

APPENDIX 8.2: COLLISION RISK (MARSH HARRIER)**ESTIMATION OF MARSH HARRIER COLLISION FATALITY RATE**

Input data	Symbol	Derivation	Flight activity zone					
			VP1	VP2	VP3	VP4	VP5	Overall
Collision risk for species (calculated separately; see Appendix 8.2b)	C		0.088	0.088	0.088	0.088	0.088	0.088
Avoidance rate	A		0.99	0.99	0.99	0.99	0.99	0.99
Mean length of species (m)	l		0.425	0.425	0.425	0.425	0.425	0.425
Mean flight speed of species (m/sec)	v		14	14	14	14	14	14
Mean depth of rotor, back to front (m)	d		2.359	2.359	2.359	2.359	2.359	2.359
Flight activity survey area (km ²)	SA		0.8645	0.7855	1.1645	0.8355	1.0129	4.6629
No. turbines	N		2	5	4	7	4	22
Radius of rotor-sweep (m)	r		41	41	41	41	41	41
Height of 'middle flight-height' observed (m)	m		112	112	112	112	112	112
Time (bird-secs) species recorded flying 'middle flight-height'	t		713	137	18	556	0	1424
No. hours observations undertaken when species present in area	h		72	72	72	72	72	360
Max No. potential hours pa species flying over site	p		2932	2932	2932	2932	2932	2932
Max proportion potential hours pa species likely flying (i.e. excluding bad weather)	pp		0.99	0.99	0.99	0.99	0.99	0.99
Computations								
Non-avoidance rate		1 - A	0.01	0.01	0.01	0.01	0.01	0.01
d + l		d + l	2.784	2.784	2.784	2.784	2.784	2.784
Flight risk volume (m ³)	V _w	SA x 1000 x 1000 x 2r	70889000	64411000	95489000	68511000	83057800	382357800
Combined volume swept out by rotors (m ³)	V _r	N x πr ² x (d + l)	29416.54	73541.35	58833.08	102957.89	58833.08	323581.93
Estimated bird-secs flying within rotor-sweep height	F	t x 2r/m	522.02	100.30	13.18	407.07	0	1042.57
Estimated bird-secs flying within rotor-sweep height per hour of observation	Fhr ⁻¹	F/h	7.25	1.39	0.18	5.65	0	2.90
Bird occupancy pa within flight risk volume (secs)	Occ (V _w)	Fhr ⁻¹ x (p x pp)	21045.15	4043.74	531.29	16411.08	0	8406.25
Bird occupancy pa of volume swept by rotors (secs)	Occ (V _r)	Occ (V _w) x (V _r /V _w)	8.73	4.62	0.33	24.66	0	7.11
Time taken for bird to fly through and clear rotors	T	d + l / v	0.20	0.20	0.20	0.20	0.20	0.20
No.bird transits pa	BT	Occ (V _r) / T	43.92	23.22	1.65	124.02	0	35.77
No. fatalities pa with no avoidance	F _{na}	BT x C	3.86	2.04	0.14	10.91	0	3.15
No. fatalities pa	F	F _{na} x (1 - A)	0.04	0.02	0.00	0.11	0	0.03
Time between each fatality (years)		1/F	25.88	48.94	690.33	9.16	N/A	31.76

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA

K: [1D or [3D] (0 or 1)		Calculation of alpha and p(collision) as a function of radius										
NoBlades	3						Upwind:			Downwind:		
MaxChord	4.14 m	r/R	c/C	α	collide	contribution	collide	contribution	collide	contribution		
Pitch (degrees)	5	radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r		
BirdLength	0.425 m	0.025	0.575	10.87	39.30	1.00	0.00125	38.88	1.00	0.00125		
Wingspan	1.225 m	0.075	0.575	3.62	13.24	0.57	0.00425	12.82	0.55	0.00412		
F: Flapping (0) or gliding (+1)	0	0.125	0.702	2.17	9.21	0.39	0.00493	8.70	0.37	0.00466		
		0.175	0.860	1.55	7.72	0.33	0.00579	7.10	0.30	0.00532		
Bird speed	14 m/sec	0.225	0.994	1.21	6.79	0.29	0.00655	6.07	0.26	0.00586		
RotorDiam	82 m	0.275	0.947	0.99	5.41	0.23	0.00638	4.73	0.20	0.00557		
RotationPeriod	5.00 sec	0.325	0.899	0.84	4.45	0.19	0.00620	3.80	0.16	0.00529		
		0.375	0.851	0.72	3.74	0.16	0.00601	3.12	0.13	0.00502		
Bird aspect ratio: β	0.35	0.425	0.804	0.64	3.19	0.14	0.00581	2.61	0.11	0.00476		
		0.475	0.756	0.57	2.76	0.12	0.00561	2.21	0.09	0.00450		
		0.525	0.708	0.52	2.40	0.10	0.00540	1.89	0.08	0.00425		
		0.575	0.660	0.47	2.10	0.09	0.00519	1.63	0.07	0.00401		
		0.625	0.613	0.43	1.85	0.08	0.00496	1.41	0.06	0.00378		
		0.675	0.565	0.40	1.64	0.07	0.00473	1.23	0.05	0.00355		
		0.725	0.517	0.37	1.45	0.06	0.00449	1.07	0.05	0.00333		
		0.775	0.470	0.35	1.28	0.05	0.00425	0.94	0.04	0.00312		
		0.825	0.422	0.33	1.15	0.05	0.00407	0.85	0.04	0.00299		
		0.875	0.374	0.31	1.04	0.04	0.00390	0.77	0.03	0.00288		
		0.925	0.327	0.29	0.94	0.04	0.00372	0.70	0.03	0.00279		
		0.975	0.279	0.28	0.85	0.04	0.00354	0.64	0.03	0.00269		
Overall p(collision) =					Upwind		9.7%		Downwind		8.0%	
					Average		8.8%					