TECHNICAL APPENDIX 9.5: TORFICHEN WIND FARM COLLISION RISK MODELLING CALCULATIONS

October 2023

TECHNICAL APPENDIX 9.5: TORFICHEN WIND FARM COLLISION RISK MODELLING CALCULATIONS

INTRODUCTION

This Technical Appendix sets out the collision risk modelling that has been undertaken to support the ornithological assessment of the proposed Torfichen Wind Farm (the 'Proposed Development'). The collision risk modelling was carried out for all the key target species recorded flying through the collision risk zone at rotor height (as per SNH guidance 2018). Rotor height was 30-180 m above ground level.

The modelling included six target raptor species (osprey, goshawk, red kite, hen harrier, peregrine and merlin) and two breeding waders (curlew and lapwing). The collision risk for each of these species was modelled using the non-direct flight model. In addition, wintering/migrating whooper swans, greylag geese, barnacle geese, pink-footed geese, golden plover and herring gulls were observed flying through the collision risk zone and were also modelled to determine their collision risk. As their flights were largely direct ones through the site, the direct flight model was applied. No other key species were recorded flying through the collision risk zone at rotor height.

The collision risk model used in this assessment (Band *et al.* 2007) was run as a two-stage process. Firstly, the risk is calculated making the assumption that flight patterns are unaffected by the presence of the wind turbines, i.e. that no avoidance action is taken. This is essentially a mechanistic calculation, with the collision risk calculated as the product of (i) the probability of a bird flying through the rotor swept area, and (ii) the probability of a bird colliding if it does so. This probability is then multiplied by the estimated numbers of bird movements through the wind farm rotors at the risk height (i.e. the height of the rotating rotor blades) in order to estimate the theoretical numbers at risk of collision if they take no avoiding action.

The second stage then incorporates the probability that the birds, rather than flying blindly into the turbines, will actually take a degree of avoiding action, as has been shown to occur in all studies of birds at existing wind farms. NatureScot has recommended a precautionary approach, using a value of 98% as a general default avoidance rate, 99% for some larger raptors (including red kite and hen harrier) and 99.8% for geese (SNH 2017). This precautionary approach is useful as an initial filter to identify sites where collision risk is clearly not an issue, but does not necessarily provide a realistic estimate of actual likely collision rates when compared with data from existing wind farms. The magnitude of the impact was determined as a percentage increase in the existing baseline mortality (to put the potential wind farm mortality into the ecological context of the birds' population dynamics), though professional judgement was also applied in the assessment of any non-negligible magnitude collision risks predicted.

Body sizes and baseline mortality rates were taken from Robinson (2005) and flight speeds from Alerstam *et al.* (2007).

BAND MODEL SPREADSHEETS (STAGE 1)

Firstly, the standard Band model spreadsheets (Band *et al*. 2007) are presented for each species modelled in turn. These provide the information used to calculate the risk that individuals of each species would face if they flew through the Proposed Development rotor swept area. For the first species, for example, whooper swan, this gives an overall 7.2% chance of collision.

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA												
Whooper Swan												
Only enter input parameters in blue												
K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**									
NoBlades	3						Upwind:				Downwind:	
MaxChord	4.1	m	r/R	c/C	a	collide		contribution	collide		contribution	
Pitch (degrees)	15		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r	
BirdLength	1.52	m	0.025	0.575	11.01	51.02	1.00	0.00125	49.80	1.00	0.00125	
Wingspan	2.3	m	0.075	0.575	3.67	17.41	0.40	0.00302	16.19	0.37	0.00281	
F: Flapping (0) or gliding (+1)	0		0.125	0.702	2.20	11.93	0.28	0.00345	10.44	0.24	0.00302	
			0.175	0.860	1.57	9.89	0.23	0.00400	8.07	0.19	0.00326	
Bird speed	17.3	m/sec	0.225	0.994	1.22	8.69	0.20	0.00452	6.58	0.15	0.00342	
RotorDiam	150	m	0.275	0.947	1.00	7.06	0.16	0.00449	5.05	0.12	0.00321	
RotationPeriod	7.50	sec	0.325	0.899	0.85	5.92	0.14	0.00445	4.01	0.09	0.00301	
			0.375	0.851	0.73	5.07	0.12	0.00439	3.26	0.08	0.00283	
			0.425	0.804	0.65	4.43	0.10	0.00436	2.73	0.06	0.00268	
			0.475	0.756	0.58	4.06	0.09	0.00446	2.45	0.06	0.00269	
Bird aspect ratio: b	0.66		0.525	0.708	0.52	3.74	0.09	0.00454	2.24	0.05	0.00272	
			0.575	0.660	0.48	3.47	0.08	0.00462	2.07	0.05	0.00275	
			0.625	0.613	0.44	3.24	0.07	0.00468	1.94	0.04	0.00280	
			0.675	0.565	0.41	3.03	0.07	0.00473	1.83	0.04	0.00286	
			0.725	0.517	0.38	2.85	0.07	0.00477	1.75	0.04	0.00293	
			0.775	0.470	0.36	2.68	0.06	0.00480	1.68	0.04	0.00301	
			0.825	0.422	0.33	2.53	0.06	0.00482	1.63	0.04	0.00311	
			0.875	0.374	0.31	2.38	0.06	0.00482	1.59	0.04	0.00322	
			0.925	0.327	0.30	2.25	0.05	0.00482	1.56	0.04	0.00333	
			0.975	0.279	0.28	2.13	0.05	0.00480	1.54	0.04	0.00346	
				Overall p(collision) =			**Upwind**	**8.6%**		**Downwind**	**5.8%**	
								Average	**7.2%**			

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA												
Greylag Goose												
Only enter input parameters in blue												
K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**									
NoBlades	3						Upwind:				Downwind:	
MaxChord	4.1	m	r/R	c/C	a	collide		contribution	collide		contribution	
Pitch (degrees)	15		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r	
BirdLength	0.82	m	0.025	0.575	10.89	43.25	1.00	0.00125	42.03	0.98	0.00123	
Wingspan	1.64	m	0.075	0.575	3.63	14.82	0.35	0.00260	13.60	0.32	0.00239	
F: Flapping (0) or gliding (+1)	0		0.125	0.702	2.18	10.36	0.24	0.00303	8.87	0.21	0.00260	
			0.175	0.860	1.56	8.76	0.20	0.00359	6.94	0.16	0.00284	
Bird speed	17.1	m/sec	0.225	0.994	1.21	7.80	0.18	0.00411	5.69	0.13	0.00300	
RotorDiam	150	m	0.275	0.947	0.99	6.34	0.15	0.00408	4.33	0.10	0.00278	
RotationPeriod	7.50	sec	0.325	0.899	0.84	5.31	0.12	0.00404	3.40	0.08	0.00259	
			0.375	0.851	0.73	4.54	0.11	0.00398	2.73	0.06	0.00240	
			0.425	0.804	0.64	3.94	0.09	0.00392	2.24	0.05	0.00222	
			0.475	0.756	0.57	3.46	0.08	0.00384	1.85	0.04	0.00206	
Bird aspect ratio: b	0.50		0.525	0.708	0.52	3.06	0.07	0.00375	1.55	0.04	0.00191	
			0.575	0.660	0.47	2.76	0.06	0.00371	1.36	0.03	0.00183	
			0.625	0.613	0.44	2.53	0.06	0.00369	1.23	0.03	0.00179	
			0.675	0.565	0.40	2.32	0.05	0.00367	1.12	0.03	0.00177	
			0.725	0.517	0.38	2.14	0.05	0.00363	1.04	0.02	0.00176	
			0.775	0.470	0.35	1.97	0.05	0.00357	0.97	0.02	0.00177	
			0.825	0.422	0.33	1.82	0.04	0.00351	0.92	0.02	0.00178	
			0.875	0.374	0.31	1.68	0.04	0.00343	0.88	0.02	0.00181	
			0.925	0.327	0.29	1.55	0.04	0.00335	0.85	0.02	0.00185	
			0.975	0.279	0.28	1.42	0.03	0.00325	0.83	0.02	0.00190	
				Overall p(collision) =			**Upwind**	**7.0%**		**Downwind**	**4.2%**	
								Average	**5.6%**			

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA												
Pink-footed Goose												
Only enter input parameters in blue												
K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**									
NoBlades	3					Upwind:			Downwind:			
MaxChord	4.1	m	r/R	c/C	a	collide		contribution	collide		contribution	
Pitch (degrees)	15		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r	
BirdLength	0.68	m	0.025	0.575	11.01	42.43	0.98	0.00123	41.21	0.95	0.00119	
Wingspan	1.52	m	0.075	0.575	3.67	14.55	0.34	0.00252	13.33	0.31	0.00231	
F: Flapping (0) or gliding (+1)	0		0.125	0.702	2.20	10.21	0.24	0.00295	8.72	0.20	0.00252	
			0.175	0.860	1.57	8.66	0.20	0.00351	6.84	0.16	0.00277	
Bird speed	17.3	m/sec	0.225	0.994	1.22	7.73	0.18	0.00402	5.62	0.13	0.00293	
RotorDiam	150	m	0.275	0.947	1.00	6.28	0.15	0.00399	4.27	0.10	0.00272	
RotationPeriod	7.50	sec	0.325	0.899	0.85	5.26	0.12	0.00395	3.35	0.08	0.00252	
			0.375	0.851	0.73	4.49	0.10	0.00390	2.69	0.06	0.00233	
			0.425	0.804	0.65	3.90	0.09	0.00383	2.19	0.05	0.00216	
			0.475	0.756	0.58	3.42	0.08	0.00375	1.81	0.04	0.00199	
Bird aspect ratio: b	0.45		0.525	0.708	0.52	3.02	0.07	0.00367	1.52	0.04	0.00184	
			0.575	0.660	0.48	2.68	0.06	0.00356	1.28	0.03	0.00170	
			0.625	0.613	0.44	2.40	0.06	0.00347	1.10	0.03	0.00159	
			0.675	0.565	0.41	2.19	0.05	0.00342	0.99	0.02	0.00155	
			0.725	0.517	0.38	2.01	0.05	0.00336	0.91	0.02	0.00152	
			0.775	0.470	0.36	1.84	0.04	0.00330	0.84	0.02	0.00151	
			0.825	0.422	0.33	1.69	0.04	0.00322	0.79	0.02	0.00151	
			0.875	0.374	0.31	1.54	0.04	0.00312	0.75	0.02	0.00152	
			0.925	0.327	0.30	1.41	0.03	0.00302	0.72	0.02	0.00154	
			0.975	0.279	0.28	1.29	0.03	0.00290	0.70	0.02	0.00157	
				Overall p(collision) =			**Upwind**	**6.7%**		**Downwind**	**3.9%**	
								Average	**5.3%**			

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA											
Barnacle Goose											
Only enter input parameters in blue											
K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**								
NoBlades	3					Upwind:			Downwind:		
MaxChord	4.1	m	r/R	c/C	a	collide		contribution	collide		contribution
Pitch (degrees)	15		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
BirdLength	0.64	m	0.025	0.575	10.82	40.19	0.95	0.00118	38.97	0.92	0.00115
Wingspan	1.38	m	0.075	0.575	3.61	13.80	0.32	0.00244	12.58	0.30	0.00222
F: Flapping (0) or gliding (+1)	0		0.125	0.702	2.16	9.74	0.23	0.00287	8.26	0.19	0.00243
			0.175	0.860	1.55	8.31	0.20	0.00342	6.49	0.15	0.00267
Bird speed	17	m/sec	0.225	0.994	1.20	7.45	0.18	0.00394	5.34	0.13	0.00283
RotorDiam	150	m	0.275	0.947	0.98	6.05	0.14	0.00392	4.04	0.10	0.00262
RotationPeriod	7.50	sec	0.325	0.899	0.83	5.07	0.12	0.00387	3.16	0.07	0.00242
			0.375	0.851	0.72	4.33	0.10	0.00382	2.52	0.06	0.00223
			0.425	0.804	0.64	3.76	0.09	0.00376	2.05	0.05	0.00205
			0.475	0.756	0.57	3.29	0.08	0.00368	1.69	0.04	0.00189
Bird aspect ratio: b	0.46		0.525	0.708	0.52	2.91	0.07	0.00359	1.41	0.03	0.00174
			0.575	0.660	0.47	2.58	0.06	0.00349	1.18	0.03	0.00160
			0.625	0.613	0.43	2.34	0.06	0.00344	1.04	0.02	0.00153
			0.675	0.565	0.40	2.14	0.05	0.00339	0.94	0.02	0.00149
			0.725	0.517	0.37	1.95	0.05	0.00333	0.86	0.02	0.00146
			0.775	0.470	0.35	1.79	0.04	0.00326	0.79	0.02	0.00144
			0.825	0.422	0.33	1.64	0.04	0.00318	0.74	0.02	0.00144
			0.875	0.374	0.31	1.50	0.04	0.00308	0.70	0.02	0.00144
			0.925	0.327	0.29	1.36	0.03	0.00297	0.67	0.02	0.00146
			0.975	0.279	0.28	1.24	0.03	0.00285	0.65	0.02	0.00149
				Overall p(collision) =			**Upwind**	**6.5%**		**Downwind**	**3.8%**
								Average	**5.2%**		

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA												
Osprey												
Only enter input parameters in blue												
K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**									
NoBlades	3						Upwind:				Downwind:	
MaxChord	4.1	m	r/R	c/C	a	collide		contribution	collide		contribution
Pitch (degrees)	15		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
BirdLength	0.56	m	0.025	0.575	8.47	33.44	1.00	0.00125	32.22	0.97	0.00121
Wingspan	1.6	m	0.075	0.575	2.82	11.55	0.35	0.00261	10.33	0.31	0.00233
F: Flapping (0) or gliding (+1)	0		0.125	0.702	1.69	8.16	0.25	0.00307	6.67	0.20	0.00251
			0.175	0.860	1.21	6.97	0.21	0.00367	5.14	0.15	0.00271
Bird speed	13.3	m/sec	0.225	0.994	0.94	6.27	0.19	0.00424	4.15	0.12	0.00281
RotorDiam	150	m	0.275	0.947	0.77	5.12	0.15	0.00424	3.11	0.09	0.00257
RotationPeriod	7.50	sec	0.325	0.899	0.65	4.31	0.13	0.00422	2.41	0.07	0.00235
			0.375	0.851	0.56	3.71	0.11	0.00418	1.90	0.06	0.00215
			0.425	0.804	0.50	3.23	0.10	0.00413	1.53	0.05	0.00195
			0.475	0.756	0.45	2.85	0.09	0.00407	1.24	0.04	0.00178
Bird aspect ratio: b	0.35		0.525	0.708	0.40	2.53	0.08	0.00399	1.02	0.03	0.00162
			0.575	0.660	0.37	2.25	0.07	0.00390	0.85	0.03	0.00147
			0.625	0.613	0.34	2.03	0.06	0.00382	0.73	0.02	0.00138
			0.675	0.565	0.31	1.86	0.06	0.00378	0.66	0.02	0.00134
			0.725	0.517	0.29	1.71	0.05	0.00372	0.61	0.02	0.00133
			0.775	0.470	0.27	1.57	0.05	0.00365	0.57	0.02	0.00133
			0.825	0.422	0.26	1.44	0.04	0.00356	0.58	0.02	0.00144
			0.875	0.374	0.24	1.32	0.04	0.00346	0.60	0.02	0.00158
			0.925	0.327	0.23	1.20	0.04	0.00335	0.61	0.02	0.00170
			0.975	0.279	0.22	1.10	0.03	0.00321	0.62	0.02	0.00181
				Overall p(collision) =			**Upwind**	**7.2%**		**Downwind**	**3.7%**
								Average	**5.5%**		

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA												
Red Kite												
Only enter input parameters in blue												
K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**									
NoBlades	3						Upwind:				Downwind:	
MaxChord	4.1	m	r/R	c/C	a	collide		contribution	collide		contribution
Pitch (degrees)	15		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
BirdLength	0.63	m	0.025	0.575	7.64	32.14	1.00	0.00125	30.92	1.00	0.00125
Wingspan	1.85	m	0.075	0.575	2.55	11.12	0.37	0.00278	9.90	0.33	0.00247
F: Flapping (0) or gliding (+1)	0		0.125	0.702	1.53	7.82	0.26	0.00326	6.33	0.21	0.00264
			0.175	0.860	1.09	6.65	0.22	0.00388	4.82	0.16	0.00281
Bird speed	12	m/sec	0.225	0.994	0.85	5.97	0.20	0.00448	3.86	0.13	0.00289
RotorDiam	150	m	0.275	0.947	0.69	4.89	0.16	0.00449	2.88	0.10	0.00264
RotationPeriod	7.50	sec	0.325	0.899	0.59	4.13	0.14	0.00448	2.23	0.07	0.00241
			0.375	0.851	0.51	3.56	0.12	0.00445	1.76	0.06	0.00219
			0.425	0.804	0.45	3.11	0.10	0.00441	1.41	0.05	0.00200
			0.475	0.756	0.40	2.75	0.09	0.00435	1.15	0.04	0.00181
Bird aspect ratio: b	0.34		0.525	0.708	0.36	2.44	0.08	0.00428	0.94	0.03	0.00165
			0.575	0.660	0.33	2.20	0.07	0.00422	0.80	0.03	0.00153
			0.625	0.613	0.31	2.02	0.07	0.00421	0.72	0.02	0.00150
			0.675	0.565	0.28	1.86	0.06	0.00419	0.66	0.02	0.00149
			0.725	0.517	0.26	1.72	0.06	0.00415	0.64	0.02	0.00154
			0.775	0.470	0.25	1.59	0.05	0.00410	0.67	0.02	0.00173
			0.825	0.422	0.23	1.46	0.05	0.00403	0.69	0.02	0.00190
			0.875	0.374	0.22	1.35	0.05	0.00394	0.70	0.02	0.00205
			0.925	0.327	0.21	1.24	0.04	0.00383	0.71	0.02	0.00219
			0.975	0.279	0.20	1.14	0.04	0.00371	0.71	0.02	0.00231
				Overall p(collision) =			**Upwind**	**7.8%**		**Downwind**	**4.1%**
								Average	**6.0%**		

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA											
Goshawk											
Only enter input parameters in blue											
K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**								
NoBlades	3						Upwind:			Downwind:	
MaxChord	4.1	m	r/R	c/C	a	collide		contribution	collide		contribution
Pitch (degrees)	15		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
BirdLength	0.55	m	0.025	0.575	7.19	27.78	0.98	0.00123	26.56	0.94	0.00118
Wingspan	1.5	m	0.075	0.575	2.40	9.67	0.34	0.00257	8.45	0.30	0.00224
F: Flapping (0) or gliding (+1)	0		0.125	0.702	1.44	6.90	0.24	0.00305	5.41	0.19	0.00239
			0.175	0.860	1.03	5.95	0.21	0.00369	4.13	0.15	0.00256
Bird speed	11.3	m/sec	0.225	0.994	0.80	5.40	0.19	0.00430	3.29	0.12	0.00262
RotorDiam	150	m	0.275	0.947	0.65	4.44	0.16	0.00432	2.43	0.09	0.00236
RotationPeriod	7.50	sec	0.325	0.899	0.55	3.75	0.13	0.00432	1.85	0.07	0.00212
			0.375	0.851	0.48	3.24	0.11	0.00430	1.43	0.05	0.00190
			0.425	0.804	0.42	2.83	0.10	0.00426	1.13	0.04	0.00170
			0.475	0.756	0.38	2.50	0.09	0.00421	0.90	0.03	0.00151
Bird aspect ratio: b	0.37		0.525	0.708	0.34	2.26	0.08	0.00420	0.76	0.03	0.00141
			0.575	0.660	0.31	2.07	0.07	0.00421	0.67	0.02	0.00136
			0.625	0.613	0.29	1.90	0.07	0.00420	0.60	0.02	0.00132
			0.675	0.565	0.27	1.75	0.06	0.00417	0.55	0.02	0.00132
			0.725	0.517	0.25	1.61	0.06	0.00412	0.59	0.02	0.00152
			0.775	0.470	0.23	1.48	0.05	0.00406	0.62	0.02	0.00169
			0.825	0.422	0.22	1.36	0.05	0.00398	0.63	0.02	0.00185
			0.875	0.374	0.21	1.25	0.04	0.00388	0.64	0.02	0.00199
			0.925	0.327	0.19	1.15	0.04	0.00376	0.65	0.02	0.00211
			0.975	0.279	0.18	1.05	0.04	0.00362	0.64	0.02	0.00222
				Overall p(collision) =			**Upwind**	**7.6%**		**Downwind**	**3.7%**
								Average	**5.7%**		

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA											
Hen Harrier											
Only enter input parameters in blue											
K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**								
NoBlades	3						Upwind:			Downwind:	
MaxChord	4.1	m	r/R	c/C	a	collide		contribution	collide		contribution
Pitch (degrees)	15		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
BirdLength	0.48	m	0.025	0.575	5.79	20.17	0.89	0.00111	18.95	0.83	0.00104
Wingspan	1.1	m	0.075	0.575	1.93	7.13	0.31	0.00235	5.91	0.26	0.00195
F: Flapping (0) or gliding (+1)	0		0.125	0.702	1.16	5.24	0.23	0.00288	3.75	0.16	0.00206
			0.175	0.860	0.83	4.64	0.20	0.00357	2.82	0.12	0.00217
Bird speed	9.1	m/sec	0.225	0.994	0.64	4.30	0.19	0.00425	2.19	0.10	0.00216
RotorDiam	150	m	0.275	0.947	0.53	3.56	0.16	0.00430	1.55	0.07	0.00187
RotationPeriod	7.50	sec	0.325	0.899	0.45	3.03	0.13	0.00433	1.12	0.05	0.00160
			0.375	0.851	0.39	2.69	0.12	0.00443	0.88	0.04	0.00145
			0.425	0.804	0.34	2.42	0.11	0.00452	0.71	0.03	0.00133
			0.475	0.756	0.30	2.19	0.10	0.00458	0.59	0.03	0.00123
Bird aspect ratio: b	0.44		0.525	0.708	0.28	2.01	0.09	0.00463	0.50	0.02	0.00116
			0.575	0.660	0.25	1.84	0.08	0.00465	0.52	0.02	0.00132
			0.625	0.613	0.23	1.69	0.07	0.00465	0.57	0.02	0.00156
			0.675	0.565	0.21	1.56	0.07	0.00463	0.60	0.03	0.00178
			0.725	0.517	0.20	1.44	0.06	0.00458	0.62	0.03	0.00197
			0.775	0.470	0.19	1.33	0.06	0.00452	0.63	0.03	0.00215
			0.825	0.422	0.18	1.22	0.05	0.00443	0.63	0.03	0.00230
			0.875	0.374	0.17	1.12	0.05	0.00432	0.63	0.03	0.00243
			0.925	0.327	0.16	1.03	0.05	0.00418	0.62	0.03	0.00254
			0.975	0.279	0.15	0.94	0.04	0.00403	0.61	0.03	0.00262
				Overall p(collision) =			**Upwind**	**8.1%**		**Downwind**	**3.7%**
								Average	**5.9%**		

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA											
Peregrine											
Only enter input parameters in blue											
K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**								
NoBlades	3						Upwind:			Downwind:	
MaxChord	4.1	m	r/R	c/C	a	collide		contribution	collide		contribution
Pitch (degrees)	15		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
BirdLength	0.42	m	0.025	0.575	7.70	26.01	0.86	0.00107	24.79	0.82	0.00102
Wingspan	1.02	m	0.075	0.575	2.57	9.08	0.30	0.00225	7.86	0.26	0.00195
F: Flapping (0) or gliding (+1)	0		0.125	0.702	1.54	6.60	0.22	0.00273	5.11	0.17	0.00211
			0.175	0.860	1.10	5.78	0.19	0.00335	3.96	0.13	0.00229
Bird speed	12.1	m/sec	0.225	0.994	0.86	5.30	0.18	0.00394	3.19	0.11	0.00237
RotorDiam	150	m	0.275	0.947	0.70	4.34	0.14	0.00395	2.34	0.08	0.00212
RotationPeriod	7.50	sec	0.325	0.899	0.59	3.67	0.12	0.00394	1.76	0.06	0.00189
			0.375	0.851	0.51	3.16	0.10	0.00392	1.35	0.04	0.00168
			0.425	0.804	0.45	2.76	0.09	0.00387	1.05	0.03	0.00148
			0.475	0.756	0.41	2.44	0.08	0.00382	0.83	0.03	0.00131
Bird aspect ratio: b	0.41		0.525	0.708	0.37	2.20	0.07	0.00382	0.70	0.02	0.00121
			0.575	0.660	0.33	2.00	0.07	0.00380	0.60	0.02	0.00113
			0.625	0.613	0.31	1.82	0.06	0.00376	0.52	0.02	0.00107
			0.675	0.565	0.29	1.66	0.05	0.00370	0.46	0.02	0.00102
			0.725	0.517	0.27	1.51	0.05	0.00363	0.42	0.01	0.00102
			0.775	0.470	0.25	1.38	0.05	0.00354	0.46	0.02	0.00117
			0.825	0.422	0.23	1.26	0.04	0.00343	0.48	0.02	0.00130
			0.875	0.374	0.22	1.14	0.04	0.00331	0.49	0.02	0.00142
			0.925	0.327	0.21	1.04	0.03	0.00317	0.50	0.02	0.00152
			0.975	0.279	0.20	0.93	0.03	0.00301	0.50	0.02	0.00160
				Overall p(collision) =			**Upwind**	**6.8%**		**Downwind**	**3.1%**
								Average	**4.9%**		

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA											
Merlin											
Only enter input parameters in blue											
K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**								
NoBlades	3						Upwind:			Downwind:	
MaxChord	4.1	m	r/R	c/C	a	collide		contribution	collide		contribution
Pitch (degrees)	15		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
BirdLength	0.28	m	0.025	0.575	7.19	21.02	0.74	0.00093	19.80	0.70	0.00088
Wingspan	0.56	m	0.075	0.575	2.40	7.41	0.26	0.00197	6.19	0.22	0.00164
F: Flapping (0) or gliding (+1)	0		0.125	0.702	1.44	5.55	0.20	0.00245	4.06	0.14	0.00180
			0.175	0.860	1.03	4.99	0.18	0.00309	3.16	0.11	0.00196
Bird speed	11.3	m/sec	0.225	0.994	0.80	4.65	0.16	0.00370	2.54	0.09	0.00202
RotorDiam	150	m	0.275	0.947	0.65	3.82	0.14	0.00372	1.81	0.06	0.00177
RotationPeriod	7.50	sec	0.325	0.899	0.55	3.23	0.11	0.00372	1.33	0.05	0.00153
			0.375	0.851	0.48	2.80	0.10	0.00372	0.99	0.04	0.00132
			0.425	0.804	0.42	2.48	0.09	0.00373	0.77	0.03	0.00116
			0.475	0.756	0.38	2.22	0.08	0.00373	0.61	0.02	0.00103
Bird aspect ratio: b	0.50		0.525	0.708	0.34	1.99	0.07	0.00370	0.49	0.02	0.00091
			0.575	0.660	0.31	1.80	0.06	0.00366	0.40	0.01	0.00081
			0.625	0.613	0.29	1.63	0.06	0.00360	0.33	0.01	0.00073
			0.675	0.565	0.27	1.48	0.05	0.00353	0.28	0.01	0.00068
			0.725	0.517	0.25	1.34	0.05	0.00343	0.32	0.01	0.00082
			0.775	0.470	0.23	1.21	0.04	0.00332	0.35	0.01	0.00095
			0.825	0.422	0.22	1.09	0.04	0.00319	0.36	0.01	0.00106
			0.875	0.374	0.21	0.98	0.03	0.00304	0.37	0.01	0.00115
			0.925	0.327	0.19	0.88	0.03	0.00287	0.38	0.01	0.00123
			0.975	0.279	0.18	0.78	0.03	0.00269	0.37	0.01	0.00128
				Overall p(collision) =			**Upwind**	**6.4%**		**Downwind**	**2.5%**
								Average	**4.4%**		

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA												
Golden Plover												
Only enter input parameters in blue												
K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**									
NoBlades	3						Upwind:				Downwind:	
MaxChord	4.1	m	r/R	c/C	a	collide		contribution	collide		contribution
Pitch (degrees)	15		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
BirdLength	0.28	m	0.025	0.575	8.72	26.75	0.78	0.00098	25.53	0.75	0.00093
Wingspan	0.72	m	0.075	0.575	2.91	9.32	0.27	0.00204	8.10	0.24	0.00177
F: Flapping (0) or gliding (+1)	0		0.125	0.702	1.74	6.85	0.20	0.00250	5.36	0.16	0.00196
			0.175	0.860	1.25	6.05	0.18	0.00309	4.23	0.12	0.00216
Bird speed	13.7	m/sec	0.225	0.994	0.97	5.57	0.16	0.00366	3.46	0.10	0.00227
RotorDiam	150	m	0.275	0.947	0.79	4.55	0.13	0.00365	2.54	0.07	0.00204
RotationPeriod	7.50	sec	0.325	0.899	0.67	3.83	0.11	0.00363	1.92	0.06	0.00182
			0.375	0.851	0.58	3.28	0.10	0.00359	1.48	0.04	0.00162
			0.425	0.804	0.51	2.85	0.08	0.00354	1.15	0.03	0.00143
			0.475	0.756	0.46	2.51	0.07	0.00348	0.90	0.03	0.00125
Bird aspect ratio: b	0.39		0.525	0.708	0.42	2.22	0.06	0.00340	0.71	0.02	0.00109
			0.575	0.660	0.38	1.97	0.06	0.00331	0.57	0.02	0.00096
			0.625	0.613	0.35	1.78	0.05	0.00324	0.48	0.01	0.00087
			0.675	0.565	0.32	1.60	0.05	0.00316	0.40	0.01	0.00079
			0.725	0.517	0.30	1.45	0.04	0.00306	0.35	0.01	0.00073
			0.775	0.470	0.28	1.30	0.04	0.00295	0.30	0.01	0.00069
			0.825	0.422	0.26	1.17	0.03	0.00282	0.29	0.01	0.00069
			0.875	0.374	0.25	1.05	0.03	0.00267	0.31	0.01	0.00079
			0.925	0.327	0.24	0.93	0.03	0.00252	0.32	0.01	0.00087
			0.975	0.279	0.22	0.82	0.02	0.00234	0.33	0.01	0.00094
				Overall p(collision) =			**Upwind**	**6.0%**		**Downwind**	**2.6%**
								Average	**4.3%**		

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA												
Lapwing												
Only enter input parameters in blue												
K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**									
NoBlades	3						Upwind:				Downwind:	
MaxChord	4.1	m	r/R	c/C	a	collide		contribution	collide		contribution
Pitch (degrees)	15		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
BirdLength	0.3	m	0.025	0.575	7.58	24.23	0.81	0.00102	23.00	0.77	0.00097
Wingspan	0.84	m	0.075	0.575	2.53	8.48	0.29	0.00214	7.26	0.24	0.00183
F: Flapping (0) or gliding (+1)	0		0.125	0.702	1.52	6.23	0.21	0.00262	4.74	0.16	0.00199
			0.175	0.860	1.08	5.51	0.19	0.00324	3.68	0.12	0.00217
Bird speed	11.9	m/sec	0.225	0.994	0.84	5.08	0.17	0.00384	2.97	0.10	0.00224
RotorDiam	150	m	0.275	0.947	0.69	4.17	0.14	0.00385	2.16	0.07	0.00199
RotationPeriod	7.50	sec	0.325	0.899	0.58	3.52	0.12	0.00384	1.61	0.05	0.00176
			0.375	0.851	0.51	3.03	0.10	0.00382	1.22	0.04	0.00154
			0.425	0.804	0.45	2.65	0.09	0.00378	0.94	0.03	0.00134
			0.475	0.756	0.40	2.33	0.08	0.00372	0.73	0.02	0.00116
Bird aspect ratio: b	0.36		0.525	0.708	0.36	2.07	0.07	0.00365	0.56	0.02	0.00099
			0.575	0.660	0.33	1.86	0.06	0.00360	0.46	0.02	0.00089
			0.625	0.613	0.30	1.69	0.06	0.00354	0.39	0.01	0.00081
			0.675	0.565	0.28	1.53	0.05	0.00347	0.33	0.01	0.00074
			0.725	0.517	0.26	1.38	0.05	0.00337	0.31	0.01	0.00076
			0.775	0.470	0.24	1.25	0.04	0.00326	0.34	0.01	0.00090
			0.825	0.422	0.23	1.13	0.04	0.00314	0.36	0.01	0.00101
			0.875	0.374	0.22	1.02	0.03	0.00299	0.38	0.01	0.00111
			0.925	0.327	0.20	0.91	0.03	0.00283	0.38	0.01	0.00119
			0.975	0.279	0.19	0.81	0.03	0.00266	0.38	0.01	0.00125
				Overall p(collision) =			**Upwind**	**6.4%**		**Downwind**	**2.7%**
								Average	**4.6%**		

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA											
Curlew											
Only enter input parameters in blue											
K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**								
NoBlades	3						Upwind:			Downwind:	
MaxChord	4.1	m	r/R	c/C	a	collide		contribution	collide		contribution
Pitch (degrees)	15		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
BirdLength	0.55	m	0.025	0.575	10.38	33.58	0.82	0.00103	32.36	0.79	0.00099
Wingspan	0.9	m	0.075	0.575	3.46	11.60	0.28	0.00213	10.38	0.25	0.00191
F: Flapping (0) or gliding (+1)	0		0.125	0.702	2.08	8.38	0.21	0.00257	6.89	0.17	0.00211
			0.175	0.860	1.48	7.30	0.18	0.00313	5.47	0.13	0.00235
Bird speed	16.3	m/sec	0.225	0.994	1.15	6.63	0.16	0.00366	4.52	0.11	0.00250
RotorDiam	150	m	0.275	0.947	0.94	5.39	0.13	0.00364	3.38	0.08	0.00228
RotationPeriod	7.50	sec	0.325	0.899	0.80	4.51	0.11	0.00360	2.61	0.06	0.00208
			0.375	0.851	0.69	3.86	0.09	0.00355	2.05	0.05	0.00189
			0.425	0.804	0.61	3.35	0.08	0.00349	1.64	0.04	0.00171
			0.475	0.756	0.55	2.99	0.07	0.00348	1.38	0.03	0.00161
Bird aspect ratio: b	0.61		0.525	0.708	0.49	2.69	0.07	0.00346	1.18	0.03	0.00153
			0.575	0.660	0.45	2.43	0.06	0.00343	1.03	0.03	0.00145
			0.625	0.613	0.42	2.21	0.05	0.00339	0.91	0.02	0.00139
			0.675	0.565	0.38	2.01	0.05	0.00333	0.81	0.02	0.00134
			0.725	0.517	0.36	1.83	0.04	0.00326	0.73	0.02	0.00131
			0.775	0.470	0.33	1.67	0.04	0.00318	0.67	0.02	0.00128
			0.825	0.422	0.31	1.52	0.04	0.00308	0.63	0.02	0.00127
			0.875	0.374	0.30	1.39	0.03	0.00298	0.59	0.01	0.00127
			0.925	0.327	0.28	1.26	0.03	0.00286	0.57	0.01	0.00129
			0.975	0.279	0.27	1.14	0.03	0.00273	0.55	0.01	0.00132
				Overall p(collision) =			**Upwind**	**6.2%**		**Downwind**	**3.3%**
								Average	**4.7%**		

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA											
Herring Gull											
Only enter input parameters in blue											
K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**								
NoBlades	3						Upwind:			Downwind:	
MaxChord	4.1	m	r/R	c/C	a	collide		contribution	collide		contribution
Pitch (degrees)	15		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
BirdLength	0.6	m	0.025	0.575	8.15	30.90	0.97	0.00121	29.68	0.93	0.00116
Wingspan	1.44	m	0.075	0.575	2.72	10.71	0.33	0.00251	9.49	0.30	0.00222
F: Flapping (0) or gliding (+1)	0		0.125	0.702	1.63	7.62	0.24	0.00298	6.13	0.19	0.00239
			0.175	0.860	1.16	6.55	0.20	0.00358	4.73	0.15	0.00259
Bird speed	12.8	m/sec	0.225	0.994	0.91	5.92	0.19	0.00417	3.81	0.12	0.00268
RotorDiam	150	m	0.275	0.947	0.74	4.85	0.15	0.00417	2.84	0.09	0.00244
RotationPeriod	7.50	sec	0.325	0.899	0.63	4.09	0.13	0.00415	2.18	0.07	0.00221
			0.375	0.851	0.54	3.52	0.11	0.00412	1.71	0.05	0.00200
			0.425	0.804	0.48	3.07	0.10	0.00408	1.36	0.04	0.00181
			0.475	0.756	0.43	2.70	0.08	0.00401	1.10	0.03	0.00163
Bird aspect ratio: b	0.42		0.525	0.708	0.39	2.44	0.08	0.00400	0.94	0.03	0.00154
			0.575	0.660	0.35	2.23	0.07	0.00400	0.83	0.03	0.00148
			0.625	0.613	0.33	2.04	0.06	0.00399	0.74	0.02	0.00145
			0.675	0.565	0.30	1.87	0.06	0.00396	0.68	0.02	0.00143
			0.725	0.517	0.28	1.72	0.05	0.00391	0.63	0.02	0.00142
			0.775	0.470	0.26	1.59	0.05	0.00384	0.61	0.02	0.00148
			0.825	0.422	0.25	1.46	0.05	0.00377	0.64	0.02	0.00164
			0.875	0.374	0.23	1.34	0.04	0.00367	0.65	0.02	0.00178
			0.925	0.327	0.22	1.23	0.04	0.00356	0.66	0.02	0.00191
			0.975	0.279	0.21	1.13	0.04	0.00343	0.67	0.02	0.00203
				Overall p(collision) =			**Upwind**	**7.3%**		**Downwind**	**3.7%**
								Average	**5.5%**		

KEY SPECIES FLIGHT ACTIVITY AND COLLISON RISK: DIRECT FLIGHT MODEL (STAGE 2)

The second section of this Technical Appendix provides example calculations that have been made of the key species flight activity within the collision risk zone.

The model was run separately for each of zones across the collision risk area that were visible from each of the two Vantage Points (VPs) (all areas were visible from only a single VP, with no overlap). Bird flight activity within each of these zones was calculated separately.

For the direct flight variant of the Band model (used for whooper swan, greylag goose, pink-footed goose, barnacle goose, golden plover and herring gull), flight activity was calculated as the total number of flights through each of the five collision zones (delineated according to which VPs the zone was visible), estimated from the VP data (clipping mapped flights in QGIS to those zones and calculating the numbers of flights per hour at rotor height over each season). An example calculation is given below in **Table 9.5.1.** The total risk for the whole wind farm was calculated as the sum of the risks for each of the five zones (A-E), and the last row gives the mean risk over the two winters.

Table 9.5.1: Collision risk calculations for pink-footed goose for the 2021-22 and 2022-23 winters using the direct flight Band model.

TORFICHEN WIND FARM										
BAND ET AL 2007 COLLISION MODEL (DIRECT FLIGHTS)										
	Pink-footed Goose	*Winter only*								
	2021-22					**2022-23**				
	Zone A	**Zone B**	**Zone C**	**Zone D**	**Zone E**	**Zone A**	**Zone B**	**Zone C**	**Zone D**	**Zone E**
Collision risk height	150	150	150	150	150	150	150	150	150	150
Risk corridor Width	1,850	1,000	2,070	1,970	2,020	1,850	1,000	2,070	1,970	2,020
Risk corridor Area	277,500	150,000	310,500	295,500	303,000	277,500	150,000	310,500	295,500	303,000
Annual number of flights through collision zone at rotor ht	411,561	81,849	115,614	73,646	7,894	499,631	85,378	438,703	362,322	270,609
No turbines	5	1	5	4	3	5	1	5	4	3
Rotor diameter	150	150	150	150	150	150	150	150	150	150
Rotor swept area	17671	17671	17671	17671	17671	17671	17671	17671	17671	17671
Allowance for overlap	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Proportion of risk window occupied by rotors	16%	6%	14%	12%	9%	16%	6%	14%	12%	9%
Annual no bird rotor passes	65521	4821	16450	8808	691	79542	5029	62420	43335	23674
Band individual collision risk	5.3%	5.3%	5.3%	5.3%	5.3%	5.3%	5.3%	5.3%	5.3%	5.3%
Turbine downtime	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
Non-avoidance collisions	2951	217	741	397	31	3582	226	2811	1952	1066
Avoidance rate	99.80%	99.80%	99.80%	99.80%	99.80%	99.80%	99.80%	99.80%	99.80%	99.80%
Predicted collisions per year	**5.901**	**0.434**	**1.482**	**0.793**	**0.062**	**7.164**	**0.453**	**5.622**	**3.903**	**2.132**
Total annual collision risk					***8.7***					***19.3***
									Mean:	*14.0*

KEY SPECIES FLIGHT ACTIVITY AND COLLISON RISK: NON-DIRECT FLIGHT MODEL (STAGE 2)

As an example, for the variable non-direct flight modelling, the collision risk calculations for hen harrier for each of the winter and breeding baseline periods (breeding 2021 and 2022, winter 2021-22 and 2022-23) is shown in **Table 9.5.2**. This requires an estimate of the amount of time that each species was present within the collision risk zone for its bird activity input, calculated from the amount of time observed in each zone during the VP surveys (as the percentage occupancy rate of each zone, i.e. the percentage of observation time that each species was observed flying at rotor height within the zone). This occupancy of the collision risk zone was determined from the flight tracks and divided by the observation time for each month to give the monthly occupancy rate (percentage of time present in the collision zone). The overall occupancy was then calculated for each of the four survey periods (breeding 2021 and 2022, winter 2021-22 and 2022-23). The survey results for these periods are given in **Technical Appendices 9.1, 9.2, 9.3 and 9.4** respectively.

As for the direct flight model, the total risk for the whole wind farm was calculated as the sum of the risks for each of the five zones.

Table 9.5.2. Collision risk calculations for hen harrier using the non-direct random flight Band model.

TORFICHEN WIND FARM																				
BAND ET AL 2007 COLLISION MODEL (OCCUPANCY)																				
	Hen Harrier	*All year*																		
	2021-22					**2022-23**					2021					2022				
	Zone A	**Zone B**	**Zone C**	**Zone D**	**Zone E**	**Zone A**	**Zone B**	**Zone C**	**Zone D**	**Zone E**	**Zone A**	**Zone B**	**Zone C**	**Zone D**	**Zone E**	**Zone A**	**Zone B**	**Zone C**	**Zone D**	**Zone E**
Collision Zone Area (ha)	250	47	189	126	242	250	47	189	126	242	250	47	189	126	242	250	47	189	126	242
Hub Ht	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105
Rotor diameter	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150
Upper rotor ht	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
Lower rotor ht	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
Percentage of observation time seen flying in collision zone at rotor ht	**0.00%**	**0.00%**	**0.05%**	**0.25%**	**0.06%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.000%**	**0.000%**	**0.000%**	**0.000%**	**0.000%**	**0.000%**	**0.000%**	**0.000%**	**0.000%**
Season length	212	212	212	212	212	212	212	212	212	212	153	153	153	153	153	153	153	153	153	153
Activity per day	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0
Total flight activity in collision zone at rotor ht	0.000	0.000	0.992	5.198	1.203	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Flight risk volume	3.750E+08	7.050E+07	2.835E+08	1.890E+08	3.630E+08	3.750E+08	7.050E+07	2.835E+08	1.890E+08	3.630E+08	3.750E+08	7.050E+07	2.835E+08	1.890E+08	3.630E+08	3.750E+08	7.050E+07	2.835E+08	1.890E+08	3.630E+08
No Turbines	**5**	**1**	**5**	**4**	**3**	**5**	**1**	**5**	**4**	**3**	**5**	**1**	**5**	**4**	**3**	**5**	**1**	**5**	**4**	**3**
Rotor radius	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**
Rotor depth	**4.1**	**4.1**	**4.1**	**4.1**	**4.1**	**4.1**	**4.1**	**4.1**	**4.1**	**4.1**	**4.1**	**4.1**	**4.1**	**4.1**	**4.1**	**4.1**	**4.1**	**4.1**	**4.1**	**4.1**
Bird length	**0.48**	**0.48**	**0.48**	**0.48**	**0.48**	**0.48**	**0.48**	**0.48**	**0.48**	**0.48**	**0.48**	**0.48**	**0.48**	**0.48**	**0.48**	**0.48**	**0.48**	**0.48**	**0.48**	**0.48**
Swept volume	404676	80935	404676	323741	242806	404676	80935	404676	323741	242806	404676	80935	404676	323741	242806	404676	80935	404676	323741	242806
Bird occupancy of swept volume	0.00	0.00	5.10	32.05	2.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bird speed	**9.1**	**9.1**	**9.1**	**9.1**	**9.1**	**9.1**	**9.1**	**9.1**	**9.1**	**9.1**	**9.1**	**9.1**	**9.1**	**9.1**	**9.1**	**9.1**	**9.1**	**9.1**	**9.1**	**9.1**
Rotor transit time	0.503	0.503	0.503	0.503	0.503	0.503	0.503	0.503	0.503	0.503	0.503	0.503	0.503	0.503	0.503	0.503	0.503	0.503	0.503	0.503
No of rotor transits	0	0	10	64	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turbine downtime	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
Band collision rate	5.9%	5.9%	5.9%	5.9%	5.9%	5.9%	5.9%	5.9%	5.9%	5.9%	5.9%	5.9%	5.9%	5.9%	5.9%	5.9%	5.9%	5.9%	5.9%	5.9%
Non-avoid collisions	0.0	0.0	0.5	3.2	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Avoidance rate	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%
Collision prediction	**0.000**	**0.000**	**0.005**	**0.032**	**0.003**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
OVERALL TOTAL					**0.040**					**0.000**					**0.000**					**0.000**

REFERENCES

- Alerstam, T., Rosén, M., Bäckman, J., Ericson, P. & Hellgren, O. 2007. Flight speeds among bird species: allometric and phylogenetic effects. PLoS Biology, 5.
- Band, W., M. Madders, and D. P. Whitfield. 2007. Developing field and analytical methods to assess avian collision risk at wind farms. Page 15pp in M. Lucas, de, G. F. E. Janss, and M. Ferrer, editors. Birds and Wind Farms. Quercus, Madrid.
- Robinson, R.A. 2005 BirdFacts: profiles of birds occurring in Britain & Ireland (BTO Research Report 407). BTO, Thetford (http://www.bto.org/birdfacts).
- Scottish Natural Heritage 2017. Avoidance Rates for the onshore SNH Wind Farm Collision Risk Model. SNH.
- Scottish Natural Heritage. 2018. Assessing Significance of Impacts from Onshore Wind Farms Outwith Designated Areas. SNH Guidance.