Appendix 5.1

Keerglen Wind Farm, Vantage Point (VP) Survey Details, April 2019 to March 2021

Keerglen Wind Farm

APPENDIX 5.1

Keerglen Wind Farm,

Vantage Point (VP) Survey Details,

April 2019 to March 2021

Date	Season	VP no.	Duration (hrs)	Start Time	Weather conditions
	Summer no. 1				
08/04/2019	Summer	1	3	11.00	Dry, Moderate visibility, E F4
08/04/2019	Summer	2	3	15.10	Dry, Moderate visibility, E F4
26/04/2019	Summer	2	3	08.30	Dry, Good visibility, NE 3
26/04/2019	Summer	1	3	12.15	Dry, Good visibility, NE 3-4
29/04/2019	Summer	2	3	07.30	Dry, Good visibility, S wind, F4
29/04/2019	Summer	1	3	11.30	Dry, Good visibility, SW wind, F3-4
21/05/2019	Summer	2	3	13:00	Dry, Good visibility, SW wind, F3
21/05/2019	Summer	1	3	16:40	Dry, Good visibility, SW wind, F3
17/06/2019	Summer	1	3	11.40	Dry, Good visibility, W wind, F4
17/06/2019	Summer	2	3	15:20	Dry, Good visibility, W wind, F4
21/06/2019	Summer	2	3	11:30	Dry, Good visibility, NE wind, F4
21/06/2019	Summer	1	3	15:45	Dry, Good visibility, NE wind, F3
08/07/2019	Summer	1	3	12:30	Dry, Good visibility, WSW wind, F3-4
08/07/2019	Summer	2	3	16:00	Dry, Good visibility, WSW wind, F4
30/07/2019	Summer	1	3	09:05	Drizzle, Moderate visibility, NW wind, F4
30/07/2019	Summer	2	3	13:20	Drizzle, Moderate visibility, NW wind, F4
23/08/2019	Summer	1	3	12:20	Dry, Good visibility, SW wind, F4-5
23/08/2019	Summer	2	3	16:20	Dry, Good visibility, SW wind, F5
24/08/2019	Summer	2	3	07:30	Showers, Good visibility, S wind, F3
24/08/2019	Summer	1	3	11:00	Showers, Good visibility, S wind, F3
12/09/2019	Summer	1	3	09:00	Showers, Good visibility, SW wind, F4
12/09/2019	Summer	2	3	12:45	Dry, Good visibility, NW wind, F4-5
13/09/2019	Summer	2	3	10:00	Dry, Good visibility, W wind, F3
13/09/2019	Summer	1	3	15:00	Dry, Good visibility, W wind, F4
	Winter no. 1				
22/10/2019	Winter	2	3	08:00	Showers, Moderate visibility, SW wind, F4
22/10/2019	Winter	1	3	12:15	Showers, Moderate visibility, SW wind, F4
24/10/2019	Winter	1	3	08:00	Squalls, Good visibility, SW wind, F3

Date	Season	VP no.	Duration (hrs)	Start Time	Weather conditions
24/10/2019	Winter	2	3	12:00	Squalls, Good visibility, SW wind, F3
08/11/2019	Winter	1	3	07:45	Dry, Good visibility, NE wind, F3
08/11/2019	Winter	2	3	11.45	Dry, Good visibility, NE wind, F4
11/11/2019	Winter	2	3	09:00	Dry, Good visibility, NW wind, F5
11/11/2019	Winter	1	3	13.10	Dry, Good visibility, NW wind, F4
02/12/2019	Winter	2	3	08.30	Dry, Good visibility, SW wind, F4-5
02/12/2019	Winter	1	3	12.30	Dry, Moderate visibility, SW wind, F4
16/12/2019	Winter	1	3	09:30	Dry, Good visibility, SSW wind, F5
16/12/2019	Winter	2	3	14:00	Drizzle, Good visibility, SSW wind, F4
24/01/2020	Winter	2	3	07.36	Drizzle, Mod. visibility, S wind, F4-5
24/01/2020	Winter	1	3	11:55	Drizzle, Mod. visibility, S wind, F4
29/01/2020	Winter	1	3	10:00	Showers, Good visibility, SW wind, F4-5
29/01/2020	Winter	2	3	14:15	Showers, Good visibility, SW wind, F4
07/02/2020	Winter	1	3	10:00	Dry, Good visibility, SE wind, F4
07/02/2020	Winter	2	3	14:20	Showers, Good visibility, SE wind, F5
23/02/2020	Winter	2	3	07:40	Dry, Good visibility, W wind, F4+
23/02/2020	Winter	1	3	11:50	Dry, Good visibility, W wind, F4
06/03/2020	Winter	1	3	08:15	Showers, Mod. visibility, WNW wind, F4
06/03/2020	Winter	2	3	12:30	Showers, Good visibility, WNW wind, F4-5
30/03/2020	Winter	2	3	10:04	Dry, Good visibility, N wind, F3-4
30/03/2020	Winter	1	3	17:20	Dry, Good visibility, N wind, F3-4
	Summer no. 2				
11/04/2020	Summer	2	3	13:30	Dry, Good visibility, SW wind, F3
11/04/2020	Summer	1	3	17:30	Dry, Good visibility, W wind, F3-4
27/04/2020	Summer	1	3	07:08	Squalls, Good visibility, NE wind, F3-4
27/04/2020	Summer	2	3	11:30	Dry, Good visibility, N wind, F4
20/05/2020	Summer	1	3	09:45	Dry, Good visibility, SSE wind, F3
20/05/2020	Summer	2	3	14:30	Dry, Good visibility, SSE wind, F3
21/05/2020	Summer	2	3	07:50	Dry, Good visibility, SW wind, F2-3
21/05/2020	Summer	1	3	12:00	Dry, Good visibility, SSE wind, F4-5
18/06/2020	Summer	2	3	07:45	Dry, Good visibility, NNE wind, F1-2
18/06/2020	Summer	1	3	12:15	Dry, Good visibility, NNE wind, F1-2
19/06/2020	Summer	2	3	14:20	Dry, Good visibility, SSW wind, F3
19/06/2020	Summer	1	3	17:50	Dry, Good visibility, SSW wind, F3

Date	Season	VP no.	Duration (hrs)	Start Time	Weather conditions
29/07/2020	Summer	2	3	07:00	Dry, Good visibility, S wind, F1-2
29/07/2020	Summer	1	3	10:30	Showers, Mod visibility, SSE wind, F2-3
30/07/2020	Summer	1	3	08:00	Showers, Good visibility, SSE wind, F4+
30/07/2020	Summer	2	3	18:00	Dry, Good visibility, SE wind, F4
26/08/2020	Summer	1	3	07:30	Dry, Good visibility, SSW wind, F2
26/08/2020	Summer	2	3	11:45	Dry, Good visibility, SSW wind, F4
28/08/2020	Summer	2	3	08:00	Showers, Poor-mod. visibility, N wind, F4-5
28/08/2020	Summer	1	3	11:30	Showers, Mod visibility, N wind, F4-5
18/09/2020	Summer	2	3	07:25	Showers, Mod visibility, E wind, F2-3
18/09/2020	Summer	1	3	11:10	Dry, Good visibility, E wind, F3
19/09/2020	Summer	1	3	07:00	Dry, Good visibility, ENE wind, F4
19/09/2020	Summer	2	3	10:30	Dry, Good visibility, ENE wind, F4
	Winter no. 2				
23/10/2020	Winter	2	3	08:10	Dry, Good visibility, SW wind, F4
23/10/2020	Winter	1	3	11:40	Showers, Good visibility, SW wind, F4
24/10/2020	Winter	2	3	11:30	Dry, Good visibility, SWE wind, F4
24/10/2020	Winter	1	3	15:20	Showers, Good visibility, S wind, F4-5
24/11/2020	Winter	1	3	09:30	Showers, Good visibility, NW wind, F3-4
24/11/2020	Winter	2	3	14:00	Dry, Good visibility, NW wind, F4
26/11/2020	Winter	2	3	10:00	Dry, Good visibility, SW wind, F2
26/11/2020	Winter	1	3	13:30	Dry, Good visibility, SW wind, F2
29/12/2020	Winter	1	3	09.30	Sleet, Good visibility, NW F4-5
29/12/2020	Winter	2	3	13.30	Sleet, Good visibility, NW F4-5
30/12/2020	Winter	2	3	08.05	Sleet, Good visibility, NW F2-3
30/12/2020	Winter	1	3	12.15	Sleet, Good visibility, NW F2-3
25/01/2021	Winter	1	3	09.05	Sleet, Good visibility, SW F3
25/01/2021	Winter	2	3	14.25	Showers, Good visibility, SW F4
26/01/2021	Winter	2	3	08.30	Showers, Good visibility, SE F3
26/01/2021	Winter	1	3	12.30	Showers, Good visibility, S F4
24/02/2021	Winter	1	3	09.00	Dry, Good visibility, SW F4-5
24/02/2021	Winter	2	3	13.00	Showers, Good visibility, SW F4
25/02/2021	Winter	2	3	07.20	Dry, Good visibility, WSW F5
25/02/2021	Winter	1	3	15.30	Dry, Good visibility, WSW F5
12/03/2021	Winter	1	3	08.30	Showers, Good visibility, SW F4
12/03/2021	Winter	2	3	12.00	Drizzle, Mod. visibility, SW F4

Date	Season	VP no.	Duration (hrs)	Start Time	Weather conditions
13/03/2021	Winter	2	3	12.00	Dry, Good visibility, W F4-5
13/03/2021	Winter	1	3	16.15	Dry, Good visibility, W F5

Appendix 5.2

Keerglen Wind Farm, Vantage Point Survey Flight Line Results, 2019-2021

Keerglen Wind Farm

APPENDIX 5.2

Keerglen Wind Farm,

Vantage Point Survey

Flight Line Results,

2019-2021

Keerglen Wind Farm - Vantage Point Survey Flightline Data 2019-2021

VP no.	Date	Mapnote / Flightline No.	Common Name	Species Quantity	Time of Obs.	Total Duration (s)	0-20 m (s)	20-50 m (s)	50-100 m (s)	100-180 m (s)	>180 m (s)	Comment
	Summer No. 1											
2	08/04/2019	1	Kestrel	1	15:58	120	0	90	30	-	-	Male hunting close to forest edge - on & off site
1	26/04/2019	2	Kestrel	1	14.14	180	0	90	90	-	-	Hovering / hunting along river corridor
2	26/04/2019	3	Golden plover	1	09.14	30	30	-	-	-	-	Bird flew in and landed on bog - continued calling for more than 30 min - response heard but bird not seen
2	29/04/2019	4	Great black backed gull	1	08.51	70	-	-	70	-	-	Flying along river corridor - adult
1	21/05/2019	5	Kestrel	1	17.12	50	-	-	50	0	0	Flew across site - male
1	08/07/2019	6	Kestrel	1	13:10	180	60	40	80	-	-	Hunting - male
1	08/07/2019	7	Kestrel	1	14.17	200	50	70	80	-	-	Hunting - male prob same bird
2	30/07/2019	8	Kestrel	1	14.33	100	100	-	-	-	-	Male hunting then landed on peat bank & preened for 51 min
2	30/07/2019	9	Buzzard	2	15.07	180	-	-	60	120	-	Pair circling over forest - offsite
2	23/08/2019	10	Sparrowhawk	1	17.15	240	-	-	180	60	-	Circling - female type
2	24/08/2019	11	Buzzard	1	09.17	145	-	-	145	-	-	Flying - mostly off site
2	12/09/2019	12	Kestrel	1	15.00	135	-	90	45	-	-	Male hunting / flying
	Winter no. 1											
2	22/10/2019	13	Golden plover	14	09.45	420	-	30	190	-	-	Flock circling & then onto bog
1	24/10/2019	14	Sparrowhawk	1	14.12	20	20	-	-	-	-	Hunting edge of forest/river
2	08/11/2019	15	Kestrel	1	14.17	190	-	140	50	-	-	Female hunting
2	11/11/2019	16	Kestrel	1	10.25	90	-	40	500	-	-	Female hunting
1	02/12/2019	17	Peregrine	1	14.01	40	-	-	40	-	-	Flew over site eastwards - small bird (male?)
2	16/12/2019	18	Golden plover	4	15.03	25	25	-	-	-	-	Landed on bog
1	29/01/2020	19	Buzzard	1	10.53	90	-	-	90	-	-	Circling over forest
2	23/02/2020	20	Sparrowhawk	2	09.48	160	-	40	100	20	-	Pair rising- offsite
1	06/03/2020	21	Kestrel	1	10.36	45	-	45	-	-	-	Hunting along river edge
2	30/03/2020	22	Buzzard	2	12.15	200	-	-	100	100	-	Pair over forest
1	30/03/2020	23	Lesser black backed gull	2	16.04	170	-	30	140	-	-	Adults
	Summer no. 2											
2	11/04/2020	24	Buzzard	1	15.32	120	-	-	120	-	-	Flying
2	27/04/2020	25	Sparrowhawk	2	11.55	180	-	-	100	80	-	Pair rising over woods
1	21/05/2020	26	Golden Eagle	1	12.56	600	50	50	200	100	200	Probable sub-adult - missing feathers in tail and some primaries - landed on site twice - mobbed by HCs - flew

VP no.	Date	Mapnote / Flightline No.	Common Name	Species Quantity	Time of Obs.	Total Duration (s)	0-20 m (s)	20-50 m (s)	50-100 m (s)	100-180 m (s)	>180 m (s)	Comment
												north and could still be seen greater than 500 m from site for long period.
1	18/06/2020	27	Kestrel	1	12.45	180	20	130	30	-	-	Male hunting - dropped to ground on presumed prey item
2	19/06/2020	28	Buzzard	1	16.02	260	-	110	150	-	-	Flying over forest
1	29/07/2020	29	Sparrowhawk	1	07.00	15	15	-	-	-	-	Male bird with prey item
2	30/07/2020	30	Kestrel	1	18.20	115	-	75	40	-	-	Male quartering
2	30/07/2020	31	Kestrel	1	19.00	140	20	60	60	-	-	Probable same male
1	26/08/2020	32	Sparrowhawk	1	08.43	30	30	-	-	-	-	Male left perch and started hunting
2	26/08/2020	33	Golden plover	21	14.20	420	90	150	80	-	-	Flock circling over bog
2	28/02/2020	34	Golden plover	14	10.52	400	50	200	150	-	-	Flock circling over bog on & off site
1	18/09/2020	35	Buzzard	3	12.23	600	-	100	200	200	100	Trio circling and rising - mostly offsite - calling heard
2	19/09/2020	36	Kestrel	1	11.11	45	-	45	-	-	-	Hovering along edge of forest
	Winter no. 2											
2	23/10/2020	37	Buzzard	1	09.56	120	60	60	-	-	-	Flying low
1	23/10/2020	38	Kestrel	1	13.00	90	-	30	60	-	-	Flying
2	24/11/2020	39	Peregrine	1	14.43	120	-	-	90	30	-	Flying
1	30/12/2020	40	Buzzard	1	12.46	175	-	25	50	100	-	Flew across site
1	25/01/2021	41	Kestrel	1	11.35	180	60	60	60	-	-	Male hunting along river corridor
2	26/01/2021	42	Golden plover	19	11.15	600	20	30	150	200	200	Flock looping over bog - landed
2	24/02/2021	43	Golden plover	23	13.07	240	40	40	160	-	-	Circling and then landed on bog
2	25/02/2021	44	Golden plover	27	09.20	550	60	90	400	-	-	Flying up from bog and then back then
2	25/02/2021	45	Golden plover	42	10.02	600	50	100	450	-	-	Above flock merging with more birds and flew NW
1	25/02/2021	46	Sparrowhawk	2	15.43	240	-	50	140	50	-	Pair soaring
2	12/03/2021	47	Kestrel	1	14.16	110	10	100	-	-	-	Male hunting - dropped to ground
2	13/03/2021	48	Golden plover	15	12.49	64	15	22	27	-	-	Flew south out of site
2	13/03/2021	49	Buzzard	2	13.28	180	-	-	100	80	-	Pair rising

Appendix 5.3a

Summer 2019 Flightlines

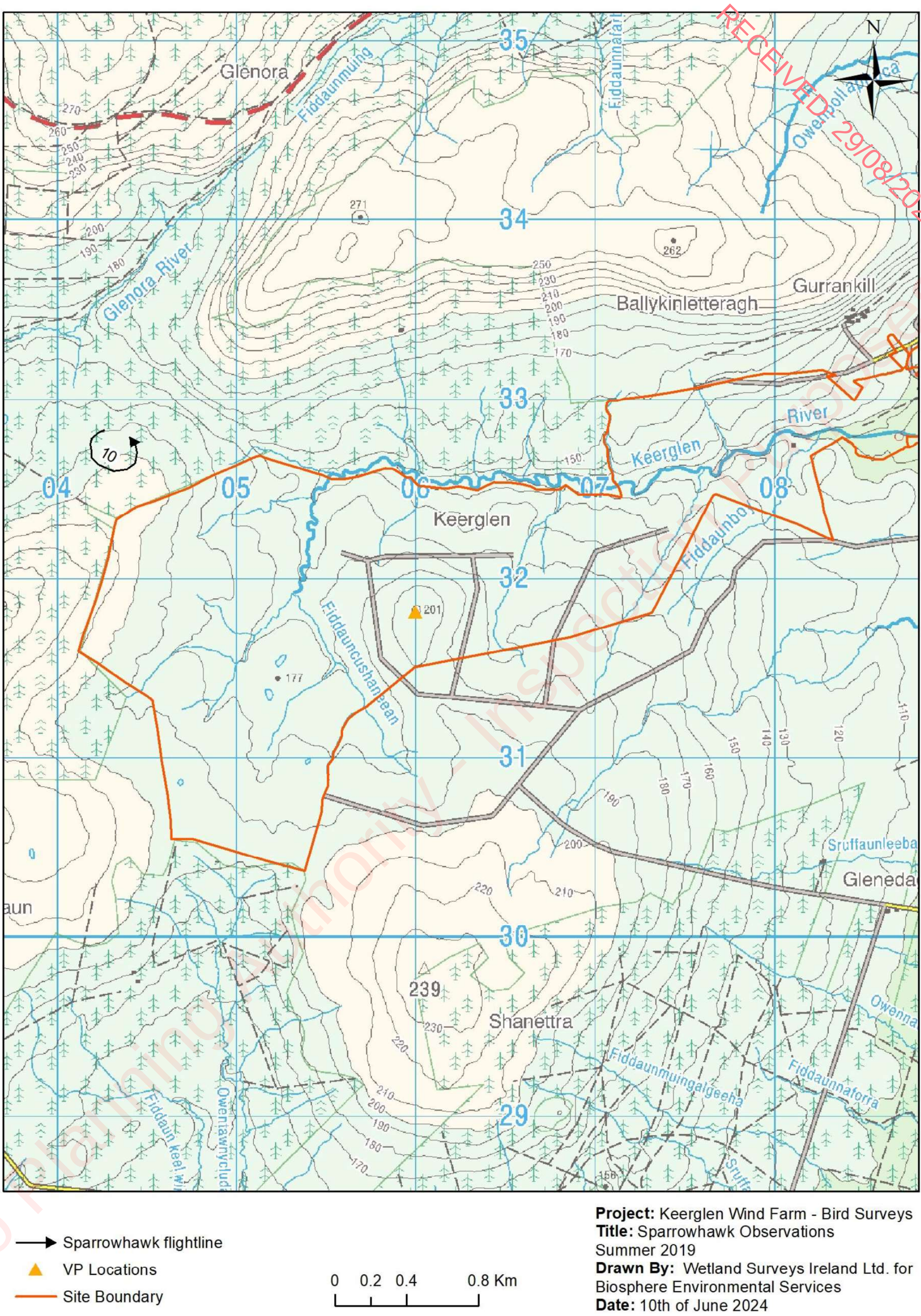
Keerglen Wind Farm

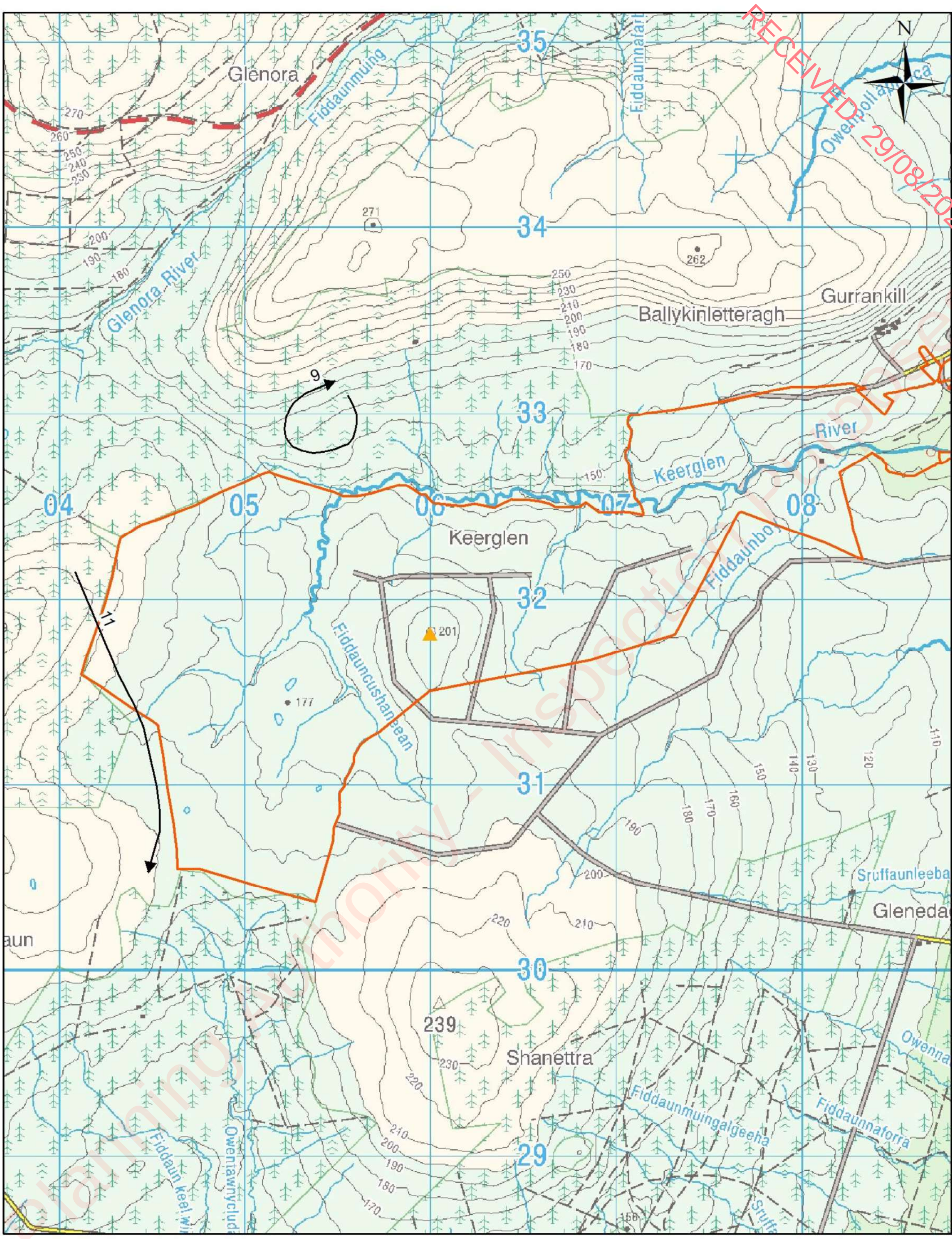
APPENDIX 5.3a

Keerglen Wind Farm

Vantage Point Survey Flightlines - Summer 2019

(details of flightline numbers are given in Appendix 5.2)


Glenora
Glenora River
Keerglen
Keerglen River
Ballykinletteragh
Gurrankill
Shanettra
Glenedag
201
177
239
262
271
Fiddaunmuing
Fiddauncushaneean
Fiddaunbo
Sruffaunleeba
Fiddaunmuingalgeeha
Fiddaunnaforra
Owenpollaphuca
Owennaw
10
N
Sparrowhawk flightline
VP Locations
Site Boundary
0
0.2
0.4
0.8 Km
Project: Keerglen Wind Farm - Bird Surveys
Title: Sparrowhawk Observations
Summer 2019
Drawn By: Wetland Surveys Ireland Ltd. for
Biosphere Environmental Services
Date: 10th of June 2024



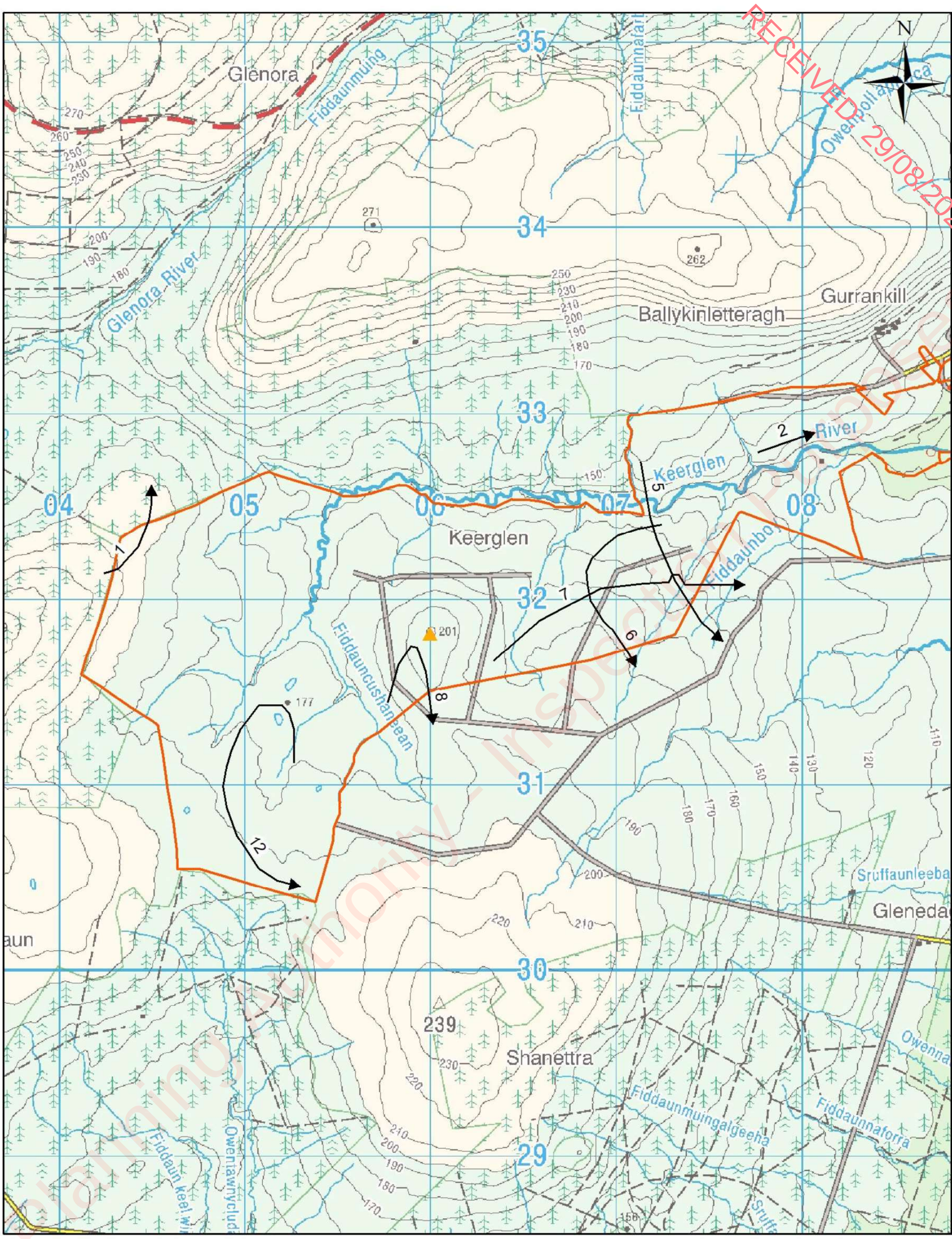
Buzzard flightline

VP Locations

Site Boundary

0 0.2 0.4 0.8 Km

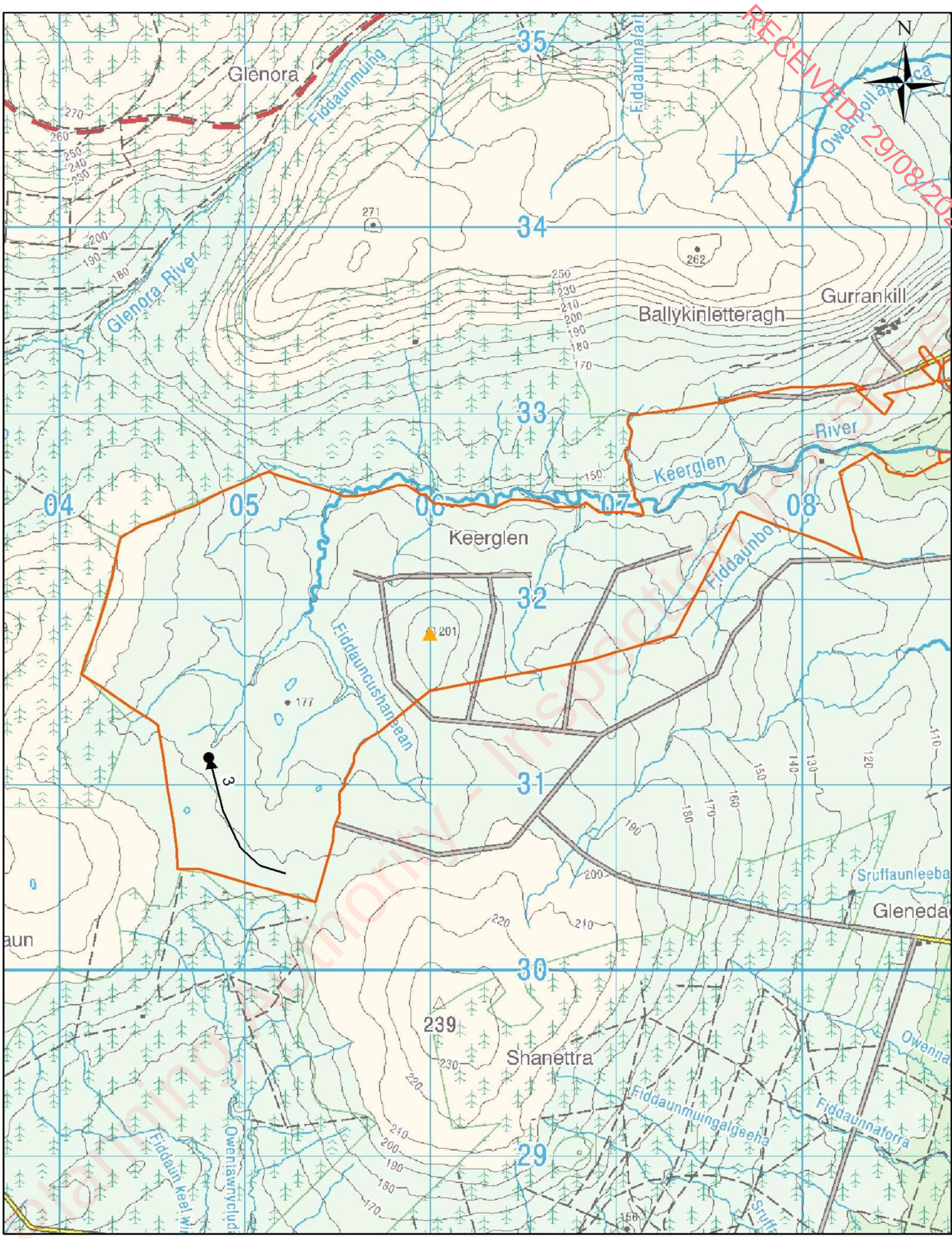
Project: Keerglen Wind Farm - Bird Surveys
Title: Buzzard Observations
Summer 2019
Drawn By: Wetland Surveys Ireland Ltd. for Biosphere Environmental Services
Date: 10th of June 2024



- Kestrel flightline
- VP Locations
- Site Boundary

0 0.2 0.4 0.8 Km

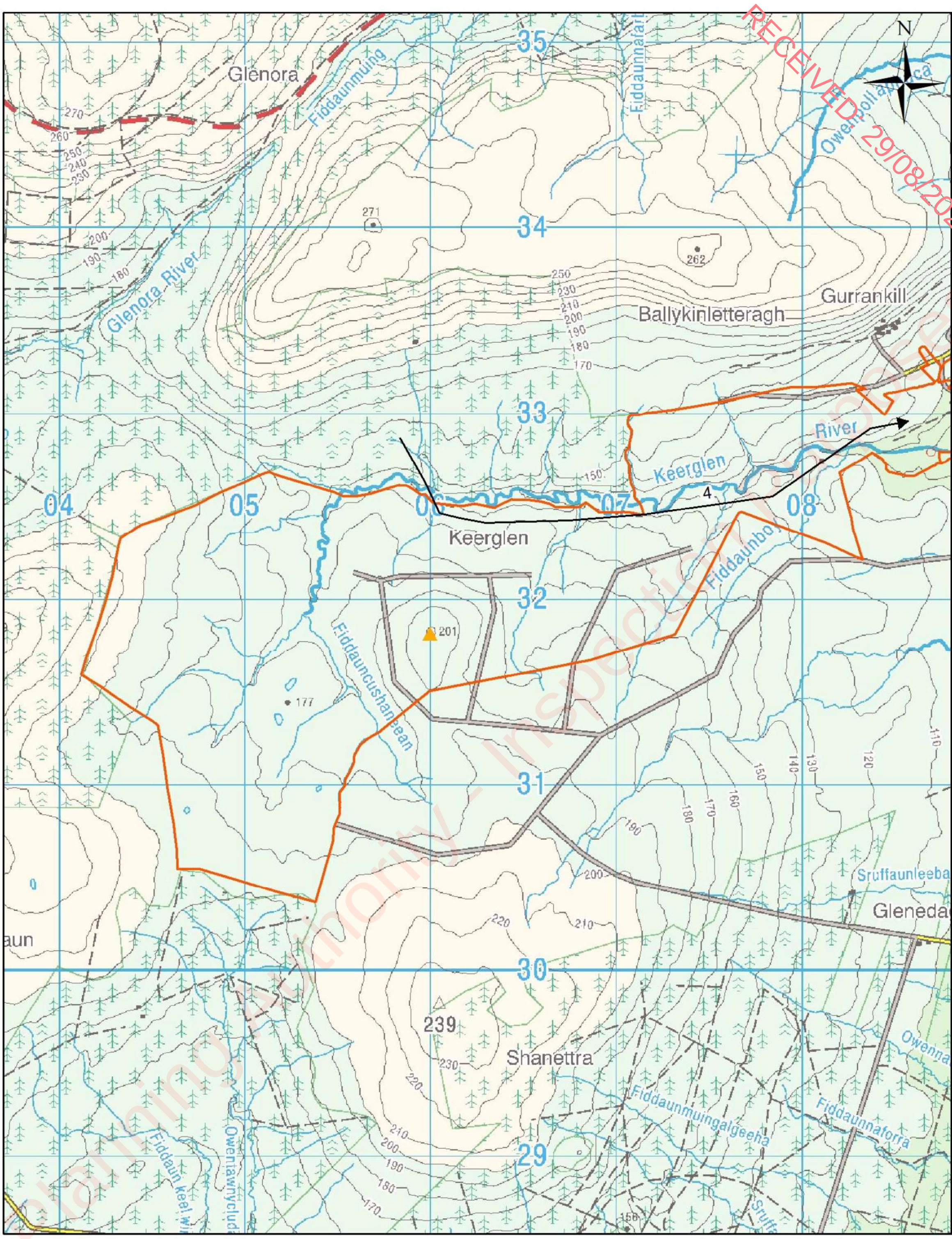
Project: Keerglen Wind Farm - Bird Surveys
Title: Kestrel Observations
Summer 2019
Drawn By: Wetland Surveys Ireland Ltd. for
Biosphere Environmental Services
Date: 10th of June 2024



- Golden Plover ground observation
- Golden Plover flightline
- VP Locations
- Site Boundary

0 0.2 0.4 0.8 Km

Project: Keerglen Wind Farm - Bird Surveys
Title: Golden Plover Observations
Summer 2019
Drawn By: Wetland Surveys Ireland Ltd. for Biosphere Environmental Services
Date: 10th of June 2024



Great Black-backed Gull flightline

VP Locations

Site Boundary

0 0.2 0.4 0.8 Km

Project: Keerglen Wind Farm - Bird Surveys
Title: Buzzard Observations
Summer 2019
Drawn By: Wetland Surveys Ireland Ltd. for Biosphere Environmental Services
Date: 10th of June 2024

Appendix 5.3b

Winter 2019 2020 Flightlines

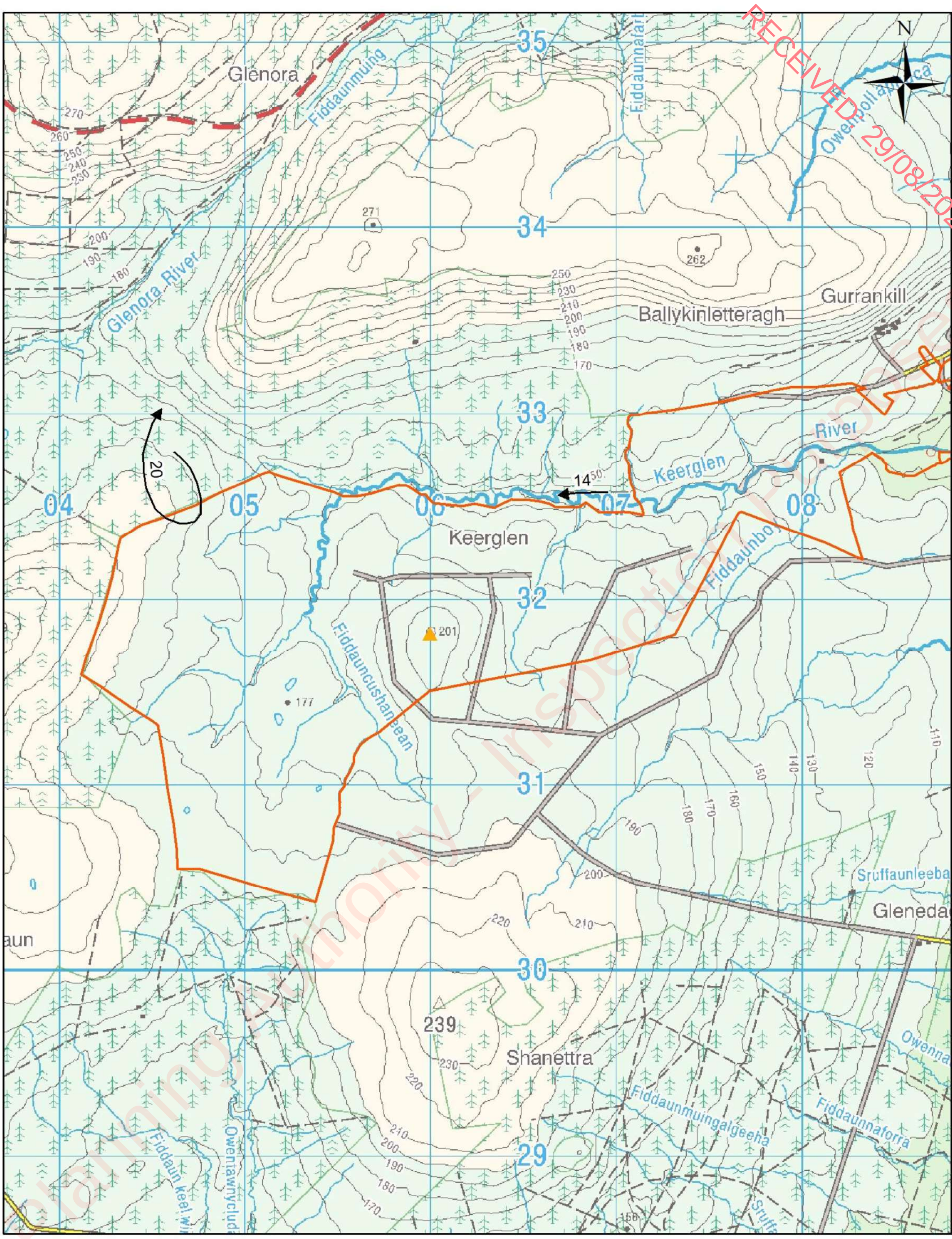
Keerglen Wind Farm

APPENDIX 5.3b

Keerglen Wind Farm

Vantage Point Survey Flightlines - Winter 2019-2020

(details of flightline numbers are given in Appendix 5.2)



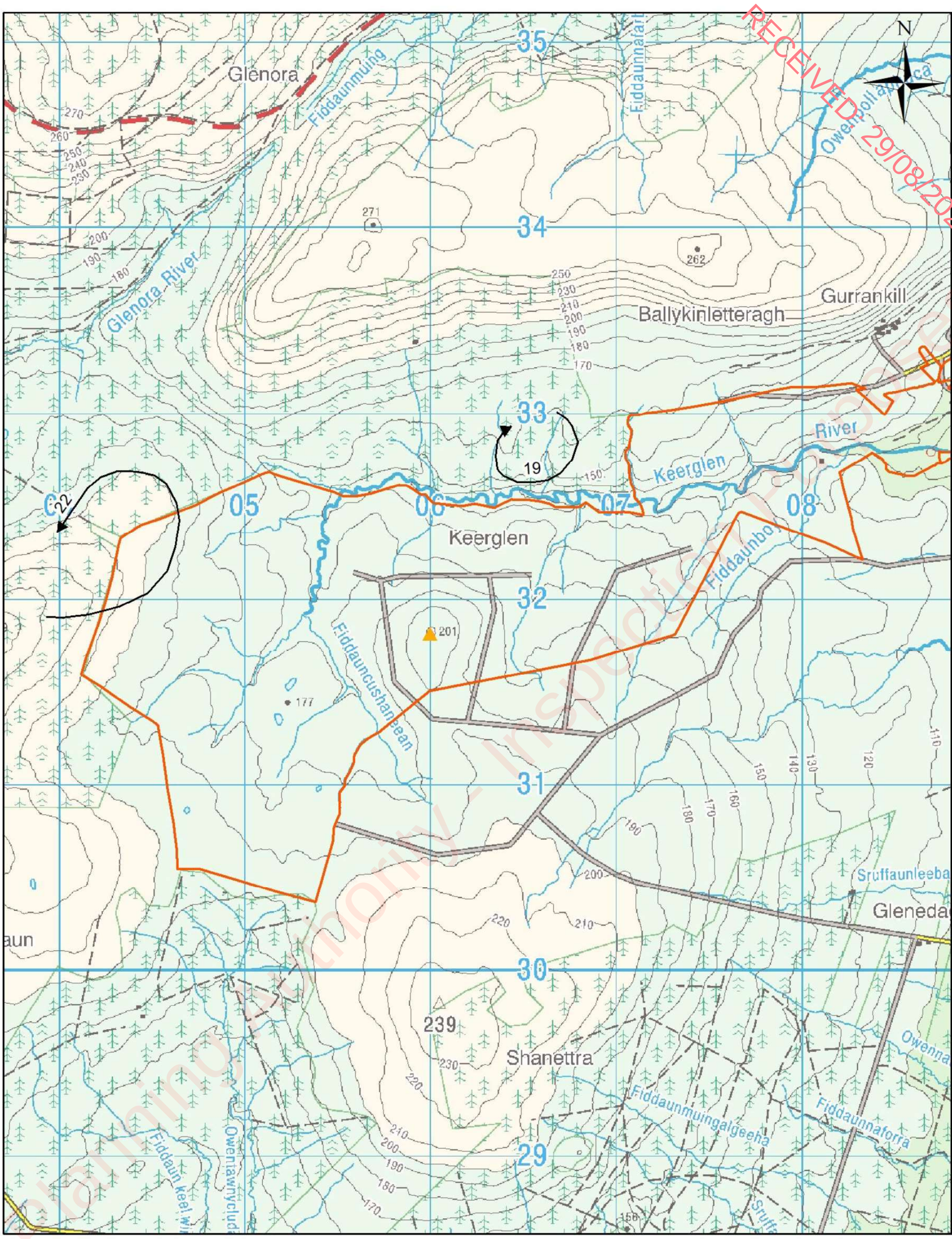
Sparrowhawk flightline

VP Locations

Site Boundary

0 0.2 0.4 0.8 Km

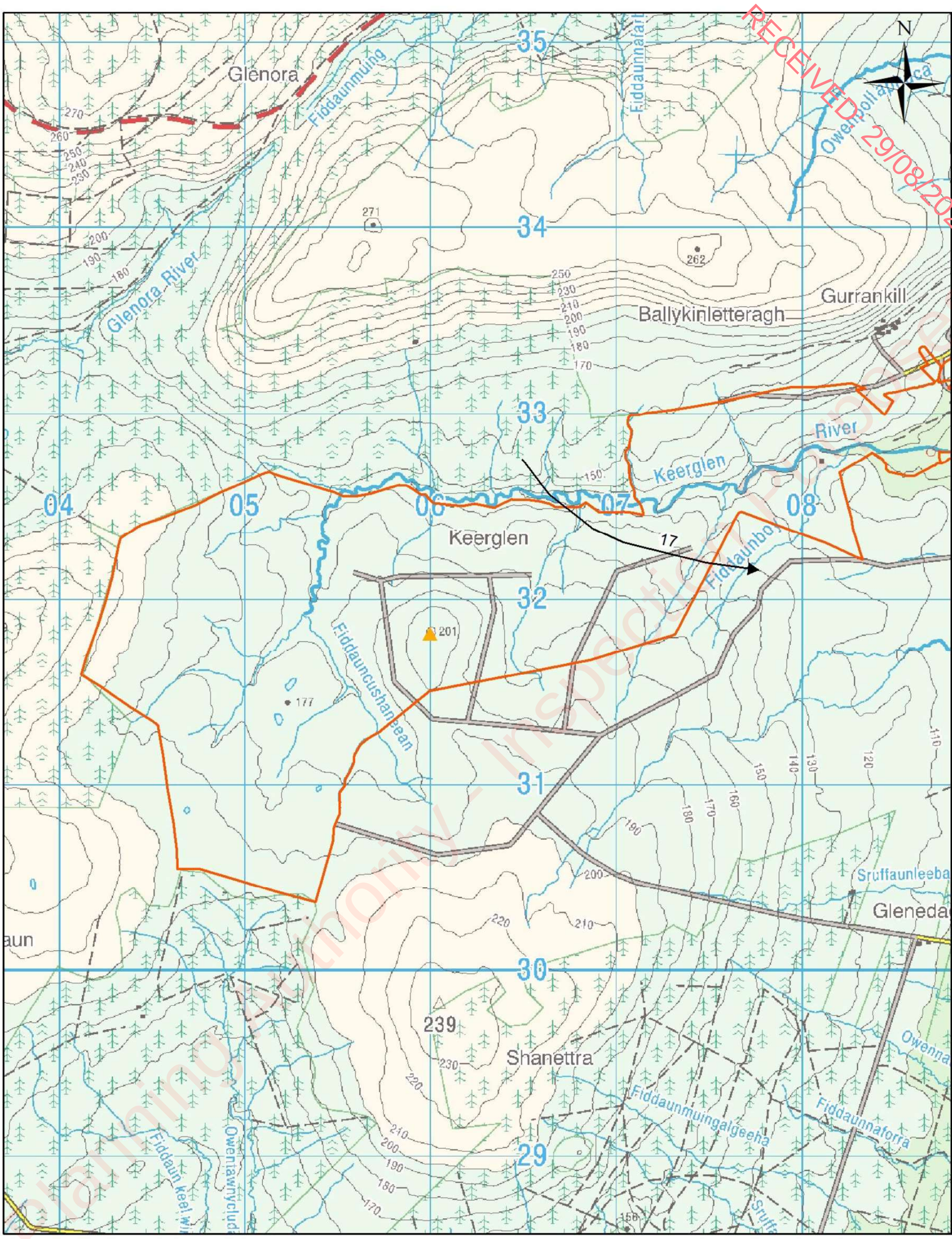
Project: Keerglen Wind Farm - Bird Surveys
Title: Sparrowhawk Observations
Winter 2019-2020
Drawn By: Wetland Surveys Ireland Ltd. for Biosphere Environmental Services
Date: 10th of June 2024



Buzzard flightline
VP Locations
Site Boundary

0 0.2 0.4 0.8 Km

Project: Keerglen Wind Farm - Bird Surveys
Title: Buzzard Observations Winter 2019-2020
Drawn By: Wetland Surveys Ireland Ltd. for Biosphere Environmental Services
Date: 10th of June 2024



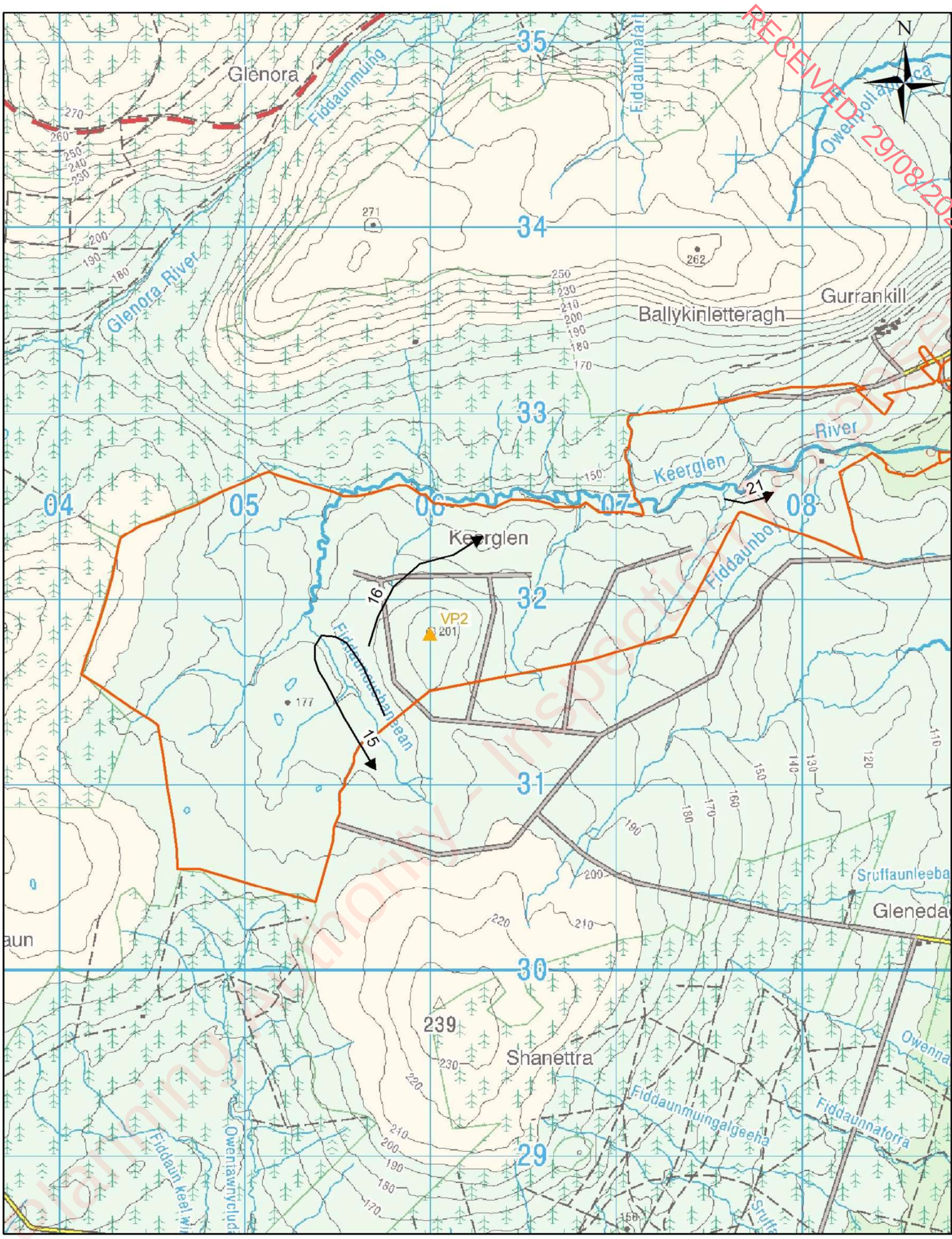
→ Peregrine flightline

▲ VP Locations

— Site Boundary

0 0.2 0.4 0.8 Km

Project: Keerglen Wind Farm - Bird Surveys
Title: Peregrine Observations
Winter 2019-2020
Drawn By: Wetland Surveys Ireland Ltd. for
Biosphere Environmental Services
Date: 10th of June 2024



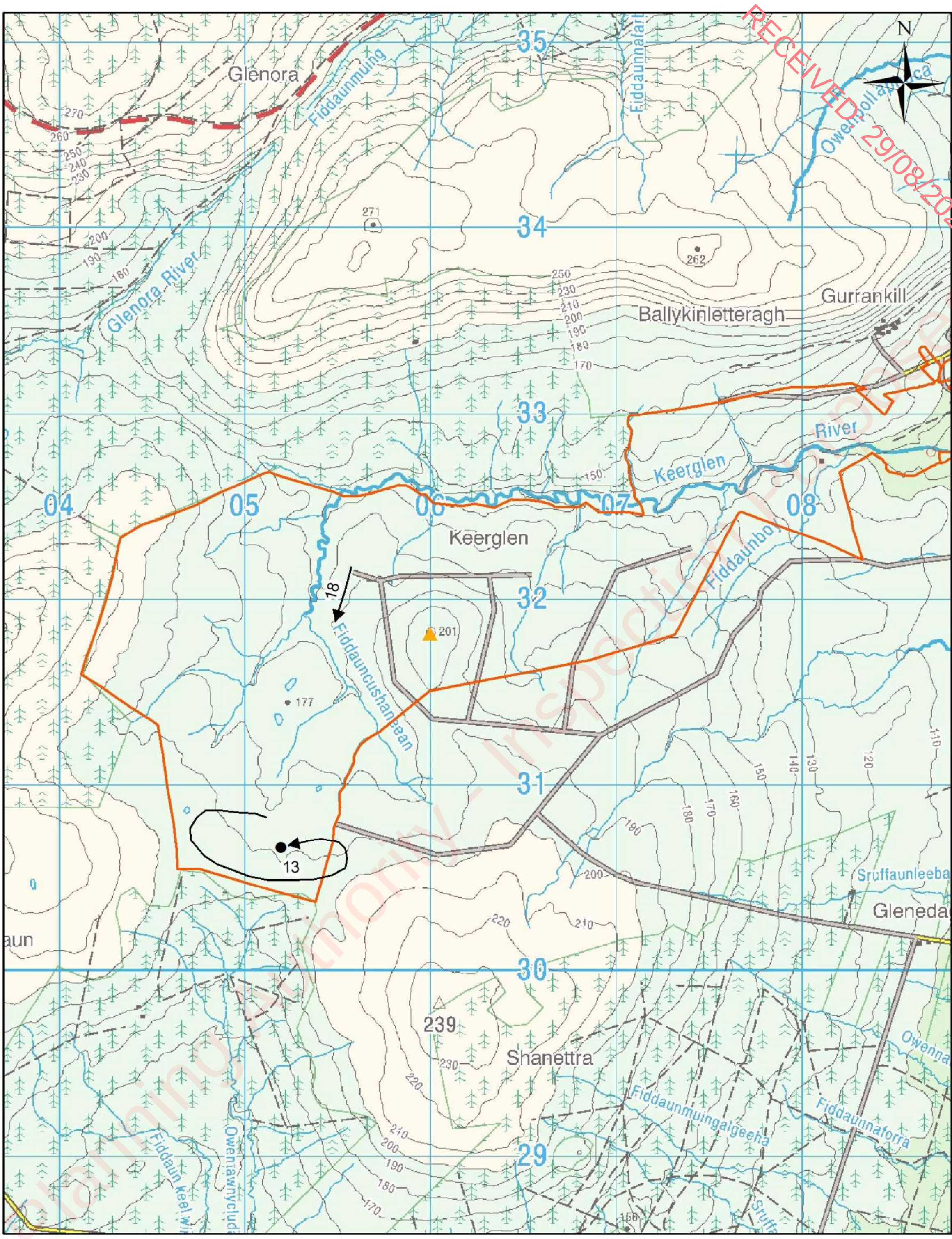
Kestrel flightline

VP Locations

Site Boundary

0 0.2 0.4 0.8 Km

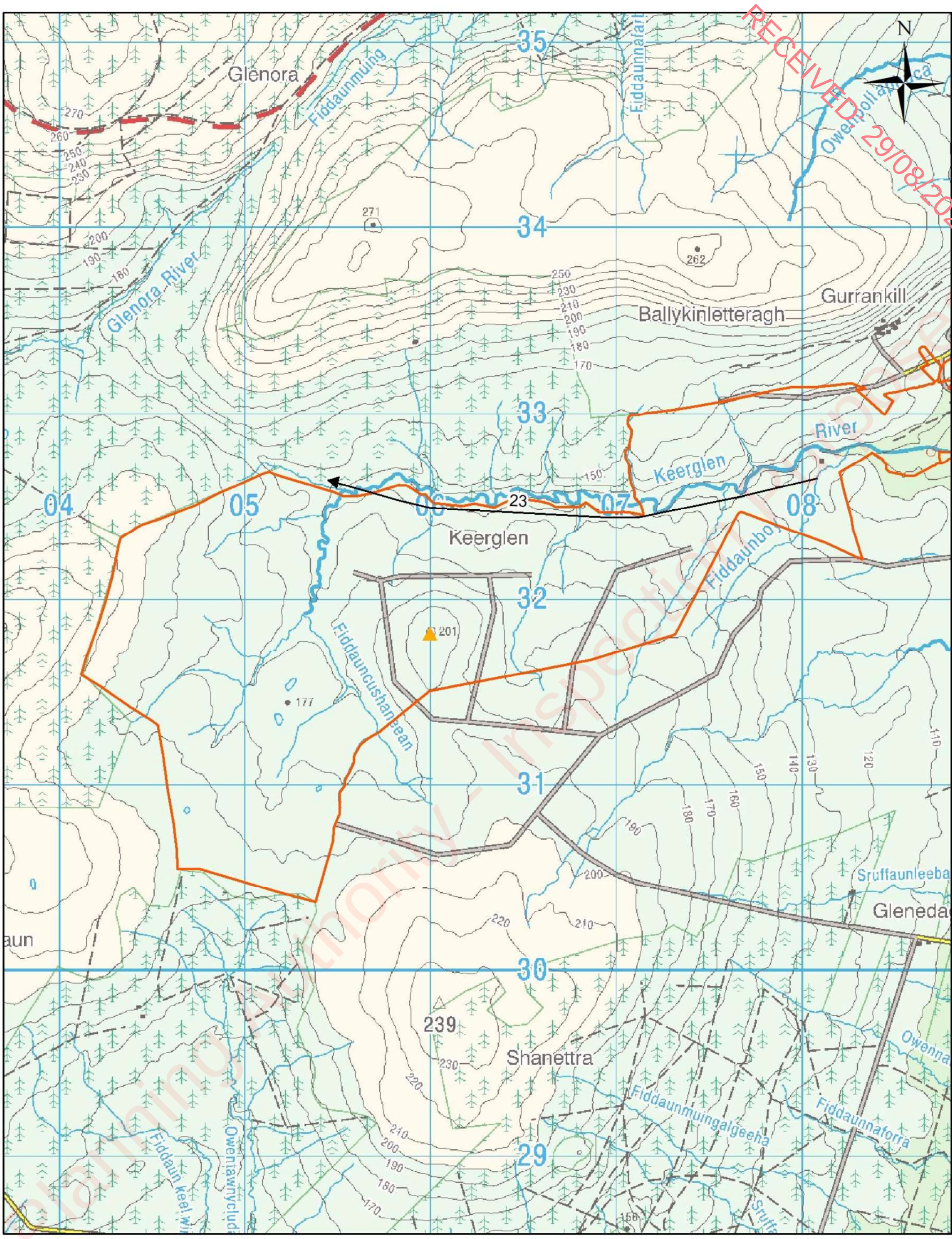
Project: Keerglen Wind Farm - Bird Surveys
Title: Kestrel Observations
Winter 2019-2020
Drawn By: Wetland Surveys Ireland Ltd. for Biosphere Environmental Services
Date: 10th of June 2024



Golden Plover ground observation
Golden Plover flightline
VP Locations
Site Boundary

0 0.2 0.4 0.8 Km

Project: Keerglen Wind Farm - Bird Surveys
Title: Golden Plover Observations
Winter 2019-2020
Drawn By: Wetland Surveys Ireland Ltd. for Biosphere Environmental Services
Date: 10th of June 2024



- Lesser Black-backed Gull flightline
- VP Locations
- Site Boundary

0 0.2 0.4 0.8 Km

Project: Keerglen Wind Farm - Bird Surveys
Title: Lesser Black-backed Gull Observations Winter 2019-2020
Drawn By: Wetland Surveys Ireland Ltd. for Biosphere Environmental Services
Date: 10th of June 2024

Appendix 5.3c

Summer 2020 Flightlines

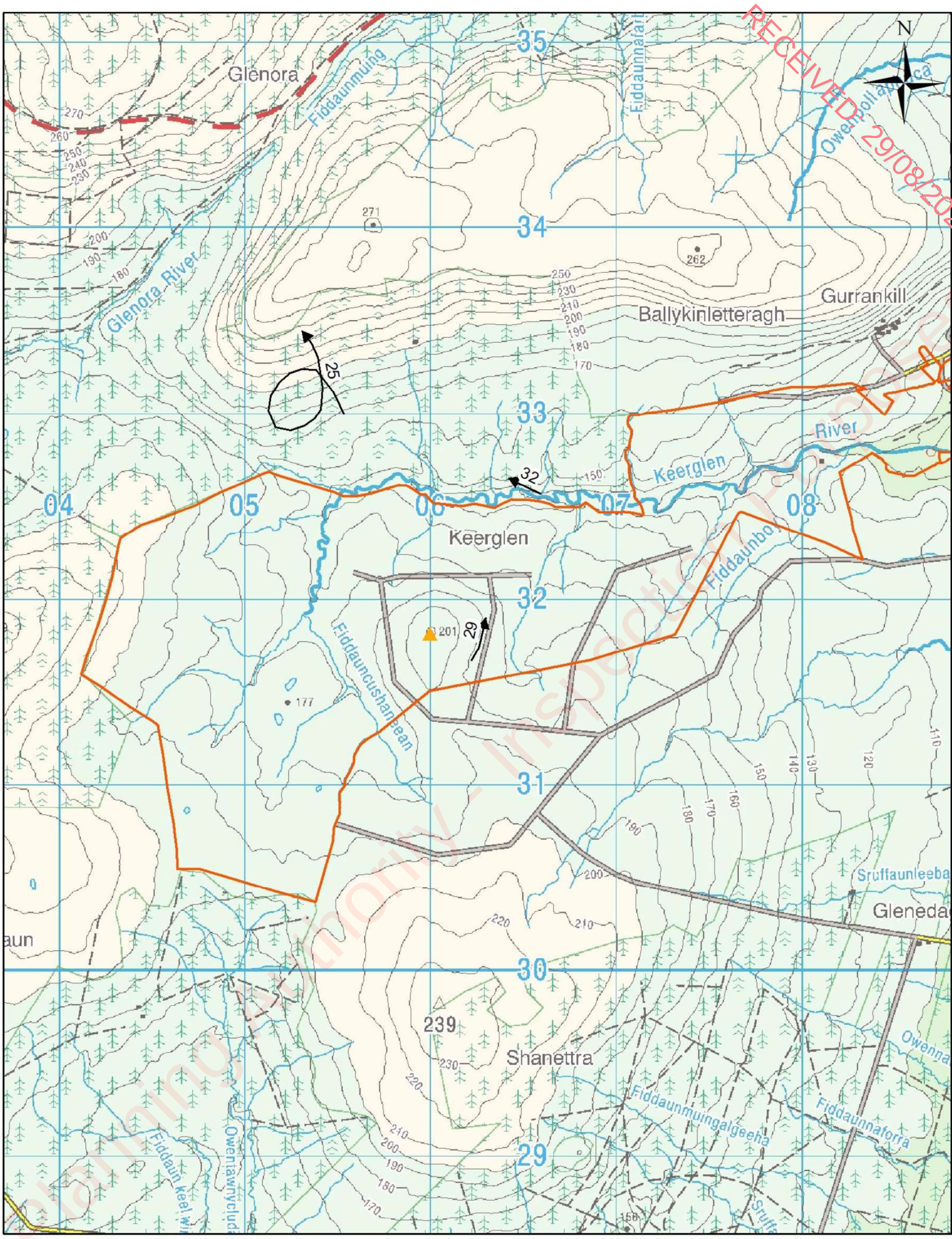
Keerglen Wind Farm

APPENDIX 5.3c

Keerglen Wind Farm

Vantage Point Survey Flightlines - Summer 2020

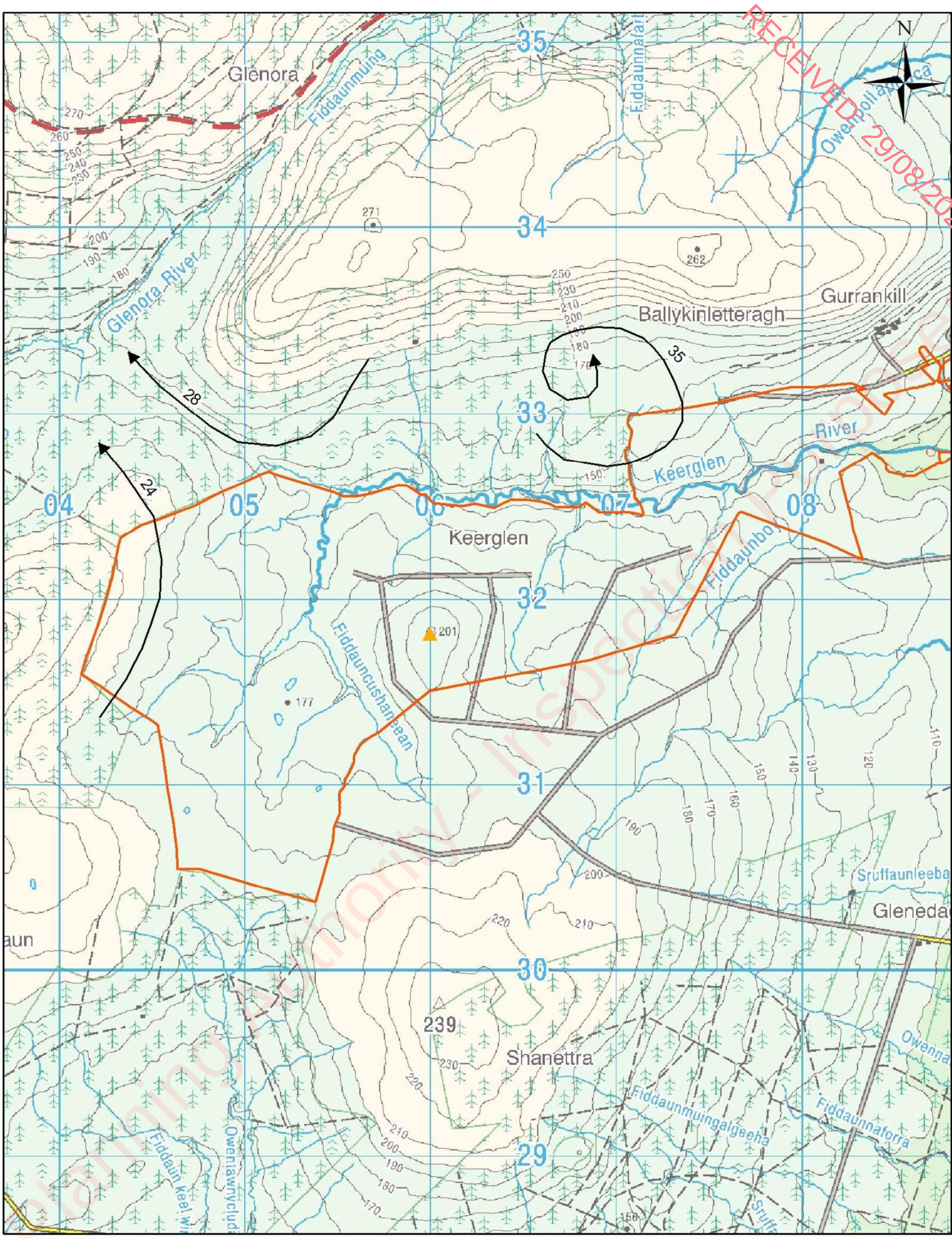
(details of flightline numbers are given in Appendix 5.2)



Sparrowhawk flightline
VP Locations
Site Boundary

0 0.2 0.4 0.8 Km

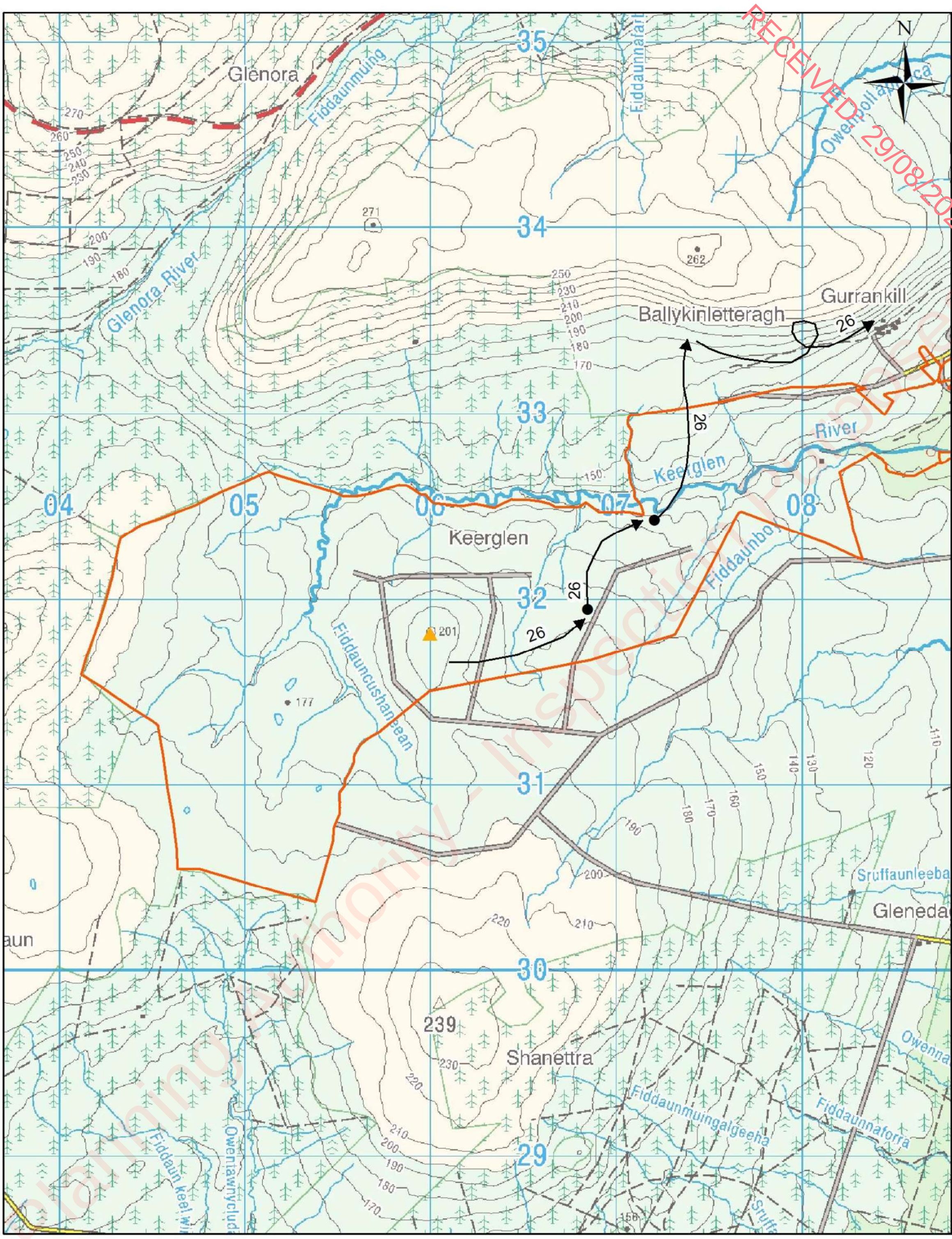
Project: Keerglen Wind Farm - Bird Surveys
Title: Sparrowhawk Observations Summer 2020
Drawn By: Wetland Surveys Ireland Ltd. for Biosphere Environmental Services
Date: 10th of June 2024



Buzzard flightline
VP Locations
Site Boundary

0 0.2 0.4 0.8 Km

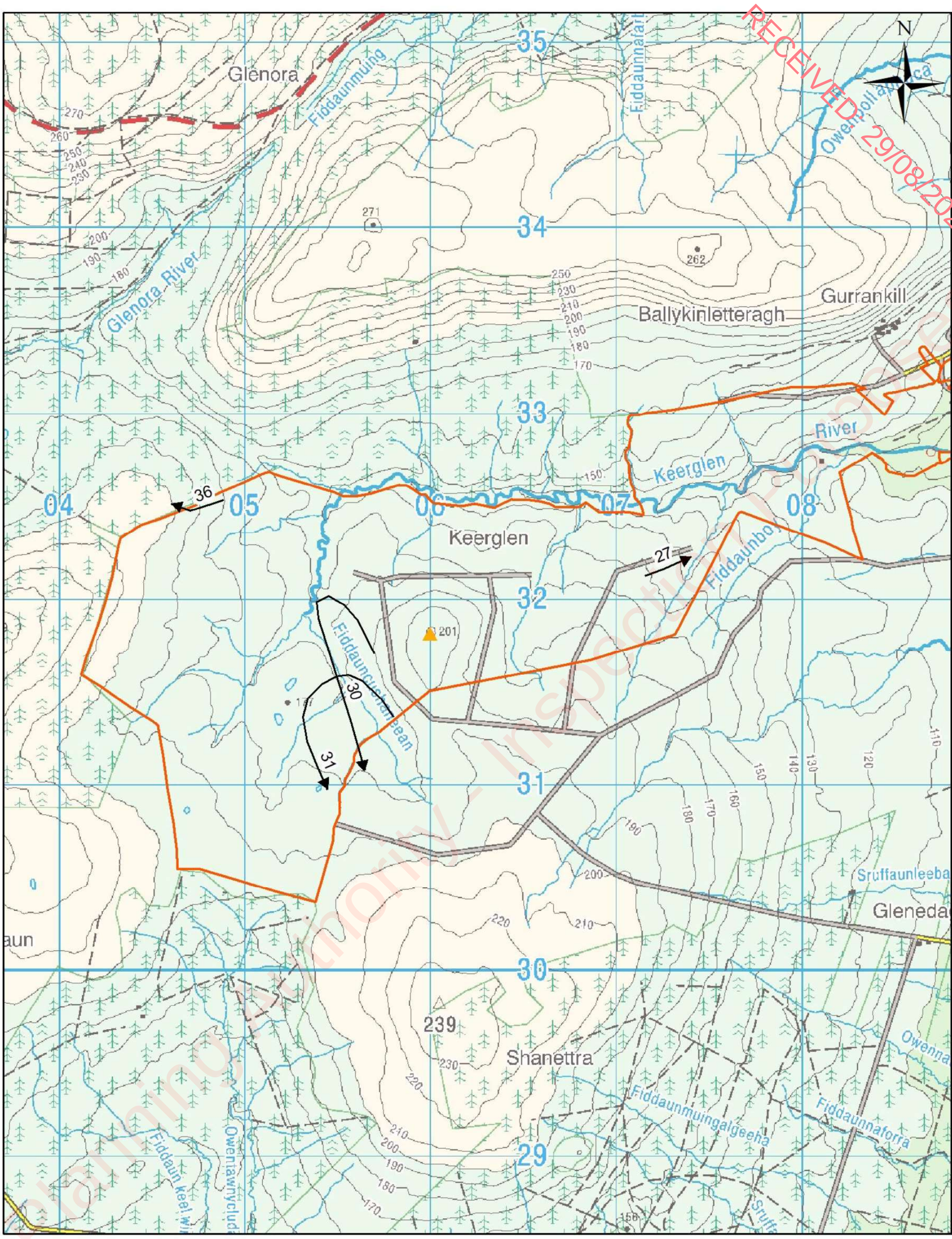
Project: Keerglen Wind Farm - Bird Surveys
Title: Buzzard Observations
Summer 2020
Drawn By: Wetland Surveys Ireland Ltd. for Biosphere Environmental Services
Date: 10th of June 2024



- Golden Eagle ground observation
- Golden Eagle flightline
- VP Locations
- Site Boundary

0 0.2 0.4 0.8 Km

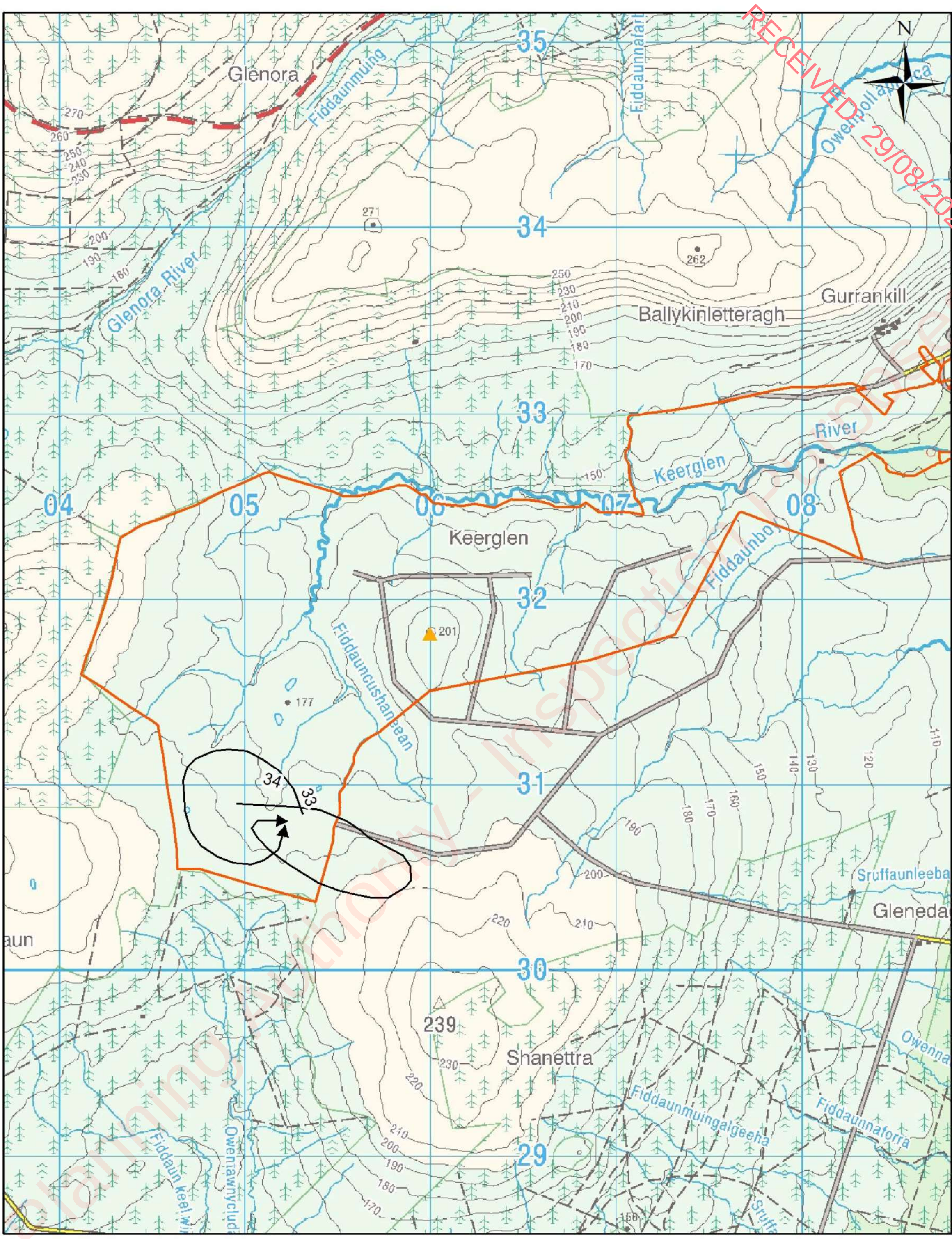
Project: Keerglen Wind Farm - Bird Surveys
Title: Golden Eagle Observations
Summer 2020
Drawn By: Wetland Surveys Ireland Ltd. for Biosphere Environmental Services
Date: 10th of June 2024



Kestrel flightline
VP Locations
Site Boundary

0 0.2 0.4 0.8 Km

Project: Keerglen Wind Farm - Bird Surveys
Title: Kestrel Observations
Summer 2020
Drawn By: Wetland Surveys Ireland Ltd. for Biosphere Environmental Services
Date: 10th of June 2024



Golden Plover flightline

VP Locations

Site Boundary

0 0.2 0.4 0.8 Km

Project: Keerglen Wind Farm - Bird Surveys
Title: Golden Plover Observations Summer 2020
Drawn By: Wetland Surveys Ireland Ltd. for Biosphere Environmental Services
Date: 10th of June 2024

Appendix 5.3d

Winter 2020 2021 Flightlines

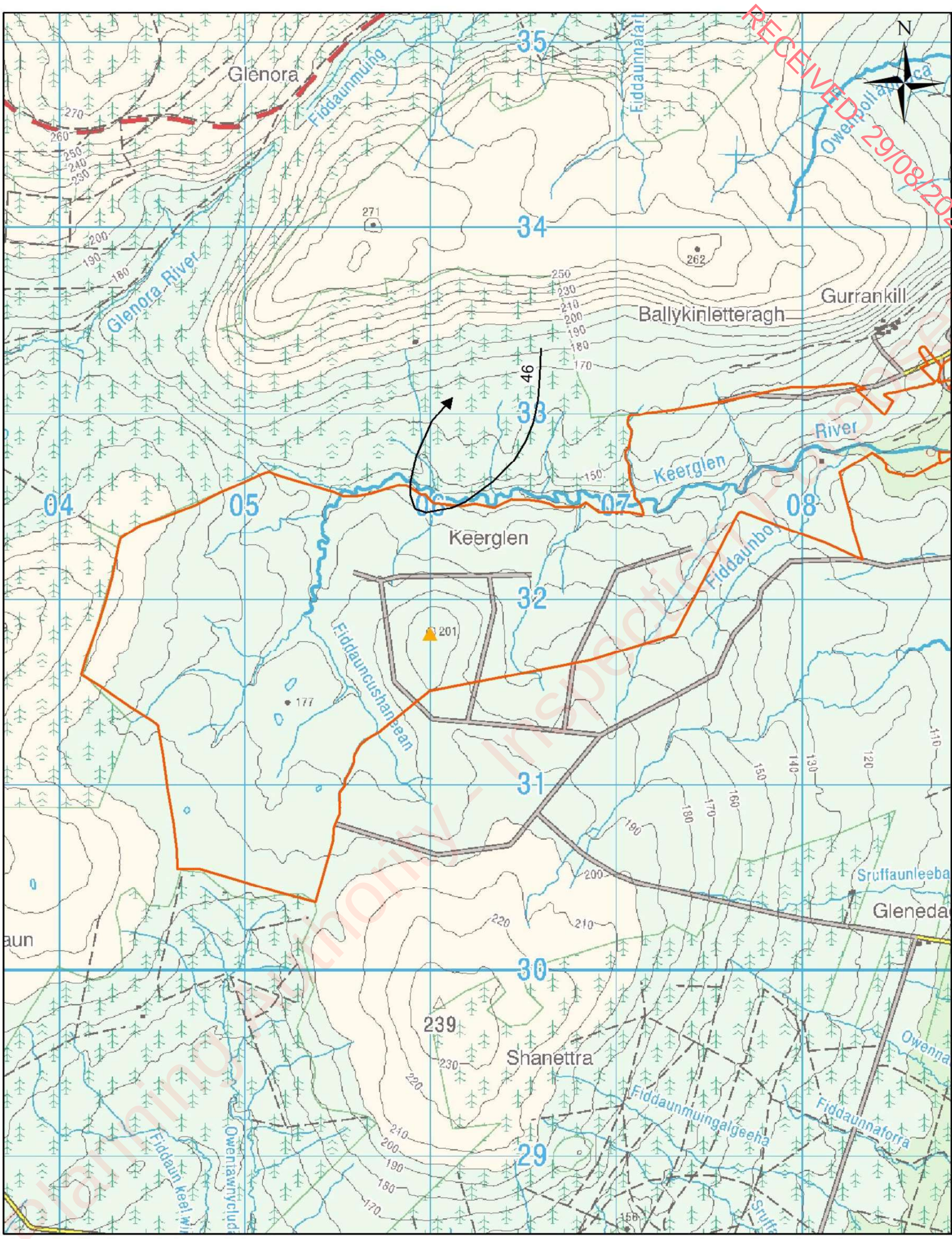
Keerglen Wind Farm

APPENDIX 5.3d

Keerglen Wind Farm

Vantage Point Survey Flightlines - Winter 2020-2021

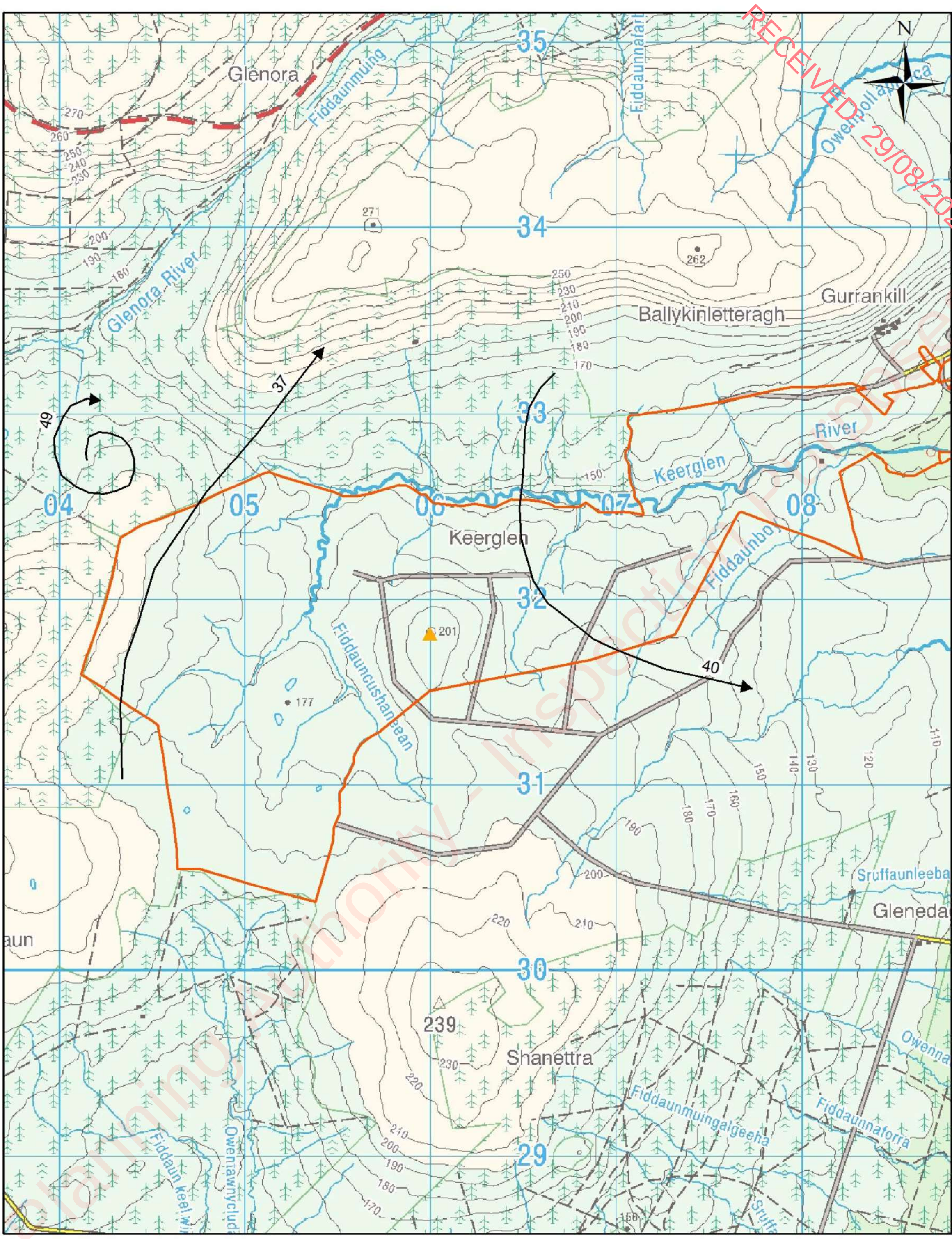
(details of flightline numbers are given in Appendix 5.2)



- Sparrowhawk flightline
- VP Locations
- Site Boundary

0 0.2 0.4 0.8 Km

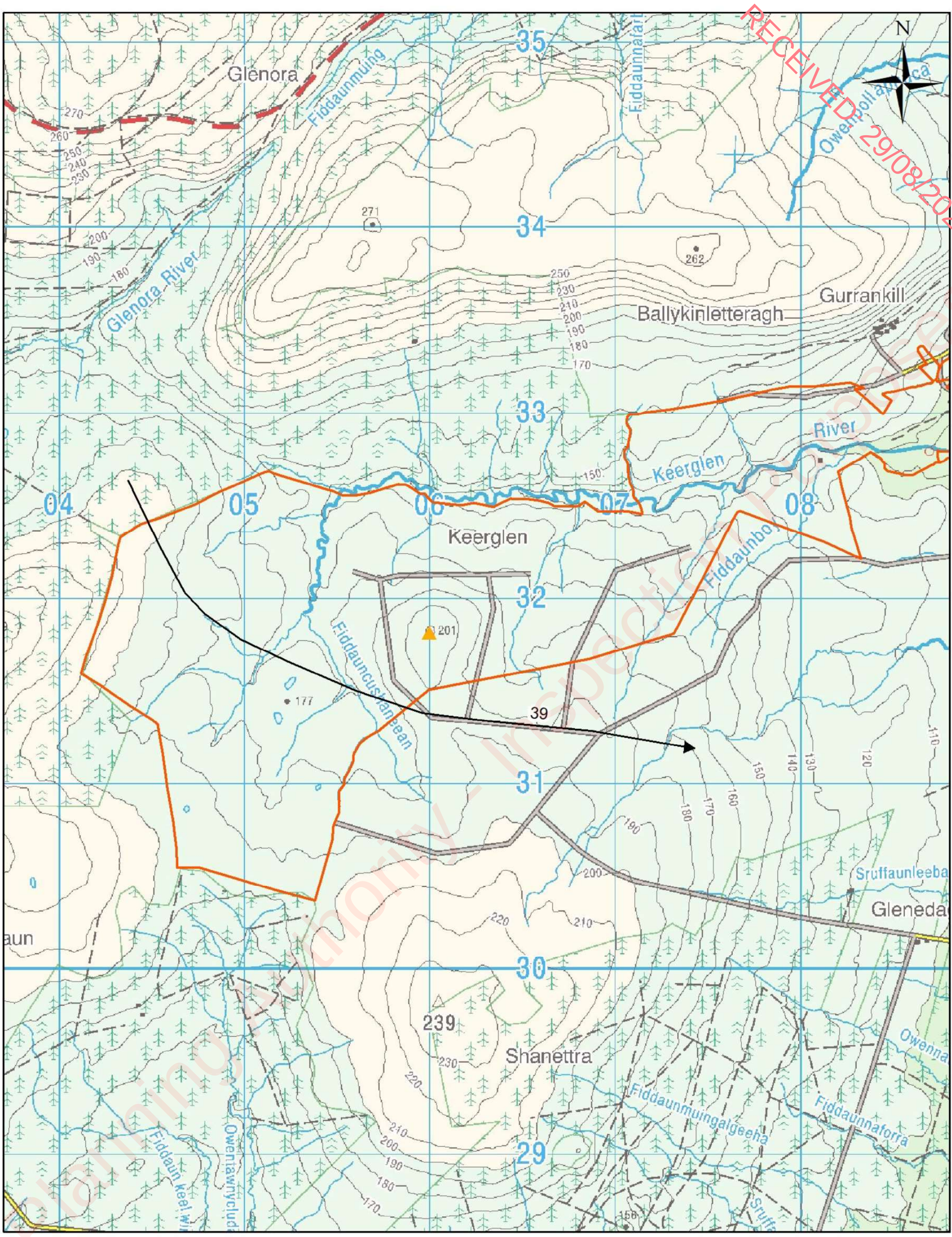
Project: Keerglen Wind Farm - Bird Surveys
Title: Sparrowhawk Observations
Winter 2020-2021
Drawn By: Wetland Surveys Ireland Ltd. for Biosphere Environmental Services
Date: 10th of June 2024



Buzzard flightline
VP Locations
Site Boundary

0 0.2 0.4 0.8 Km

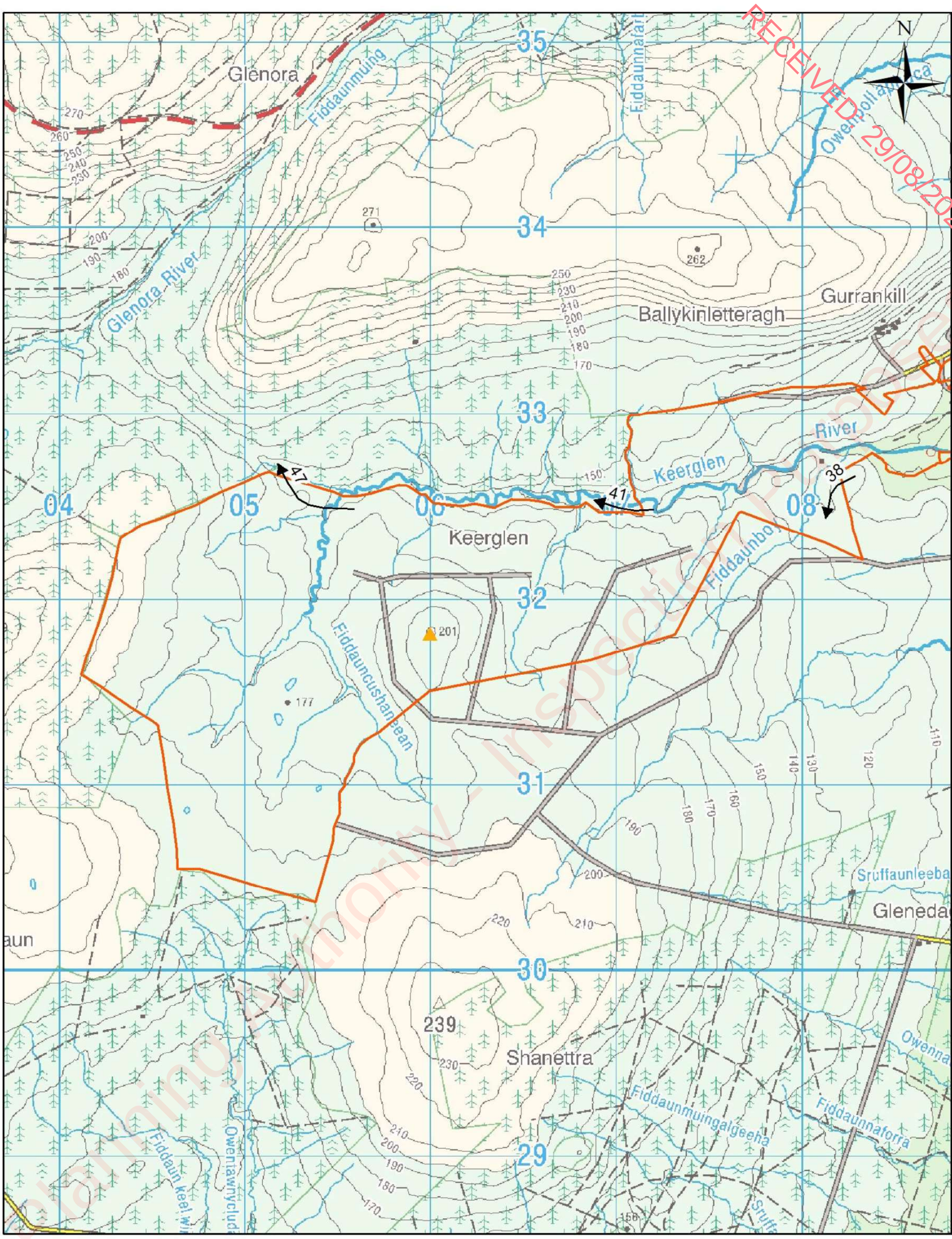
Project: Keerglen Wind Farm - Bird Surveys
Title: Golden Plover Observations
Winter 2020-2021
Drawn By: Wetland Surveys Ireland Ltd. for Biosphere Environmental Services
Date: 10th of June 2024



Peregrine flightline
VP Locations
Site Boundary

0 0.2 0.4 0.8 Km

Project: Keerglen Wind Farm - Bird Surveys
Title: Peregrine Observations
Winter 2020-2021
Drawn By: Wetland Surveys Ireland Ltd. for Biosphere Environmental Services
Date: 10th of June 2024



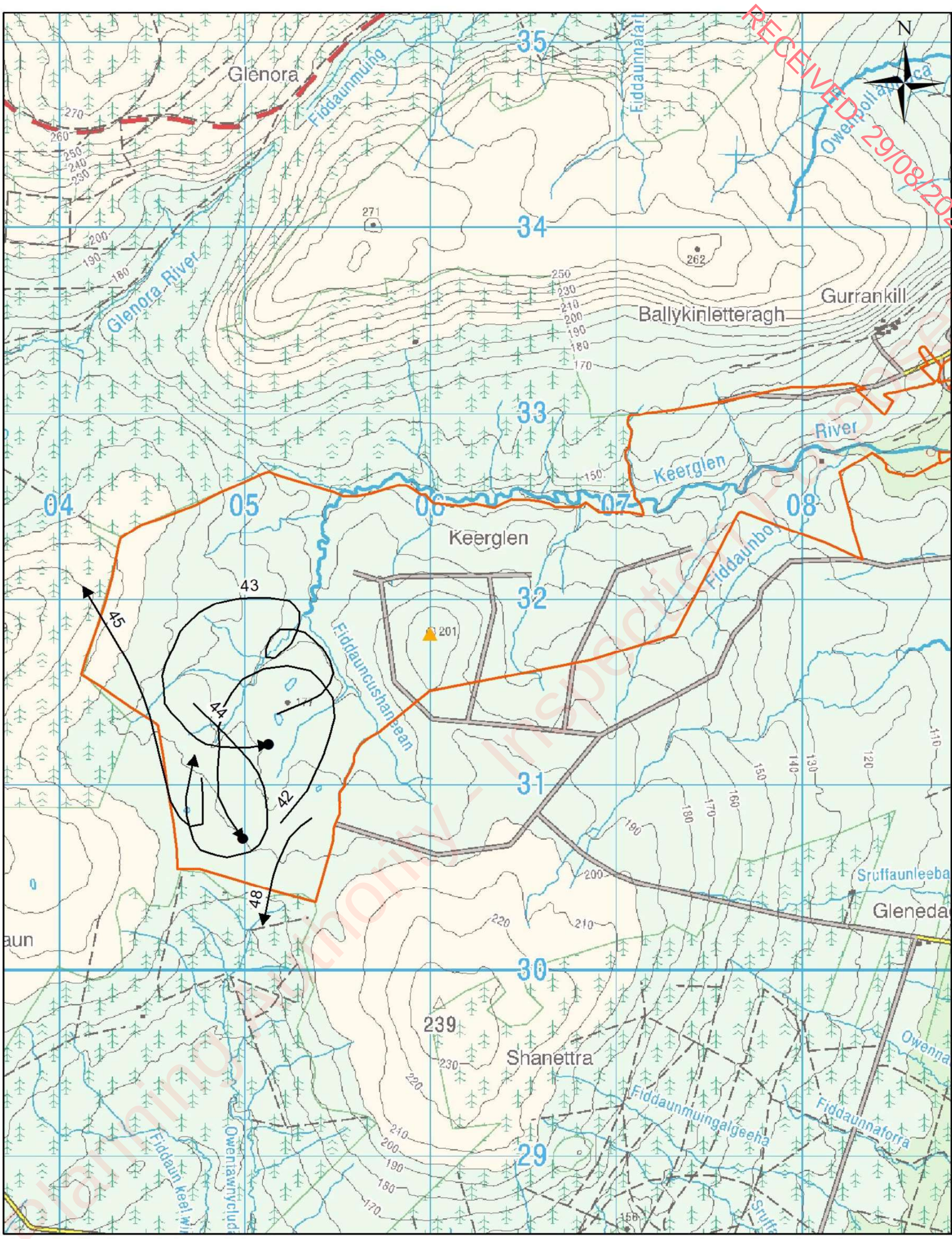
Kestrel flightline

VP Locations

Site Boundary

0 0.2 0.4 0.8 Km

Project: Keerglen Wind Farm - Bird Surveys
Title: Kestrel Observations
Winter 2020-2021
Drawn By: Wetland Surveys Ireland Ltd. for Biosphere Environmental Services
Date: 10th of June 2024



- Golden Plover ground observation
- Golden Plover flightline
- VP Locations
- Site Boundary

0 0.2 0.4 0.8 Km

Project: Keerglen Wind Farm - Bird Surveys
Title: Golden Plover Observations
Winter 2020-2021
Drawn By: Wetland Surveys Ireland Ltd. for Biosphere Environmental Services
Date: 10th of June 2024

Appendix 5.4

Keerglen Wind Farm: Breeding & Wintering Transect Survey Details, 2019-2021

Keerglen Wind Farm

APPENDIX 5.4 – Keerglen Wind Farm: Breeding & Wintering Transect Survey Details, 2019-2021

Date	Month	Observer	Transect	Start Time	Finish Time	Weather	Visibility
23/04/2019	April	MH	T2	12.24	14.44	Dry, Wind SE, F4	Good
23/04/2019	April	MH	T1	15.30	17.14	Dry, Wind E, F4	Good
20/05/2019	May	MH	T2	09.35	12.07	Dry, Wind NW, F2	Good
20/05/2019	May	MH	T1	13.15	16.00	Dry, Wind NW, F3	Good
14/11/2019	November	MH	T2	09.05	11.37	Dry and sunny, Wind NE, F3-4	Good
14/11/2019	November	MH	T1	12:50	14:40	Showers, Wind NE, F4	Good
15/12/2019	December	MH	T2	08:30	11:26	Dry, Wind S, F1	Good
15/12/2019	December	MH	T1	12:39	14:35	Showers, Wind NE, F2-3	Moderate
24/02/2020	February	MH	T2	09.10	11.42	Showers, Wind W, F3	Good
24/02/2020	February	MH	T1	14.00	15.36	Dry, Wind W, F3-4	Good
28/04/2020	April	MH	T2	08:15	10:38	Dry, Wind NE F2	Good
28/04/2020	April	MH	T1	12:00	14:13	Dry, Wind NE F3	Good
01/06/2020	June	BM	T2	07.15	10.05	Dry, Wind SW F3	Good
01/06/2020	June	BM	T1	11.00	12.23	Dry, Wind SW, F2	Good
23/12/2020	December	MH	T1	09.00	11.30	Showers, Wind N F3-4	Good
23/12/2020	December	MH	T2	12.20	15.45	Showers, Wind N F3	Good
18/01/2021	January	MH	T1	11.05	13.10	Drizzle, Wind SW F2	Mod-Good
18/01/2021	January	MH	T2	14.10	17.00	Dry, Wind SW, F2-3	Good
26/02/2021	February	BM	T2	08.00	10.30	Dry, Wind SW, F3	Good
26/02/2021	February	BM	T1	12.00	14.20	Dry, Wind SW, F3	Good

Appendix 5.5

Breeding and Wintering Transect Survey Results, 2019-2021

Keerglen Wind Farm

APPENDIX 5.5

Breeding and Wintering Transect Survey Results, 2019-2021

Figures refer to total counts of single birds, seen or heard, along transect.

Colour code is after Gilbert et al. (2021) Birds of Conservation Concern in Ireland 4: 2020-2026

(Green list; Amber list; Red list)

<u>TRANSECT 2</u>, YEAR 1: SUMMER 2019 & WINTER 2019/20

Common Name	23/04/19	20/05/19	14/11/19	15/12/19	24/02/20
Blackbird	1	-	-	-	1
Chaffinch	-	-	-	-	-
Coal Tit	-	-	-	-	-
Golden Plover	2	1	1	4	-
Grey Heron	-	1	-	-	-
Hooded Crow	3	2	-	-	3
Mallard	2	-	-	-	-
Meadow Pipit	7	10	4	-	4
Mistle Thrush	-	-	-	-	2
Raven	-	1	3	2	-
Red Grouse	1	-	-	2	-
Robin	-	-	-	1	-
Skylark	4	9	-	-	-
Snipe	1	1	3	2	6
Stonechat	-	-	2	1	-
Woodpigeon	-	-	-	-	-
Wren	-	1	2	-	1

TRANSECT 1, YEAR 1: SUMMER 2019 & WINTER 2019/20

Common Name	23/04/19	20/05/19	14/11/19	15/12/19	24/02/20
Blackbird	2	1	-	-	2
Chaffinch	3	-	4	-	1
Coal tit	3	2	4	-	-
Golden Plover	-	-	-	-	-
Goldcrest	1	2	-	-	-
Grey Heron	-	-	-	-	-
Hooded Crow	2	1	4	2	1
Kestrel	-	-	1	-	-
Linnet	3	2	-	-	4
Mallard	-	-	-	-	-
Meadow Pipit	4	7	4	2	1
Mistle Thrush	-	1	-	-	2
Raven	-	-	3	-	-
Red Grouse	-	-	1	-	-
Robin	1	-	1	-	-
Skylark	3	6	-	-	-
Snipe	-	-	5	8	4
Stonechat	2	-	3	-	1
Swallow	-	5	-	-	-
Wheatear	1	1	-	-	-
Willow Warbler	2	5	-	-	-
Woodcock	-	-	1	3	-
Woodpigeon	4	2	-	5	-
Wren	-	-	1	-	1

TRANSECT 2, YEAR 2: SUMMER 2020 & WINTER 2020/21

Common Name	28/04/20	010/06/20	23/12/20	18/01/21	26/02/21
Blackbird	-	2	-	-	-
Chaffinch	2	-	-	-	-
Coal Tit	-	-	-	-	-
Golden Plover	1	-	-	4	-
Grey Heron	-	-	-	-	1
Hooded Crow	3	4	-	-	3
Mallard	-	-	-	-	-
Meadow Pipit	9	14	3	-	5
Mistle Thrush	-	-	-	-	-
Raven	2	-	1	2	-
Red Grouse	-	1	2	-	-
Robin	-	-	-	-	-
Skylark	6	9	-	-	-
Snipe	2	-	1	2	3
Stonechat	-	-	1	1	-
Woodpigeon	-	-	-	-	3
Wren	2	-	-	1	2

TRANSECT 1, YEAR 2: SUMMER 2020 & WINTER 2020/21

Common Name	28/04/20	010/06/20	23/12/20	18/01/21	26/02/21
Blackbird	1	-	-	2	1
Chaffinch	-	-	3	2	-
Coal Tit	-	5	-	-	3
Golden Plover	-	-	-	-	-
Goldcrest	2	-	-	-	1
Grey Heron	-	-	1	-	1
Hooded Crow	2	4	3	2	1
Linnet	2	-	-	-	-
Mallard	2	-	-	-	-
Meadow Pipit	5	9	3	-	7
Mistle Thrush	-	4	-	-	3
Raven	-	4	2	2	6
Red Grouse	1	-	2	-	1
Robin	2	-	-	-	1
Skylark	3	7	-	-	-
Snipe	-	-	6	5	2
Stonechat	-	3	1	1	2
Swallow	3	12	-	-	-
Willow Warbler	6	9	-	-	-
Wheatear	1	2	-	-	-
Woodpigeon	7	3	-	-	9
Wren	2	-	2	1	1

Appendix 5.6

Keerglen Wind Farm: Merlin and Woodcock Surveys, Details, 2021

Keerglen Wind Farm

APPENDIX 5.6 – Keerglen Wind Farm: Merlin and Woodcock Surveys, Details, 2021

Date	Species	Observer	Start Time	Finish Time	Weather	Visibility	Result
	Merlin						
23/04/2021	Merlin survey I	BM / JA	09.30	13.15	Dry, Wind, NW F2	Good	No sightings or signs
24/05/2021	Merlin survey II	BM / JA	08.15	12:20	Dry, Wind W, F3	Good	No sightings or signs
16/06/2021	Merlin survey III	JA / BM	10:00	13:10	Dry, Wind S, F2	Good	No sightings or signs
	Woodcock						
23/05/2021	Woodcock survey I	BM / JA	21:15	23:55	Dry, Wind W, F2	Good	No sightings or signs
17/06/2021	Woodcock survey II	BM / JA	21:40	00:15	Dry, Wind SW, F1-2	Good	No sightings or signs

Appendix 5.7

Keerglen Red Grouse Survey March 2020

Keerglen Wind Farm

APPENDIX 5.7

KEERGLEN WIND FARM

RED GROUSE SURVEY
MARCH 2020

Prepared for

ABO Wind Ireland

by

BioSphere Environmental Services

29 La Touche Park, Greystones, Co. Wicklow

Tel: 01-2875249; E-mail: maddenbio20@gmail.com

Contents

FIGURES

TABLES

1. Introduction

Baseline ecological surveys are underway at Keerglen, Co. Mayo to inform an Environmental Impact Assessment Report relating to the development of a wind farm. As part of the baseline ornithological survey programme, which includes Vantage Point watches and transect surveys, a Red Grouse *Lagopus lagopus* survey is required to assess the potential breeding population at this site. The present report describes such a survey which was carried out in March 2020.

2. Red Grouse

Red Grouse is a Red Listed species owing to a serious decline in population (at least 50%) over the past 25 years (Colhoun & Cummins, 2013). Red Grouse is associated with heaths, blanket bog and raised bog. Its diet is almost exclusively ling heather *Calluna vulgaris* and its distribution is therefore restricted to peatland habitats that have ling heather. During the last national survey in Ireland Red Grouse were found in wet heath, upland blanket bog and lowland blanket bog (Cummins *et al*, 2010).

Red Grouse establish territories in autumn and defend them over the winter. Nesting begins during April depending on the weather. Incubation is usually within 19 to 25 days and fledging within 12-13 days. Red Grouse are largely single brooded and typically nest on the ground in vegetation which is taller than average. The nesting season from incubation to fledged young extends between April and June (Watson and Moss, 2008).

3. The Study Site

The study site lies to the south of Ballycastle in north Co. Mayo (Figure 1). The site supports cutover bog, drains, intact blanket bog, wet heath, streams and access tracks for turf cutting and grazing. Much of the site has been cut by sausage machine, leaving parts of the bog surface severely degraded with large areas of bare peat. Owing to the sites micro topography some areas have not been subject to machine cutting and here tall heather remains (see Plate 1). This has given a mosaic of both degraded cutover bog and areas of good heather cover. A small rise or hill lies within the study site. The northern side of the hill supports some tall heather cover. Intact blanket bog lies to the west of the Fiddauncushaneean watercourse and is part of the Ummeratarry Bog NHA (code 001570). The blanket bog is part of the study site. Near continuous conifer plantation lies immediately to the southwest, west and north of the study site, with mostly cutover bog to the south, east and northeast.

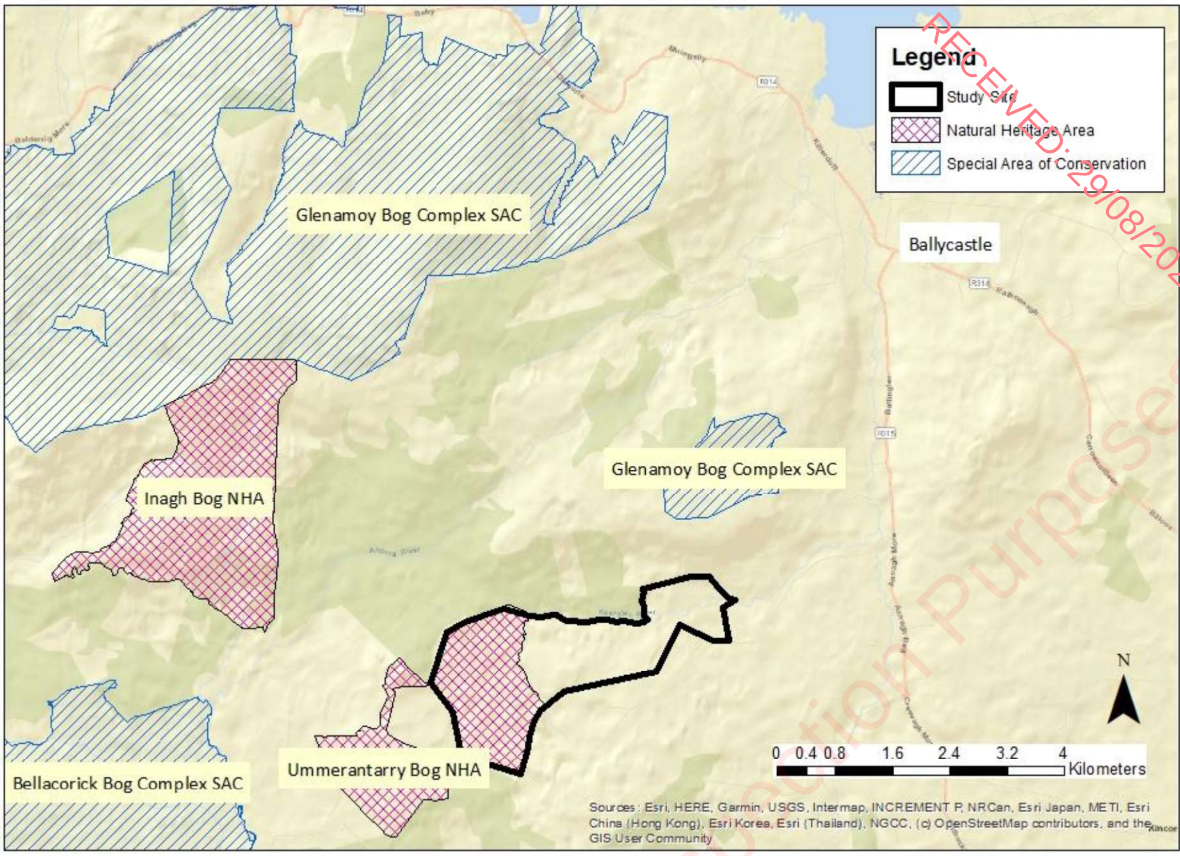


FIGURE 1. LOCATION OF STUDY SITE (OUTLINED IN BLACK) AT KEERGLEN, NORTH CO. MAYO.

PLATE 1. VIEW OF KEERGLEN SITE LOOKING NORTH-EASTWARDS ACROSS BLANKET BOG THAT HAS BEEN CUT TO VARYING EXTENTS. THIS BOG PROVIDES SUITABLE HABITAT FOR RED GROUSE.

4. Survey Methods

The Red Grouse survey was undertaken on March 26th 2020 under licence (011/2020) (see Appendix I). As required, the local conservation ranger, Sam Birch, was contacted prior to the survey. Surveys were conducted by Jackie Hunt and Mick Hogan in association with BioSphere Environmental Services. The survey team have extensive previous experience in Red Grouse survey.

Standard survey methods using tape playback (Cummins *et al*, 2013) were used. Line transects were walked within the study area, to cover as much of the study site as possible over one survey day (Figure 2). At intervals of 250m along the transect the call of the male Red Grouse was played for 30 seconds using a megaphone (full volume and playing call of Red Grouse). When deemed necessary (increased wind, terrain preventing carriage of sound) the call was played a second time, but no more. Any response to the call was recorded and mapped (male call in response, bird flies up in response). As each surveyor walked the transect, the ground was scanned for signs of Red Grouse (single droppings, single roost, double roost, roost with caecal pellets, feathers). Any signs of Red Grouse and any flushed or responding birds were recorded and mapped. All movements of Red Grouse were mapped and care was taken to avoid double counting.

The following signs were recorded, following Murray *et al.*, 2002:

- **Roost sites.** Piles of Red Grouse droppings indicate that a bird has been sitting or roosting over-night. If the droppings have white caps this indicates a fresh roost site where the bird is likely to have been roosting at this location in the last 1-3 nights (depending on the weather). Soft droppings or caecal pellets may also be present and are a classic indicator of a fresh roost site (Murray *et al.*, 2003). Roost sites may be of a single bird or two birds. Where two dropping piles are located (spaced up to 1m apart) this indicates a pair roost site. A pair roost site indicates the presence of a potentially breeding pair of Red Grouse. During transect surveys all roost sites were recorded together with detail on “single or paired”, “fresh or old”.
- **Red Grouse droppings**. Grouse droppings indicate that Grouse are present in an area. While grouse are feeding and moving around they will leave droppings. Where the white cap is present on a dropping this indicates that it is fresh (c. 1-3 days, depending on the weather) or old (c. up to 4 weeks, depending on the weather). During transect surveys all Red Grouse droppings were recorded with detail regarding “fresh or old”.
- **Flushed male or female Red Grouse**. If Red Grouse are present in an area during day time they will sit tight unless the disturbance source comes very close at which point the bird will fly quickly out of the way.

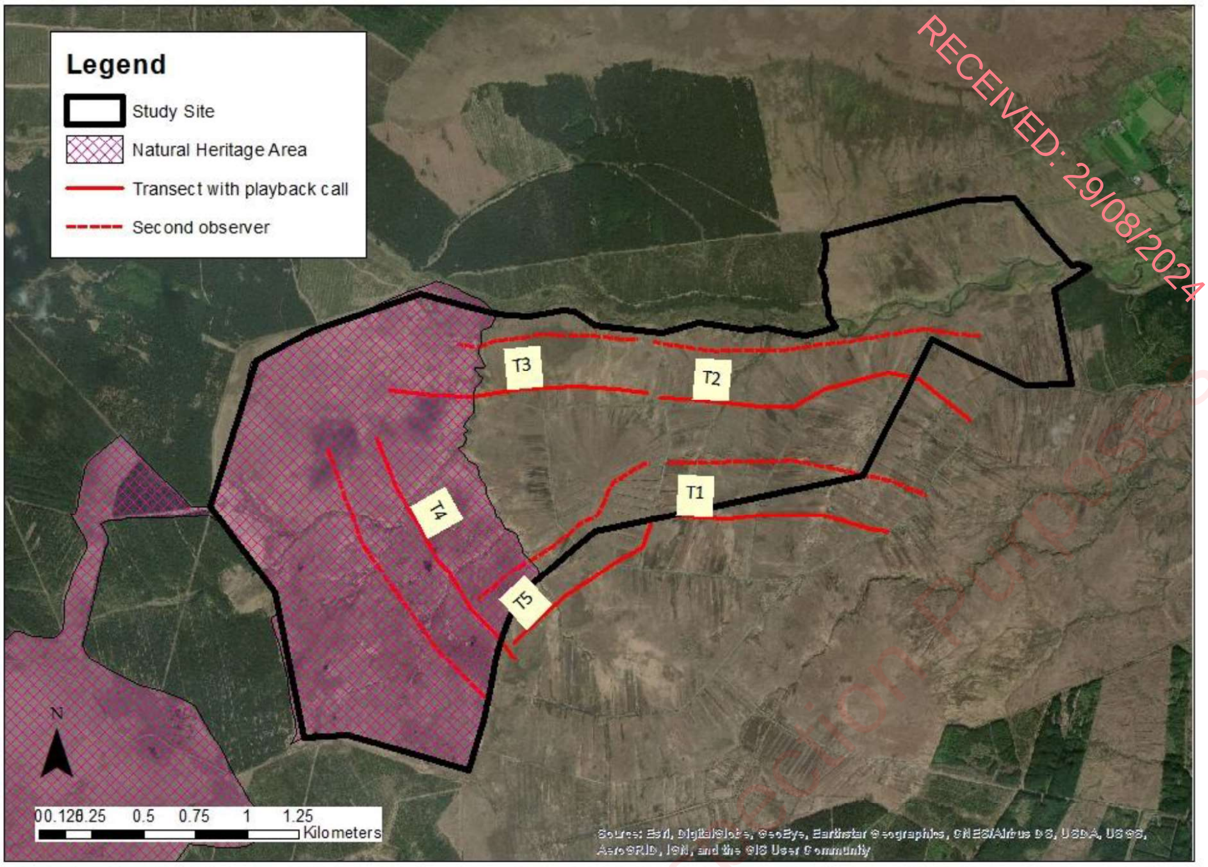


FIGURE 2. ROUTE OF TRANSECT SURVEY WITHIN THE STUDY SITE AT KEERGLEN.

5. Survey Results

Weather on the day was cloudy with light to moderate winds, good visibility and no rain.

The tape playback survey elicited ten responses (call back with/without flight) from male Red Grouse (Table 1 & Figure 3). Signs of Red Grouse were recorded in two locations: at one location there was a paired roost and at another a single dropping. Both were considered to be old, i.e. present for more than 3 days.

A number of additional bird species were recorded while on site, the most notable being a flock of c. 70 Golden Plover. Other birds recorded included Meadow Pipit, Skylark and Snipe. These birds were not recorded systematically but were noted during the transect survey. Use of the site by fox and hare was also noted owing to the presence of scat and droppings.

TABLE 1. RESULTS FROM PLAYBACK SURVEYS.

Observation (RG response/signs).	**Other Observations**
Transect 1. Start at 0940	
A. Response from male RG, distant; location approximate B. Response from male RG and short flight C. Male RG standing on ridge, then flew towards observation point B D. Male RG flew up and called *<u>Note</u>: Obs. B and C considered to be the same RG; likely that bird at B flew behind the transects, called from location C then flew back to general area of obs. B.*	6S, 2MP, 1RN, 70GP circling overhead. MA, Fox scat
Transect 2. Start at 1100	
Heard RG (same bird as observation D) E. Response from male RG, short flight and back to ground. F. Response from male RG and short flight from hillside (tall heather).	2S, 7MP, 3RN, Pair MA, HC, 4SN, 30GP in flight Hare droppings, Fox scat
Transect 3 start at 1315	
RG paired roost old G. Response from male RG; distant call	MP, S, MP, MP, S, MP, 2SN, MP, SN
Transect 4 start at 1405	
H. Response from male RG and flight. I. RG response; very distant. Single old dropping at side of stream *Note: H is considered to be same bird as observation G.*	
Transect 5 start 1520. End of survey at 1540	
J. Male RG call *<u>Note</u>. Considered to be same as bird from observation F*	MP

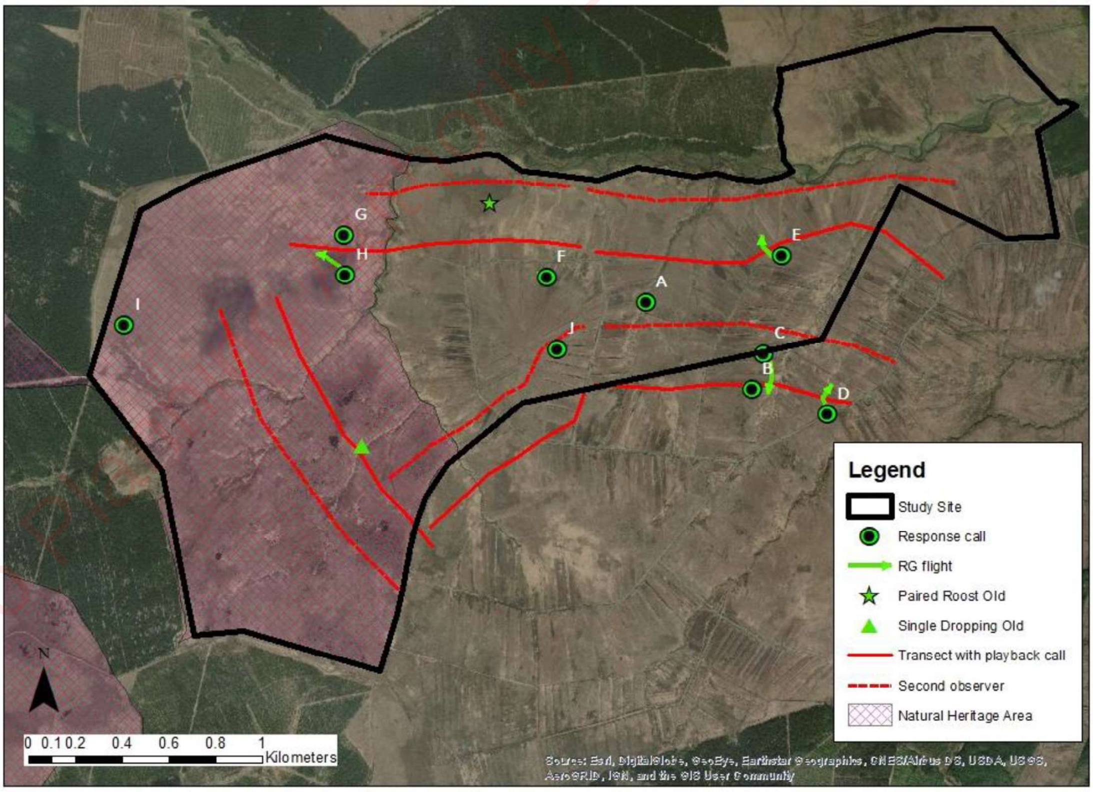


FIGURE 3. RESULTS FROM TAPE PLAYBACK SURVEYS FOR RED GROUSE.

6. Discussion

While ten calls were elicited during the survey, consideration of the call locations together with observations during the field survey indicates that 6 territorial males were present in the survey area (Figure 4). Vantage Point watches had indicated that Red Grouse were present at this site and the present survey has confirmed their presence and provided an estimate of population size in the pre-breeding season.

The total survey area represents approximately $6km^2$. Based on six Red Grouse territories, this gives a density of 1 Red Grouse per km^2. Typical Red Grouse densities in Ireland were estimated to be 1.1 individuals per km^2 of suitable habitat. Densities in West Connaught are estimated at 0.64 males per km^2 (Cummins *et al*, 2010). The Owenduff/Nephin Complex SPA which supports an extensive area of largely intact blanket bog lies west of the study site. A systematic survey of Red Grouse was completed at the SPA site in 2016 (McLoughlin & Hunt, 2016) and densities of 1.4-1.5 males per km^2 were recorded. The present sample survey indicates that Red Grouse densities within the study site are comparable to those nationally and regionally. While the extent of Red Grouse territories within the survey area is not known (i.e. which areas and habitat type are included in each territory), the results indicate a higher density of Red Grouse within the cutover bog dominated habitat than in the intact blanket bog habitat (NHA component). More detailed consideration of the habitat present may explain this further, however it was noted during the survey that while the bog was severely degraded it retained a diversity of micro habitats or habitat features. Tall heather was present within the cutover bog and on the hill slope. In addition, the cutover bog is crossed by tracks with grit which would be used by grouse to aid digestion. Perhaps the diversity of habitat features meets more of the foraging and shelter requirements of Red Grouse than intact blanket bog which can be quite homogenous.

Fox scat was noted from two locations during the Red Grouse survey. Fox predate ground nesting birds and are likely to detect Red Grouse nests.

Other bird present included typical passerines of the bog habitat present, with Skylark and Meadow Pipit regularly recorded. The wader Snipe is also typically found in the wetter areas of this habitat.

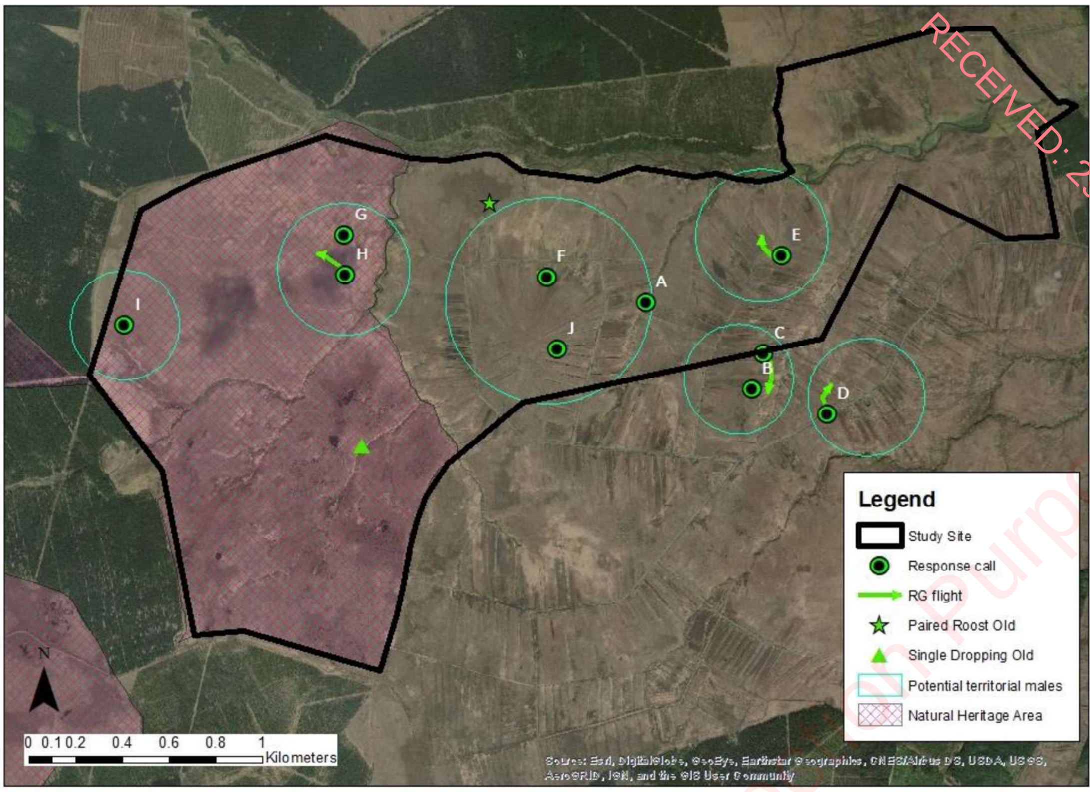


FIGURE 4. POTENTIAL TERRITORIAL MALES

7. Conclusion

A minimum of six territorial Red Grouse males were recorded at the Keerglen study site. This represents six potential pairs of Red Grouse with a density of 1 pair per km^2. This provides a baseline for future monitoring at this site.

References

Cummins, S., Bleasdale, A., Douglas, C., Newton, S., O'Halloran, J. & Wilson, H.J. (2010) The status of Red Grouse in Ireland and the effects of land use, habitat and habitat quality on their distribution. *Irish Wildlife Manuals*, No. 50. NPWS, Department of the Environment, Heritage and Local Government, Dublin.

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Murray, T., Clotworthy, C. & Bleasdale, A. 2013. A Survey of Red Grouse (*Lagopus lagopus scoticus*) in the Owenduff/Nephin Complex Special Protection Area. *Irish Wildlife Manual*s, No. 77. National Parks and Wildlife Service, Department of the Arts, Heritage and the Gaeltacht, Ireland

Watson, A. & Moss, R. 2008. *Grouse*. The Natural History of British and Irish Species. The New Naturalist Library. Collins, London.

Appendix 1 – Copy of Licence for Red Grouse Survey at Keerglen, Co, Mayo

An Roinn Cultúir,
Oidhreachta agus Gaeltachta
Department of Culture,
Heritage and the Gaeltacht

Licence No. 011/2020 **Amended**

NATIONAL PARKS & WILDLIFE SERVICE

Wildlife Acts 1976 to 2018 - Section 35

The Minister for Culture, Heritage and the Gaeltacht, in exercise of the powers conferred on the Minister by Section 35 of the Wildlife Acts 1976 to 2018 authorises:

Applicant: Brian Madden / BioSphere Environmental Services (on behalf of ABO Wind Ireland)

Address: 29 La Touche Park, Greystones, Co. Wicklow. A63 E024

Licencee's: Brian Madden - Joe Adamson - Mick Hogan - Jackie Hunt

To use a tape-luring device for the birds specified in Column 2 for the purpose of identifying their presence in the area specified in column 3 during the period
From **26 February 2020** to **31 March 2020**

Subject to the conditions listed overleaf.

SCHEDULE

1	2	3
TYPE OF DEVICE	**SPECIES**	**AREA**
Tape Lure	**Red Grouse** (*Lagopus lagopus hibernicus*)	**Keerglen (Grid Ref: G 0631) Townland of Keerglen, Co. Mayo.**

Dated this the 19 of March 2020

For the Minister for Culture, Heritage and the Gaeltacht

Gerry Leckey

National Parks & Wildlife Services LICENCE

Conditions

1. This licence shall be produced for inspection on a request being made on that behalf by a member of An Garda Síochána or any person appointed by the Minister for Culture, Heritage and the Gaeltacht under Section 72 of the Wildlife Acts 1976 to 2018, to be an authorised person for the purpose of the Acts.

2. This licence may be revoked at any time by the Minister for Culture, Heritage and the Gaeltacht.

3. Note: Licence duration - Date of issue to 31 March 2020.

4. Note: Licence must not extend beyond the 31 March 2020.

5. Note: Licence valid only to survey at areas marked on map accompanying this application.

6. Note: License valid only for applicants named on licence.

7. Note: If looking to enter any National Park/Nature Reserve you will need to get a permit (in addition to this licence).

8. Note: The applicant must ensure that landowner permission is received to enter onto private land.

9. Note: It is the responsibility of the applicant to ensure compliance with any other necessary permits, licences or permissions from the appropriate authorities are in place before undertaking the survey.

10. Note: This survey must be conducted according to NPWS/BWI methodology for red grouse fieldwork.

11. Note: The playback duration should be sufficiently short so as not to cause undue distress, there should be a limit of 30 seconds playback in each territory holding area.

12. Note: Surveying should only be conducted in favourable weather conditions: i.e. no rain, light winds and good visibility.

13. Note: NPWS Conservation Ranger: Sam Birch Mobile: 085 8007697 must be contacted prior to the commencement of survey under the terms of this licence.

14. Note: (a) A return of survey results, Should include a map displaying the transects walked, where the tape lure was played and where the birds replied to the calls, no later than the 30th June 2020. To be forwarded to:
    the Wildlife Licence Unit: Wildlifelicence@chg.gov.ie
    (b) All report(s) must be received by the Wildlife Licensing Unit, for our records, and will then be forwarded to the Birds Unit & all relevant NPWS Regional Staff.

15. Note: Please include a map(s) with each Section 35 application, with the boundry outlined for each County and the Townland names included on the map, where the survey will be conducted.

Any query in relation to this licence should be made to:

Wildlife Licensing Unit
National Parks and Wildlife Service
Department of Culture, Heritage and the Gaeltacht
90 North King Street
Smithfield
Dublin 7. D07 N7CV

01 888 3236 wildlifelicence@chg.gov.ie

National Parks & Wildlife Services
LICENCE

Appendix 5.8

Keerglen Hinterland Survey Details 2019-2021

Keerglen Wind Farm

APPENDIX 5.8 – Keerglen Wind Farm: Hinterland Survey Details, 2021-2022

Date	Site	Observer	Start Time	Finish Time	Weather	Visibility
	Summer 2021 Surveys					
25/05/2021	Ballykinletteragh	BM	08.00	12.20	Dry, wind SW, F2	Good
25/05/2021	Cluddaun	BM	14.00	17.30	Dry, wind SW, F3	Good
25/05/2021	Srahmeen	JA	08.20	12.15	Dry, wind SW, F2	Good
25/05/2021	Inagh	JA	13.40	17.20	Dry, wind NW, F3	Good
25/06/2021	Ballykinletteragh	JA	08.15	12.30	Dry, wind NW, F2-3	Good
25/06/2021	Cluddaun	JA	14:30	18:15	Dry, wind W F2	Good
25/06/2021	Srahmeen	BM	08:00	12.00	Dry, wind NW, F2-3	Good
25/06/2021	Inagh	BM	13:45	17:45	Dry, wind W, F2	Good
	Winter 2021-22 Surveys					
29/11/2021	Ballykinletteragh	BM	09.00	12.20	Dry, Wind, S F2	Good
29/11/2021	Cluddaun	BM	13.10	16.30	Showers, Wind SW, F3	Good
29/11/2021	Srahmeen	JA	08.45	12.15	Dry, Wind SW, F3	Good
29/11/2021	Inagh	JA	13:00	16:15	Dry, Wind SW, F2	Good
27/01/2022	Ballykinletteragh	JA	08.45	12:15	Dry, Wind NW, F3	Good
27/01/2022	Cluddaun	JA	13:15	17:00	Dry, Wind NW, F2-3	Good
27/01/2022	Srahmeen	BM	09.00	13.00	Dry, Wind NW, F3	Good
27/01/2022	Inagh	BM	14:00	17:20	Dry, Wind NW, F2-3	Good

Appendix 5.9

Keerglen Hinterland Survey Results 2021

Keerglen Wind Farm

APPENDIX 5.9 – KEERGLEN WIND FARM

Hinterland Survey Results, Summer 2021 & Winter 2021-22

H1 = Ballykinletteragh Bog

H2 = Cluddaun Bog

H3 = Srahmeen Bog

H4 = Inagh Bog

HINTERLAND SUMMER SURVEYS: 2021

Location	Date	Species	Details
H1	25/05/21	Golden plover	Bird calling almost continuously for 45 min on open bog c. 1 km WNW of 262m high point. Made a short flight of 20 m during period, otherwise stationery
		Kestrel	Male hunting forest edge to north of VP for 180 sec, then flew over forest
		Red grouse	Call heard to west of VP at start of watch. Some pellets (several days old) found in general area in later walk-over
H2	25/05/21	Buzzard	1-2 birds active over the forests to north of open bog several times during watch.
		Snipe	Heard drumming on open bog at 16.40 hrs - likely to be breeding here
H3	25/05/21	Golden plover	At least 1 pair active within 1 km WSW of VP - calling and local flights.
		Snipe	Bird drumming several times during first hour of watch.
H4	25/05/21	Golden plover	Estimate 2 pairs active in area within 1 km of VP location. One bird flew in to bog at 16.05 hrs & joining a calling bird
		Kestrel	Male hunting along forest edge on east of bog
		Buzzard	1-2 birds heard calling from forest to east
H1	25/06/21	Golden plover	Single call heard over c. 1 min on arrival at site but not afterwards. Coming from general NW direction as before.
		Red grouse	Walk-over recorded 2 lots of pellets, one very fresh, to northeast of VP.
H2	25/06/21		No target species
H3	25/06/21	Golden plover	At least 1 pr still active, as in May
		Red grouse	Signs recorded on bog
H4	25/06/21	Merlin	At 15.48 hrs, bird flew east to west across bog c. 300m north of the VP - observed for c. 30 sec and then may have landed on bog. Likely a male bird.
		Kestrel	Hunting along forest edge on east side of bog
		Red grouse	Bird flushed during walk-over c.500 m north of VP location

HINTERLAND WINTER SURVEYS: 2021-2022

	Location	Date	Species	Details
	H1	29/11/21	Golden plover	Flock of 7 birds on bog c. 200m north of VP. Flew eastwards.
			Buzzard	1 circling over forests to west
	H2	29/11/21	Snipe	3 flushed on short walk-over
	H3	29/11/21	Golden plover	Flock of c.15 circling and then landed. Later up again and landed in same general area - c.300 m to northwest of VP
	H4	29/11/21	Snipe	5 flushed in walk-over survey.
			Red grouse	One flushed and fresh signs c. 500m north of VP
	H1	27/01/21	Kestrel	1 hunting along forest edge to NW of VP.
			Red grouse	Calls heard on two occasions - appeared to be from open bog to NE of VP.
	H2	27/01/21	Snipe	1 snipe flushed - generally very quiet
	H3	27/01/21	Red grouse	Two flushed in walk-over - c. 500m SSW of VP.
	H4	27/01/21	Golden plover	6 birds on bog then flew up in a northwards direction (probably landed further north)
			Snipe	5 separate birds flushed on walk-over

Appendix 5.10

Collision Risk Modelling

Keerglen Wind Farm

VEON Forestry, Ecology & Environment

Collision Risk Modelling

Collision Risk Modelling Calculations
For target species at the proposed Keerglen Wind Farm
(Summer 2019 to Winter 2020/2021)

Compiled by: Veon Ecology,
David M. McGillycuddy B.Sc. (Hons) in Wildlife Biology.

Prepared for: Biosphere Environmental Services.

Completion Date: 21st June 2024

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Details of relevant qualifications/ affiliations/years of experience	David M. McGillycuddy B.Sc. (Hons) in Wildlife Biology at MTU, ACIEEM Munster Technological University (MTU) Over 7 years' experience working as an ecologist & wildlife education officer, completing several key projects and produced reports regarding Climate Action Plans (CAP), Biodiversity Management Plans (BMP), Natura Impact Statements (NIS), Ecological Impact Assessments (EcIA) & habitat mapping etc.
Describe scope of contribution in preparing this report	Desktop Survey, Collision Risk Modelling, Collision Risk Assessment, Finalising report.

Veon Ltd. Veon Ecology							
Revision	Description	Author:	Date	Reviewed By:	Date	Authorised by:	Doc Ref:
1	Draft Report	DM	21/06/2024	DP	21/06/2024	-	14498
2	Final Report	DM	21/06/2024	DP	21/06/2024	-	14498

Executive Summary

This report presents the outcomes of a Collision Risk Assessment for target species at the proposed Keerglen Wind Farm Development (Summer 2019 to Winter 2020/2021) located in the townlands of Keerglen, Ballykinlettragh and Ballinglen, Co. Mayo.

The modelling was carried out using the Scottish Natural Heritage (SNH) Collision Risk Model (Scottish Natural Heritage 2000; Band *et al.,* 2007). The bird occupancy method (SNH 2000) was used to calculate the number of bird transits through the rotors, and the spreadsheet accompanying the SNH report was used to calculate collision probabilities for birds transiting the rotors.

The results of the model are solely speculative and representative of worst-case scenario estimates, only drawing conclusions by assuming likely levels of active avoidance by specific species. As such, results obtained are dependent on the quality of field observation data and accuracy of the avoidance rates used and must therefore be interpreted with a certain degree of caution.

Section 1: INTRODUCTION

1.1 Background

Veon Ltd. (Veon Ecology) has been appointed by Biosphere Environmental Services, to carry out a Collision Risk Assessment for target bird species at the proposed Keerglen Wind Farm Development located in the townlands of Keerglen, Ballykinlettragh and Ballinglen, Co. Mayo. This Assessment uses standardised Collision Risk Modelling (CRM) methods. This document has been prepared by David McGillycuddy of (Veon Ecology) Veon Ltd. to assess the collision risk for birds (i.e. target species) at the proposed Wind Farm Site. The collision risk assessment, prepared by David McGillycuddy B.Sc. (Hons) in Wildlife Biology at MTU, ACIEEM, is based on vantage point surveys undertaken at the development site from the breeding and wintering seasons of 2019 - 2021 inclusive. The data represents a 24-month survey period, consisting of two breeding (summer) seasons and two non-breeding (wintering) seasons, in full compliance with the Scottish Natural Heritage guidelines, SNH (2017).

Collision risk is calculated using a mathematical model to predict the numbers of individual birds, of a particular species (i.e. target species), that may collide with moving wind turbine rotor blades. The modelling method and calculations used in this collision risk assessment follows Scottish Natural Heritage (SNH) guidance often referred to as the Band Model (Band et al. 2007). The calculations and results attained from the Band model must be interpreted with a degree of caution. The bird occupancy method (SNH, 2000) was used to calculate the number of bird transits through the rotors, and the spreadsheet accompanying the SNH report was used to calculate collision probabilities for birds transiting the rotors occupied space.

The collision risk modelling used data from vantage point (VP) surveys carried out in the summers of 2019 and 2020, and winters of 2019/2020 and 2020/2021. Vantage point surveys were SNH compliant (SNH, 2017). Surveys were undertaken from April 2019 to March 2021, from No. 2 fixed Vantage Point (VP) locations, (i.e. VP1 and VP2) (**See Appendix 1**). The locations of these VPs were strategically positioned to provide the maximum viewshed of the survey area from the minimum number of locations. No. 8 target species were recorded in flight within the study area during survey work. These include the following species; Kestrel, Golden Plover, Great Black-backed Gull, Buzzard, Sparrowhawk, Peregrine, Lesser Black-backed Gull and Golden Eagle. No. 2 of the target species recorded (i.e. Great Black-backed Gull and Golden Eagle) were present during the summer surveys only, while No. 2 of the target species recorded (i.e. Peregrine and Lesser Black-backed Gull) were present during the winter surveys only. The other remaining species were present throughout the year.

Two stages are involved in the model:

- **Stage 1:** This includes the estimation of the number of birds or flights passing through the wind turbines rotor blades swept air space. Two forms of collision risk modelling are considered when referencing the Band Model. These are referred to as the "Regular Flight Model" and the "Random Flight Model". Transits are calculated in this assessment using the "Random Flight" model, due to the bird flight distribution and behaviour recorded.

- **Stage 2:** This includes the calculation of the probability of a bird strike occurring with rotor blades. The probability is calculated using a statistical spreadsheet which considers the turbine parameters and avian biometrics. This spreadsheet is publicly available on the NatureScot (formerly SNH) website[1].

The results of Stage 1 and Stage 2 modelling, gives a theoretical annual collision mortality rate and is based on the assumption that birds (i.e. target species) make no attempt to avoid colliding with the proposed turbines. Thus, an informal third stage is applied to the Stage 1 and Stage 2 results. The final stage of the assessment provides for a "real life" scenario, i.e. to account for the avoidance measures taken by each bird species, worked out as a percentage applied to the stage 1 and 2 results. Birds usually demonstrate high rates of avoidance (i.e. 95-99%) according to SNH (2018). This final stage as a result is typically the most important feature of collision risk modelling.

[1] NatureScot, Wind farm impacts on birds - Calculating the probability of collision, available at: https://www.nature.scot/sites/default/files/2018-09/Wind%20farm%20impacts%20on%20birds%20-%20Probability%20of%20collision.xls

1.2 Proposed Development and Site Description

The proposed wind farm development is located in north County Mayo, approximately 6km southwest of Ballycastle. The coordinates for the approximate centre of the site are 54.22982127, -9.43057633. The Site is extensive and covers a large area, comprising of c. 573 hectares in total. The receiving environment for the proposed wind turbine locations is representative of peatland habitats and adjoining lands under active management for forestry and agriculture. The proposed development site is located relatively close (<15km) to other constructed and proposed windfarm developments (i.e. Killala windfarm, Oweninny Wind Farm and Glenora Wind Farm).

The proposed wind farm design on which this CRM is based, is comprised of No. 8 Wind Turbine Generators (WTGs) (Candidate Models: Vestas V136/V150 and Nordex N133/N149). The Collision Risk Assessment (CRA) makes assumptions on the turbine specifications, such as rotor diameter and rotational speed. Because the final choice of turbine is not known at this stage, the worst-case scenario is assumed. The worst-case scenario is a combination of the maximum collision risk area (affected by hub height and rotor blade length), maximum number of turbines proposed and minimum turbine downtime (i.e. non-operational time) using the specifications of the candidate WTG turbines. Turbine specifications for the proposed development site used as per this CRM are shown below in **Table 1.1**.

Table 1.1: Wind turbine specification and parameters for the proposed Wind farm development.

Wind Farm Components/Turbine Parameters	
Technical Information and Wind Farm Component	**Data used/Scenario Modelled**
Turbine model	Vestas V150-4.5 MW
Number of turbines	8
Number of blades per turbine rotor	3
Rotor blade maximum chord (m) (i.e., depth of blade)	4.2
Blade Length (m)	73.9
Rotor Radius (m)	75
Rotor Diameter (m)	150
Circumference of blade tip (m) (Pi x Rotor Diameter)	471
Swept area (m^2) (Pi x Rotor Radius^2)	17,671
Turbine Tip height (m)	180
Hub height (m)	105
Maximum height to blade tip (m)	180
Minimum height to blade tip (m)	30
Swept height (m)	30 - 180
Average Rotational period (s)	4.76
Turbine operation time*	85%
Mean pitch angle of the blade during normal operation (degrees)**	13°

* The European Wind Energy Association (2016) provides an average operation time of a turbine of between 70% and 85%. In following the precautionary principal approach this CRM uses the 85% figure.
** The pitch angle of the turbine blade is determined by wind speed, which is variable depending on several factors including, location, local topographic, landscape etc. To maintain a constant operating speed the pitch angle of the blade is altered. The pitch angle of the turbine blade is greater in higher wind speeds to "feather" the wind in order to control rotation speed. The figure of 13° used in this assessment is derived from specifications provided by the client which advocates an average pitch of between 6 – 13 degrees along the length of the turbine blade. In following the precautionary principal approach, the greater 13° figure has been adopted as part of this model.

1.3 Statement of Authority

David McGillycuddy holds a B.Sc. (Hons) in Wildlife Biology from MTU and is a qualified ecologist with over 7 years of experience in ecological research, teaching, and assessment. He is an Associate member of the Chartered Institute of Ecology and Environmental Management (ACIEEM) and has a strong background in experimental design and data analysis. David has managed a range of large-scale, multi-disciplinary ecological projects, including research and targeted management work for species of conservation concern. David also has substantial GIS knowledge with experience in handling, presenting and analysing spatial data using a variety of software (including use of ArcGIS and QGIS).

David is an ecologist with Veon Ltd. and Veon Ecology and is experienced in several key environmental projects and the production of ecological reports regarding Biodiversity Action Plans (BAP), Climate Action Plans (CAP), Invasive Species Management Plans (ISMP), Natura Impact Statement (NIS), Ecological Impact Assessment (EcIA), etc.

1.4 Data Sources

The following data and information were provided for this collision risk assessment:

- Data outlining all observations of flight activity recorded during the VP surveys.
- Mapping of the proposed turbine locations.
- Technical specifications for the proposed WTG turbines.
- GIS mapping of flight lines recorded during the summers of 2019 and 2020 and winters of 2019/2020 and 2020/2021 VP surveys.
- Clarification regarding survey methodology.
- Mapping of the VP locations.

All of the survey data used in this assessment was provided externally by the client. Additional information, including technical details (e.g. turbine specifications) were also provided by the client.

1.5 Target Species

The target species were selected in line with SNH (2017) guidance, thereby enabling VP surveys to focus on the species of greatest importance. In general target species are those species that are afforded a higher level of legislation protection and also includes species which are more likely to be subject to impacts from wind farms, e.g. breeding and non-breeding species forming qualifying features for nearby Special Protection Areas (SPAs), or species listed on Annex I of the Birds Directive.

Data was examined in detail for those species for which flight activity was recorded during the baseline surveys. Not all target species were recorded at the site across all two years of survey work. Bird flights considered to represent a potential collision risk were those flight lines that passed within the Collision Risk Zone (CRZ) at Potential Collision Height (PCH) i.e. at collision risk height and within the turbine envelope. For the purposes of collision risk modelling, a 500 m radius buffer was drawn around each of the proposed turbine locations. This buffer was used as the flight activity survey area, following SNH (2017) guidance.

A proportionate approach to CRM was followed, whereby it was only run for species that met a specified threshold of flight activity. The threshold used was of No. 3 flights, or at least 10 individuals, recorded within the CRZ at PCH within either season, over the course of all survey years. Thus, any species which was recorded using the site only very occasionally, and for which a nil or negligible collision impact could therefore be predicted, were excluded.

No. 4 species fulfilled the criteria for undertaking CRM:

- Kestrel (*Falco tinnunculus*)
- Golden Plover (*Pluvialis apricaria*)
- Buzzard (*Buteo buteo*)
- Sparrowhawk (*Accipiter nisus*)

Other species of conservation concern were recorded during the vantage point surveys but were excluded from consideration in the collision risk analysis due to the following reasons:

Great Black-backed Gull (*Larus marinus*) was observed flying within the collision risk zone during the surveys. However, only No. 1 flight (No. 1 individual) meeting the criteria was recorded across all survey years. Thus, due to the low frequency of recorded flights, the collision risk for Great Black-backed Gull can be assumed to be effectively zero. As a result, they are excluded from further consideration in the analysis. Peregrine (*Falco peregrinus*) was observed flying within the collision risk zone during the surveys. However, only No. 2 flights (No. 2 individuals) meeting the criteria was recorded across all survey years. Thus, due to the low frequency of recorded flights, the collision risk for Peregrine can be assumed to be effectively zero. As a result, they are excluded from further consideration in the analysis. Lesser Black-backed Gull (*Larus fuscus*) was observed flying within the collision risk zone during the surveys. However, only No. 1 flight (No. 2 individuals) meeting the criteria was recorded across all survey years. Thus, due to the low frequency of recorded flights, the collision risk for Lesser Black-backed Gull can be assumed to be effectively zero. As a result, they are excluded from further consideration in the analysis. Golden Eagle (*Aquila chrysaetos*) was observed flying within the collision risk zone during the surveys. However, only No. 1 flight (No. 1 individual) meeting the criteria was recorded across all survey years. Thus, due to the low frequency of recorded flights, the collision risk for Golden Eagle can be assumed to be effectively zero. As a result, they are excluded from further consideration in the analysis.

1.6 Seasonal Definitions

The data used in this CRM was collected over a period of 24 months from April 2019 to March 2021 inclusive, thereby providing data for two breeding season cycles and two winter cycles for the target species. For each target species included in the CRM, collision risk predictions were calculated for both relevant seasonal periods within each 12-month cycle. The sum of these separate summer and winter CRM results was taken as the predicted annual collision risk rather than using results from a single all-year CRM. This method minimised any potential biases that may arise from seasonal variation in daylength and the number of hours of activity available to each species in each month. This was to increase precision of the CRM and to ensure that any potential underestimation or overestimation for a species risk of collision was minimised as much as possible.

The summer season was defined as running from April to September inclusive (six months) for 2019 and 2020, and the winter season from October to March inclusive (six months) for 2019/20 and 2020/21. Therefore, over the entire survey period, two summer surveys and two winter surveys were completed. Survey watches were typically 2 * 3 hours = 6 hours per VP per month (See **Table 1.2**).

Table 1.2: Keerglen VP data (VP1-2) survey effort overview.

Vantage point survey effort (VP 1-2)			
Survey Period	**Months**	**Effort/Month**	**Total hours per VP**
Summer 2019	April-September	6 hours	36
Winter 2019 - 2020	October-March	6 hours	36
Summer 2020	April-September	6 hours	36
Winter 2020 - 2021	October-March	6 hours	36

The number of hours that birds are potentially active during the day for the breeding and non-breeding season forms part of the CRM model. This is calculated as 15 hours per day for the summer survey period (i.e. the breeding season) and 10 hours per day for the winter survey period (i.e. the non-breeding season). These figures of activity are based on the average calculation of daylight minutes within the season of analysis and are likely to be over-estimated. These figures would be difficult to quantify in simple terms otherwise, although, the use of an over-estimation of species activity time increases the likelihood of a collision as birds are considered to be more active (i.e. increased flights) than if activity hours were reduced. This approach therefore offers an additional precaution in determining collision risk, and therefore a more robust estimation for collision risk assessment. These flight activity hours were calculated from timeanddate.com.

It is assumed that Golden Plover are active for 25% of the night along with daylight hours (as per SNH guidance) accounting for wader activity and this is incorporated into the model.

1.7 Limitations and Constraints

There are a number of limitations and constraints associated with pre-planning ecological assessments for potential development sites, as well as constraints and limitations inherent to the collection and analysis of field-based ecological data. The field survey data evaluated as part of this Collision Risk Assessment was received from the client. The data comprised of the following:

- Bird flight data from timed vantage point surveys. This data consisted of flights within the rotor-swept height bands. The vantage point surveys recorded flight heights in five bands: 0-20 m; 20-50 m; 50-100 m; 100-180 m and >180 m. The 20-50 m, 50-100 m and 100-180 m height bands have been taken to represent the flight activity within the potential collision risk height zone. Flight duration (in seconds) for all bird observations along with data relevant to each flight record (date, weather conditions, timing, VP number (location), etc.) were provided.
- Vantage Point survey effort data (i.e. hours of observations) on a monthly basis during the summer and winter seasons of 2019 - 2021 (April 2019 to March 2021 inclusive) for all VP survey work undertaken.
- Description and metrics for the wind farm as a whole as well as for individual turbine parameters.
- Area viewed from each vantage point.

This CRM relates specifically to the provided vantage point survey data which has not been independently validated by the author of this report. Any variation in the coverage of the vantage points surveyed during fieldwork, flight data, layout of the wind farm/turbine locations as well as the individual turbine specifications would require the outputs from this CRM to be amended.

For field-based surveys, the availability of suitable weather conditions is important with good visibility and little wind or rain. The flight data used as part of this CRM was collected during optimal weather conditions, as determined by best practice guidance. The requirement in the SNH (2017) guidance is for 36 hours of VP survey effort per season. For a single species, this is equivalent to 72 hours of VP survey effort per year.

Section 2: ASSESSMENT AND METHODOLOGY

In regard to the Band Model, two forms of collision risk modelling are typically considered. These are generally referred to as the "Regular Flight Model" and the "Random Flight Model". The "Regular Flight Model" is generally applied to flightlines which comprise of a more regular pattern such as a commuting corridor between feeding grounds, migratory routes and roosting sites. As a result, the "Regular Flight Model" is typically more relevant for aquatic bird species, particularly swans and geese. The alternative "Random Flight Model" is more relevant for species and scenarios whereby no apparent flight routes or patterns can be associated with a species within the survey area. Thus, Random flights is most prevalent when investigating hunting or foraging flight behaviour.

Collision risk modelling adopts a mathematical approach to determining the probability of a bird species colliding with wind turbine rotors at a pre-defined site and is described in detail by Band *et al*. (2007) and Scottish Natural Heritage (SNH, 2000), with additional supporting information provided by Scottish Natural Heritage (SNH, 2018).

The resulting output from the model indicates the number of birds likely to collide with rotors of all No. 8 turbines per year of operation of the proposed wind farm as a whole. The inverse of this (i.e. the number of years over which a single fatality would be likely) is additionally calculated.

The **Random Flight Model** examines the predicted number of transits through the windfarm site with regard to all flights recorded within the viewshed (i.e. a 2km arc of the vantage point) as randomly occurring. The random flight model therefore assumes that any observed flight could occur both within and outside of the wind farm site with equal likelihood. The viewshed of a given VP should extend to a distance no greater than 2km and include an arc of no greater than 180 degrees, as per the SNH (2017) guidelines. Any flights recorded within the rotor swept height and inside the 2km arc of the vantage point are included in the model.

The Random Flight Model has a number of limitations and assumptions.

- Both habitat and bird activity will remain the same over time and be unchanged during the operational stage of the proposed windfarm development.
- Bird activity is not spatially explicit, i.e. bird activity is equal throughout the viewshed area, and this is equal to activity in the proposed windfarm development area.
- All flight activity used in the model occurred within the viewshed area calculated at the lowest swept rotor height.

The **Regular Flight Model** examines the predicted number of transits through a cross-sectional area of the windfarm which represents the width of the commuting corridor. A "risk window" comprises of a 2-dimensional line which represents the width of the windfarm in addition to a 500m buffer for each of the turbines, multiplied by the rotor diameter. All flights which pass through the identified risk window, within the swept height of the turbines, are included in the collision risk modelling. Any regular flights more than 500m from the turbine layout can be excluded from analysis.

The Regular Flight Model has a number of limitations and assumptions.

- The turbine rotor swept area is 2-dimensional, i.e. there is a single row of turbines in the windfarm. This represents all turbines within the commuting corridor accounted for by a single straight-line.
- Birds in an observed flight only cross the turbine area once and do not pass through the cross-section a second time (or multiple times).
- It is assumed that bird activity is spatially explicit.

Further details regarding both the Random and Regular Flight Model calculations are available on the NatureScot (formerly SNH) website[2].

[2] NatureScot, Wind Farms and Birds: Calculating a theoretical collision risk assuming no avoiding action, available at: https://www.nature.scot/sites/default/files/2017-09/Guidance%20Note%20-%20Windfarms%20and%20birds%20-%20Calculating%20a%20theoretical%20collision%20risk%20assuming%20no%20avoiding%20action.pdf

The data used as part of the model, such as the number, size, dimensions and likely functioning of the proposed turbines for the Wind Farm Development Site (See **Table 1.1**) forms part of the calculations, along with the available bird biometric data (See **Table 3.2**). These values are modelled with the standardised field data collected using best practice methods on surveying birds flight activity within the proposed development site.

The data is collectively modelled to predict the number of bird flights through the rotors of all turbines within the site on an annual basis (CRM Stage 1) as well as the probability that a bird flying through the turbine will collide with the rotors (CRM Stage 2). The product of the numerical output from these two stages of assessment then predicts the number of birds likely to collide with the rotors of the turbines if no avoiding action is taken. This value is then corrected using the available avoidance rates (CRM Stage 3), to give a final indication of collision risk (number of bird colliding with the turbine rotors per annum).

The steps used to derive the collision risk for birds observed at the proposed development site according to the Band Model are summarised below:

- Stage 1 (Band model): this model uses observations of birds flying through the study area during vantage point surveys to calculate the number of birds estimated to fly through the proposed turbines blade swept areas.
- Stage 2 (Band model): this model calculates the collision risk for an individual bird flying through a rotating turbine blade. The collision risk depends on the flight behaviour and biometrics.
- The result of the number of birds calculated to fly through the turbines annually is then multiplied by the collision risk probability. This calculation gives the worst-case scenario and assumes that birds flying through the site make no attempt to avoid turbines.
- Stage 3: An avoidance factor is applied to the results of the collision risk model, to account for avoidance of the turbine rotors by bird species. Avoidance rates are available from SNH online bird collision risk guidance (SNH 2018). This avoidance rate corrects for the ability of the birds to detect and move around the turbines. This final output after all steps of modelling is a real-world estimation of the number of collisions that may occur at the proposed wind farm, based on observed bird activity during the survey period.

Several assumptions were made in the calculations of the collision risk for the proposed Keerglen Wind Farm development. These assumptions are tailored specifically to Keerglen Wind Farm development and are as follows:

- Birds in flight within the study area at heights between 30m and 180m above ground level are assumed to be in danger of collision with the rotating turbine blades.
- In general, no preference was taken for birds using gliding or flapping flight through the study area for target species as they exhibit both behaviours. In the calculation of the percentage risk of collision for a bird flying through a rotating turbine, the mean of the worst-case scenario (i.e. a bird flying upwind through a turbine using flapping flight whilst the turbine is at its fastest rotation speed) and the best-case scenario (i.e. a bird flying downwind through a rotating turbine using a gliding flight, whilst the turbine is at its slowest rotation speed) has been used for birds which exhibit both flapping and gliding flight.

The collision risk assessment also makes assumptions on the turbine specifications, such as rotor diameter and rotational speed. The worst-case scenario is a combination of the maximum collision risk area (i.e. swept area determined by hub height and rotor blade length), maximum number of turbines proposed and turbine operational time. The turbine and wind farm characteristics for the purposes of this assessment at the proposed Wind Farm development site are presented in **Table 1.1**.

2.1 Determination of Bird Flights Through the Rotor Swept Area

Stage 1 of the CRM determines the number of transits through the rotors for a given period or season. For the calculations below, this is expressed as the number of birds flying through the rotors per season (Breeding and Non-breeding).

Flight data was recorded at fixed vantage point locations from April 2019 to March 2021 inclusive and the data was provided to Veon Ecology, to undertake the collision risk modelling for the relevant target species. Behavioural observations were also recorded with the minimum requirement of 36 hours per VP per season (breeding and non-breeding) and 72 hours of VP survey effort per year achieved.

A potential collision height (PCH) of between 30m and 180m above ground was established based on the candidate turbines having a maximum blade tip height of 180m, and a rotor diameter of 150m. This ensured that the PCH was within the turbine swept area. The flight heights of species were classified into different height bands (HB). The height bands used during flight activity surveys were:

- HB 1: 0 - 20 m
- HB 2: 20 - 50m
- HB 3: 50 - 100m
- HB 4: 100 - 180m
- HB 5: 180 m +

As the proposed rotor swept height covers the range 30m to 180m, all flights within height bands 2, 3 and 4 were considered as being at potential collision risk. Note that the actual height range covered by height bands 2, 3 and 4 is 20m to 180m. Thus, this represents a precautionary approach as any bird flights at a height of 20m to 29m would be outside the PCH but will have been included within the model as being at risk.

The arc for each vantage point is a 180° arc with a radius of 2km from the vantage point location, which represents the theoretical maximum coverage area. The viewshed represents the actual area visible to the surveyor at a specified height above ground level from the vantage point location within each vantage point arc. GIS computer software was used to generate the viewsheds for each VP. Flight data from the viewshed mapping for each VP was used to inform this CRM.

In the case of birds observed during surveys, flights recorded were classified for the purpose of the analysis as "randomly" distributed flights which could occur anywhere within the given viewsheds. The "Random Flight Model" is used in cases of irregular flight activity, such as that displayed by raptors occupying a recognized territory, or by waders. This model requires calculation of the proportion of time birds were observed flying per unit of survey area. Therefore the "Random Flight Model" was applied for each target species to calculate the predicted number of transits through the proposed Wind Farm site.

The proportion of flight time between 20m and 180m for a bird species for each of the VPs was calculated. If multiple birds were observed in one flight, the seconds spent at PCH were calculated by multiplying the number of birds observed per flight by the duration of the flight at PCH (in line with SNH, 2000).

The hours that a species may potentially be active in either a breeding or non-breeding season was calculated to include daylight, one hour before sunrise, and one hour after sunset (dusk) for all species. These flight activity hours were calculated from timeanddate.com. During the summer survey period (breeding season), the calculation assumes 15 hours of activity per day, while for the winter survey period (non-breeding season), it assumes 10 hours of activity per day. These activity figures are derived from the average calculation of daylight minutes within the respective seasons under analysis. However, it's important to note that these figures are likely to be over-estimated.

Flight activity was used to calculate the number of bird passes through the rotor for each VP in turn, and per turbine within each viewshed before being calculated for the entire wind farm. The Stage 1 calculation was carried out for each season (i.e. breeding and wintering) for each species.

2.2 Probability of Collision of Birds Passing Through the Rotor Swept Area

The probability of a bird flying through the rotors and colliding with the turbine blades is determined in Stage 2 of the CRM. The probability of a collision depends on the species biometrics including size (both length and wingspan) and average flight speed. In order to simplify the calculations for this CRM, all birds are assumed to be of simple cruciform shape, with the wings half-way down the length of the body. Characteristics of the turbine and rotor blades are also required as part of the calculations, including the pitch and width of the turbine rotor blades and the rotation speed of the proposed turbines. For Stage 2 of the CRM, the turbine rotor blades are assumed to have no thickness, although the blade depth is considered in Stage 1 of the model.

The risk of a bird colliding with the turbine rotor blades varies depending on whether the bird passes through the rotor swept area towards the tip of the blade (where the blades are present for a smaller proportion of the time, have a shorter chord width, and a faster rotational time), or next to the turbine hub (where the blades have a wider chord width, occupy a larger volume of airspace, and travel at slower speeds). Towards the blade tips, it is the length of the bird that offers greater contribution to the determination of the risk of collision. Closer to the turbine hub, the wingspan of the bird compared to the physical distance between the blades is the controlling factor. The bird is assumed to enter the rotor swept area at random anywhere along the disc.

The calculations determine the collision risk at several locations along the length of the rotor blade (in intervals of 0.05R, where R is the radius of the rotor swept area) using numerical integration of various elements in relation to the rotors (notably angular velocity of the blade and chord width) and the bird (such as the point at which the bird enters the rotor along the radius and the flight speed of the bird). These are calculated for both downwind and up-wind flights and averaged to give a probability of collision per season, assuming no avoiding action is taken.

The calculations are performed in the SNH collision risk model, where the relevant data on the turbines and bird biometrics are entered into the model, and the model estimates the probability of a collision when a bird flies through the rotor area. This calculation is based solely upon the behaviour and biometrics of the bird and the specifications of the turbines proposed at the Keerglen site.

For the Keerglen Wind Farm development site, the average probability of each species passing through the wind farm and colliding with the rotors if it takes no avoiding action, is presented in **Table 3.4**.

Section 3: RESULTS

The collision risks were calculated using flight data recorded during vantage point watches at No. 2 fixed vantage point locations (VP1-VP2) within the study area between April 2019 to March 2021. The relevant target species recorded within the potential collision risk zone included Kestrel, Golden Plover, Buzzard and Sparrowhawk.

The calculation parameters are outlined in **Tables 3.1, 3.2** and **Table 3.3**. A worked example of the calculation of collision risk for Kestrel is available in **Appendix 5**. **Table 3.1** below presents the details on the viewshed area for each VP.

Table 3.1: Summary of CRM parameters for VPs at Keerglen Wind Farm.

Vantage Point	VP Arc (ha)	Viewshed area within VP Arc (ha)	Viewshed Coverage (%)	Turbine Buffer Area Within Viewshed (ha)	No. of Turbines Within Viewshed	Total Survey Effort (hrs)
VP 1	628	625	99.52	223	4	144
VP 2	628	628	100	131	4	144

Species-specific morphometric measurements, flight speeds and avoidance rates are shown in **Table 3.2.** The amount of time a species was observed flying at heights of between 20 - 180 m, i.e. within the potential collision height, is presented in **Table 3.3** below. Birds in flight within the study area at heights between 20m and 180m are assumed to be in danger of collision with the rotating turbine blades. Bird biometric parameters were obtained from Alerstam *et al.* (2007), Wilson *et al.* (2015), and the British Trust for Ornithology (BTO) (2000).

Table 3.2: Avian Biometric Data and Avoidance Rates.

Avian Biometric Data and Avoidance Rates				
Species Name	Length (m)	Wingspan (m)	Mean flight speed (m/s)	Avoidance rates (%)
Kestrel	0.34	0.76	10.1	95
Golden Plover	0.275	0.715	17.9	98
Buzzard	0.54	1.2	13.3	98
Sparrowhawk	0.33	0.67	10	98

Table 3.3: Bird-seconds spent by species at potential collision height (20-180m).

Seconds spent at PCH (2019-2021)							
Species Name (BTO Code)	Seconds in flight at PCH (20-180m)						Total secs at PCH over 24 Months
	2019/2020			2020/2021			
	Summer	Winter	Total	Summer	Winter	Total	
Kestrel (K.)	755	325	1080	440	370	810	1890
Golden Plover (GP)	0	3080	3080	9730	44745	54475	57555
Buzzard (BZ)	505	490	995	1880	595	2475	3470
Sparrowhawk (SH)	240	320	560	360	480	840	1400

Table 3.4: Number of collisions predicted for target species without the application of avoidance rates.

Species	Year	Predicted collisions per season without avoidance rates applied		
		Summer	Winter	Total
Kestrel	2019/20	3.87	0.76	4.63
	2020/21	1.85	1.31	3.16
Golden Plover	2019/20	0.00	9.65	9.65
	2020/21	43.18	140.16	183.34
Buzzard	2019/20	2.04	1.56	3.6
	2020/21	13.72	2.08	15.8
Sparrowhawk	2019/20	0.72	0.64	1.36
	2020/21	1.08	1.94	3.02

Table 3.5: Number of collisions predicted for target species with the application of avoidance rates.

Species	Year	Predicted collisions per season with avoidance rates applied			Predicted collisions over 30-year lifetime of the windfarm		
		Summer	Winter	Total	Summer	Winter	Total
Kestrel	2019/20	0.193	0.038	0.231	5.798	1.137	6.935
	2020/21	0.092	0.066	0.158	2.769	1.972	4.741
Golden Plover	2019/20	0.000	0.193	0.193	0.000	5.789	5.789
	2020/21	0.864	2.803	3.667	25.906	84.095	110.001
Buzzard	2019/20	0.041	0.031	0.072	1.224	0.939	2.163
	2020/21	0.274	0.042	0.316	8.229	1.247	9.476
Sparrowhawk	2019/20	0.036	0.013	0.049	1.085	0.386	1.471
	2020/21	0.054	0.039	0.093	1.627	1.163	2.79

Table 3.6: Mean number of collisions predicted for target species with avoidance rates.

Target Species number of collisions predicted			
Species Name	Mean no. of predicted collisions per year	Mean no. of predicted collisions per 30 years	Equivalent to 1 bird every x (years)
Kestrel (K.)	0.1945	5.838	5.139
Golden Plover (GP)	1.93	57.895	0.518
Buzzard (BZ)	0.194	5.820	5.155
Sparrowhawk (SH)	0.071	2.131	14.081

Table 3.7: Summary collision modelling results.

Species	Model	Collision Risk			Mean no. of predicted collisions per year			Estimated collisions per 30 years	One Bird Collision
		Flapping	Gliding	Overall	Without Avoidance	Avoidance Factor	With Avoidance		
Kestrel	Random	6.3%	6.2%	6.25%	3.895	95%	0.195	5.838	5 years
Golden Plover	Random	4.5%	-	4.5%	96.495	98%	1.930	57.895	<1 year
Buzzard	Random	6.3%	6.2%	6.25%	9.700	98%	0.194	5.820	5 years
Sparrowhawk	Random	6.2%	6.2%	6.2%	2.190	98%	0.071	2.131	14 years

Section 4: CONCLUSION

This CRM has been completed for the proposed Keerglen Wind Farm development. A "Random" collision risk model has been conducted for birds observed during vantage points surveys at the proposed Wind Farm using the Band Model, following best practice guidance from NatureScot. The VP survey data used for this CRM was collected over two summer surveys (breeding seasons) and two winter surveys (non-breeding seasons), which meets the requirements of current SNH guidelines.

Collision risk models provide theoretical predictions of the probability of bird collisions with wind turbine rotor blades. The results are affected by sources of uncertainty including natural variability in bird populations, accuracy of the available information regarding species avoidance rates, turbine specifications, and the representativeness of the survey data. As such, the results are considered to be a best estimate of collision risk, rather than a precise figure. As a result, the predicted collision risk should be considered only an indication of the potential collision risk significance for each target species.

Due to the low frequency of recorded flights, the collision risk for Great Black-backed Gull, Peregrine, Lesser Black-backed Gull and Golden Eagle can be assumed to be effectively zero. At least one collision within the nominal 30-year operational phase of the wind farm is predicted for Sparrowhawk. The collision risk for Kestrel is estimated at 0.195 birds per year (or 5.838 birds over the nominal 30-year operational phase), collision risk for Golden Plover is estimated at 1.930 birds per year (or 57.895 birds over the nominal 30-year operational phase) and collision risk for Buzzard is estimated at 0.194 birds per year (or 5.820 birds over the nominal 30-year operational phase).

Additional mortality caused by collisions relative to background mortality rate should be assessed to evaluate the population level consequences for these species. Following the magnitude of effects outlined in Percival (2003), a <1% increase in background mortality corresponds with a negligible effect and a 1-5% increase in background mortality corresponds with a low effect.

The population-level consequences of predicted collision risks can be assessed by considering the additional mortality that would be caused (assuming that the collision risk is non-additive) relative to the population at a national and county level. For Kestrel, Golden Plover, Buzzard, and Sparrowhawk there is a <1% increase in background mortality rate (negligible effect) of the national and county populations (See **Table 6.12**). It must be noted however that the adopted county population is an estimate based on the proportion of the national population split by county area, used due to a lack of a county estimate.

In conclusion and with regard to the limitations and assumptions presented by collision risk modelling, the resulting predicted collisions should only be considered an indication and not a definitive result. Thus, the outputs of the collision risk modelling should be used solely as a comparative tool rather than an accurate indicator of bird mortality risk. Therefore, it is advised to interpret the results of CRM analyses as indicating only the order of magnitude of the predicted collision risk for given target species.

Section 5: REFERENCES

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Section 6: APPENDICES

Appendix 1. FIGURES AND MAPS

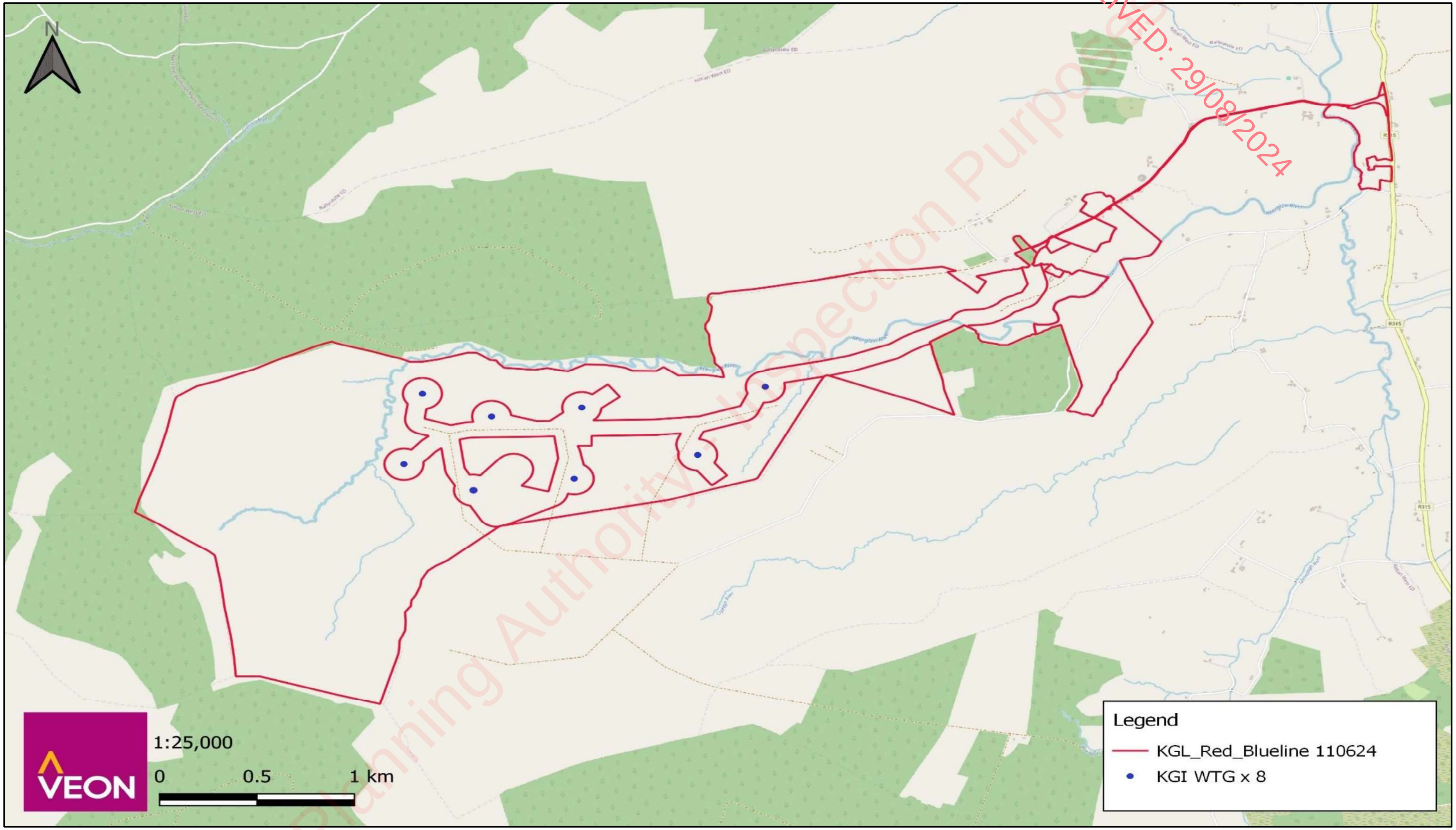

Figure 6.1: Site location and boundary indicating the area proposed for turbines.

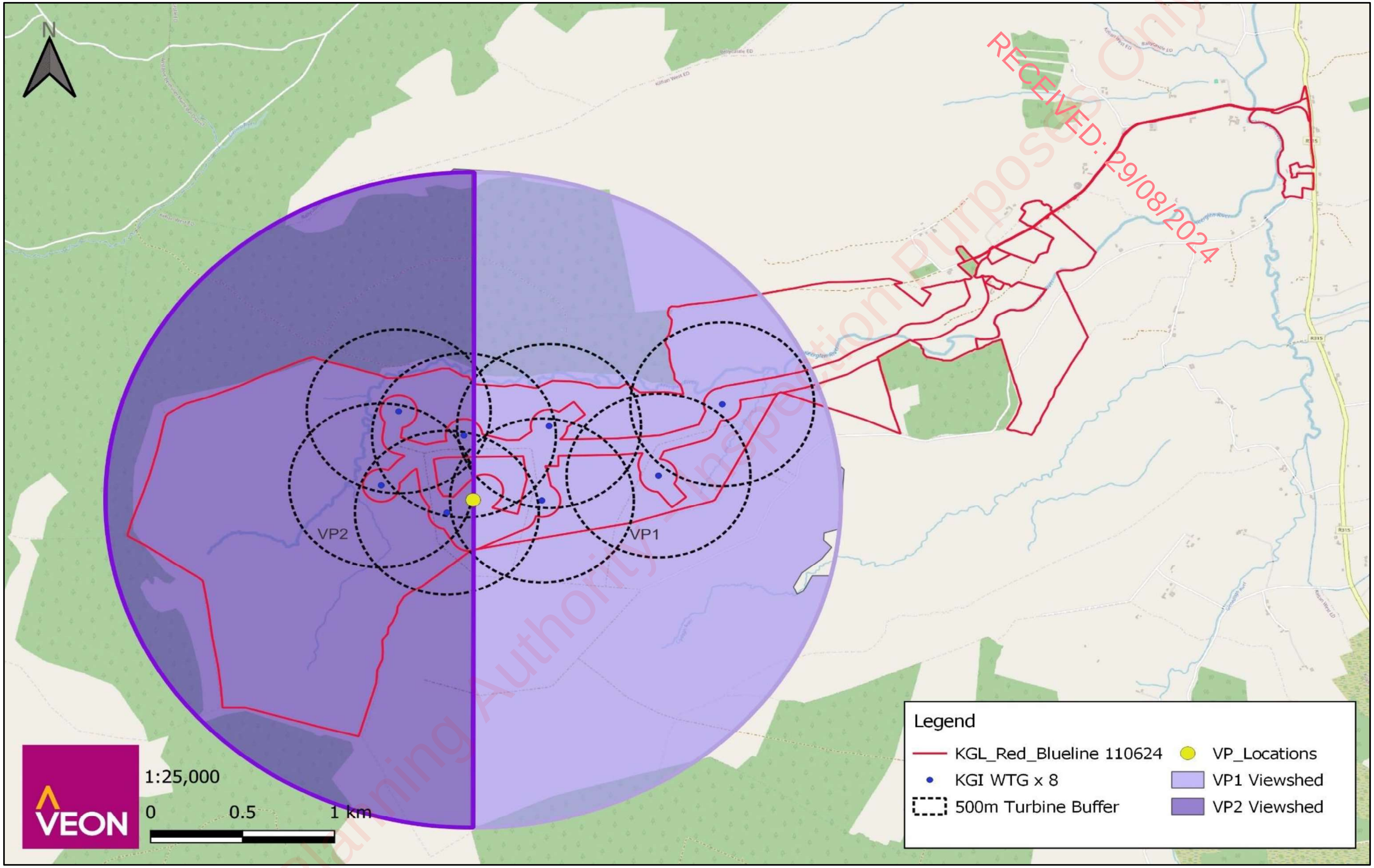

Figure 6.2: Vantage Point locations and viewshed map.

Appendix 2. VANTAGE POINT SURVEY EFFORT

VANTAGE POINT SURVEY EFFORT (HOURS) FOR SUMMER 2019

Table 6.1: Keerglen VP data (VP1-2) survey effort Summer 2019.

Survey Effort Data (Summer 2019 April-September)							
Vantage Point	April	May	June	July	August	September	Total Hours
VP 1	6	6	6	6	6	6	36
VP 2	6	6	6	6	6	6	36
Total	12	12	12	12	12	12	72

VANTAGE POINT SURVEY EFFORT (HOURS) FOR WINTER 2019-2020

Table 6.2: Keerglen VP data (VP1-2) survey effort Winter 2019-2020.

Survey Effort Data (Winter 2019-2020 October-March)							
Vantage Point	October	November	December	January	February	March	Total Hours
VP 1	6	6	6	6	6	6	36
VP 2	6	6	6	6	6	6	36
Total	12	12	12	12	12	12	72

VANTAGE POINT SURVEY EFFORT (HOURS) FOR SUMMER 2020

Table 6.3: Keerglen VP data (VP1-2) survey effort Summer 2020.

Survey Effort Data (Summer 2020 April-September)							
Vantage Point	April	May	June	July	August	September	Total Hours
VP 1	6	6	6	6	6	6	36
VP 2	6	6	6	6	6	6	36
Total	12	12	12	12	12	12	72

VANTAGE POINT SURVEY EFFORT (HOURS) FOR WINTER 2020-2021

Table 6.4: Keerglen VP data (VP1-2) survey effort Winter 2020-2021.

Survey Effort Data (Winter 2020-2021 October-March)							
Vantage Point	October	November	December	January	February	March	Total Hours
VP 1	6	6	6	6	6	6	36
VP 2	6	6	6	6	6	6	36
Total	12	12	12	12	12	12	72

Summary of vantage point (VP) watch variables, April 2019 to March 2021

Table 6.5: Summary of vantage point (VP) - Survey Details.

Date	Season	VP no.	Duration (hrs)	Start Time	Weather conditions
	Summer no. 1				
08/04/2019	Summer	1	3	11.00	Dry, Moderate visibility, E F4
08/04/2019	Summer	2	3	15.10	Dry, Moderate visibility, E F4
26/04/2019	Summer	2	3	08.30	Dry, Good visibility, NE 3
26/04/2019	Summer	1	3	12.15	Dry, Good visibility, NE 3-4
29/04/2019	Summer	2	3	07.30	Dry, Good visibility, S wind, F4
29/04/2019	Summer	1	3	11.30	Dry, Good visibility, SW wind, F3-4
21/05/2019	Summer	2	3	13:00	Dry, Good visibility, SW wind, F3
21/05/2019	Summer	1	3	16:40	Dry, Good visibility, SW wind, F3
17/06/2019	Summer	1	3	11.40	Dry, Good visibility, W wind, F4
17/06/2019	Summer	2	3	15:20	Dry, Good visibility, W wind, F4
21/06/2019	Summer	2	3	11:30	Dry, Good visibility, NE wind, F4
21/06/2019	Summer	1	3	15:45	Dry, Good visibility, NE wind, F3
08/07/2019	Summer	1	3	12:30	Dry, Good visibility, WSW wind, F3-4
08/07/2019	Summer	2	3	16:00	Dry, Good visibility, WSW wind, F4
30/07/2019	Summer	1	3	09:05	Drizzle, Moderate visibility, NW wind, F4
30/07/2019	Summer	2	3	13:20	Drizzle, Moderate visibility, NW wind, F4
23/08/2019	Summer	1	3	12:20	Dry, Good visibility, SW wind, F4-5
23/08/2019	Summer	2	3	16:20	Dry, Good visibility, SW wind, F5
24/08/2019	Summer	2	3	07:30	Showers, Good visibility, S wind, F3
24/08/2019	Summer	1	3	11:00	Showers, Good visibility, S wind, F3
12/09/2019	Summer	1	3	09:00	Showers, Good visibility, SW wind, F4
12/09/2019	Summer	2	3	12:45	Dry, Good visibility, NW wind, F4-5
13/09/2019	Summer	2	3	10:00	Dry, Good visibility, W wind, F3
13/09/2019	Summer	1	3	15:00	Dry, Good visibility, W wind, F4
	Winter no. 1				
22/10/2019	Winter	2	3	08:00	Showers, Moderate visibility, SW wind, F4
22/10/2019	Winter	1	3	12:15	Showers, Moderate visibility, SW wind, F4
24/10/2019	Winter	1	3	08:00	Squalls, Good visibility, SW wind, F3
24/10/2019	Winter	2	3	12:00	Squalls, Good visibility, SW wind, F3
08/11/2019	Winter	1	3	07:45	Dry, Good visibility, NE wind, F3
08/11/2019	Winter	2	3	11.45	Dry, Good visibility, NE wind, F4
11/11/2019	Winter	2	3	09:00	Dry, Good visibility, NW wind, F5
11/11/2019	Winter	1	3	13.10	Dry, Good visibility, NW wind, F4
02/12/2019	Winter	2	3	08.30	Dry, Good visibility, SW wind, F4-5
02/12/2019	Winter	1	3	12.30	Dry, Moderate visibility, SW wind, F4

Date	Season	VP no.	Duration (hrs)	Start Time	Weather conditions
16/12/2019	Winter	1	3	09:30	Dry, Good visibility, SSW wind, F5
16/12/2019	Winter	2	3	14:00	Drizzle, Good visibility, SSW wind, F4
24/01/2020	Winter	2	3	07.36	Drizzle, Mod. visibility, S wind, F4-5
24/01/2020	Winter	1	3	11:55	Drizzle, Mod. visibility, S wind, F4
29/01/2020	Winter	1	3	10:00	Showers, Good visibility, SW wind, F4-5
29/01/2020	Winter	2	3	14:15	Showers, Good visibility, SW wind, F4
07/02/2020	Winter	1	3	10:00	Dry, Good visibility, SE wind, F4
07/02/2020	Winter	2	3	14:20	Showers, Good visibility, SE wind, F5
23/02/2020	Winter	2	3	07:40	Dry, Good visibility, W wind, F4+
23/02/2020	Winter	1	3	11:50	Dry, Good visibility, W wind, F4
06/03/2020	Winter	1	3	08:15	Showers, Mod. visibility, WNW wind, F4
06/03/2020	Winter	2	3	12:30	Showers, Good visibility, WNW wind, F4-5
30/03/2020	Winter	2	3	10:04	Dry, Good visibility, N wind, F3-4
30/03/2020	Winter	1	3	17:20	Dry, Good visibility, N wind, F3-4
	Summer no. 2				
11/04/2020	Summer	2	3	13:30	Dry, Good visibility, SW wind, F3
11/04/2020	Summer	1	3	17:30	Dry, Good visibility, W wind, F3-4
27/04/2020	Summer	1	3	07:08	Squalls, Good visibility, NE wind, F3-4
27/04/2020	Summer	2	3	11:30	Dry, Good visibility, N wind, F4
20/05/2020	Summer	1	3	09:45	Dry, Good visibility, SSE wind, F3
20/05/2020	Summer	2	3	14:30	Dry, Good visibility, SSE wind, F3
21/05/2020	Summer	2	3	07:50	Dry, Good visibility, SW wind, F2-3
21/05/2020	Summer	1	3	12:00	Dry, Good visibility, SSE wind, F4-5
18/06/2020	Summer	2	3	07:45	Dry, Good visibility, NNE wind, F1-2
18/06/2020	Summer	1	3	12:15	Dry, Good visibility, NNE wind, F1-2
19/06/2020	Summer	2	3	14:20	Dry, Good visibility, SSW wind, F3
19/06/2020	Summer	1	3	17:50	Dry, Good visibility, SSW wind, F3
29/07/2020	Summer	2	3	07:00	Dry, Good visibility, S wind, F1-2
29/07/2020	Summer	1	3	10:30	Showers, Mod visibility, SSE wind, F2-3
30/07/2020	Summer	1	3	08:00	Showers, Good visibility, SSE wind, F4+
30/07/2020	Summer	2	3	18:00	Dry, Good visibility, SE wind, F4
26/08/2020	Summer	1	3	07:30	Dry, Good visibility, SSW wind, F2
26/08/2020	Summer	2	3	11:45	Dry, Good visibility, SSW wind, F4
28/08/2020	Summer	2	3	08:00	Showers, Poor-mod. visibility, N wind, F4-5
28/08/2020	Summer	1	3	11:30	Showers, Mod visibility, N wind, F4-5
18/09/2020	Summer	2	3	07:25	Showers, Mod visibility, E wind, F2-3
18/09/2020	Summer	1	3	11:10	Dry, Good visibility, E wind, F3
19/09/2020	Summer	1	3	07:00	Dry, Good visibility, ENE wind, F4

Date	Season	VP no.	Duration (hrs)	Start Time	Weather conditions
19/09/2020	Summer	2	3	10:30	Dry, Good visibility, ENE wind, F4
	Winter no. 2				
23/10/2020	Winter	2	3	08:10	Dry, Good visibility, SW wind, F4
23/10/2020	Winter	1	3	11:40	Showers, Good visibility, SW wind, F4
24/10/2020	Winter	2	3	11:30	Dry, Good visibility, SWE wind, F4
24/10/2020	Winter	1	3	15:20	Showers, Good visibility, S wind, F4-5
24/11/2020	Winter	1	3	09:30	Showers, Good visibility, NW wind, F3-4
24/11/2020	Winter	2	3	14:00	Dry, Good visibility, NW wind, F4
26/11/2020	Winter	2	3	10:00	Dry, Good visibility, SW wind, F2
26/11/2020	Winter	1	3	13:30	Dry, Good visibility, SW wind, F2
29/12/2020	Winter	1	3	09.30	Sleet, Good visibility, NW F4-5
29/12/2020	Winter	2	3	13.30	Sleet, Good visibility, NW F4-5
30/12/2020	Winter	2	3	08.05	Sleet, Good visibility, NW F2-3
30/12/2020	Winter	1	3	12.15	Sleet, Good visibility, NW F2-3
25/01/2021	Winter	1	3	09.05	Sleet, Good visibility, SW F3
25/01/2021	Winter	2	3	14.25	Showers, Good visibility, SW F4
26/01/2021	Winter	2	3	08.30	Showers, Good visibility, SE F3
26/01/2021	Winter	1	3	12.30	Showers, Good visibility, S F4
24/02/2021	Winter	1	3	09.00	Dry, Good visibility, SW F4-5
24/02/2021	Winter	2	3	13.00	Showers, Good visibility, SW F4
25/02/2021	Winter	2	3	07.20	Dry, Good visibility, WSW F5
25/02/2021	Winter	1	3	15.30	Dry, Good visibility, WSW F5
12/03/2021	Winter	1	3	08.30	Showers, Good visibility, SW F4
12/03/2021	Winter	2	3	12.00	Drizzle, Mod. visibility, SW F4
13/03/2021	Winter	2	3	12.00	Dry, Good visibility, W F4-5
13/03/2021	Winter	1	3	16.15	Dry, Good visibility, W F5

Appendix 3. VANTAGE POINT BIRD FLIGHTLINE DATA

Table 6.6: Bird Flightline Data 2019-2021.

VP no.	Date	Map note / Flightline No.	Common Name	Species Quantity	Time of Obs.	Total Duration (s)	0-20 m (s)	20-50 m (s)	50-100 m (s)	100-180 m (s)	>180 m (s)	Comment
	Summer no. 1											
2	08/04/2019	1	Kestrel	1	15:58	120	0	90	30	-	-	Male hunting close to forest edge - on & off site
1	26/04/2019	2	Kestrel	1	14.14	180	0	90	90	-	-	Hovering / hunting along river corridor
2	26/04/2019	3	Golden plover	1	09.14	30	30	-	-	-	-	Bird flew in and landed on bog - continued calling for more than 30 min - response heard but bird not seen
2	29/04/2019	4	Great black backed gull	1	08.51	70	-	-	70	-	-	Flying along river corridor - adult
1	21/05/2019	5	Kestrel	1	17.12	50	-	-	50	0	0	Flew across site - male
1	08/07/2019	6	Kestrel	1	13:10	180	60	40	80	-	-	Hunting - male
1	08/07/2019	7	Kestrel	1	14.17	200	50	70	80	-	-	Hunting - male prob same bird
2	30/07/2019	8	Kestrel	1	14.33	100	100	-	-	-	-	Male hunting then landed on peat bank & preened for 51 min
2	30/07/2019	9	Buzzard	2	15.07	180	-	-	60	120	-	Pair circling over forest - offsite
2	23/08/2019	10	Sparrowhawk	1	17.15	240	-	-	180	60	-	Circling - female type
2	24/08/2019	11	Buzzard	1	09.17	145	-	-	145	-	-	Flying - mostly off site
2	12/09/2019	12	Kestrel	1	15.00	135	-	90	45	-	-	Male hunting / flying
	Winter no. 1											
2	22/10/2019	13	Golden plover	14	09.45	420	-	30	190	-	-	Flock circling & then onto bog
1	24/10/2019	14	Sparrowhawk	1	14.12	20	20	-	-	-	-	Hunting edge of forest/river
2	08/11/2019	15	Kestrel	1	14.17	190	-	140	50	-	-	Female hunting
2	11/11/2019	16	Kestrel	1	10.25	90	-	40	500	-	-	Female hunting
1	02/12/2019	17	Peregrine	1	14.01	40	-	-	40	-	-	Flew over site eastwards - small bird (male?)
2	16/12/2019	18	Golden plover	4	15.03	25	25	-	-	-	-	Landed on bog
1	29/01/2020	19	Buzzard	1	10.53	90	-	-	90	-	-	Circling over forest
2	23/02/2020	20	Sparrowhawk	2	09.48	160	-	40	100	20	-	Pair rising- offsite
1	06/03/2020	21	Kestrel	1	10.36	45	-	45	-	-	-	Hunting along river edge
2	30/03/2020	22	Buzzard	2	12.15	200	-	-	100	100	-	Pair over forest
1	30/03/2020	23	Lesser black backed gull	2	16.04	170	-	30	140	-	-	Adults

VP no.	Date	Map note / Flightline No.	Common Name	Species Quantity	Time of Obs.	Total Duration (s)	0-20 m (s)	20-50 m (s)	50-100 m (s)	100-180 m (s)	>180 m (s)	Comment
	Summer no. 2											
2	11/04/2020	24	Buzzard	1	15.32	120	-	-	120	-	-	Flying
2	27/04/2020	25	Sparrowhawk	2	11.55	180	-	-	100	80	-	Pair rising over woods
1	21/05/2020	26	Golden Eagle	1	12.56	600	50	50	200	100	200	Probable sub-adult - missing feathers in tail and some primaries - landed on site twice - mobbed by HCs - flew north and could still be seen greater than 500 m from site for long period.
1	18/06/2020	27	Kestrel	1	12.45	180	20	130	30	-	-	Male hunting - dropped to ground on presumed prey item
2	19/06/2020	28	Buzzard	1	16.02	260	-	110	150	-	-	Flying over forest
1	29/07/2020	29	Sparrowhawk	1	07.00	15	15	-	-	-	-	Male bird with prey item
2	30/07/2020	30	Kestrel	1	18.20	115	-	75	40	-	-	Male quartering
2	30/07/2020	31	Kestrel	1	19.00	140	20	60	60	-	-	Probable same male
1	26/08/2020	32	Sparrowhawk	1	08.43	30	30	-	-	-	-	Male left perch and started hunting
2	26/08/2020	33	Golden plover	21	14.20	420	90	150	80	-	-	Flock circling over bog
2	28/02/2020	34	Golden plover	14	10.52	400	50	200	150	-	-	Flock circling over bog on & off site
1	18/09/2020	35	Buzzard	3	12.23	600	-	100	200	200	100	Trio circling and rising - mostly offsite - calling heard
2	19/09/2020	36	Kestrel	1	11.11	45	-	45	-	-	-	Hovering along edge of forest
	Winter no. 2											
2	23/10/2020	37	Buzzard	1	09.56	120	60	60	-	-	-	Flying low
1	23/10/2020	38	Kestrel	1	13.00	90	-	30	60	-	-	Flying
2	24/11/2020	39	Peregrine	1	14.43	120	-	-	90	30	-	Flying
1	30/12/2020	40	Buzzard	1	12.46	175	-	25	50	100	-	Flew across site
1	25/01/2021	41	Kestrel	1	11.35	180	60	60	60	-	-	Male hunting along river corridor
2	26/01/2021	42	Golden plover	19	11.15	600	20	30	150	200	200	Flock looping over bog - landed
2	24/02/2021	43	Golden plover	23	13.07	240	40	40	160	-	-	Circling and then landed on bog
2	25/02/2021	44	Golden plover	27	09.20	550	60	90	400	-	-	Flying up from bog and then back then
2	25/02/2021	45	Golden plover	42	10.02	600	50	100	450	-	-	Above flock merging with more birds and flew NW
1	25/02/2021	46	Sparrowhawk	2	15.43	240	-	50	140	50	-	Pair soaring
2	12/03/2021	47	Kestrel	1	14.16	110	10	100	-	-	-	Male hunting - dropped to ground
2	13/03/2021	48	Golden plover	15	12.49	64	15	22	27	-	-	Flew south out of site
2	13/03/2021	49	Buzzard	2	13.28	180	-	-	100	80	-	Pair rising

Appendix 4. COLLISION RISK ASSESSMENT CALCULATIONS

Table 6.7: Probability of collision – Stage 2 Calculations.

Key Target Species Stage 2 Calculations							
Species Name (BTO Code)	Flapping bird			Gliding bird			Mean probability of Collision Risk (Flapping + Gliding)/2
	Upwind	Downwind	Average	Upwind	Downwind	Average	
Kestrel (K.)	8.8%	3.8%	6.3%	8.7%	3.7%	6.2%	6.25%
Golden Plover (GP)	6.3%	2.7%	4.5%	-	-	-	4.5%
Buzzard (BZ)	8.5%	4.1%	6.3%	8.4%	4.0%	6.2%	6.25%
Sparrowhawk (SH)	8.8%	3.7%	6.2%	8.7%	3.7%	6.2%	6.2%

Table 6.8: Avian Biometric Data and Avoidance Rates.

Avian Biometric Data and Avoidance Rates				
Species Name	Length (m)	Wingspan (m)	Mean flight speed (m/s)	Avoidance rates (%)
Kestrel	0.34	0.76	10.1	95
Golden Plover	0.275	0.715	17.9	98
Buzzard	0.54	1.2	13.3	98
Sparrowhawk	0.33	0.67	10	98

Table 6.9: Bird-seconds spent by species at Potential Collision Height (20-180m) within VP 1 Viewshed.

Species (BTO Code)	Year	Bird-seconds spent by species at Potential Collision Height (20-180m) for each month within Vantage Point 1 viewshed											
		April	May	June	July	August	September	October	November	December	January	February	March
Kestrel (K.)	2019/20	180	50	0	270	0	0	0	0	0	0	0	45
	2020/21	0	0	160	0	0	0	90	0	0	180	0	0
Golden Plover (GP)	2019/20	0	0	0	0	0	0	0	0	0	0	0	0
	2020/21	0	0	0	0	0	0	0	0	0	0	0	0
Buzzard (BZ)	2019/20	0	0	0	0	0	0	0	0	0	90	0	0
	2020/21	0	0	0	0	0	1500	0	0	175	0	0	0
Sparrowhawk (SH)	2019/20	0	0	0	0	0	0	0	0	0	0	0	0
	2020/21	0	0	0	0	0	0	0	0	0	0	480	0

Table 6.10: Bird-seconds spent by species at Potential Collision Height (20-180m) within VP 2 Viewshed.

Species (BTO Code)	Year	Bird-seconds spent by species at Potential Collision Height (20-180m) for each month within Vantage Point 2 viewshed											
		April	May	June	July	August	September	October	November	December	January	February	March
Kestrel (K.)	2019/20	120	0	0	0	0	135	0	280	0	0	0	0
	2020/21	0	0	0	235	0	45	0	0	0	0	0	100
Golden Plover (GP)	2019/20	0	0	0	0	0	0	3080	0	0	0	0	0
	2020/21	0	0	0	0	9730	0	0	0	0	7220	36790	735
Buzzard (BZ)	2019/20	0	0	0	360	145	0	0	0	0	0	0	400
	2020/21	120	0	260	0	0	0	60	0	0	0	0	360
Sparrowhawk (SH)	2019/20	0	0	0	0	240	0	0	0	0	0	320	0
	2020/21	360	0	0	0	0	0	0	0	0	0	0	0

Table 6.11: Bird-seconds spent by species at Potential Collision Height (20-180m) for each VP (1-2).

Species (BTO Code)	Year	VP 1 Seconds spent at PCH		VP 2 Seconds spent at PCH	
		Summer	Winter	Summer	Winter
Kestrel (K.)	2019/20	500	45	255	280
	2020/21	160	270	280	100
Golden Plover (GP)	2019/20	0	0	0	3080
	2020/21	0	0	9730	44745
Buzzard (BZ)	2019/20	0	90	505	400
	2020/21	1500	175	380	420
Sparrowhawk (SH)	2019/20	0	0	240	320
	2020/21	0	480	360	0

Table 6.12: Calculations of potential increases in annual mortality rates due to the predicted collision mortality.

Parameter	Kestrel		Golden Plover		Buzzard		Sparrowhawk	
	County Population[A]	National Population[B]	County Population[A]	National Population[B]	County Population[A]	National Population[B]	County Population[A]	National Population[B]
Population Size	~ 1073.11	~ 13500	~ 6415.40	~ 80707	~ 154.10	~ 1938	~ 942.67	~ 11859
Annual Survival Rate[C]	0.69	0.69	0.73	0.73	0.9	0.9	0.69	0.69
Annual background mortality (Pop*(1-Surv))	332.664	4185	1732.16	21790.89	15.41	193.8	292.23	3676.29
Predicted annual collision mortality	0.195	0.195	1.930	1.930	0.194	0.194	0.071	0.071
Percentage of population	0.018	0.001	0.03	0.002	0.126	0.01	0.007	0.005
Magnitude (Percival, 2003)	<1% (Negligible)	<1% (Negligible)	<1% (Negligible)	<1% (Negligible)	<1% (Negligible)	<1% (Negligible)	<1% (Negligible)	<1% (Negligible)

A: Estimate based on proportion of population split by county area, used due to a lack of a county estimate
B: NPWS (2012) Article 12 Report - Ireland's bird species' status and trends for the period 2013-2018
C: Adult survival rates available at: www.bto.org/understanding-birds/birdfacts

Appendix 5. WORKED CALCULATIONS

Table 6.13: Calculation of collision probability for Kestrel passing (Flapping) through rotor area.

K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**								
NoBlades	3					Upwind:			Downwind:		
MaxChord	4.2	m	r/R	c/C	α	collide		contribution	collide		contribution
Pitch (degrees)	13		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
BirdLength	0.34	m	0.025	0.575	4.08	13.25	0.83	0.00103	12.16	0.76	0.00095
Wingspan	0.76	m	0.075	0.575	1.36	4.78	0.30	0.00224	3.69	0.23	0.00173
F: Flapping (0) or gliding (+1)	0		0.125	0.702	0.82	3.63	0.23	0.00283	2.30	0.14	0.00179
			0.175	0.860	0.58	3.31	0.21	0.00361	1.68	0.10	0.00184
Bird speed	10.1	m/sec	0.225	0.994	0.45	3.13	0.20	0.00439	1.25	0.08	0.00176
RotorDiam	150	m	0.275	0.947	0.37	2.67	0.17	0.00458	0.88	0.06	0.00151
RotationPeriod	4.76	sec	0.325	0.899	0.31	2.34	0.15	0.00475	0.65	0.04	0.00131
			0.375	0.851	0.27	2.09	0.13	0.00490	0.48	0.03	0.00113
			0.425	0.804	0.24	1.89	0.12	0.00501	0.37	0.02	0.00098
			0.475	0.756	0.21	1.72	0.11	0.00509	0.39	0.02	0.00116
Bird aspect ratioo: β	0.45		0.525	0.708	0.19	1.57	0.10	0.00515	0.45	0.03	0.00146
			0.575	0.660	0.18	1.44	0.09	0.00518	0.48	0.03	0.00174
			0.625	0.613	0.16	1.33	0.08	0.00518	0.51	0.03	0.00199
			0.675	0.565	0.15	1.22	0.08	0.00515	0.52	0.03	0.00221
			0.725	0.517	0.14	1.13	0.07	0.00510	0.53	0.03	0.00240
			0.775	0.470	0.13	1.04	0.06	0.00501	0.53	0.03	0.00257
			0.825	0.422	0.12	0.95	0.06	0.00490	0.53	0.03	0.00270
			0.875	0.374	0.12	0.87	0.05	0.00476	0.52	0.03	0.00281
			0.925	0.327	0.11	0.80	0.05	0.00459	0.50	0.03	0.00289
			0.975	0.279	0.10	0.72	0.05	0.00440	0.48	0.03	0.00295
				Overall p(collision) =			**Upwind**	**8.8%**		**Downwind**	**3.8%**
								Average	**6.3%**		

Table 6.14: Calculation of collision probability for Kestrel passing (Gliding) through rotor area.

K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**								
NoBlades	3					Upwind:			Downwind:		
MaxChord	4.2	m	r/R	c/C	α	collide		contribution	collide		contribution
Pitch (degrees)	13		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
BirdLength	0.34	m	0.025	0.575	4.08	12.12	0.76	0.00095	11.03	0.69	0.00086
Wingspan	0.76	m	0.075	0.575	1.36	4.40	0.27	0.00206	3.32	0.21	0.00155
F: Flapping (0) or gliding (+1)	1		0.125	0.702	0.82	3.40	0.21	0.00265	2.08	0.13	0.00162
			0.175	0.860	0.58	3.15	0.20	0.00344	1.52	0.09	0.00166
Bird speed	10.1	m/sec	0.225	0.994	0.45	3.00	0.19	0.00422	1.13	0.07	0.00158
RotorDiam	150	m	0.275	0.947	0.37	2.67	0.17	0.00458	0.88	0.06	0.00151
RotationPeriod	4.76	sec	0.325	0.899	0.31	2.34	0.15	0.00475	0.65	0.04	0.00131
			0.375	0.851	0.27	2.09	0.13	0.00490	0.48	0.03	0.00113
			0.425	0.804	0.24	1.89	0.12	0.00501	0.37	0.02	0.00098
			0.475	0.756	0.21	1.72	0.11	0.00509	0.39	0.02	0.00116
Bird aspect ratioo: β	0.45		0.525	0.708	0.19	1.57	0.10	0.00515	0.45	0.03	0.00146
			0.575	0.660	0.18	1.44	0.09	0.00518	0.48	0.03	0.00174
			0.625	0.613	0.16	1.33	0.08	0.00518	0.51	0.03	0.00199
			0.675	0.565	0.15	1.22	0.08	0.00515	0.52	0.03	0.00221
			0.725	0.517	0.14	1.13	0.07	0.00510	0.53	0.03	0.00240
			0.775	0.470	0.13	1.04	0.06	0.00501	0.53	0.03	0.00257
			0.825	0.422	0.12	0.95	0.06	0.00490	0.53	0.03	0.00270
			0.875	0.374	0.12	0.87	0.05	0.00476	0.52	0.03	0.00281
			0.925	0.327	0.11	0.80	0.05	0.00459	0.50	0.03	0.00289
			0.975	0.279	0.10	0.72	0.05	0.00440	0.48	0.03	0.00295
				Overall p(collision) =			**Upwind**	**8.7%**		**Downwind**	**3.7%**
								Average	**6.2%**		

Table 6.15: Calculation of collision risk parameters for Kestrel Summer VP Surveys 2019.

Kestrel, Summer VP Surveys: April 2019-Sept 2019				
Measurements	Code	Value		
Rotor radius (metres)	R	75		
Rotor diameter (metres)	RD	150		
Max chord width of turbine blades (metres)	d	4.2		
Bird length (metres)	l	0.34		
Average flight speed (m/s)	s	10.1		
Daily Duration of Activity (hrs)	TDD	15		
Length of Season (days)	Tss	183		
Wingspan (m)		0.76		
Mean pitch of blade (degrees)		13		
Rotors per turbine		3		
Rotational period (seconds)		4.76		
Turbine operational time (%)		85		
			Vantage Point	
			VP 1	VP 2
Total Survey time over 6 months (secs)	T		129600	129600
Total flight at Rotor Height 20 – 180m (bird-secs)	sPCH		500	255
No. of turbines in viewshed	x		4	4
Survey area visible from VP (hectares)	Avp		625	628
Flight Risk Area, i.e. 500m buffer of turbines within viewshed (hectares)	Afr		223	131
Availability of species activity during survey period (hrs)	Sa		2745	2745

Table 6.16: Stage 1 calculation of collision risk for Kestrel Summer VP Surveys 2019.

Stage 1 Calculations				
Measurements	**Code**	**Calculation**	**VP 1**	**VP 2**
Proportion of Bird flight-time between 20 - 180m	t	sPCH/T	0.00386	0.0020
Flight activity in visible area per hectare	F	t/Avp	6.17284E-06	3.13311E-06
Proportion of Bird flight time in Risk Area	Trisk	F*Afr	0.001376543	0.000410437
Bird occupancy of Risk Area (hrs/season)	n	Trisk*Sa	3.778611111	1.126650411
Flight Risk volume (m³)	Vw	(Afr*RD)*10000	334500000	196500000
Actual volume of air swept by rotors (m³)	o	x*(πr2(d+l))	320751	320751
Bird occupancy of rotor swept area (bird-secs)	b	3600*(n*(o/Vw))	13.043874	6.620596875
Time taken for Bird to pass through rotors (secs)	v	(d+l)/s	0.44950495	0.44950495
Number of Bird passes through the rotor during survey period	N	b/v	29.01831	14.72864063
Total transits adjusted for maximum operation of turbines (85%)	Tn	N*0.85	24.6655635	12.51934453
Number of transits per turbine within viewshed	TnT	Tn/x	6.166390875	3.129836133
Average TnT of all VP's (VP 1-2)	ATnT	(TnT1+TnT2)/2	7.731308941	
Number of transits across windfarm	NT	ATnT*(Total no. turbines)	61.85047153	

Table 6.17: Stage 2 calculation of collision risk for Kestrel Summer VP Surveys 2019.

Stage 2 Calculation	Calculation	Result
Collision Probability (%)	(Model)	6.25%
Collisions during study period	NT*Collision Probability	3.87
Collisions during study period with 95% Avoidance Rate	*0.05	0.193282724
Over 30-year duration of windfarm	*30	5.798481706