Appendix 10.2:
Collision Risk Modelling

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2026

Shepherds' Rig Wind Farm Section 36C

Appendix 10.2: Collision Risk Modelling

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Introduction

1. Birds that are not displaced by the Proposed Varied Development would be potentially vulnerable to collision with the 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.

2. Further studies in the field of bird-windfarm research are required to establish with certainty the extent to which birds can avoid collision with wind turbines, although an increasing body of evidence suggests that avoidance capacity is very high (Whitfield & Madders, 2006[1]; Urquhart & Whitfield, 2016[2]; SNH, 2018[3]). The indications from studies are that collisions are rare events (e.g., Fielding *et al*., 2021)[4] and occur mainly at sites where there are unusual concentrations of birds and turbines, or where the behaviour of the birds' concerned leads to high-risk situations (e.g., Gill *et al*., 1996[5]; Percival, 1998[6]; de Lucas *et al.,* 2007[7]). Examples include migration flyways, and where the food resource, and therefore level of bird activity, is exceptional.

Collision Risk Modelling

3. The Band collision risk model (CRM) (Band *et al*., 2007)[8] was used to estimate the potential number of goshawk, red kite and hen harrier collisions likely to occur due to the Proposed Varied Development. The model requires input data based on species biometrics and flight characteristics, turbine specification and data on flights observed at the site.

4. NatureScot guidance on collision risk modelling was used (SNH, 2000[9]; Band *et al*., 2007). This is a three-stage process, which involves:

    1) An assessment of the probability of a collision, based on a bird flying through an operational turbine; and

    2) An estimation of the number of birds passing through the swept zone of the turbine blades.

    Multiplying stages 1 and 2 provides an estimate of collision risk with the turbines, assuming no avoidance action. After, the third stage is applied:

[1] Madders, M. & Whitfield, D.P. (2006). Upland raptors and the assessment of wind farm impacts. Ibis, 148, pp 43-56.
[2] Urquhart, B. & Whitfield, D.P. (2016). Derivation of an avoidance rate for red kite *Milvus milvus* suitable for onshore wind farm collision risk modelling Natural Research Information Note 7. Available at https://www.natural-research.org/ecological-research-charity/our-publications
[3] Scottish Natural Heritage (SNH). (2018). Avoidance Rates for the onshore SNH Wind Farm Collision Risk Model. SNH Information and Guidance Note. Scottish Natural Heritage, Battleby.
[4] Fielding, A.H., Anderson, D., Benn, S., Dennis, R., Geary, M., Weston, E. & Whitfield, D.P. (2021). Non-territorial GPS-tagged golden eagles *Aquila chrysaetos* a two Scottish wind farms: Avoidance influenced by preferred habitat distribution, wind speed and blade motion status. PLoS ONE 16(8): e0254159. https://doi.org/10.1371/journal.pone.0254159
[5] Gill, J.P., Townsley, M. & Mudge, G.P. (1996). Review of the impacts of wind farms and other aerial structures upon birds. SNH Review 21: 68pp.
[6] Percival, S.M. (1998). Birds and Turbines: managing potential planning issues. Proc. of the 20th BWEA Conference 1998: pp 345-350.
[7] de Lucas, M., Janss, G.F.E. & Ferrer, M. (eds). (2007). Birds and Wind Power: Risk Assessment and Mitigation. Quercus, Madrid.
[8] 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.
[9] SNH. (2000). Windfarms and Birds: Calculating a theoretical collision risk assuming no avoiding action. SNH Information and Guidance Note. Scottish Natural Heritage, Battleby.

3) An avoidance rate is applied to account for the fact that many species will take avoidance action.

5. The result of the model provides an estimate of the number of collisions that can be expected over a year or for the lifetime of the wind farm.

6. For the turbines proposed, the probability of a goshawk, red kite or hen harrier being struck by a turbine blade when passing through the rotor swept volume has been estimated assuming no avoidance (see **Appendix 1**). However, it is widely accepted that raptors are able to avoid turbine blades in a number of ways. Birds may exercise avoidance by detecting the wind farm or turbine and modifying their flight lines to avoid the structures (Macro avoidance). At close proximity, birds may see an oncoming blade and emergency avoidance action can be taken (Micro avoidance) (SNH, 2000). As such, an avoidance rate (SNH, 2018)[10] was applied to each model to estimate the collision risk for each species respectively.

Windfarm characteristics

7. The proposed scheme has eleven turbines and the flight risk volume (Vw), in these analyses, is based on a buffer constructed with a radius of 500 m (area = 732 ha), centred on the turbine locations with a height that was equal to the diameter of the turbine blades (163 m). The turbines used for the collision risk modelling were based on a hub height of 138.5 m, giving an overall tip height of 220 m. Turbine specifications were obtained from the manufacturer[11] and are shown where relevant.

Viewsheds

8. Flight data were obtained from a total of four Vantage Points (VPs). Viewsheds were estimated using a Digital Elevation Model (DEM) and a 20 m vertical offset above the ground surface (lowest point of rotor sweep at 57 m) (**Figure 1**). Other details of the viewshed calculation are given in **Table 1**.

Table 1. Vantage point survey effort and visible areas within the 500 m buffer drawn around the turbines.

VP	Visible area with 500m turbine buffer (ha)	Hours of observation (hrs)
2	332.8	72.00
3	199.4	72.00
5	234.0	72.00
6	268.7	72.00

Flight activity within 500 m of turbines

9. A summary of flight activity recorded within 500 m of the proposed turbines is given in **Table 2**. All flights that passed within 500 m of the proposed turbines are shown in **Figure 2**.

[10] Scottish Natural Heritage (SNH). (2018). Avoidance Rates for the onshore SNH Wind Farm Collision Risk Model. SNH Information and Guidance Note. Scottish Natural Heritage, Battleby.
[11] https://www.nordex-online.com/en/product/n163-5-x/

Table 2. Summary of flight activity recorded within 500 m of the proposed turbines.

Species	Total flights	'At-risk' flights	No. individuals 'at-risk'	CRM undertaken
Goshawk	8	5	5	**Yes**
Greylag goose	4	1	1	No
Hen harrier	2	1	1	**Yes**
Merlin	1	0	0	No
Pink-footed goose	2	2	130	No
Red kite	26	13	16	**Yes**
Whooper swan	1	1	17	No

10. An 'at–risk' flight is one which passes into the 500 m turbine buffer with at least part of its flight at an altitude between 50 m and 250 m. Professional judgement was used as to whether a CRM was undertaken for each species, based on the Nature Conservation Importance of the species and the number of 'at-risk' flights or the number of individuals potentially 'at-risk'.

11. Details of 'at-risk' flights for consideration under a CRM are shown in **Table 3**. The total flight duration recorded during the vantage point watches was adjusted to give an estimate for the total expected over the period of occupancy by each species. The total potential flying time for each species was estimated from the sum of the day lengths of each day. Day length was estimated, for each day, using the method of Forsythe *et al*. (1995)[12] at latitude 55.2117 ° N.

Table 3. Flight durations recorded within VP viewsheds and clipped to 500 m survey buffer. Part, or all, of these flights at a height of 50 – 250 m agl places them at risk of a collision with the turbine blades (shaded columns).

Species	Season	VP No.	No. of birds	Total flight time (sec)	Time in height band (sec)					
					<20m	20-50m	50-100m	100-150m	150-250m	>250m
Goshawk	Sep-Mar	2	1	390		15	15	135	225	
			1	34		34				
		3	1	311	47	264				
			1	154		154				
			1	30			30			
			1	28			28			
			1	199		92	107			
			1	475		123	352			
Goshawk Total			8	1621	47	682	532	135	225	
Hen harrier	Apr-Aug	6	1	6		6				
			1	567			92	46	64	365
Hen harrier Total			2	573		6	92	46	64	365
Merlin	Sep-Mar	6	1	21		21				
Merlin Total			1	21		21				

[12] Forsythe, W.C., Rykiel, E.J., Stahl, R.S., Wu, H. & Schoolfield, R.M. (1995). A model comparison for day length as a function of latitude and day of year. Ecological Modelling. 80: 87 –95

Table 3. Flight durations recorded within VP viewsheds and clipped to 500 m survey buffer. Part, or all, of these flights at a height of 50 – 250 m agl places them at risk of a collision with the turbine blades (shaded columns).

Species	Season	VP No.	No. of birds	Total flight time (sec)	Time in height band (sec)					
					<20m	20-50m	50-100m	100-150m	150-250m	>250m
Red kite	Apr-Aug	2	1	58	53		5			
			1	234	1	7	226			
			1	41			41			
		3	1	142			2	33	107	
		6	1	40			13	27		
			1	34			34			
			1	542	121	182	106	45	88	
			1	13		13				
	Sep-Mar	2	1	99		99				
			1	62			62			
			1	137		72	65			
			1	101		101				
			1	67		67				
			1	24			24			
			1	276		276				
			1	103		103				
			1	81		81				
			1	9		9				
		3	3	571		571				
			4	169			169			
			1	257		75	90	92		
			1	241		121	90	30		
			1	11		11				
			3	1		1				
			2	116		116				
		5	1	84		84				
Red kite Total			34	3513	175	1989	927	227	195	
Whooper swan	Sep-Mar	2	17	2180			2180			
Whooper swan Total			17	2180			2180			
Greylag goose	Apr-Aug	3	3			*				
			2		*	*				
	Sep-Mar	3	1			*	*			
		6	2			*				
Greylag goose Total			8		*	*	*			
Pink-footed goose	Apr-Aug	5	30				*			
		2	100						*	
Pink-footed goose Total			130				*		*	

Species-specific information

12. **Table 4** summarises the species-specific information used in the collision risk calculations. Collision probability was obtained using the SNH (2000)[9] model and details, for each species, are available in **Appendix 1**. Species length and wingspan have been derived using a mean of the figures

presented within Snow & Perrins (1998)[13] and flight speeds were derived using Alerstam *et al.* (2007)[14] or Provan & Whitfield (2006)[15] as suggested by NatureScot (SNH, 2014)[16].

Table 4. Species-specific information used in the collision risk calculations.

Species	Bird length			Wingspan			Flight speed (ms^{-1})	Collision probability (%)	Total potential flying time (hrs)
	Min (cm)	Max (cm)	Average (m)	Min (cm)	Max (cm)	Average (m)			
Goshawk	48	62	**0.55**	135	165	**1.50**	14	5.3%	4,494
Red kite	60	66	**0.63**	175	195	**1.85**	11	6.6%	4,494
Hen harrier	44	52	**0.48**	100	120	**1.10**	13	5.3%	4,494

Results

13. **Table 5** summarises the results of collision risk modelling for each of the species.

Table 5. Collision risk modelling results.

Species	Occupancy	Avoidance Rate (%)	Birds colliding per year	Years per collision
Goshawk	All year	98.0	0.078	12.7
Red kite	All year	99.0	0.058	17.3
Hen harrier	All year	99.0	0.008	122.7

[13] Snow, D. W. & Perrins, C. M. (1998). The Birds of the Western Palearctic. Concise Edition. Oxford University Press.
[14] Alerstam T., Rosén M., Bäckman J., Ericson P.G.P. & Hellgren O. (2007). Flight speeds among bird species: allometric and phylogenetic effects. PLoS Biol, **5**, 1656-1662
[15] Provan, S. & Whitfield, D.P. (2006). Avian flight speeds and biometrics for use in collision risk modelling. Report to Scottish Natural Heritage from Natural Research (Projects) Ltd
[16] SNH. (2014). Bird Speeds and Biometrics for Collision Risk Modelling. Scottish Natural Heritage, Inverness.

WIND FARM PARAMETERS		
Size of windfarm envelope	732	ha
Number of turbines	11	
Rotor diameter	163	m
Hub height	138.5	m
Max. chord	4.15	m
Pitch	15.0	degrees
Rotation period	5.8	s
Turbine operation time	85	%

BIRD PARAMETERS		
Length	0.55	m
Wingspan	1.50	m
Flapping (0) or gliding (+1)	1	
Assumed flight speed	14	ms^-1
Number of hours birds potentially present	4494	hrs
Assumed avoidance rate	98	%

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

VP	Watch Data		Bird Flight Data	
	Area (ha)	Time (hrs)	Total (s)	'Risk height' (s)
2	332.8	72.00	424	375
3	199.4	72.00	1197	517
5	234.0	72.00	0	0
6	268.7	72.00	0	0
Totals	1034.9	288.0	1621	892

Flight Activity Per Unit Time & Area			Weighted By Observation Effort		
VP	Observation effort (HaHr)	Flying time at 'risk height' (Hahr^-1)	VP	Weighting	Adjusted time at 'risk height' (Hahr^-1)
2	23963.12	0.0000043	2	0.322	0.0000014
3	14355.88	0.0000100	3	0.193	0.0000019
5	16845.35	0.0000000	5	0.226	0.0000000
6	19349.19	0.0000000	6	0.260	0.0000000
Totals	74513.54	0.0000036	Totals	1.000	0.0000033
			Mean activity hr^-1 in wind farm		
				Risk height	0.24331%
				Rotor height	0.19830%

MORTALITY ESTIMATE		
Flight risk volume (Vw)	1192746342	m^3
Rotor radius^2	6642.25	m
Combined rotor swept area (Va)	229540	m^2
Vr = Va * (d + l)	1078837	m^3
Bird occupancy (n)	8.91	hrs / yr
Bird occupancy of rotor swept vol (b)	29.02	bird-secs
Bird transit time (t)	0.34	secs
No. of transits through rotors	86.44	per year
Estimated no. of collisions	3.92	per year
After allowing for avoidance	0.078	per year
i.e. equivalent to one bird every	**12.7**	**years**

WIND FARM PARAMETERS		
Size of windfarm envelope	732	ha
Number of turbines	11	
Rotor diameter	163	m
Hub height	138.5	m
Max. chord	4.15	m
Pitch	15.0	degrees
Rotation period	5.8	s
Turbine operation time	85	%

BIRD PARAMETERS		
Length	0.63	m
Wingspan	1.85	m
Flapping (0) or gliding (+1)	1	
Assumed flight speed	11	ms^-1
Number of hours birds potentially present	4494	hrs
Assumed avoidance rate	99	%

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

VP	Watch Data		Bird Flight Data	
	Area (ha)	Time (hrs)	Total (s)	'Risk height' (s)
2	332.8	72.00	1292	423
3	199.4	72.00	1508	613
5	234.0	72.00	84	0
6	268.7	72.00	629	313
Totals	1034.9	288.0	3513	1349

Flight Activity Per Unit Time & Area			Weighted By Observation Effort		
VP	Observation effort (HaHr)	Flying time at 'risk height' (Hahr^-1)	VP	Weighting	Adjusted time at 'risk height' (Hahr^-1)
2	23963.12	0.0000049	2	0.322	0.0000016
3	14355.88	0.0000119	3	0.193	0.0000023
5	16845.35	0.0000000	5	0.226	0.0000000
6	19349.19	0.0000045	6	0.260	0.0000012
Totals	74513.54	0.0000053	Totals	1.000	0.0000050

Mean activity hr^-1 in wind farm	
Risk height	0.36799%
Rotor height	0.29991%

MORTALITY ESTIMATE		
Flight risk volume (Vw)	1192746342	m^3
Rotor radius^2	6642.25	m
Combined rotor swept area (Va)	229540	m^2
Vr = Va * (d + l)	1097200	m^3
Bird occupancy (n)	13.48	hrs / yr
Bird occupancy of rotor swept vol (b)	44.64	bird-secs
Bird transit time (t)	0.43	secs
No. of transits through rotors	102.72	per year
Estimated no. of collisions	5.79	per year
After allowing for avoidance	0.058	per year
i.e. equivalent to one bird every	**17.3**	**years**

WIND FARM PARAMETERS		
Size of windfarm envelope	732	ha
Number of turbines	11	
Rotor diameter	163	m
Hub height	138.5	m
Max. chord	4.15	m
Pitch	15.0	degrees
Rotation period	5.8	s
Turbine operation time	85	%

BIRD PARAMETERS		
Length	0.48	m
Wingspan	1.10	m
Flapping (0) or gliding (+1)	1	
Assumed flight speed	13	ms^-1
Number of hours birds potentially present	4494	hrs
Assumed avoidance rate	99	%

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

VP	Watch Data		Bird Flight Data	
	Area (ha)	Time (hrs)	Total (s)	'Risk height' (s)
2	332.8	72.00	0	0
3	199.4	72.00	0	0
5	234.0	72.00	0	0
6	268.7	72.00	573	202
Totals	1034.9	288.0	573	202

Flight Activity Per Unit Time & Area			Weighted By Observation Effort		
VP	Observation effort (HaHr)	Flying time at 'risk height' (Hahr^-1)	VP	Weighting	Adjusted time at 'risk height' (Hahr^-1)
2	23963.12	0.0000000	2	0.322	0.0000000
3	14355.88	0.0000000	3	0.193	0.0000000
5	16845.35	0.0000000	5	0.226	0.0000000
6	19349.19	0.0000029	6	0.260	0.0000008
Totals	74513.54	0.0000007	Totals	1.000	0.0000008

Mean activity hr^-1 in wind farm	
Risk height	0.05510%
Rotor height	0.04491%

MORTALITY ESTIMATE		
Flight risk volume (Vw)	1192746342	m^3
Rotor radius^2	6642.25	m
Combined rotor swept area (Va)	229540	m^2
Vr = Va * (d + l)	1062769	m^3
Bird occupancy (n)	2.02	hrs / yr
Bird occupancy of rotor swept vol (b)	6.47	bird-secs
Bird transit time (t)	0.36	secs
No. of transits through rotors	18.18	per year
Estimated no. of collisions	0.81	per year
After allowing for avoidance	0.008	per year
i.e. equivalent to one bird every	**122.7**	**years**

Appendix 1

Probability of collision; goshawk

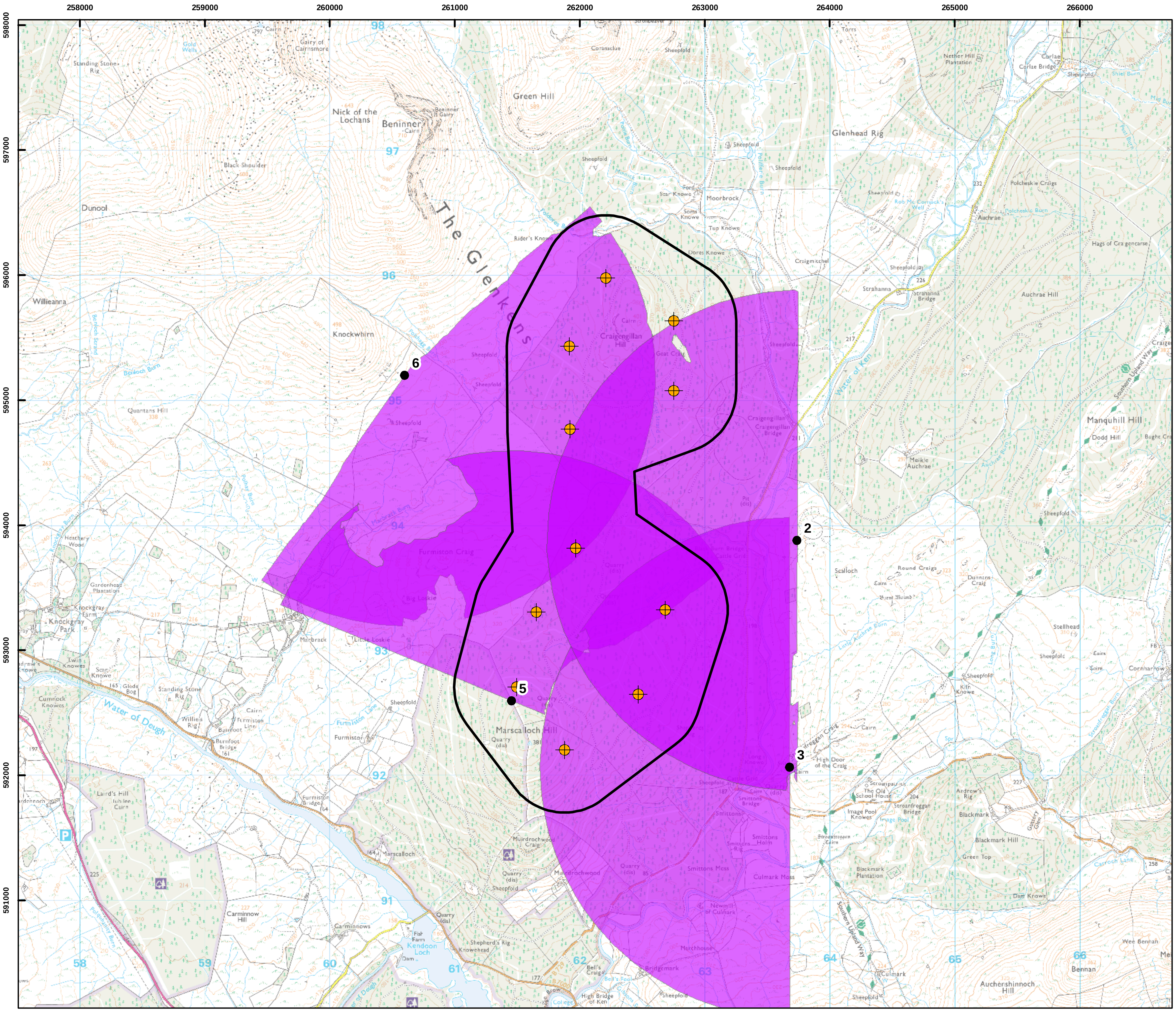
K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**									
NoBlades	3						Upwind:				Downwind:	
MaxChord	4.15	m	r/R	c/C	α	collide			collide			
Pitch (degrees)	15.0		radius	chord	alpha	length	p(collision)	y(x)	length	p(collision)		y(x)
			0				1.00	0.000		1.00		0.000
BirdLength	0.55	m	0.05	0.575	3.15	10.90	0.40	0.040	9.67	0.36		0.036
Wingspan	1.5	m	0.1	0.622	1.58	6.11	0.23	0.045	4.77	0.18		0.035
F: Flapping (0) or gliding (+1)	1		0.15	0.781	1.05	5.13	0.19	0.057	3.46	0.13		0.039
			0.2	0.939	0.79	4.73	0.18	0.070	2.71	0.10		0.040
Bird speed	14	m/sec	0.25	0.971	0.63	4.10	0.15	0.076	2.01	0.07		0.037
RotorDiam	163	m	0.3	0.923	0.53	3.44	0.13	0.077	1.46	0.05		0.032
RotationPeriod	5.77	sec	0.35	0.875	0.45	2.95	0.11	0.077	1.07	0.04		0.028
			0.4	0.827	0.39	2.57	0.10	0.076	0.80	0.03		0.024
integration interval	0.05		0.45	0.780	0.35	2.48	0.09	0.083	0.81	0.03		0.027
			0.5	0.732	0.32	2.26	0.08	0.084	0.69	0.03		0.026
Bird aspect ratioo: β	0.37		0.55	0.684	0.29	2.07	0.08	0.085	0.60	0.02		0.025
			0.6	0.637	0.26	1.90	0.07	0.085	0.56	0.02		0.025
			0.65	0.589	0.24	1.76	0.07	0.085	0.61	0.02		0.029
			0.7	0.541	0.23	1.62	0.06	0.084	0.64	0.02		0.033
			0.75	0.494	0.21	1.50	0.06	0.083	0.66	0.02		0.037
			0.8	0.446	0.20	1.38	0.05	0.082	0.68	0.03		0.040
			0.85	0.398	0.19	1.27	0.05	0.080	0.68	0.03		0.043
			0.9	0.350	0.18	1.17	0.04	0.078	0.68	0.03		0.045
			0.95	0.303	0.17	1.08	0.04	0.076	0.67	0.03		0.048
			1	0.255	0.16	0.99	0.04	0.073	0.66	0.02		0.049
			Overall p(collision) =				**Upwind**	**7.3%**		**Downwind**		**3.4%**
							Average	**5.3%**				

Probability of collision; red kite

K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**									
NoBlades	3						Upwind:				Downwind:	
MaxChord	4.15	m	r/R	c/C	α	collide			collide			
Pitch (degrees)	15.0		radius	chord	alpha	length	p(collision)	y(x)	length	p(collision)		y(x)
			0				1.00	0.000		1.00		0.000
BirdLength	0.63	m	0.05	0.575	2.48	9.25	0.44	0.044	8.01	0.38		0.038
Wingspan	1.85	m	0.1	0.622	1.24	5.22	0.25	0.049	3.88	0.18		0.037
F: Flapping (0) or gliding (+1)	1		0.15	0.781	0.83	4.40	0.21	0.062	2.72	0.13		0.039
			0.2	0.939	0.62	4.07	0.19	0.077	2.05	0.10		0.039
Bird speed	11	m/sec	0.25	0.971	0.50	3.55	0.17	0.084	1.47	0.07		0.035
RotorDiam	163	m	0.3	0.923	0.41	3.01	0.14	0.085	1.02	0.05		0.029
RotationPeriod	5.77	sec	0.35	0.875	0.35	2.60	0.12	0.086	0.72	0.03		0.024
			0.4	0.827	0.31	2.55	0.12	0.096	0.77	0.04		0.029
integration interval	0.05		0.45	0.780	0.28	2.33	0.11	0.099	0.65	0.03		0.028
			0.5	0.732	0.25	2.14	0.10	0.101	0.69	0.03		0.033
Bird aspect ratioo: β	0.34		0.55	0.684	0.23	1.98	0.09	0.103	0.75	0.04		0.039
			0.6	0.637	0.21	1.84	0.09	0.104	0.79	0.04		0.045
			0.65	0.589	0.19	1.71	0.08	0.105	0.81	0.04		0.050
			0.7	0.541	0.18	1.60	0.08	0.106	0.83	0.04		0.055
			0.75	0.494	0.17	1.49	0.07	0.105	0.83	0.04		0.059
			0.8	0.446	0.15	1.39	0.07	0.105	0.83	0.04		0.063
			0.85	0.398	0.15	1.29	0.06	0.104	0.82	0.04		0.066
			0.9	0.350	0.14	1.20	0.06	0.102	0.81	0.04		0.069
			0.95	0.303	0.13	1.11	0.05	0.100	0.80	0.04		0.072
			1	0.255	0.12	1.03	0.05	0.097	0.78	0.04		0.073
			Overall p(collision) =				**Upwind**	**8.8%**		**Downwind**		**4.4%**
							Average	**6.6%**				

Probability of collision; hen harrier

K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**								
NoBlades	3						Upwind:			Downwind:	
MaxChord	4.15	m	r/R	c/C	α	collide			collide		
Pitch (degrees)	15.0		radius	chord	alpha	length	p(collision)	y(x)	length	p(collision)	y(x)
			0				1.00	0.000		1.00	0.000
BirdLength	0.48	m	0.05	0.575	2.93	9.42	0.38	0.038	8.19	0.33	0.033
Wingspan	1.1	m	0.1	0.622	1.46	5.35	0.21	0.043	4.01	0.16	0.032
F: Flapping (0) or gliding (+1)	1		0.15	0.781	0.98	4.58	0.18	0.055	2.90	0.12	0.035
			0.2	0.939	0.73	4.28	0.17	0.068	2.26	0.09	0.036
Bird speed	13	m/sec	0.25	0.971	0.59	3.73	0.15	0.075	1.65	0.07	0.033
RotorDiam	163	m	0.3	0.923	0.49	3.14	0.13	0.075	1.16	0.05	0.028
RotationPeriod	5.77	sec	0.35	0.875	0.42	2.89	0.12	0.081	1.01	0.04	0.028
			0.4	0.827	0.37	2.58	0.10	0.083	0.81	0.03	0.026
integration interval	0.05		0.45	0.780	0.33	2.33	0.09	0.084	0.66	0.03	0.024
			0.5	0.732	0.29	2.13	0.09	0.085	0.55	0.02	0.022
Bird aspect ratioo: β	0.44		0.55	0.684	0.27	1.95	0.08	0.086	0.48	0.02	0.021
			0.6	0.637	0.24	1.79	0.07	0.086	0.54	0.02	0.026
			0.65	0.589	0.23	1.64	0.07	0.086	0.58	0.02	0.030
			0.7	0.541	0.21	1.52	0.06	0.085	0.61	0.02	0.034
			0.75	0.494	0.20	1.40	0.06	0.084	0.62	0.02	0.037
			0.8	0.446	0.18	1.29	0.05	0.082	0.63	0.03	0.040
			0.85	0.398	0.17	1.18	0.05	0.080	0.63	0.03	0.043
			0.9	0.350	0.16	1.08	0.04	0.078	0.63	0.03	0.045
			0.95	0.303	0.15	0.99	0.04	0.075	0.62	0.02	0.047
			1	0.255	0.15	0.90	0.04	0.072	0.60	0.02	0.048
			Overall p(collision) =			**Upwind**		**7.3%**	**Downwind**		**3.2%**
							Average	**5.3%**			



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Key

- Proposed turbine locations
- Flight Activity Survey Area
- Vantage Points
- Viewsheds

Date produced: 02/04/2026

Source: NRP LTD

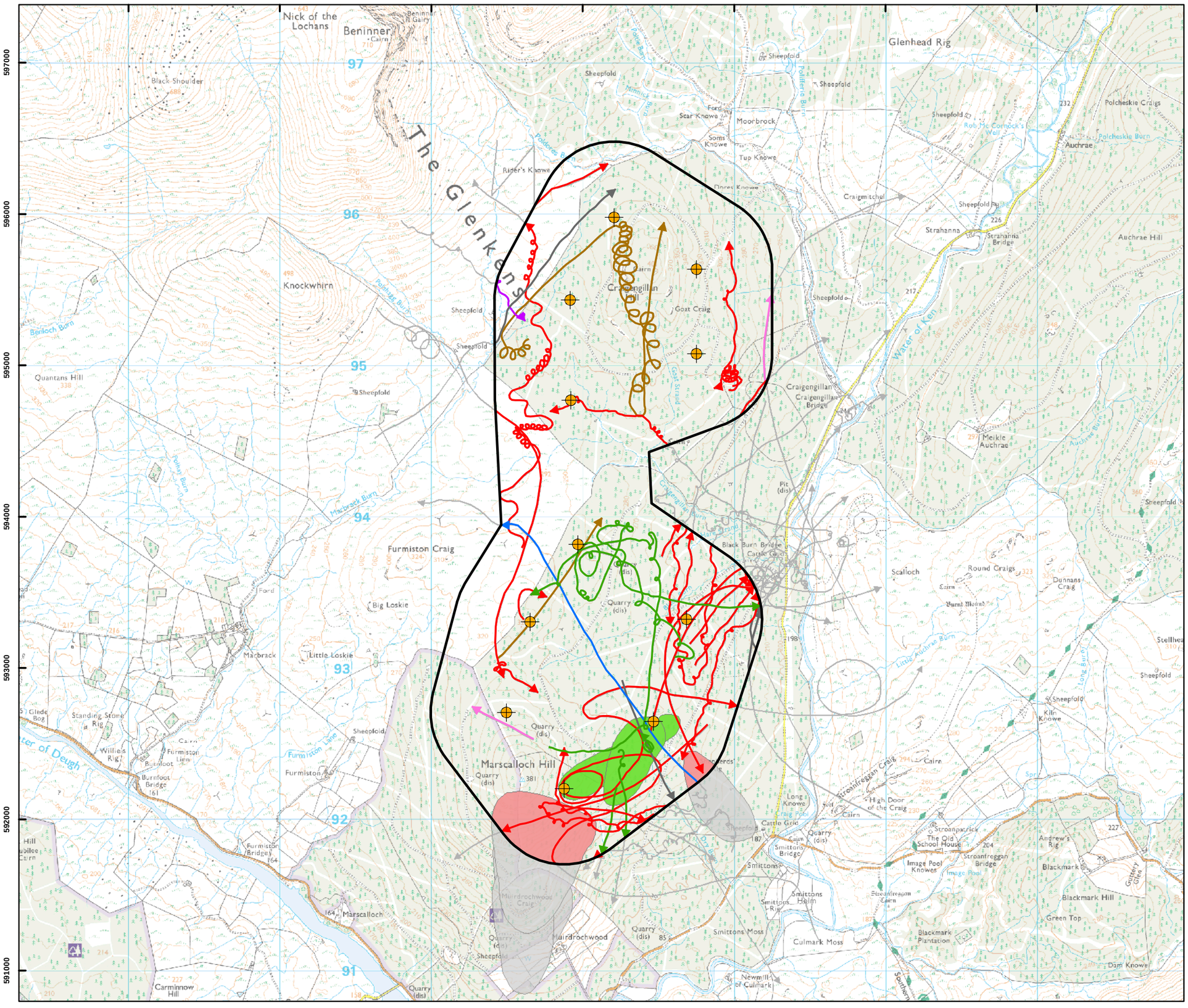
N

0 0.25 0.5 1 km

Figure 1.

Vantage Points and viewsheds

Shepherd's Rig



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nrp NATURAL RESEARCH PROJECTS LIMITED

Key

- Proposed turbine locations
- Flight Activity Survey Area

Flight lines

- Goshawk
- Greylag goose
- Hen harrier
- Merlin
- Pink-footed goose
- Red kite
- Whooper swan

Flight areas

- Goshawk
- Red kite

Date produced: 02/04/2026
Source: NRP LTD

N

0 0.25 0.5 1 km

Figure 2.

Flights used in collision risk modelling

Shepherd's Rig