



Appendix 5.8

Collision Risk Model Report

Knockanarragh Wind Farm EIAR Volume 3

Knockanarragh Wind Farm Limited

27 November 2023



Knockanarragh Wind Farm

Avian Collision Risk

Knockanarragh Wind Farm Ltd

Building 4200, Cork Airport Business Park, Cork, T12 D23C, Cork, Ireland

Prepared by:

SLR Consulting Limited

Office 4.04, Clockwise Offices, Savoy Tower, 77
Renfrew Street, Glasgow, G2 3BZ

SLR Project No.: 501.00727.00008

Client Reference No: N/A

16 October 2023

Revision: 00

Revision Record

| Revision | Date | Prepared By | Checked By | Authorised By |
|----------|------------------------|-------------|------------------|------------------|
| 0 | 2 November 2023 | Mike Austen | Dr Jonathon Dunn | Dr Jonathon Dunn |
| | Click to enter a date. | | | |
| | Click to enter a date. | | | |
| | Click to enter a date. | | | |
| | Click to enter a date. | | | |

Basis of Report

This document has been prepared by SLR Consulting Limited (SLR) with reasonable skill, care and diligence, and taking account of the timescales and resources devoted to it by agreement with Knockannaragh Wind Farm Ltd (the Client) as part or all of the services it has been appointed by the Client to carry out. It is subject to the terms and conditions of that appointment.

SLR shall not be liable for the use of or reliance on any information, advice, recommendations and opinions in this document for any purpose by any person other than the Client. Reliance may be granted to a third party only in the event that SLR and the third party have executed a reliance agreement or collateral warranty.

Information reported herein may be based on the interpretation of public domain data collected by SLR, and/or information supplied by the Client and/or its other advisors and associates. These data have been accepted in good faith as being accurate and valid.

The copyright and intellectual property in all drawings, reports, specifications, bills of quantities, calculations and other information set out in this report remain vested in SLR unless the terms of appointment state otherwise.

This document may contain information of a specialised and/or highly technical nature and the Client is advised to seek clarification on any elements which may be unclear to it.

Information, advice, recommendations and opinions in this document should only be relied upon in the context of the whole document and any documents referenced explicitly herein and should then only be used within the context of the appointment.



Table of Contents

| | |
|---|-----------|
| Basis of Report | i |
| 1.0 Introduction | 1 |
| 1.1 Primary Target Species..... | 1 |
| 2.0 Methods | 2 |
| 2.1 Prediction of Rotor Transits from Vantage Point Survey Data | 2 |
| 2.1.1 Year 1, Year 2 and Year 3 Survey Data | 2 |
| 2.1.2 Viewshed Data | 2 |
| 2.1.3 Flight Selection for CRM..... | 4 |
| 2.1.4 Correcting Survey PCH to Actual PCH..... | 4 |
| 2.1.5 Seasonal Definitions..... | 5 |
| 2.1.6 Undertaking CRM..... | 5 |
| 2.1.7 Bird Biometrics and Avoidance Rates..... | 6 |
| 2.1.8 Wind Farm and Turbine Parameters..... | 6 |
| 2.2 Knockanarragh Occupancy Data | 7 |
| 3.0 Collision Risk Modelling Results | 15 |

Tables in Text

| | |
|---|----|
| Table 2-1: VP Surveys undertaken at Knockanarragh, Apr 2019 – Sep 2021 | 2 |
| Table 2-2: Knockanarragh VP Viewshed Data, North Cluster, Turbine Type 1 | 3 |
| Table 2-3: Knockanarragh VP Viewshed Data, North Cluster, Turbine Type 2..... | 3 |
| Table 2-4: Knockanarragh VP Viewshed Data, South Cluster, Turbine Type 1 | 3 |
| Table 2-5: Knockanarragh VP Viewshed Data, South Cluster, Turbine Type 2 | 4 |
| Table 2-6: Bird Biometrics and Avoidance Rates used in CRM..... | 6 |
| Table 2-7: Wind Farm and Turbine Parameters | 6 |
| Table 2-8: Details of Whooper Swan occupancy within 500 m Buffer of Turbines | 8 |
| Table 2-9: Details of Mallard Occupancy within 500 m Buffer of Turbines | 8 |
| Table 2-10: Details of Peregrine Occupancy within 500 m Buffer of Turbines | 9 |
| Table 2-11: Details of Kestrel Occupancy within 500 m Buffer of Turbines..... | 10 |
| Table 2-12: Details of Golden Plover Occupancy within 500 m Buffer of Turbines | 11 |
| Table 2-13: Details of Lapwing Occupancy within 500 m Buffer of Turbines | 12 |
| Table 2-14: Details of Curlew Occupancy within 500 m Buffer of Turbines..... | 13 |
| Table 2-15: Golden Plover, Proportions of Flight Lines within 500 m Buffer of Turbines..... | 14 |
| Table 3-1: Summary of CRM Output (N Array)..... | 15 |
| Table 3-2: Summary of CRM Output (S Array) | 16 |
| Table 3-3: Summary of CRM Output (North & South Array Combined) | 17 |



Appendices

Appendix A CRM Band Models

- A.1 Whooper Swan Turbine Type 1
- A.2 Whooper Swan Turbine Type 2
- A.3 Mallard Turbine Type 1
- A.4 Mallard Turbine Type 2
- A.5 Kestrel Turbine Type 1
- A.6 Kestrel Turbine Type 2
- A.7 Peregrine Turbine Type 1
- A.8 Peregrine Turbine Type 2
- A.9 Lapwing Turbine Type 1
- A.10 Lapwing Turbine Type 2
- A.11 Golden Plover Turbine Type 1
- A.12 Golden Plover Turbine Type 2
- A.13 Curlew Turbine Type 1
- A.14 Curlew Turbine Type 2



1.0 Introduction

This report presents the results of Collision Risk Modelling (CRM) undertaken for seven bird species to inform the assessment of potential ornithological impacts relating to the proposed Knockanarragh Wind Farm, which has a layout comprising eight turbines (in two arrays).

As advised by Knockanarragh Wind Farm Ltd, modelling was based on the use of two turbine options:

- Turbine Type 1 155 6.6 MW, each with a rotor diameter of 155 m, tip height of 175 m and hub height of 97.5 m.
- Type 2 7.2 MW turbines, each with a rotor diameter of 162 m, tip height of 180 m and hub height of 99 m.

The CRM was undertaken in accordance with current NatureScot (NS) (formerly Scottish Natural Heritage (SNH)) guidance, which is recognised as standard best practice guidance through the UK and Ireland to inform impact assessment for onshore wind farms. Further details regarding the methodology used, including details of assumptions used and any corrections applied, are provided in Section 2. The monitoring results are presented in Section 3 and copies of the modelling calculations for each species modelled are included in Appendix A.

1.1 Primary Target Species

Target species for the surveys were defined by legal and/ or conservation status and vulnerability to impacts caused by wind turbines, as defined in NS Guidance (SNH 2017¹).

Bird species of high conservation importance are those which are Annex I species and other species of high conservation importance which are considered to be vulnerable to impacts from wind farm developments.

The following species are therefore considered relevant as primary target species:

- Annex I raptor and owl species;
- Breeding and migratory wildfowl; and
- Breeding and migratory waders.

¹ SNH (2017). *Recommended Bird Survey Methods to Inform Impact Assessment of Onshore Wind Farms. Version 2.*



2.0 Methods

The standard Band CRM (Band *et. al.* 2007²) was used to estimate collision risk based on recorded target species activity levels and flight behaviour, proposed turbine numbers and specifications, and the relevant species biometrics and flight characteristics. Modelling collision risk under the Band CRM is a two-stage process. Stage 1 estimates the number of birds that fly through the rotor swept disc. Stage 2 predicts the proportion of these birds that have the potential to be hit by a rotor blade. Combining both stages produces an estimate of collision mortality in the absence of any avoidance action/behaviour by birds. Avoidance rates are then applied to generate predicted rates of collision mortality.

2.1 Prediction of Rotor Transits from Vantage Point Survey Data

2.1.1 Year 1, Year 2 and Year 3 Survey Data

The number of birds that fly through the rotor swept area was estimated using flight data gathered during baseline surveys carried out by MKO during April 2019 to September 2021.

The surveys gathered data from three vantage points (VPs). The total number of hours are as shown in **Table 2-1** (MKO, 2021a³; MKO, 2021b⁴; MKO, 2021c⁵).

Table 2-1: VP Surveys undertaken at Knockanarragh, Apr 2019 – Sep 2021

| VP Number | ITM Grid Coordinates (x,y) | Hours of Survey Completed (hrs:mins) | | | | | Total |
|-----------|----------------------------|--------------------------------------|---------------------|---------------------|---------------------|---------------------|--------|
| | | Apr 2019 – Aug 2019 | Sep 2019 – Mar 2020 | Apr 2020 – Aug 2020 | Sep 2020 – Mar 2021 | Apr 2021 – Sep 2021 | |
| 1 | 661384, 764614 | 24:00 | 36:00 | 30:00 | 42:00 | 37:05 | 169:05 |
| 2 | 663593, 766914 | 24:00 | 36:00 | 30:00 | 47:00 | 36:30 | 173:30 |
| 3 | 662466, 768621 | 00:00 | 29:00 | 30:00 | 48:00 | 37:15 | 144:15 |

2.1.2 Viewshed Data

Viewshed data, i.e., the area visible from each VP within each wind farm polygon (WP)⁶, are summarised in **Table 2-2**. Separate analyses were undertaken for each turbine model as follows.

² Band, W., Madders, M. and Whitfield, D.P. (2007) Developing Field and Analytical Methods to Assess Avian Collision Risk at Wind Farms. In: De Lucas, M., Janss, G. and Ferrer, M., Eds., *Birds and Wind Power*, Quercus Editions, Madrid, 259-275.

³ MKO. (2021a). *Crowinstown - Year 1 Bird Survey Report 2019-2020*.

⁴ MKO. (2021b). *Crowinstown - Year 2 Bird Survey Report 2020-2021*.

⁵ MKO. (2021c). *Crowinstown – Year 3 Bird Survey Report Ap21-Sep21*.

⁶ The survey wind farm polygon (WP) includes the area within 500m of the outermost turbine blades.



2.1.2.1 North Cluster

Turbine Type 1

Based on an offset of 20 m, the combined viewshed area (minus overlap) from VP2 and VP3 (1,803,626 m²) represents 89.1% of the survey WP (2,023,257 m²) (**Table 2-2**).

Table 2-2: Knockanarragh VP Viewshed Data, North Cluster, Turbine Type 1

| VP / Viewshed Number | Area of visibility (m ²)* |
|--|--|
| VP 2 viewshed | 478,636 |
| VP 3 viewshed | 1,803,626 |
| VP 2-3 viewshed combined (minus overlap) | 1,803,626 |
| | * area calculated in GIS using offset of 20 m above ground level |

Turbine Type 2

Based on an offset of 18 m, the combined viewshed area (minus overlap) from VP2 and VP3 (1,791,720 m²) represents 87.3% of the survey WP (2,051,413 m²) (**Table 2-3**).

Table 2-3: Knockanarragh VP Viewshed Data, North Cluster, Turbine Type 2

| VP / Viewshed Number | Area of visibility (m ²)* |
|--|--|
| VP 2 viewshed | 433,442 |
| VP 3 viewshed | 1,791,720 |
| VP 2-3 viewshed combined (minus overlap) | 1,791,720 |
| | * area calculated in GIS using offset of 18 m above ground level |

2.1.2.2 South Cluster

Turbine Type 1

Based on an offset of 20 m, the combined viewshed area (minus overlap) from VP1 and VP2 (2,539,998 m²) represents 90.4% of the survey WP (2,808,596 m²).

Table 2-4: Knockanarragh VP Viewshed Data, South Cluster, Turbine Type 1

| VP / Viewshed Number | Area of visibility (m ²)* |
|--|--|
| VP 1 viewshed | 2,158,982 |
| VP 2 viewshed | 401,438 |
| VP 1-2 viewshed combined (minus overlap) | 2,539,998 |
| | * area calculated in GIS using offset of 20 m above ground level |

Turbine Type 2

Based on an offset of 18 m, the combined viewshed area (minus overlap) from VP1 and VP2 (2,427,822 m²) represents 85.4% of the survey WP (2,842,355 m²).



Table 2-5: Knockanarragh VP Viewshed Data, South Cluster, Turbine Type 2

| VP / Viewshed Number | Area of visibility (m ²)* |
|--|--|
| VP 1 viewshed | 2,140,555 |
| VP 2 viewshed | 289,604 |
| VP 1-2 viewshed combined (minus overlap) | 2,427,822 |
| | * area calculated in GIS using offset of 18 m above ground level |

2.1.3 Flight Selection for CRM

In order to select flights liable to incur a potential risk of collision, i.e., within the areas occupied by proposed turbines, the CRM used only observations collected within each WP – defined by a 500 m buffer around the proposed outermost turbine locations. The size of buffer takes into account rotor blade length and potential spatial errors in flight recording accuracy. It is known that bird detection rates vary between species. To ensure the CRM used robust measures of flight activity, a 2 km distance truncation was used in the viewshed from each VP, i.e., only flights within 2 km of each VP were included (as per NS guidance).

Analysis in MS Excel and GIS identified those flights that were at Potential Collision Height (PCH) and within each WP. Flight times that were used in the CRM were derived from field data for each flight. Time spent at different flight heights was estimated in a database from interval data for flights that entered the WP. Flying time estimated to occur within the survey recording height bands (see following section) was used to determine the period that target species were at risk of collision with the rotors.

For golden plover, which recorded long flights which moved inside and outside each WP, including the time spent outside the at-risk areas was considered over-precautionary and likely to produce substantial over-estimates of collision risk. Further adjustments were made by calculating the proportion of each clipped flightline and factoring this into the occupancy calculations.

2.1.4 Correcting Survey PCH to Actual PCH

The baseline surveys utilised the following four height bands:

- 1 0-10 m
- 2 10-25 m
- 3 25-175 m
- 4 >175 m

The PCH for the turbines is as follows:

- Turbine Type 1 (tip height of 175 m and hub height of 97.5 m):
 - 20-175 m (rotor diameter 155 m).
- Turbine Type 2 (tip height of 180 m and hub height of 99.0 m):
 - 18-180 m (rotor diameter 162 m).

As such, all flights within a survey PCH of 10-175 m were included for CRM. While there could be a small amount of height band 4 within PCH for Turbine Type 2 (5 m), it is unlikely to make a material difference given the difficulties in estimating flight heights at >175 m. To account for a rotor diameter of 155 m, the model adjusted the occupancy by rotor diameter /



survey risk height (i.e., 155/165 (93.9%)). Similarly, to account for a rotor diameter of 162 m, the model adjusted the occupancy by rotor diameter/ survey risk height (i.e., 162/165 (98.2%))

2.1.5 Seasonal Definitions

CRMs were constructed using data from the periods used in the survey design (see **Table 2-1**). These broadly equate to the breeding and non-breeding season periods for most bird species, defined as April – August (breeding season) and September – March (non-breeding season). For the third breeding season (in 2021), September was also included for sake of continuity.

The theoretical time that birds could be active with potential for turbine collisions was assumed to be the period between sunrise and sunset within each survey period using the latitude of the Site⁷.

For wildfowl (i.e., mallard and whooper swan), and waders (i.e., golden plover, lapwing and curlew), which could be active nocturnally, an additional 25% of nocturnal hours were added to the daylight hours to give a more accurate representation of the available hours for these species (as per Band *et al.*, 2007).

2.1.6 Undertaking CRM

Collision risk modelling employs an estimated three-dimensional risk volume⁸, in keeping with the assumption that flight directions are random in space. For species with non-directional (e.g., random, circling and foraging) flights, the occupancy data are derived by multiplying the numbers of a particular species flying through the survey risk area by the total time spent.

The following parameters were entered into a bespoke modelling spreadsheet:-

- The total observation effort within the risk volume (V_w) visible from each VP;
- The occupancy total: the total time spent by a particular species flying within the risk volume (V_w) visible from each VP;
- The volume of V_w (m^3) visible from each VP (this is area covered by the outermost turbines without the 500m buffer);
- An estimation of average daylight hours within the season of analysis;
- Species-specific bird parameters (**Table 2-6**); and
- Wind farm parameters (**Table 2-7**).

The NS CRM spreadsheet⁹ calculates the probability of collision for each particular species. The model then combines this probability of collision with the observed flight activity per unit area (hours per hectare) weighted for observation effort from each VP to produce an estimate of the number of transits through the rotor blades. Mortality estimates are then derived by applying species-specific avoidance rates.

⁷ <https://www.timeanddate.com> [Accessed in September 2023].

⁸ Calculated by multiplying the area of the wind farm by the diameter of the rotors.

⁹ <https://www.nature.scot/wind-farm-impacts-birds-calculating-probability-collision> [Accessed in September 2023].



2.1.7 Bird Biometrics and Avoidance Rates

Measurements and flight speeds of the species for which CRM was undertaken were derived from British Trust for Ornithology (BTO)¹⁰, Provan & Whitfield (2007¹¹), Bruderer & Boldt (2001¹²) and Alerstram *et al.* (2007¹³). The avoidance rates for these species are taken from NS (2018¹⁴).

Table 2-6: Bird Biometrics and Avoidance Rates used in CRM

| Species name | Bird length (m) | Wingspan (m) | Flight speed (m/s) | Avoidance rate (%) |
|---------------|-----------------|--------------|--------------------|--------------------|
| Whooper swan | 1.52 | 2.3 | 17.3 | 99.5 |
| Mallard | 0.58 | 0.9 | 22.0 | 98.0 |
| Peregrine | 0.45 | 1.1 | 14.0 | 98.0 |
| Kestrel | 0.34 | 0.8 | 12.7 | 95.0 |
| Golden plover | 0.28 | 0.72 | 17.5 | 98.0 |
| Lapwing | 0.28 | 0.7 | 18.0 | 98.0 |
| Curlew | 0.55 | 0.9 | 13.9 | 98.0 |

In addition to the NS 98% default avoidance rate, there has been recent research that shows that for European golden plover, an avoidance rate of 99.8% may be more appropriate. This is based on empirical evidence collected during post-construction monitoring surveys for operational wind farms in England¹⁵. Consequently, we have presented the results using the two avoidance rates to show the range of possible collision estimates.

2.1.8 Wind Farm and Turbine Parameters

The wind turbine parameters used in the CRM are detailed in **Table 2-7**, based on the information provided by Knockanarragh Wind Farm Ltd.

Table 2-7: Wind Farm and Turbine Parameters

| Parameter | Value |
|---------------------------------------|--------------------------|
| North Array | |
| Size of survey wind farm polygon (WP) | Turbine Type 1: 202.3 ha |
| | Turbine Type 2: 205.1 ha |
| Number of turbines | 3 |
| South Array | |

¹⁰ <https://www.bto.org/understanding-birds/birdfacts> [Accessed in September 2023].

¹¹ Provan, S. and Whitfield, D.P. (2007) Avian flight speeds and biometrics for use in collision risk modelling. Report to Scottish Natural Heritage.

¹² Bruderer, B. and Bolt, A. (2001) Flight characteristics of birds: 1. Radar measurements of speeds, *Ibis*, **143**, 178 – 204.

¹³ Alerstam T, Rosén M, Bäckman J, Ericson PG, Hellgren O. (2007). Flight speeds among bird species: allometric and phylogenetic effects. *PLoS Biol*.

¹⁴ SNH (2018) Avoidance rates for the onshore SNH wind farm collision risk model. <https://www.nature.scot/doc/wind-farm-impacts-birds-use-avoidance-rates-naturescot-wind-farm-collision-risk-model#:~:text=2.%20Recommended%20avoidance%20rates%20%20%20Species%20,%20SNH%20%282013%29%20%207%20more%20rows%20.> [Accessed in July 2023].

¹⁵ https://www.ballivorwindfarmplanning.ie/wp-content/uploads/sites/38/2023/04/Appendix_7-6_Collision_Risk_Assessment.pdf [Accessed October 2023]



| Parameter | Value |
|---------------------------------------|--------------------------|
| Size of survey wind farm polygon (WP) | Turbine Type 1: 280.9 ha |
| | Turbine Type 2: 284.2 ha |
| Number of turbines | 5 |
| Turbine Type 1 | |
| Rotor radius / diameter | 77.5 m / 155.0 m |
| Hub height | 97.5 m |
| Max. chord | 4.5 m |
| Pitch | 6° |
| Rotation period | 5.45s (max 11.01 rpm) |
| Turbine operation time | 97% |
| Turbine Type 2 | |
| Rotor radius / diameter | 82 m / 162 m |
| Hub height | 99.0 m |
| Max. chord | 4.3 m |
| Pitch | 6° |
| Rotation period | 4.96s (max 12.1 rpm) |
| Turbine operation time | 97% |

2.2 Knockanarragh Occupancy Data

Using the MKO survey data^{3,4,5} the occupancy of species with sufficient data to be taken forward to CRM¹⁶ are presented in **Table 2-8** to **Table 2-14** (inclusive) present the seasonal primary target species occupancy data within each height band, and the total at-risk occupancy data used in the CRM.

Table 2-15 presents the proportion of each individual golden plover flightline within each WP which was used to adjust the at-risk occupancy data, as described in **Section 2.1.3**.

¹⁶ Sufficient flight activity was defined as a minimum total of five flights or minimum ten individuals of each primary target species recorded in the WP during each season of analysis. Numbers below these thresholds are likely to result in negligible predicted mortality.



Table 2-8: Details of Whooper Swan occupancy within 500 m Buffer of Turbines

| Period | VP No. | No. of flights | No. of birds | Total flying time (s) | Time in height category (s) | | | | |
|--------------------|--------|----------------|--------------|-----------------------|-----------------------------|-----------|--------------|----------|--------------|
| | | | | | <10 m | 10-25 m | 25-175 m | >175 m | At risk |
| North Array | | | | | | | | | |
| Apr-19 to Aug-19 | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sep-19 to Mar-20 | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Apr-20 to Aug-20 | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sep-20 to Mar-21 | VP2 | 2 | 6 | 440 | 0 | 0 | 440 | 0 | 440 |
| | VP3 | 1 | 4 | 180 | 0 | 80 | 100 | 0 | 180 |
| Apr-21 to Sep-21 | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | | 3 | 10 | 620 | 0 | 80 | 540 | 0 | 620 |
| South Array | | | | | | | | | |
| Apr-19 to Aug-19 | VP1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sep-19 to Mar-20 | VP1 | 1 | 4 | 280 | 0 | 0 | 280 | 0 | 280 |
| | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Apr-20 to Aug-20 | VP1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sep-20 to Mar-21 | VP1 | 1 | 11 | 4,180 | 0 | 0 | 4,180 | 0 | 4,180 |
| | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Apr-21 to Sep-21 | VP1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | | 2 | 15 | 4,460 | 0 | 0 | 4,460 | 0 | 4,460 |

Table 2-9: Details of Mallard Occupancy within 500 m Buffer of Turbines

| Period | VP No. | No. of flights | No. of birds | Total flying time (s) | Time in height category (s) | | | | |
|--------------------|--------|----------------|--------------|-----------------------|-----------------------------|---------|----------|--------|---------|
| | | | | | <10 m | 10-25 m | 25-175 m | >175 m | At risk |
| North Array | | | | | | | | | |
| Apr-19 to Aug-19 | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |



| Period | VP No. | No. of flights | No. of birds | Total flying time (s) | Time in height category (s) | | | | |
|--------------------|--------|----------------|--------------|-----------------------|-----------------------------|------------|------------|----------|------------|
| | | | | | <10 m | 10-25 m | 25-175 m | >175 m | At risk |
| Sep-19 to Mar-20 | VP3 | 4 | 19 | 665 | 0 | 295 | 370 | 0 | 665 |
| Apr-20 to Aug-20 | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sep-20 to Mar-21 | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Apr-21 to Sep-21 | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | | 4 | 19 | 665 | 0 | 295 | 370 | 0 | 665 |
| South Array | | | | | | | | | |
| Apr-19 to Aug-19 | VP1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sep-19 to Mar-20 | VP1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Apr-20 to Aug-20 | VP1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sep-20 to Mar-21 | VP1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Apr-21 to Sep-21 | VP1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 2-10: Details of Peregrine Occupancy within 500 m Buffer of Turbines

| Period | VP No. | No. of flights | No. of birds | Total flying time (s) | Time in height category (s) | | | | |
|--------------------|--------|----------------|--------------|-----------------------|-----------------------------|---------|----------|--------|---------|
| | | | | | <10 m | 10-25 m | 25-175 m | >175 m | At risk |
| North Array | | | | | | | | | |
| Apr-19 to Aug-19 | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sep-19 to Mar-20 | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Apr-20 to Aug-20 | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sep-20 to Mar-21 | VP2 | 1 | 1 | 135 | 0 | 30 | 105 | 0 | 135 |
| | VP3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |



| Period | VP No. | No. of flights | No. of birds | Total flying time (s) | Time in height category (s) | | | | |
|--------------------|--------|----------------|--------------|-----------------------|-----------------------------|------------|------------|-----------|------------|
| | | | | | <10 m | 10-25 m | 25-175 m | >175 m | At risk |
| Apr-21 to Sep-21 | VP2 | 1 | 1 | 180 | 0 | 10 | 150 | 20 | 160 |
| | VP3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | | 2 | 2 | 315 | 0 | 40 | 255 | 20 | 295 |
| South Array | | | | | | | | | |
| Apr-19 to Aug-19 | VP1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sep-19 to Mar-20 | VP1 | 1 | 1 | 60 | 0 | 30 | 30 | 0 | 60 |
| | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Apr-20 to Aug-20 | VP1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sep-20 to Mar-21 | VP1 | 2 | 2 | 303 | 0 | 59 | 244 | 0 | 303 |
| | VP2 | 2 | 2 | 105 | 10 | 40 | 55 | 0 | 95 |
| Apr-21 to Sep-21 | VP1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP2 | 1 | 1 | 180 | 0 | 10 | 150 | 20 | 160 |
| Total | | 6 | 6 | 648 | 10 | 139 | 479 | 20 | 618 |

Table 2-11: Details of Kestrel Occupancy within 500 m Buffer of Turbines

| Period | VP No. | No. of flights | No. of birds | Total flying time (s) | Time in height category (s) | | | | |
|--------------------|--------|----------------|--------------|-----------------------|-----------------------------|--------------|--------------|----------|--------------|
| | | | | | <10 m | 10-25 m | 25-175 m | >175 m | At risk |
| North Array | | | | | | | | | |
| Apr-19 to Aug-19 | VP2 | 1 | 1 | 20 | 0 | 20 | 0 | 0 | 20 |
| | VP3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sep-19 to Mar-20 | VP2 | 3 | 3 | 63 | 0 | 45 | 18 | 0 | 63 |
| | VP3 | 4 | 4 | 750 | 0 | 420 | 330 | 0 | 750 |
| Apr-20 to Aug-20 | VP2 | 2 | 3 | 1,116 | 104 | 366 | 646 | 0 | 1,012 |
| | VP3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sep-20 to Mar-21 | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP3 | 4 | 4 | 418 | 29 | 234 | 155 | 0 | 389 |
| Apr-21 to Sep-21 | VP2 | 1 | 1 | 176 | 63 | 113 | 0 | 0 | 113 |
| | VP3 | 1 | 2 | 40 | 0 | 40 | 0 | 0 | 40 |
| Total | | 16 | 18 | 2,583 | 196 | 1,238 | 1,149 | 0 | 2,387 |
| South Array | | | | | | | | | |
| | VP1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |



| Period | VP No. | No. of flights | No. of birds | Total flying time (s) | Time in height category (s) | | | | |
|------------------|--------|----------------|--------------|-----------------------|-----------------------------|------------|------------|----------|--------------|
| | | | | | <10 m | 10-25 m | 25-175 m | >175 m | At risk |
| Apr-19 to Aug-19 | VP2 | 1 | 1 | 20 | 0 | 20 | 0 | 0 | 20 |
| Sep-19 to Mar-20 | VP1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP2 | 1 | 1 | 500 | 0 | 250 | 250 | 0 | 500 |
| Apr-20 to Aug-20 | VP1 | 2 | 2 | 161 | 128 | 33 | 0 | 0 | 33 |
| | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sep-20 to Mar-21 | VP1 | 4 | 4 | 373 | 13 | 100 | 260 | 0 | 360 |
| | VP2 | 3 | 3 | 135 | 0 | 24 | 111 | 0 | 135 |
| Apr-21 to Sep-21 | VP1 | 1 | 1 | 80 | 65 | 15 | 0 | 0 | 15 |
| | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | | 12 | 12 | 1,269 | 206 | 442 | 621 | 0 | 1,063 |

Table 2-12: Details of Golden Plover Occupancy within 500 m Buffer of Turbines

| Period | VP No. | No. of flights | No. of birds | Total flying time (s) | Time in height category (s) | | | | |
|--------------------|--------|----------------|--------------|-----------------------|-----------------------------|----------------|----------------|----------|------------------|
| | | | | | <10 m | 10-25 m | 25-175 m | >175 m | At risk |
| North Array | | | | | | | | | |
| Apr-19 to Aug-19 | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sep-19 to Mar-20 | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP3 | 2 | 590 | 1,059,400 | 0 | 514,400 | 545,000 | 0 | 1,059,400 |
| Apr-20 to Aug-20 | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sep-20 to Mar-21 | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Apr-21 to Sep-21 | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | | 2 | 590 | 1,059,400 | 0 | 514,400 | 545,000 | 0 | 1,059,400 |
| South Array | | | | | | | | | |
| Apr-19 to Aug-19 | VP1 | 1 | 4 | 260 | 0 | 0 | 260 | 0 | 260 |
| | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sep-19 to Mar-20 | VP1 | 7 | 2,105 | 2,387,500 | 15,000 | 377,250 | 1,995,250 | 0 | 2,372,500 |
| | VP2 | 1 | 90 | 21,600 | 0 | 18,000 | 3,600 | 0 | 21,600 |



| Period | VP No. | No. of flights | No. of birds | Total flying time (s) | Time in height category (s) | | | | |
|------------------|--------|----------------|--------------|-----------------------|-----------------------------|----------------|------------------|----------|------------------|
| | | | | | <10 m | 10-25 m | 25-175 m | >175 m | At risk |
| Apr-20 to Aug-20 | VP1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sep-20 to Mar-21 | VP1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP2 | 3 | 400 | 105,160 | 0 | 105,160 | 0 | 0 | 105,160 |
| Apr-21 to Sep-21 | VP1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | | 12 | 2,599 | 2,514,520 | 15,000 | 500,410 | 1,999,110 | 0 | 2,499,520 |

Table 2-13: Details of Lapwing Occupancy within 500 m Buffer of Turbines

| Period | VP No. | No. of flights | No. of birds | Total flying time (s) | Time in height category (s) | | | | |
|--------------------|--------|----------------|--------------|-----------------------|-----------------------------|------------|--------------|----------|--------------|
| | | | | | <10 m | 10-25 m | 25-175 m | >175 m | At risk |
| North Array | | | | | | | | | |
| Apr-19 to Aug-19 | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sep-19 to Mar-20 | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP3 | 3 | 26 | 3,320 | 0 | 120 | 3,200 | 0 | 3,320 |
| Apr-20 to Aug-20 | VP2 | 1 | 2 | 218 | 0 | 98 | 120 | 0 | 218 |
| | VP3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sep-20 to Mar-21 | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Apr-21 to Sep-21 | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | | 4 | 28 | 3,538 | 0 | 218 | 3,320 | 0 | 3,538 |
| South Array | | | | | | | | | |
| Apr-19 to Aug-19 | VP1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sep-19 to Mar-20 | VP1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Apr-20 to Aug-20 | VP1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sep-20 to Mar-21 | VP1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |



| Period | VP No. | No. of flights | No. of birds | Total flying time (s) | Time in height category (s) | | | | |
|------------------|--------|----------------|--------------|-----------------------|-----------------------------|----------|----------|----------|----------|
| | | | | | <10 m | 10-25 m | 25-175 m | >175 m | At risk |
| Apr-21 to Sep-21 | VP1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 2-14: Details of Curlew Occupancy within 500 m Buffer of Turbines

| Period | VP No. | No. of flights | No. of birds | Total flying time (s) | Time in height category (s) | | | | |
|--------------------|--------|----------------|--------------|-----------------------|-----------------------------|--------------|--------------|----------|--------------|
| | | | | | <10 m | 10-25 m | 25-175 m | >175 m | At risk |
| North Array | | | | | | | | | |
| Apr-19 to Aug-19 | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sep-19 to Mar-20 | VP2 | 2 | 33 | 4,820 | 0 | 1,900 | 2,920 | 0 | 4,820 |
| | VP3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Apr-20 to Aug-20 | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sep-20 to Mar-21 | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Apr-21 to Sep-21 | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | | 2 | 33 | 4,820 | 0 | 1,900 | 2,920 | 0 | 4,820 |
| South Array | | | | | | | | | |
| Apr-19 to Aug-19 | VP1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sep-19 to Mar-20 | VP1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Apr-20 to Aug-20 | VP1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sep-20 to Mar-21 | VP1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Apr-21 to Sep-21 | VP1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VP2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |



Table 2-15: Golden Plover, Proportions of Flight Lines within 500 m Buffer of Turbines

| Date | VP No. | No. of birds | Total flight length (m) | Flight length (m) within 500 m | Proportion within 500 m |
|--|--------|--------------|-------------------------|--------------------------------|-------------------------|
| North Array (calculated based on Turbine Type 1) | | | | | |
| 23/12/2019 | 3 | 90 | 5741.3 | 461.4 | 0.080 |
| 23/12/2019 | 3 | 500 | 13081.9 | 1171.1 | 0.089 |
| North Array (calculated based on Turbine Type 2) | | | | | |
| 23/12/2019 | 3 | 90 | 5741.3 | 484.2 | 0.084 |
| 23/12/2019 | 3 | 500 | 13081.9 | 1227.5 | 0.094 |
| South Array (calculated based on Turbine Type 1) | | | | | |
| 12/08/2019 | 1 | 4 | 575.3 | 63.4 | 0.11 |
| 19/12/2019 | 1 | 80 | 2804.2 | 1840.2 | 0.66 |
| 24/01/2020 | 1 | 75 | 1101.9 | 734.0 | 0.67 |
| 24/01/2020 | 1 | 75 | 3242.0 | 3000.6 | 0.93 |
| 01/02/2020 | 1 | 40 | 4110.0 | 2464.0 | 0.60 |
| 01/02/2020 | 1 | 75 | 871.8 | 114.9 | 0.13 |
| 18/02/2020 | 2 | 90 | 1011.3 | 1011.3 | 1.0 |
| 13/10/2020 | 1 | 90 | 1927.5 | 534.3 | 0.28 |
| 26/10/2020 | 2 | 240 | 4146.8 | 3815.0 | 0.92 |
| 26/10/2020 | 2 | 120 | 1463.2 | 1463.2 | 1.0 |
| 26/10/2020 | 2 | 40 | 3684.5 | 2538.8 | 0.69 |
| 23/11/2020 | 1 | 57 | 1615.2 | 283.7 | 0.18 |
| 26/03/2021 | 1 | 17 | 401.5 | 160.5 | 0.40 |
| South Array (calculated based on Turbine Type 2) | | | | | |
| 12/08/2019 | 1 | 4 | 575.3 | 68.8 | 0.12 |
| 19/12/2019 | 1 | 80 | 2804.2 | 1854.4 | 0.66 |
| 24/01/2020 | 1 | 75 | 1101.9 | 740.5 | 0.67 |
| 24/01/2020 | 1 | 75 | 3242.0 | 3020.3 | 0.93 |
| 01/02/2020 | 1 | 40 | 4110.0 | 2507.0 | 0.61 |
| 01/02/2020 | 1 | 75 | 871.8 | 126.0 | 0.14 |
| 18/02/2020 | 2 | 90 | 1011.3 | 1011.3 | 1.0 |
| 13/10/2020 | 1 | 90 | 1927.5 | 545.9 | 0.28 |
| 26/10/2020 | 2 | 240 | 4146.8 | 3855.5 | 0.93 |
| 26/10/2020 | 2 | 120 | 1463.2 | 1463.2 | 1.0 |
| 26/10/2020 | 2 | 40 | 3684.5 | 2570.3 | 0.70 |
| 23/11/2020 | 1 | 57 | 1615.2 | 310.4 | 0.19 |
| 26/03/2021 | 1 | 17 | 401.5 | 170.9 | 0.43 |



3.0 Collision Risk Modelling Results

Table 3-1 summarises the predicted collision rates for the seven species under consideration. Copies of the SNH Band model calculations for each species are included in **Appendix 01** (further model spreadsheets are available upon request).

Table 3-1: Summary of CRM Output (N Array)

| Species Name | Avoidance Rate | N Array | | | | | | | | | | | | |
|---------------|----------------|----------------------------------|----------------|----------------------------------|----------------|----------------------------------|----------------|---|----------------|---|----------------|----------------|----------------|-------|
| | | Breeding Season 1 (Apr-Aug 2019) | | Breeding Season 2 (Apr-Aug 2020) | | Breeding Season 3 (Apr-Sep 2021) | | Non-breeding season 1 (Sep 19 - Mar 20) | | Non-breeding season 2 (Sep 20 - Mar 21) | | Annual | | |
| | | Turbine Type 1 | Turbine Type 2 | Turbine Type 1 | Turbine Type 2 | Turbine Type 1 | Turbine Type 2 | Turbine Type 1 | Turbine Type 2 | Turbine Type 1 | Turbine Type 2 | Turbine Type 1 | Turbine Type 2 | |
| Whooper swan | 99.5% | Modelled collisions | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.04 | 0.02 | 0.03 |
| | | No. years per collision | - | - | - | - | - | - | - | - | 25.64 | 22.62 | 41.32 | 36.36 |
| Mallard | 98% | Modelled collisions | - | - | - | - | - | - | 0.17 | 0.19 | - | - | 0.17 | 0.19 |
| | | No. years per collision | - | - | - | - | - | - | 5.74 | 5.32 | - | - | 5.74 | 5.32 |
| Kestrel | 95% | Modelled collisions | 0.04 | 0.05 | 0.37 | 0.40 | 0.05 | 0.06 | 0.26 | 0.28 | 0.08 | 0.08 | 0.33 | 0.35 |
| | | No. years per collision | 22.88 | 19.69 | 2.69 | 2.50 | 19.01 | 17.64 | 3.89 | 3.59 | 12.76 | 11.82 | 3.05 | 2.82 |
| Peregrine | 98% | Modelled collisions | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.03 | 0.00 | 0.00 | 0.01 | 0.01 | 0.02 | 0.02 |
| | | No. years per collision | - | - | - | - | 38.31 | 35.46 | - | - | 77.52 | 71.43 | 52.08 | 47.85 |
| Lapwing | 98% | Modelled collisions | 0.00 | 0.00 | 0.03 | 0.04 | 0.00 | 0.00 | 0.54 | 0.58 | 0.00 | 0.00 | 0.23 | 0.25 |
| | | No. years per collision | - | - | 28.99 | 27.03 | - | - | 1.85 | 1.71 | - | - | 4.38 | 4.06 |
| Golden Plover | 98% | Modelled collisions | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.46 | 22.74 | 0.00 | 0.00 | 8.10 | 9.00 |
| | | No. years per collision | - | - | - | - | - | - | 0.05 | 0.04 | - | - | 0.12 | 0.12 |
| | 99.8% | Modelled collisions | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.046 | 2.274 | 0.00 | 0.00 | 0.810 | 0.9 |
| | | No. years per collision | - | - | - | - | - | - | 0.5 | 0.4 | - | - | 1.2 | 1.2 |
| Curlew | 98% | Modelled collisions | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.02 | 1.13 | 0.00 | 0.00 | 0.41 | 0.39 |
| | | No. years per collision | - | - | - | - | - | - | 0.98 | 0.89 | - | - | 2.47 | 2.56 |



Table 3-2: Summary of CRM Output (S Array)

| Species Name | Avoidance Rate | S Array | | | | | | | | | | | | |
|---------------|----------------|----------------------------------|----------------|----------------------------------|----------------|----------------------------------|----------------|---|----------------|---|----------------|----------------|----------------|-------|
| | | Breeding Season 1 (Apr-Aug 2019) | | Breeding Season 2 (Apr-Aug 2020) | | Breeding Season 3 (Apr-Sep 2021) | | Non-breeding season 1 (Sep 19 - Mar 20) | | Non-breeding season 2 (Sep 20 - Mar 21) | | Annual | | |
| | | Turbine Type 1 | Turbine Type 2 | Turbine Type 1 | Turbine Type 2 | Turbine Type 1 | Turbine Type 2 | Turbine Type 1 | Turbine Type 2 | Turbine Type 1 | Turbine Type 2 | Turbine Type 1 | Turbine Type 2 | |
| Whooper swan | 99.5% | Modelled collisions | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.04 | 0.44 | 0.50 | 0.23 | 0.27 |
| | | No. years per collision | - | - | - | - | - | - | 28.82 | 25.06 | 2.29 | 1.99 | 4.36 | 3.75 |
| Kestrel | 95% | Modelled collisions | 0.01 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.20 | 0.23 | 0.17 | 0.08 | 0.19 | 0.21 |
| | | No. years per collision | 73.53 | 66.23 | 55.56 | 48.31 | 129.87 | 113.64 | 5.03 | 4.38 | 6.04 | 13.09 | 5.21 | 4.70 |
| Peregrine | 98% | Modelled collisions | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.04 | 0.01 | 0.01 | 0.06 | 0.07 | 0.05 | 0.06 |
| | | No. years per collision | - | - | - | - | 25.77 | 22.42 | 88.50 | 76.92 | 15.85 | 13.74 | 18.90 | 16.98 |
| Lapwing | 98% | Modelled collisions | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | No. years per collision | - | - | - | - | - | - | - | - | - | - | - | - |
| Golden Plover | 98% | Modelled collisions | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 15.16 | 17.78 | 26.62 | 31.25 | 19.39 | 21.47 |
| | | No. years per collision | 82.64 | 81.30 | - | - | - | - | 0.07 | 0.06 | 0.04 | 0.03 | 0.05 | 0.05 |
| | 99.8% | Modelled collisions | 0.001 | 0.001 | 0.00 | 0.00 | 0.00 | 0.00 | 1.516 | 1.778 | 2.662 | 3.125 | 1.939 | 2.147 |
| | | No. years per collision | 826.4 | 813 | - | - | - | - | 0.7 | 0.6 | 0.4 | 0.3 | 0.5 | 0.5 |
| Curlew | 98% | Modelled collisions | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | No. years per collision | - | - | - | - | - | - | - | - | - | - | - | - |



Table 3-3: Summary of CRM Output (North & South Array Combined)

| Species Name | Avoidance Rate | North & South Array Combined | | |
|---------------|----------------|------------------------------|----------------|----------------|
| | | | Annual | |
| | | | Turbine Type 1 | Turbine Type 2 |
| Whooper swan | 99.5% | Modelled collisions | 0.25 | 0.29 |
| | | No. years per collision | 3.95 | 3.40 |
| Mallard | 98% | Modelled collisions | 0.17 | 0.19 |
| | | No. years per collision | 5.74 | 5.32 |
| Kestrel | 95% | Modelled collisions | 0.52 | 0.57 |
| | | No. years per collision | 1.92 | 1.76 |
| Peregrine | 98% | Modelled collisions | 0.07 | 0.08 |
| | | No. years per collision | 13.87 | 12.53 |
| Lapwing | 98% | Modelled collisions | 0.23 | 0.25 |
| | | No. years per collision | 4.38 | 4.06 |
| Golden Plover | 98% | Modelled collisions | 27.49 | 30.47 |
| | | No. years per collision | 0.04 | 0.03 |
| | 99.8% | Modelled collisions | 2.749 | 3.047 |
| | | No. years per collision | 0.4 | 0.3 |
| Curlew | 98% | Modelled collisions | 0.41 | 0.39 |
| | | No. years per collision | 2.47 | 2.56 |





Appendix A CRM Band Models

Knockanarragh Avian Collision Risk

Avian Collision Risk

Knockanarragh Wind Farm Ltd

SLR Project No.: 501.00727.00008

16 October 2023

A.1 Whooper Swan Turbine Type 1



A.2 Whooper Swan Turbine Type 2



A.3 Mallard Turbine Type 1



A.4 Mallard Turbine Type 2



A.5 Kestrel Turbine Type 1



A.6 Kestrel Turbine Type 2



A.7 Peregrine Turbine Type 1



A.8 Peregrine Turbine Type 2



A.9 Lapwing Turbine Type 1



A.10 Lapwing Turbine Type 2



A.11 Golden Plover Turbine Type 1



A.12 Golden Plover Turbine Type 2



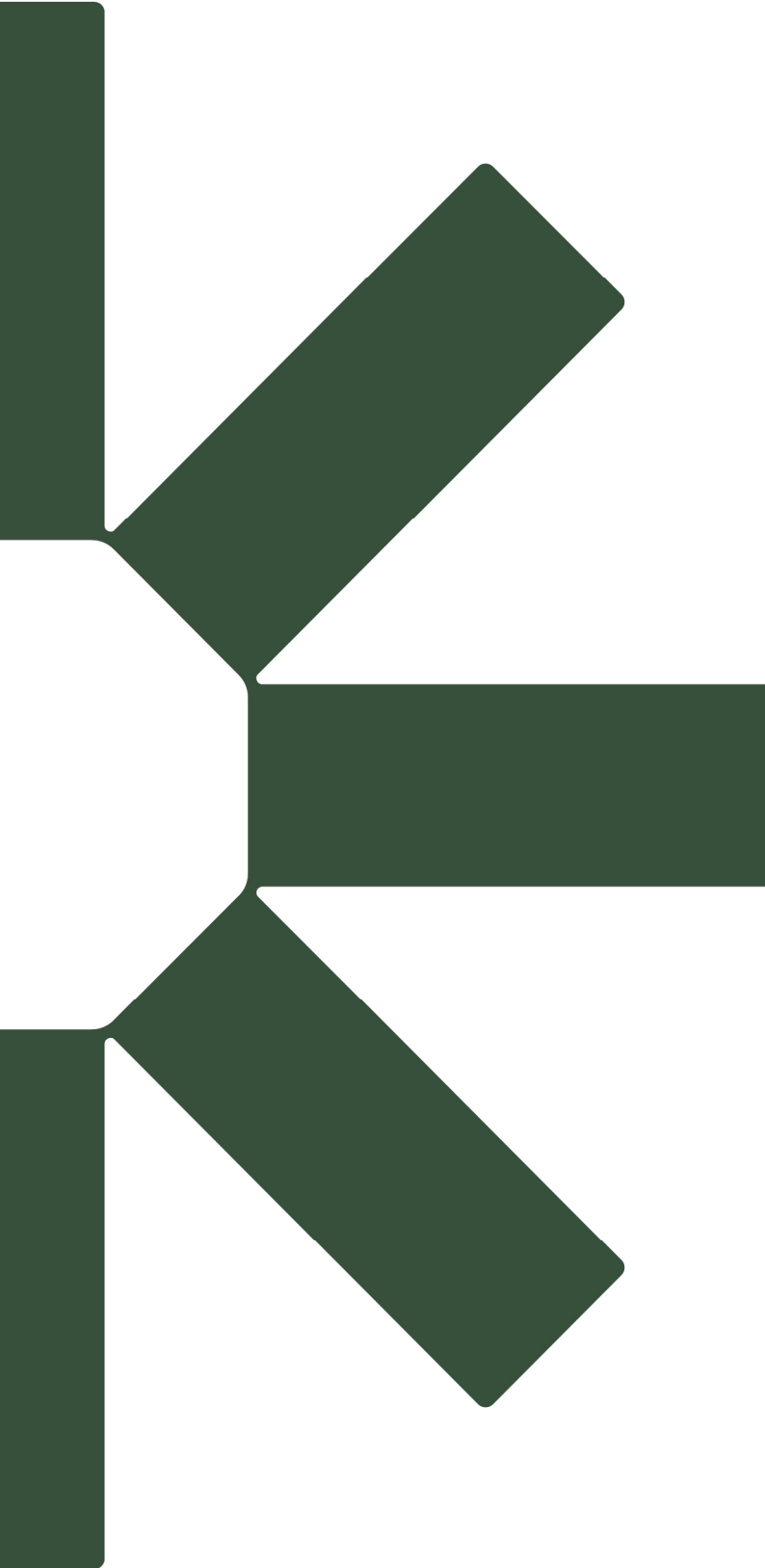
A.13 Curlew Turbine Type 1



A.14 Curlew Turbine Type 2







Making Sustainability Happen