm area (ha)**	397.60		
Daylight hours			3575.6				
Downtime			15	0.85		**D**	163.0
Vw =			648088000			**L + d**	5.88
Vr =			1962195	**No. of turbines**	16	**R**	81.5
Vr/Vw =			0.0030277				
Speed			11.5				

Vw Occupancy =	6.406	23061.8			
Vr Occupancy =	0.019	69.8			
Transit time =	0.511				
Transits =	136.559				
Collision probability from SNH sheet	0.069				
Collisions with no avoidance	9.423				
Collisions with 99% avoidance	0.094				
Collisions with 99% avoidance & downtime	0.080				
35 year mortality	3.298				
35 year mortality with 15% downtime etc	2.803				
Years for 1 death	12.486				

Hen harrier (Year 2)

VP	**Watch data**			**Flying time (s)**	**Flying time hahr-1**	**Weighted flying time ha hr^-1**	
	Area (ha)	**Time (hrs)**	**HaHr**	**Risk height**	**Risk height**	**Weighting**	**Risk height**
1	215.84	90.0	19425.60	397.60	0.0000056856	0.515438806	0.0000029306
2	202.91	90.0	18261.90	225.73	0.0000034336	0.484561194	0.0000016638
Totals	418.75	180.0	37687.50	623.34	0.0000091191	1.0000000000	0.0000045943

Mean activity hr^-1 in wind farm				**WIND FARM DATA**			
Risk height	0.00183	0.1827%		**Wind farm area (ha)**	397.60		
Daylight hours			4491.1				
Downtime			15	0.85		**D**	163.0

Vw =	648088000			**L + d**	5.88
Vr =	1962195	**No. of turbines**	16	**R**	81.5
Vr/Vw =	0.0030277				
Speed	11.5				
Vw Occupancy =	8.204	29534.1			
Vr Occupancy =	0.025	89.4			
Transit time =	0.511				
Transits =	174.885				
Collision probability from SNH sheet	0.069				
Collisions with no avoidance	12.067				
Collisions with 99% avoidance	0.121				
Collisions with 99% avoidance & downtime	0.103				
35 year mortality	4.223				
35 year mortality with 15% downtime etc	3.590				
Years for 1 death	9.749				