Technical Appendix 9.2

Collision Risk Modelling

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SCOTTISHPOWER RENEWABLES

ORNITHOLOGY Technical Appendix 9.2

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1.1 Introduction

1.1.1 Birds that are not displaced would be potentially vulnerable to collision with the wind turbines. The level of collision with wind turbines is presumed to be dependent on the level of flight activity over the proposed Development and the ability of birds to detect and manoeuvre around rotating turbine blades. Birds that collide with a turbine are likely to be killed or fatally injured. This may in turn affect the maintenance of bird populations.

1.1.2 Band *et al.* (2007) described a method by which field data on bird flight activity can be gathered and used to quantify crudely the likelihood of collisions with turbines: the 'Band' Collision Risk Model (CRM). This method is more suitable for some species than others (Madders & Whitfield 2006). For example, fast moving raptors like merlin and most songbirds are difficult to detect beyond a distance of a few hundred metres and nocturnal species are difficult to detect at all. As a result it is rarely possible to generate reliable estimates of flight activity for these species and collision risk is best determined qualitatively.

1.1.3 The Band CRM involves two methods to predict estimated collision fatalities, depending on the pattern of flight of the species involved: 'predictable' and 'unpredictable' flight methods. The predictable flight method (PFM) is appropriate when birds tend to move through an area in a relatively consistent direction, such as during migration or when moving between localised feeding and roosting sites. The unpredictable flight method (UFM) is more appropriate when flights are not in any particular direction and assumes that they are random. These two methods also differ in their field data requirements.

1.1.4 The two methods differ in the unit of exposure to collision risk. The PFM estimates a horizontal risk area which is the area of the turbine rotors facing a bird as it flies towards (with the 'intention' of flying through) the proposed Development. The extent of the Risk Area is given by the horizontal span of the proposed turbine array facing the bird on its typical flight direction multiplied by the vertical span of the proposed turbine rotors. The UFM employs an estimated risk volume, in keeping with the assumption that flight directions are random in space.

1.2 Methods

1.2.1 Data was gathered separately by RPS for an area containing 16 turbines (Polskeoch) and by NRP for an area containing five turbines (Euchanhead). The flight activity was run separately through the CRM for each area (**Annexe 1**) and then combined (**Table 1**).

1.2.2 The UFM of the Band CRM was used to estimate collision risk on peregrine and goshawk in both the breeding season and the non-breeding season, based on flight activity levels and behaviour, turbine numbers and dimensions, and bird biometrics and flight characteristics. Dimensions and operational parameters of the candidate turbine model were used to populate the CRM, including an assumed hub height of 155 m for 21 turbines and a rotor diameter of 150 m. Different height band categories were used in the Polskeoch and Euchanhead areas with 40 to 250 m used at Polskeoch and 50 to >150 m used at Euchanhead as appropriate recorded flight height bands.

1.2.3 Data on bird flight speed and biometrics were taken from Bruderer & Boldt (2001), Proven & Whitfield (2007) and Snow & Perrins (1998), and the published avoidance rates was used (SNH 2017). For each season, day length was calculated using the method of Forsythe *et al*. (1995).

1.2.4 Utilising all flight observations collected across the study area from all VPs was likely to result in underestimates or overestimates of collision risk because data was collected for areas in which no turbines were (ultimately) proposed. Therefore, it was appropriate to employ only those observations in which flights were liable to incur a potential risk of collision; i.e., within the areas occupied by proposed turbines. Consequently, the CRMs used only observations collected within a flight activity assessment area (FA), comprising a 500 m buffer (centred on the turbine tower) around proposed turbine locations. This size of buffer encompasses rotor blade length, possible shifts in proposed turbine location due to micro-siting and, crucially, potential spatial errors in flight recording accuracy due to the effects of parallax. Flight time within this buffer was calculated from the proportion of the length of each flight which fell within the 500 m buffer multiplied by the total duration of each flight (i.e. effectively assuming a constant speed for each flight). Time spent at different flight heights was estimated from time-interval data on height. To ensure that the CRMs used robust measures of flight activity, a 2 km distance truncation was assumed in the area visible from each VP.

Peregrine

1.2.5 As a pair of peregrine were present in suitable breeding habitat within the study area the CRM was run for this species. As peregrines are present on their territory all year the CRM was run the whole year.

1.2.6 A total of eight flights were included in the CRM for peregrine. Data on peregrine flight speed (13 m/s) was taken from Bruderer & Boldt (2001) and biometrics (0.42 m length, 1.0 m wingspan) from Snow & Perrins (1998) and a 98% avoidance rate was used (SNH 2017).

Goshawk

1.2.7 As goshawk showed some site fidelity and have historically bred in the area the CRM was run for this species. As goshawks are present on their territory all year the CRM was run for the whole year.

1.2.8 Following the analyses described above a total of thirteen flights were included in the CRM for goshawk. Data on goshawk flight speed (9.9 m/s) and biometrics (0.55 m length, 1.5 m wingspan) were taken from Proven & Whitfield (2007) and a 98 % avoidance rate was used (SNH 2017).

1.3 Results

1.3.1 For full modelling spreadsheets see Annexes below. Summary results are presented in **Table 1**.

Table 1. Results for collision risk modelling for data collected between April 2019 and March 2020

Species	Period	Area	No. turbines	Birds per year	One bird every x years
Peregrine	All year	Polskeoch	16	0.029	34.2
		Euchanhead	5	0.002	502.4
		Total	**21**	**0.031**	**33**
Goshawk	All year	Polskeoch	16	0.015	65.7
		Euchanhead	5	0.001	1717.7
		Total	**21**	**0.016**	**62.5**

Peregrine

1.3.2 For the data gathered throughout the year between April 2019 and March 2020, the predicted annual collision risk for peregrine is 0.031 (approximately one bird every 33 years).

Goshawk

1.3.3 For the data gathered throughout the year between April 2019 and March 2020, the predicted annual collision risk for goshawk is 0.16 (approximately one bird every 62.5 years).

1.4 References

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Annex 1 – CRM data

Peregrine – Polskeoch all year

Input Data

WIND TURBINE PARAMETERS		
Size of turbine envelope	1	ha
Number of turbines	16	
Rotor diameter	150	m
Hub height	155	m
Max. rotor depth in metres	2.0	m
Max. chord	4.20	m
Pitch	6.0	degrees
Rotation period	10.04	s
Turbine operation time	87	%

BIRD PARAMETERS		
Length	0.42	m
Wingspan	1.0	m
Flapping (0) or gliding (+1)	0	
Assumed flight speed	13	ms^-1
Number of hours birds potentially present	4495	per year
Assumed avoidance rate	98	%

BAND USED TO DEFINE 'RISK HEIGHT'		
Max height	250	m
Min height	40	m

Optional inputs

note that a value of 1 or more must be entered in Cell B3

note that the formula in Cell B19 may require to be changed according to whether the CRM is annual (from Daylight hours sheet; F11 annual is current default) or seasonal (G11 - winter; or H11 - summer)

CRM (unweighted)	*36.33595264*	*years*
CRM (weighted)	*34.20451677*	*years*

	Watch Data		Bird Flight Data	
VP	Area (ha)	Time (hrs)	Total (s)	'Risk height' (s)
19	255.3	72.0		248.0
28	337.3	75.0		12.0
32	166.4	78.0		0.0
33	279.6	75.0		153.0
34	191.6	72.0		0.0
Totals	1230.2	372.0	0.0	413.0

Collision Probability

			Calculation of alpha and p(collision) as a function of radius								
K: [1D or [3D] (0 or 1)	1						Upwind:			Downwind:	
NoBlades	3										
MaxChord	4.20	m	r/R	c/C	α	collide			collide		
Pitch (degrees)	6.0		radius	chord	alpha	length	p(collision)	y(x)	length	p(collision)	y(x)
			0				1.00	0.000		1.00	0.000
BirdLength	0.42	m	0.05	0.575	5.53	19.22	0.44	0.044	18.72	0.43	0.043
Wingspan	1.03	m	0.1	0.622	2.76	10.30	0.24	0.047	9.76	0.22	0.045
F: Flapping (0) or gliding (+1)	0		0.15	0.781	1.84	8.25	0.19	0.057	7.57	0.17	0.052
			0.2	0.939	1.38	7.26	0.17	0.067	6.43	0.15	0.059
Bird speed	13	m/sec	0.25	0.971	1.11	6.05	0.14	0.070	5.19	0.12	0.060
RotorDiam	150	m	0.3	0.923	0.92	4.91	0.11	0.068	4.10	0.09	0.057
RotationPeriod	10.02	sec	0.35	0.875	0.79	4.08	0.09	0.066	3.32	0.08	0.053
			0.4	0.827	0.69	3.46	0.08	0.064	2.74	0.06	0.050
integration interval	0.05		0.45	0.780	0.61	2.98	0.07	0.062	2.29	0.05	0.047
			0.5	0.732	0.55	2.58	0.06	0.059	1.94	0.04	0.045
Bird aspect ratioo: β	0.41		0.55	0.684	0.50	2.25	0.05	0.057	1.65	0.04	0.042
			0.6	0.637	0.46	1.98	0.05	0.055	1.42	0.03	0.039
			0.65	0.589	0.43	1.74	0.04	0.052	1.23	0.03	0.037
			0.7	0.541	0.39	1.55	0.04	0.050	1.08	0.02	0.035
			0.75	0.494	0.37	1.40	0.03	0.048	0.96	0.02	0.033
			0.8	0.446	0.35	1.26	0.03	0.046	0.87	0.02	0.032
			0.85	0.398	0.33	1.14	0.03	0.044	0.79	0.02	0.031
			0.9	0.350	0.31	1.02	0.02	0.042	0.72	0.02	0.030
			0.95	0.303	0.29	0.92	0.02	0.040	0.66	0.02	0.029
			1	0.255	0.28	0.83	0.02	0.038	0.60	0.01	0.028
				Overall p(collision) =			**Upwind**	**5.3%**		**Downwind**	**4.2%**
								Average	**4.7%**		

Results (weighted)

Flight Activity Per Unit Time & Area			Weighted By Observation Effort		
VP	Observation effort (HaHr)	Flying time at 'risk height'	VP	Weighting	Adjusted time at 'risk
19	18381.60	3.74771E-06	19	0.201	7.53514E-07
28	25297.50	1.31765E-07	28	0.277	3.64604E-08
32	12979.20	0	32	0.142	0
33	20970.00	2.0267E-06	33	0.229	4.6487E-07
34	13795.20	0	34	0.151	0
Totals	*91423.50*	*1.18124E-06*	*Totals*	1.000	1.25484E-06
			Mean activity hr^-1 in wind farm		
				Risk height	0.00013%
				Rotor height	0.00009%

MORTALITY ESTIMATE		
Flight risk volume (Vw)	1500000	m^3
Rotor radius^2	5625	m
Combined rotor swept area (Va)	282743	m^2
Vr = Va * (d + l)	684239	m^3
Bird occupancy (n)	0.00	hrs / yr
Bird occupancy of rotor swept vol (b)	6.62	bird-secs
Bird transit time (t)	0.19	secs
No. of transits through rotors	35.54	per year
Estimated no. of collisions	1.46	per year
After allowing for avoidance	0.029	per year
i.e. equivalent to one bird every	**34.2**	**years**

Peregrine – Euchanhead all year

Input Data

WIND TURBINE PARAMETERS		
Size of turbine envelope	1	ha
Number of turbines	5	
Rotor diameter	150	m
Hub height	155	m
Max. rotor depth in metres	2.0	m
Max. chord	4.20	m
Pitch	6.0	degrees
Rotation period	10.04	s
Turbine operation time	87	%

BIRD PARAMETERS		
Length	0.42	m
Wingspan	1.0	m
Flapping (0) or gliding (+1)	0	
Assumed flight speed	13	ms^-1
Number of hours birds potentially present	4495	per year
Assumed avoidance rate	98	%

BAND USED TO DEFINE 'RISK HEIGHT'		
Max height	250	m
Min height	50	m

Optional inputs
note that a value of 1 or more must be entered in Cell B3

note that the formula in Cell B19 may require to be changed according to whether the CRM is annual (from Daylight hours sheet; F11 annual is current default) or seasonal (G11 - winter; or H11 - summer)

CRM (unweighted)	*477.1028992*	*years*
CRM (weighted)	*502.3732863*	*years*

	Watch Data		Bird Flight Data	
VP	Area (ha)	Time (hrs)	Total (s)	'Risk height' (s)
1	241.2	70.3		0.0
2	386.0	72.0		0.0
3	341.9	72.0		6.0
4	296.2	72.0		79.0
Totals	1265.3	286.3	0.0	85.0

Collision Probability

			Calculation of alpha and p(collision) as a function of radius								
K: [1D or [3D] (0 or 1)	1					Upwind:			Downwind:		
NoBlades	3										
MaxChord	4.20	m	r/R	c/C	α	collide			collide		
Pitch (degrees)	6.0		radius	chord	alpha	length	p(collision)	y(x)	length	p(collision)	y(x)
			0				1.00	0.000		1.00	0.000
BirdLength	0.42	m	0.05	0.575	5.54	19.26	0.44	0.044	18.76	0.43	0.043
Wingspan	1.03	m	0.1	0.622	2.77	10.32	0.24	0.047	9.78	0.22	0.045
F: Flapping (0) or gliding (+1)	0		0.15	0.781	1.85	8.27	0.19	0.057	7.58	0.17	0.052
			0.2	0.939	1.38	7.27	0.17	0.067	6.45	0.15	0.059
Bird speed	13	m/sec	0.25	0.971	1.11	6.06	0.14	0.070	5.21	0.12	0.060
RotorDiam	150	m	0.3	0.923	0.92	4.91	0.11	0.068	4.10	0.09	0.057
RotationPeriod	10.04	sec	0.35	0.875	0.79	4.09	0.09	0.066	3.32	0.08	0.053
			0.4	0.827	0.69	3.47	0.08	0.064	2.74	0.06	0.050
integration interval	0.05		0.45	0.780	0.62	2.98	0.07	0.062	2.30	0.05	0.048
			0.5	0.732	0.55	2.59	0.06	0.059	1.94	0.04	0.045
Bird aspect ratioo: β	0.41		0.55	0.684	0.50	2.26	0.05	0.057	1.66	0.04	0.042
			0.6	0.637	0.46	1.98	0.05	0.055	1.42	0.03	0.039
			0.65	0.589	0.43	1.75	0.04	0.052	1.23	0.03	0.037
			0.7	0.541	0.40	1.55	0.04	0.050	1.08	0.02	0.035
			0.75	0.494	0.37	1.40	0.03	0.048	0.96	0.02	0.033
			0.8	0.446	0.35	1.26	0.03	0.046	0.87	0.02	0.032
			0.85	0.398	0.33	1.14	0.03	0.044	0.79	0.02	0.031
			0.9	0.350	0.31	1.02	0.02	0.042	0.72	0.02	0.030
			0.95	0.303	0.29	0.92	0.02	0.040	0.66	0.02	0.029
			1	0.255	0.28	0.83	0.02	0.038	0.60	0.01	0.028
				Overall p(collision) =			**Upwind**	**5.3%**		**Downwind**	**4.2%**
								Average	**4.7%**		

Results (weighted)

Flight Activity Per Unit Time & Area			Weighted By Observation Effort		
VP	Observation effort (HaHr)	Flying time at 'risk height'	VP	Weighting	Adjusted time at 'risk
1	16944.30	0	1	0.187	0
2	27792.00	0	2	0.306	0
3	24616.80	6.77044E-08	3	0.271	1.83798E-08
4	21326.40	1.02898E-06	4	0.235	2.42E-07
Totals	*90679.50*	*2.74171E-07*	*Totals*	1.000	2.6038E-07
			Mean activity hr^-1 in wind farm		
				Risk height	0.00003%

MORTALITY ESTIMATE		
Flight risk volume (Vw)	1500000	m^3
Rotor radius^2	5625	m
Combined rotor swept area (Va)	88357	m^2
Vr = Va * (d + l)	213825	m^3
Bird occupancy (n)	0.00	hrs / yr
Bird occupancy of rotor swept vol (b)	0.45	bird-secs
Bird transit time (t)	0.19	secs
No. of transits through rotors	2.42	per year
Estimated no. of collisions	0.10	per year
After allowing for avoidance	0.002	per year
i.e. equivalent to one bird every	**502.4**	**years**

Goshawk – Polskeoch all year

Input Data

WIND TURBINE PARAMETERS		
Size of windfarm envelope	1	ha
Number of turbines	16	
Rotor diameter	150	m
Hub height	155	m
Max. rotor depth in metres	2.0	m
Max. chord	4.20	m
Pitch	6.0	degrees
Rotation period	10.04	s
Turbine operation time	87	%

BIRD PARAMETERS		
Length	0.55	m
Wingspan	1.5	m
Flapping (0) or gliding (+1)	0	
Assumed flight speed	10	ms^-1
Number of hours birds potentially present	4495	per year
Assumed avoidance rate	98	%

BAND USED TO DEFINE 'RISK HEIGHT'		
Max height	250	m
Min height	40	m

Optional inputs

note that a value of 1 or more must be entered in Cell B3

note that the formula in Cell B19 may require to be changed according to whether the CRM is annual (from Daylight hours sheet; F11 annual is current default) or seasonal (G11 - winter; or H11 - summer)

CRM (unweighted)	*73.00926533*	*years*
CRM (weighted)	*65.74782119*	*years*

	Watch Data		Bird Flight Data	
VP	Area (ha)	Time (hrs)	Total (s)	'Risk height' (s)
19	255.3	72.0		23.0
28	337.3	75.0		158.0
32	166.4	78.0		0.0
33	279.6	75.0		0.0
34	191.6	72.0		61.0
Totals	1230.2	372.0	0.0	242.0

Collision Probability

			Calculation of alpha and p(collision) as a function of radius								
K: [1D or [3D] (0 or 1)	1					Upwind:			Downwind:		
NoBlades	3										
MaxChord	4.20	m	r/R	c/C	α	collide			collide		
Pitch (degrees)	6.0		radius	chord	alpha	length	p(collision)	y(x)	length	p(collision)	y(x)
			0				1.00	0.000		1.00	0.000
BirdLength	0.55	m	0.05	0.575	4.22	16.71	0.50	0.050	16.21	0.49	0.049
Wingspan	1.5	m	0.1	0.622	2.11	8.92	0.27	0.054	8.37	0.25	0.051
F: Flapping (0) or gliding (+1)	0		0.15	0.781	1.41	7.04	0.21	0.064	6.35	0.19	0.058
			0.2	0.939	1.05	6.13	0.19	0.074	5.31	0.16	0.064
Bird speed	10	m/sec	0.25	0.971	0.84	5.11	0.15	0.077	4.26	0.13	0.064
RotorDiam	150	m	0.3	0.923	0.70	4.17	0.13	0.076	3.36	0.10	0.061
RotationPeriod	10.04	sec	0.35	0.875	0.60	3.49	0.11	0.074	2.72	0.08	0.058
			0.4	0.827	0.53	2.98	0.09	0.072	2.25	0.07	0.054
integration interval	0.05		0.45	0.780	0.47	2.57	0.08	0.070	1.89	0.06	0.051
			0.5	0.732	0.42	2.24	0.07	0.068	1.60	0.05	0.048
Bird aspect ratioo: β	0.37		0.55	0.684	0.38	1.97	0.06	0.065	1.37	0.04	0.046
			0.6	0.637	0.35	1.76	0.05	0.064	1.21	0.04	0.044
			0.65	0.589	0.32	1.61	0.05	0.063	1.09	0.03	0.043
			0.7	0.541	0.30	1.47	0.04	0.062	0.99	0.03	0.042
			0.75	0.494	0.28	1.35	0.04	0.061	0.91	0.03	0.041
			0.8	0.446	0.26	1.24	0.04	0.060	0.85	0.03	0.041
			0.85	0.398	0.25	1.14	0.03	0.058	0.79	0.02	0.040
			0.9	0.350	0.23	1.05	0.03	0.057	0.74	0.02	0.040
			0.95	0.303	0.22	0.96	0.03	0.055	0.70	0.02	0.040
			1	0.255	0.21	0.89	0.03	0.054	0.66	0.02	0.040
				Overall p(collision) =			Upwind	6.3%		Downwind	4.8%
								Average	5.5%		

Results (weighted)

Flight Activity Per Unit Time & Area			Weighted By Observation Effort		
VP	Observation effort (HaHr)	Flying time at 'risk height'	VP	Weighting	Adjusted time at 'risk
19	18381.60	3.4757E-07	19	0.201	6.98823E-08
28	25297.50	1.73491E-06	28	0.277	4.80061E-07
32	12979.20	0	32	0.142	0
33	20970.00	0	33	0.229	0
34	13795.20	1.22829E-06	34	0.151	1.8534E-07
Totals	*91423.50*	*6.62153E-07*	*Totals*	1.000	7.35284E-07
			Mean activity hr^-1 in wind farm		
				Risk height	0.00007%
				Rotor height	0.00005%

MORTALITY ESTIMATE		
Flight risk volume (Vw)	1500000	m^3
Rotor radius^2	5625	m
Combined rotor swept area (Va)	282743	m^2
Vr = Va * (d + l)	720996	m^3
Bird occupancy (n)	0.00	hrs / yr
Bird occupancy of rotor swept vol (b)	4.09	bird-secs
Bird transit time (t)	0.26	secs
No. of transits through rotors	15.86	per year
Estimated no. of collisions	0.76	per year
After allowing for avoidance	0.015	per year
i.e. equivalent to one bird every	**65.7**	**years**

Goshawk – Euchanhead all year

Input Data

WIND TURBINE PARAMETERS		
Size of turbine envelope	1	ha
Number of turbines	5	
Rotor diameter	150	m
Hub height	155	m
Max. rotor depth in metres	2.0	m
Max. chord	4.20	m
Pitch	6.0	degrees
Rotation period	10.04	s
Turbine operation time	87	%

BIRD PARAMETERS		
Length	0.55	m
Wingspan	1.5	m
Flapping (0) or gliding (+1)	0	
Assumed flight speed	10	ms^-1
Number of hours birds potentially present	4495	per year
Assumed avoidance rate	98	%

BAND USED TO DEFINE 'RISK HEIGHT'		
Max height	250	m
Min height	50	m

Optional inputs
note that a value of 1 or more must be entered in Cell B3

note that the formula in Cell B19 may require to be changed according to whether the CRM is annual (from Daylight hours sheet; F11 annual is current default) or seasonal (G11 - winter; or H11 - summer)

CRM (unweighted)	*1283.882145*	*years*
CRM (weighted)	*1717.713198*	*years*

	Watch Data		Bird Flight Data	
VP	Area (ha)	Time (hrs)	Total (s)	'Risk height' (s)
1	241.2	70.3		28.0
2	386.0	72.0		0.0
3	341.9	72.0		0.0
4	296.2	72.0		0.0
Totals	1265.3	286.3	0.0	28.0

Collision Probability

			Calculation of alpha and p(collision) as a function of radius								
K: [1D or [3D] (0 or 1)	1					Upwind:			Downwind:		
NoBlades	3										
MaxChord	4.20	m	r/R	c/C	α	collide			collide		
Pitch (degrees)	6.0		radius	chord	alpha	length	p(collision)	y(x)	length	p(collision)	y(x)
			0				1.00	0.000		1.00	0.000
BirdLength	0.55	m	0.05	0.575	4.22	16.71	0.50	0.050	16.21	0.49	0.049
Wingspan	1.5	m	0.1	0.622	2.11	8.92	0.27	0.054	8.37	0.25	0.051
F: Flapping (0) or gliding (+1)	0		0.15	0.781	1.41	7.04	0.21	0.064	6.35	0.19	0.058
			0.2	0.939	1.05	6.13	0.19	0.074	5.31	0.16	0.064
Bird speed	10	m/sec	0.25	0.971	0.84	5.11	0.15	0.077	4.26	0.13	0.064
RotorDiam	150	m	0.3	0.923	0.70	4.17	0.13	0.076	3.36	0.10	0.061
RotationPeriod	10.04	sec	0.35	0.875	0.60	3.49	0.11	0.074	2.72	0.08	0.058
			0.4	0.827	0.53	2.98	0.09	0.072	2.25	0.07	0.054
integration interval	0.05		0.45	0.780	0.47	2.57	0.08	0.070	1.89	0.06	0.051
			0.5	0.732	0.42	2.24	0.07	0.068	1.60	0.05	0.048
Bird aspect ratioo: β	0.37		0.55	0.684	0.38	1.97	0.06	0.065	1.37	0.04	0.046
			0.6	0.637	0.35	1.76	0.05	0.064	1.21	0.04	0.044
			0.65	0.589	0.32	1.61	0.05	0.063	1.09	0.03	0.043
			0.7	0.541	0.30	1.47	0.04	0.062	0.99	0.03	0.042
			0.75	0.494	0.28	1.35	0.04	0.061	0.91	0.03	0.041
			0.8	0.446	0.26	1.24	0.04	0.060	0.85	0.03	0.041
			0.85	0.398	0.25	1.14	0.03	0.058	0.79	0.02	0.040
			0.9	0.350	0.23	1.05	0.03	0.057	0.74	0.02	0.040
			0.95	0.303	0.22	0.96	0.03	0.055	0.70	0.02	0.040
			1	0.255	0.21	0.89	0.03	0.054	0.66	0.02	0.040
				Overall p(collision) =			Upwind	6.3%		Downwind	4.8%
								Average	5.5%		

Results (weighted)

Flight Activity Per Unit Time & Area			Weighted By Observation Effort		
VP	Observation effort (HaHr)	Flying time at 'risk height'	VP	Weighting	Adjusted time at 'risk
1	16944.30	4.5902E-07	1	0.187	8.57722E-08
2	27792.00	0	2	0.306	0
3	24616.80	0	3	0.271	0
4	21326.40	0	4	0.235	0
Totals	*90679.50*	*1.14755E-07*	*Totals*	1.000	8.57722E-08
			Mean activity hr^-1 in wind farm		
				Risk height	0.00001%
				Rotor height	0.00001%

MORTALITY ESTIMATE		
Flight risk volume (Vw)	1500000	m^3
Rotor radius^2	5625	m
Combined rotor swept area (Va)	88357	m^2
Vr = Va * (d + l)	225311	m^3
Bird occupancy (n)	0.00	hrs / yr
Bird occupancy of rotor swept vol (b)	0.16	bird-secs
Bird transit time (t)	0.26	secs
No. of transits through rotors	0.61	per year
Estimated no. of collisions	0.03	per year
After allowing for avoidance	0.001	per year
i.e. equivalent to one bird every	**1717.7**	**years**

ScottishPower Renewables
9th Floor
320 St Vincent Street
Glasgow
G2 5AD

T +44 (0)141 614 0451

euchanheadrenewables@scottishpower.com

SCOTTISHPOWER
RENEWABLES