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# Collision Risk Modelling Calculations for target species at the proposed Dyrick Hill Wind Farm (Summer 2020 to Summer 2022)

**Prepared for:**

**EMPower**

EMPower

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Core House, Pouladuff Road, Cork, T12 D773, Ireland

**T: +353 21 496 4133 | E: info@ftco.ie**

**CORK | DUBLIN | CARLOW**

**www.fehilytimoney.ie**

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**REVISION CONTROL TABLE, CLIENT, KEYWORDS AND ABSTRACT**

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**Abstract:** This report details the collision risk modelling approach and results for the twelve target bird species recorded at the proposed Dyrick Hill Wind Farm in Co. Waterford between April 2020, and September 2022.

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# 1. INTRODUCTION

This report presents the results of the collision risk modelling for the proposed Dyrick Hill Wind Farm, Co. Waterford. This modelling used data from vantage point (VP) surveys carried out in the summers of 2020, 2021, and 2022, as well as in winters of 2020/2021, and 2021/2022. VP surveys were SNH (Scottish Natural Heritage) compliant (SNH 2017a). Eighteen target species were recorded in flight within the study area during survey work. Of these, 16 (buzzard, golden plover, hen harrier, herring gull, kestrel, lapwing, lesser black-backed gull, mallard, merlin, osprey, peregrine, red kite, snipe, sparrowhawk, stock dove, and swift) occurred at collision height and thus proceeded to the modelling stage. Of these 16 target species, nine occurred in winter and summer (buzzard, golden plover, hen harrier, kestrel, lesser black-backed gull, mallard, peregrine, snipe, and sparrowhawk), five occurred in summer only (herring gull, osprey, red kite, stock dove, and swift), and two occurred in winter only (lapwing and merlin). Not all target species were recorded at the site across all 2.5 years of survey work.

The modelling was carried out using the Scottish Natural Heritage 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.

# 2. DATA SOURCES

The following data and information were provided for this assessment:

- Spreadsheet data listing all observations of flight activity recorded during the VP surveys.
- GIS mapping of flight lines recorded during the summers of 2020, 2021, and 2022 and winters of 2020/2021 and 2021/2022.
- Mapping of the VP locations.
- Mapping of the constructed turbine locations.
- Technical specifications for the constructed and permitted turbines.
- Various clarifications about the survey methodology.

# 3. REVIEW AND ANALYSIS OF THE VP SURVEY COVERAGE AND RESULTS

VP locations and viewshed coverage

Three VP locations were selected to cover the site (VP1 – VP3). In February 2022, VP2 had to be moved slightly to VP2b as a result of a minor restriction in terms of access. In July 2022, tall bracken growth had impeded the view from VP2b, resulting in an additional short move to VP2d. The viewshed remained the same at both VP locations given the minor shift in locations locally.

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 (2017a) guidance.

A total of 95.24 percent of the total flight activity survey area (500m radius buffers surrounding the turbine locations) was visible from the VP locations (VPs 1-3), which is marginally less than the 97% recommended by SNH (2017a) guidance.  For the purposes of collision risk analysis, a correction factor (x1.05) has been applied to the flight durations recorded to account for the disparity in viewshed coverage. This provides a more conservative estimate of collision risk at the site.

**Table 3-1: VPs Used for Avian Surveys**

| VP Number | Grid Reference (ITM) |
|---|---|
| 1 | 614671 605630 |
| 2, 2b, 2d | 617257 605131, 617072 605532, 617061 605654 |
| 3 | 615898 605892 |

VP survey effort

VP surveys were carried out at the site monthly from April 2020 to September 2022 inclusive. The summer season was defined as running from April to September inclusive (six months) for 2020 2021, and 2022, and the winter season from October to March inclusive (six months) for 2020/21 and 2021/22. Therefore, over the entire survey period, three summer surveys and two winter surveys were completed. In addition, a round of autumn migration surveys were conducted in August and September of 2021.  Watches were 2 * 3 hours = 6 hours per VP per month.  Thus, the following survey effort was completed for the following seasons:

- Summer 2020:  3 VPs * 6 hours / VP / month * 6 months = 108 hours or 388,800 seconds. Note that, as a result of the project commencing in May of 2020, the first round of summer VP surveys were omitted. As a result, 2 hours less were conducted at VP1, with 1 hour and 35 minutes less at VP2, and 4 hours and 35 minutes less at VP3. Thus, the total for the season was 99 hours and 50 minutes, or 359,400 seconds.
- Summer 2021: 3 VPs * 6 hours / VP / month * 6 months = 108 hours or 388,800 seconds. Note that an extra ten minutes was conducted at each of the three VPs. Thus, the total was 108 hours and 30 minutes, or 390,600 seconds.
- Summer 2022: 3 VPs * 6 hours / VP / month * 6 months = 108 hours or 388,800 seconds.
- Winter 2020/2021: 3 VPs * 6 hours / VP / month * 6 months = 108 hours or 388,800 seconds. Note that an additional 25 minutes was conducted at each of the three VPs, thus the total for the season was 109 hours and 25 minutes, or 393,300 seconds.

- Winter 2021/2022: 3 VPs * 6 hours / VP / month * 6 months = 108 hours or 388,800 seconds. Note that an additional 25 minutes was conducted at each VP. Thus, the total for the season was 109 hours and 25 minutes, or 393,300 seconds.
- Autumn Migration 2021: 3VPs * 6 hours / VP * 1 month = 18 hours or 64800.

The total survey effort over the 2.5-year survey period (3 x summer seasons, 2 x winter seasons, and one round of Autumn migration surveys) was 535 hours and 10 minutes or 1,926,600 seconds. Thus, whilst VP surveys fell slightly short of the required total (VP1 by 1 hour, VP2 by 15 minutes, and VP3 by 3 hours and 35 minutes), the supplementary round of autumn migration surveys more than covered this shortfall, with VP1 exceeding requirements by 5 hours, VP2 by 5 hours and 45 minutes, and VP3 by 3 hours and 35 minutes, meaning the combined survey effort required for all seasons exceeds that required by SNH guidance (SNH, 2017a). The total survey period was also greater than the recommended 2 years of surveys required by SNH guidance (SNH, 2017a).

<u>VP survey protocol</u>

The VP surveys recorded flight activity of all target species within fixed visual envelopes, namely: 0-10m, 10-20m, 20-30m, 30-50m, 50-100m, 100-185m, and >185m. Flight durations were not classified in the field as inside and outside of the 500 m buffer boundary surrounding the turbines. Following a more conservative approach, the total duration of any flightline which intersects the boundary of the site is included in full regardless of the percentage time the flightline was outside the site i.e., all time inside and outside the site are included in the model for flightlines that intersect the site at some point.

<u>Selection of target species for the collision risk model</u>

The following 16 target species were recorded inside the 500 m turbine buffer boundary during the VP surveys between summer 2020 and summer 2022:

- Buzzard (*Buteo buteo*; Green-listed)
- Golden plover (*Pluvialis apricaria*; Annex I protected and Red-listed)
- Hen harrier (*Circus cyaneus*; Annex I protected and Amber-listed)
- Herring gull (*Larus argentatus*; Amber-listed)
- Kestrel (*Falco tinnunculus*; Red-listed)
- Lapwing (*Vanellus vanellus*; Red-listed)
- Lesser black-backed gull (*Larus fuscus*; Amber-listed)
- Mallard (*Anas platyrhynchos*; Amber-listed)
- Merlin (*Falco columbarius*; Amber-listed and Annex I protected)
- Osprey (*Pandion haliaetus*; Green-listed)
- Peregrine (*Falco peregrinus*; Green-listed and Annex I protected)
- Red kite (*Milvus milvus*; Red-listed Annex I protected)
- Snipe (Gallinago gallinago; Red-listed)
- Sparrowhawk (*Accipiter nisus*; Green-listed)
- Stock dove (*Columba oenas*; Red-listed)
- Swift (*Apus apus*; Red-listed)

Great black-backed gull (*Larus marinus*; Green-listed) and grey heron (*Ardea cinerea*; Green-listed) were also recorded during VP surveys but were not recorded in the collision risk area at rotor swept heights. Consequently, they were not included for collision risk analysis as the collision risk was predicted to be effectively zero.

Post-hoc correction of flight activity data

Flight lines that intersected the 500 m turbine buffer were included for collision risk modelling (CRM) in alignment with SNH (2017a) guidance. This is a conservative approach in relation to flightlines that pass both within and outside the 500 m turbine buffer. For flightlines of this nature, the full observation time both inside and outside the buffer has been included for modelling, rather than splitting the observation time retrospectively.

A single 12 no. turbine layout, consisting of one select model (Vestas V162) was considered, specifications of which are outlined in Table 3 2 below. The modelled turbines have a tip height of 185 m, a hub height of 104 m and a rotor diameter of 162 m. Therefore, the rotor swept height is 23– 185 m. All flight duration data within the rotor swept height were therefore considered to be at potential collision risk heights (PCHs). This corresponded to flights recorded at 20-30m, 30-50m, 50 – 100 m, and 100 – 185 m.

**Table 3-2: Turbine specifications considered at Dyrick Hill Wind Farm.**

| Turbine Model | Tip Height (m) | Hub Height (m) | Rotor Diameter (m) | Rotor Swept Height (m) |
|---|---|---|---|---|
| **Vestas V162** | 185 | 104 | 162 | 23-185 |

Flight times

Calculations were carried out using the flight times recorded in the ‘at-risk’ 500 m buffer zone area for a watch time of 2.58 years, as there were three summer seasons, two winter seasons and a round of autumn migration surveys in the study period. The calculation process accounted for this fact, allowing a probability of collision risk per year instead of per 2.58 years to be provided (see example calculation for buzzard). In the CRM calculations, flight times were averaged over 2.58 years watch time.

The total flight times for each species inside the 500 m buffer at rotor swept height across 2.58 years are shown in Table 3-3 below:

**Table 3-3: Total Flight Times (Winters 2020/21 and 2021/22, and summers 2020, 2021 and 2022)**

| Species | Total flight times in rotor swept height band (seconds)[1] |
|---|---|
| Buzzard | 67,993 |
| Golden Plover | 1,235,115 |
| Hen Harrier | 632 |
| Herring Gull | 880 |
| Kestrel | 24,475 |

[1] Flight times shown are the raw values. For collision risk calculations, they have been adjusted by multiplying by (100/95.24) to correct for viewshed coverage.

| Species | Total flight times in rotor swept height band (seconds)[1] |
|---|---|
| Lapwing | 19 |
| Lesser Black-backed Gull | 2,415 |
| Mallard | 328 |
| Merlin | 82 |
| Osprey | 480 |
| Peregrine | 439 |
| Red Kite | 200 |
| Snipe | 2,341 |
| Stock Dove | 965 |
| Sparrowhawk | 396 |
| Swift | 307 |

The biometrics and flight speed values used in the calculations for each of the target species is shown in Table 3 4 below. The bird body lengths and wingspans were sourced from the BTO bird facts website (https://www.bto.org/understanding-birds/birdfacts/find-a-species; last accessed 03rd January 2023). The flight speeds used come from Alerstam *et al.*, 2007. Birds are assumed to be active for 8 hours a day in winter and 12 hours a day in summer.

### Table 3-4: Avian Biometric Data and Avoidance Rates

| Species | Length (m) | Wingspan (m) | Average speed (m/s) | Avoidance rates[2] (%) |
|---|---|---|---|---|
| Buzzard | 0.52 | 1.20 | 13.3 | 98 |
| Golden Plover | 0.28 | 0.72 | 17.9 | 99.8[3] |
| Hen Harrier | 0.6 | 1.44 | 12.8 | 99 |
| Herring gull | 0.58 | 1.42 | 11.9 | 98 |
| Kestrel | 0.34 | 0.76 | 10.1 | 95 |
| Lapwing | 0.3 | 0.84 | 11.9 | 95 |
| Lesser Black-backed Gull | 0.58 | 1.42 | 11.9 | 98 |
| Mallard | 0.58 | 0.9 | 18.5 | 98 |
| Merlin | 0.28 | 0.56 | 45.6 | 98 |
| Osprey | 0.56 | 1.58 | 13 | 98 |

[2] Avoidance rates refer to the frequency at which birds may avoid a wind farm. SNH (2018) guidance states that this may be due to displacement from the area, avoidance of turbines or evasive action to prevent a collision. Avoidance rates may be different for different bird species and SNH (2018) guidance provides a list of recommended avoidance rates that should be applied to raw collision risk probabilities.

[3] Based on study of avoidance rates of golden plover from Gittings (2022) – see section 6 for further details.

| Species | Length (m) | Wingspan (m) | Average speed (m/s) | Avoidance rates[2] (%) |
|---|---|---|---|---|
| Peregrine | 0.42 | 1.02 | 12.1 | 98 |
| Red Kite | 0.63 | 1.85 | 7.92 | 98 |
| Snipe | 0.26 | 0.46 | 17.1 | 98 |
| Sparrowhawk | 0.33 | 0.62 | 11.3 | 98 |
| Stock Dove | 0.33 | 0.66 | 50 | 98 |
| Swift | 0.16 | 0.45 | 10.5 | 98 |

# 4. MODEL DETAILS

Collision risk calculations have been performed using a random flight model as detailed by Band *et al*., (2007).

The planned turbine model for the 12 no. turbines of the proposed development is the Vestas V162. Details of the turbine parameters are show in Table 4 1 (below). Data on blade chord length and rotational speed were provided by EMPower.

**Table 4-1: Wind Farm and Wind Turbine Parameters**

| Parameter | Value | Comments |
|---|---|---|
| Hub height (m) | 104 | Information provided by client |
| Blade diameter (m) | 162 | Information provided by client |
| Blade radius (m) | 81 | Calculated |
| Maximum swept height (m) | 185 | Information provided by client |
| Minimum swept height (m) | 23 | Calculated |
| Number of blades | 3 | Information provided by client |
| Maximum blade chord length (m) | 4.3 | Information provided by client |
| Fastest rotational speed (r.p.m) | 9.53 | Information provided by client |
| Fastest rotation period (s) | 6.296 | Calculated |
| Blade pitch (degrees) | 6 | Typical value |
| No. of turbines with these dimensions proposed | 12 | Information provided by client |
| Wind farm operation (%) | 85 | Typical value |

# 5. EXAMPLE CALCULATION OF THE COLLISON RISK FOR BUZZARD (BUTEO BUTEO)

An example of a collision risk calculation used for buzzard (based on the Vesta V162 turbine model) is provided below.

Buzzard is a resident species in the area around the proposed wind farm site. A total of 67,993 bird-seconds (i.e., each flight duration was multiplied by the number of birds flying) of buzzard flight time within the rotor swept height was observed from the VP watches in the summers of 2020, 2021, and 2022, an autumn migration survey in 2021, as well as the winters of 2020/21 and 2021/22. A correction factor was applied to all raw flight times (i.e., all flight times were multiplied by (100/95.24) to account for viewshed coverage. All flight times across the 2.58 years of surveys were averaged to calculate a mean annual flight time.

The total watch time across three summers and two winters was a total of 535 hours and 10 minutes or 1,926,600 seconds. With the addition of a round of migration surveys conducted in autumn 2021, the total rose to 553 hours and 10 minutes or 1,991,400 seconds. As flight times were averaged to mean annual flight times, the watch time was also assumed to be for a single summer and single winter i.e., a total of 72 hours or 259,200 seconds. To account for slight variations in times, the average observation time per VP, per year was calculated by summing the total observation time spent for the duration of the study period, divided by 2.58 (2.5 years plus one month [one round of migration VPs conducted in autumn 2021).

This resulted in 258,140 seconds for VP1, 259,186 seconds at VP2, and 258,721 seconds at VP3.

(i) To calculate the probability of a bird flying through the rotor swept area:

Note, the time at rotor swept height, proportion of observation time at rotor swept height and flight activity per visible hectare was calculated individually for each VP viewshed. Flight activity per visible hectares was averaged across all VPs. This accounts for the overlap in the areas that were viewed from different VPs. For the sake of brevity, only calculations for VP1 are shown below.

Flight time (corrected and averaged over 2.58 years) at which buzzards were recorded at potential collision height (PCH; heights between 23m and 185 m) at VP viewshed 1: 4612.521893 bird-seconds.

Proportion of total observation time during which buzzards were recorded in flight at PCH:

(1) t = 4612.521893/ 258,140= 0.017868328 (proportion)

The proportion of flight activity per hectare of visible area, F = t/Area of VP1 viewshed.

(2) F = 0.017868328 / 174.72 = 0.000102268 (proportion per hectare) for VP1.

This process was then repeated for all other viewsheds. The mean value of F across all VP viewsheds = 0.000152733.

The Flight Risk Area of the proposed wind farm (calculated in QGIS as the area of a minimum convex polygon based on the locations of all proposed turbines, surrounded by an additional buffer corresponding to the 81m rotor radius) = 3,397,787.45m$^2$.

Therefore, the proportion of flight time spent in flight at PCH in the wind farm area is:

(3) t2 = F * (Flight Risk Area / 10,000) = 1.52733 x $10^{-4}$ (3,397,787.45/ 10,000) = 0.051895558 (proportion)

In order to account for buzzard occupancy over the summer survey period, birds have been assumed to be present between April to September inclusive (183 days). An assumption is made that the birds are active for 12 hours per day during summer. For winter, birds have been assumed to be present between October to March inclusive (182 days) and have been assumed to be active for 8 hours per day.

(4) Occupancy, n of risk area per year = 3,652 * 0.051895558 = 189.5225765 hours per year.

The flight risk volume, Vw = flight risk area * diameter of rotors

(5) Vw = 3,397,787.45$m^2$ * 162 metres = 550,441,567.6$m^3$

Volume swept by the rotors, Vr = number of turbines * $\pi r^2$ * (d+l), where d is the average depth of the rotors, l is the average length of the birds and r is the radius of the rotors (81 m). Average chord length is assumed to be the same as average rotor depth.

(6) Vr = 12 * $\pi$*$(81)^2$ * (4.3 + 0.52) = 1,192,197.467$m^3$.

The bird occupancy of swept volume, b = n * (Vr/Vw) * 3,600, where n is the bird occupancy for the year, from (4) above.

(7) b = 189.5225765* (1192197.467/ 550,441,567.6) * 3,600 = 1477.75 seconds per year.

Time taken for a bird to fly through rotors of one turbine, t3 = (d+l)/v, where v is the average velocity of the birds.

(8) t3 = (4.3 + 0.52) / 13.3 = 0.362406015 seconds.

Therefore, number of bird transits through the rotors is:

(9) b / t3 = 1477.75/0.362406015 = 4077.60382 bird transits per year.

(ii) To calculate the probability of the birds colliding with the turbine rotors:

The probability of a bird actually colliding with the turbine blades when making a transit through a rotor depends on a number of factors that are imperfectly known and at present have to be estimated. Not least of these is the avoidance factor that is used to approximate the ability of birds to take evasive action when coming close to wind turbine blades. The method of Band et al., (2007) makes a number of assumptions: birds are assumed to be of a simple cruciform shape, turbine blades are assumed to have width and pitch angle, but no thickness, birds fly through turbines in straight lines and their flight is not affected by the slipstream of the turbine blade etc. In the calculations the length of a buzzard is taken to be 0.52 metres and the wingspan 1.2 metres (these figures are the means of published ranges taken from the BTO website on 03/01/2023). The flight velocity of buzzard is assumed to be 13.3 metres per second. The maximum chord of the blades is taken to be 4.3 metres, pitch is assumed to be 6 degrees and the rotation cycle at maximum operating speed (9.53 rpm) is taken to be 6.296 seconds per rotation.

A probability, ρ (r, ϕ), of collision for a bird at radius r from the hub and at a position along a radial line that is at angle ϕ from the vertical is calculated. This probability is then integrated over the entire rotor disc, assuming that the bird transit may be anywhere at random within the area of the disc.

Scottish Natural Heritage have made available a spreadsheet to aid the calculation of these probabilities (http://www.snh.gov.uk/planning-and-development/renewable-energy/onshore-wind/bird-collisionrisks-guidance/). For a full explanation of the calculation methods see Band *et al*., (2007).

Assuming the worst-case scenario (i.e., shortest rotation time and bird flapping rather than gliding), the average of the upwind and downwind probabilities of collision is 5.3%.

Estimated maximum operation of the wind farm is assumed to be 85%.

So, the product of the number of bird transits per year and the probability of collision (assuming 85% operation) is:

(10) 4077.603817 x 0.053 x 0.85 = 182.798 collisions per year, without any avoidance of the turbine blades by the birds.

The SNH (SNH, 2018) recommended avoidance rate for buzzard is 98%.

Therefore, the predicted number of buzzard collisions per year with 98% avoidance is:

(11) 182.80 x (1 - (98/100) = **3.66 collisions per year**.

The calculations detailed for buzzard above were also carried out for each of the other target species.

# 6. RESULTS

The results of the collision risk calculations for all target species are shown in Table 6 1, Table 6 2 and Table 6 3, below. The avoidance rate factors used are as recommended by Scottish Natural Heritage (SNH, 2010; SNH 2018).

Golden plover have been recorded in low numbers as collision fatalities at wind farms (Hoetker et al., 2006; Grunkorn 2011). The SNH guidance (SNH, 2018) does not provide a specific avoidance rate for golden plover, but states that for species not covered by the guidance "*we recommend a default value of 98%*".

However, a review (Gittings, 2022) of the development of the SNH avoidance rate guidance shows that the default avoidance rate of 98% is not based on any published empirical evidence, the trend is for avoidance rates to increase as more data becomes available, and the guidance does not always reflect the latest evidence on speciesspecific avoidance rates. Therefore, the lack of a species-specific avoidance rate for Golden Plover in the SNH avoidance rate guidance does not necessarily mean that there is not any robust data available that could be used to develop a species-specific avoidance rate for Golden Plover.

However, 3 years of post-construction monitoring sites (Gittings, 2022) indicates a much higher avoidance rate should be applied for non-breeding golden plover populations. The studies had robust survey methodologies and were carried out at wind farm sites with high levels of golden plover flight activity. The review considers that an avoidance rate of 99.8% is a suitable precautionary estimate for winter golden plover.

In further support of a high micro-avoidance rate, a study in the Netherlands of three operational wind farms where golden plovers were both diurnally and nocturnally active found no fatalities (Krijgsveld et al., 2009). Golden plovers were not recorded breeding within the 500 m turbine envelope during the survey period which reduces magnitude. The 99.8% avoidance rate reflects the high micro-avoidance rate of the species.

With the exception of buzzard, golden plover and kestrel, the probabilities of collision with turbines were all well below one per year.

**Table 6-1: No. of predicted collisions per year (assuming avoidance)[4]**

| Species | Number of predicted collisions per year |
|---|---|
| **Buzzard** | **3.66** |
| **Golden Plover[5]** | **6.21** |
| Hen Harrier | 0.02 |
| Herring gull | 0.05 |
| **Kestrel** | **2.72** |
| Lapwing | 0.00 |
| Lesser Black-backed Gull | 0.22 |

[4] With correction factors applied for the following: avoidance rates, operating time, and the fact that 95.24% and not 100% of the study area was visible during surveys. Where the number of predicted collisions is shown as 0.00, it means the number of predicted collisions are <0.01 per year. Species with >1 predicted collisions per year (assuming avoidance) are emboldened.

| Species | Number of predicted collisions per year |
|---|---|
| Mallard | 0.02 |
| Merlin | 0.01 |
| Osprey | 0.04 |
| Peregrine | 0.02 |
| Red Kite | 0.02 |
| Snipe | 0.13 |
| Sparrowhawk | 0.04 |
| Stock Dove | 0.13 |
| Swift | 0.03 |

### Table 6-2: No. of years between predicted collisions (assuming avoidance)[6]

| Species | Number of years between predicted collisions |
|---|---|
| **Buzzard** | **0.27** |
| **Golden Plover** | **0.16** |
| Hen Harrier | 56.73 |
| Herring gull | 22.13 |
| **Kestrel** | **0.37** |
| Lapwing | 491.53 |
| Lesser Black-backed Gull | 4.59 |
| Mallard | 56.43 |
| Merlin | 88.63 |
| Osprey | 27.85 |
| Peregrine | 45.76 |
| Red Kite | 48.55 |
| Snipe | 7.68 |
| Sparrowhawk | 28.23 |
| Stock Dove | 7.53 |
| Swift | 35.41 |

[6] The avoidance rates applied to the collision risk were: 99.8% for golden plover.

**Table 6-3: No. of predicted collisions in 40-year nominal lifespan of wind farm (assuming avoidance)**

| Species | Number of predicted collisions in 40-year nominal lifespan of wind farm |
|---|---|
| **Buzzard** | **146.24** |
| **Golden Plover** | **248.37** |
| Hen Harrier | 0.71 |
| Herring gull | 1.81 |
| **Kestrel** | **108.93** |
| Lapwing | 0.08 |
| Lesser Black-backed Gull | 8.71 |
| Mallard | 0.71 |
| Merlin | 0.45 |
| Osprey | 1.44 |
| Peregrine | 0.87 |
| Red Kite | 0.82 |
| Snipe | 5.21 |
| Sparrowhawk | 1.42 |
| Stock Dove | 5.31 |
| Swift | 1.13 |

# 7. DISCUSSION

The Band CRM model involves making a number of assumptions. The amount of time that a species may be active within the site is also required for the model and must be estimated with respect to the bird species' known behaviour and observations of its occurrence at the study area.

The model assumes that no action is taken by a bird to avoid collision, so that the unadjusted collision risk figures derived are purely theoretical and represent worst case estimates. In reality, birds are able to perceive potential obstacles while in flight and actively take avoiding action. Given the general absence of empirically derived avoidance estimates for individual species, additional assumptions about likely levels of active avoidance on the part of birds are generally made in order to draw conclusions. Available evidence to date (SNH, 2010; SNH, 2017; Fernley *et al*., 2006; Whitfield & Madders, 2006; Whitfield, 2009; Whitfield & Urquhart, 2015) suggests that avoidance rates are well in excess of 95%. Accordingly, outputs from collision risk analysis where precautionary avoidance rates are used must be interpreted with care.

The Band model favoured by SNH has been the subject of academic study regarding its relevance and usefulness (Chamberlain *et al*., 2005; Chamberlain *et al*., 2006) and the conclusions have been that the model can be considered to be mathematically robust. However, the main influence on the final result of collision risk analysis is the avoidance rate that is applied to the model; and without accurate avoidance rates, the usefulness of the model as a predictor of impact can be badly impaired. The avoidance rate factors used are those that are currently recommended by SNH (SNH, 2010; SNH, 2018). These avoidance rates are widely considered to be highly precautionary in nature. It should be remembered that the difference between an avoidance factor of 98% and 99% will have the effect of doubling the calculated annual collision rate. In many cases where collision mortality has been monitored for operating wind farms, observed mortality has been below that which was predicted by modelling pre-construction bird survey data.

In the case of the calculations for the proposed Dyrick Hill Wind Farm site, a conservative approach was taken in the choice of which bird flights to include in the collision risk calculations. In addition, a worst-case scenario i.e., shortest rotation time (top turbine rotating speed) and birds flapping, rather than gliding has been used. Other studies use the mean of the worst-case scenario and best-case scenario (longest rotation period and bird gliding rather than flapping) probabilities. Finally, the calculations have used the conservative downtime estimate (15%, or turbines rotating 85% of the time), but in reality, this level of downtime may be greater. A conservative correction factor was also applied to the recorded flight durations based on the assumption that 95.24% of the 500 m turbine buffer area was visible during surveys. Therefore, the likely empirical collision mortality figures should be lower than those presented here.

The species with measurable predicted collision rates are buzzard, golden plover, and kestrel. While the number of predicted collisions for all other species are negligible lapwing (Species of Conservation Interest for Dungarvan Harbour SPA) and lesser black-backed gull (0.22 predicted fatalities per year) are also considered further here.

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. The impacts at a local population for golden plover, lapwing and lesser black-backed gull are considered based on the populations of each species within the Dungarvan Harbour SPA. While additional local populations of these species are present outside and independent to the SPA population, assessing the predicted mortality rate based solely on the populations within this one SPA provides a conservative assessment of the potential impact that may arise from the proposed wind farm. The potential increase in annual mortality rates for buzzard, golden plover, kestrel, lapwing and lesser black-backed gull is shown in Table 6 4. This indicates that collision mortality would not have a significant impact at either a national or local (SPA) level for golden plover, lapwing and lesser black-backed gull.

Significant impacts are also not envisaged for kestrel at a national or county level. In the case of kestrel, it should also be noted that there is a high degree of uncertainty to the predicted collision rate. Most kestrel flight activity is usually of birds that are mainly hovering. The collision risk modelling methodology does not account for this type of flight activity, and, as hovering flight is usually stationary, inclusion of this flight activity will result in a significant overestimation of the collision risk. However, Pearce-Higgins et al. (2009) noted that previous studies have found that kestrel are "known to continue foraging activity close to turbines and to be susceptible to collision".

The predicted collision rate for buzzard equates to 0.12% of the national population and 4.62% of the county population. It must be noted however that the 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. Buzzard is a green-listed species of low conservation concern due to it ongoing increase and population size and range. The national population estimate available for the species was taken from the Article 12 report covering the period 2008-2012. As the data is more 10 years old it does not account for the continued expansion of the species range throughout Ireland and therefore certainly underestimates the current population size for this species. The predicted number of collisions for this species is 3.66 which equates to 4.62% of the county population based on an estimated population size of 79.28 County Waterford. In reality, this percentage is likely to be much less, given the underestimated population size available.

**Table 7-1: Calculations of potential increases in annual mortality rates due to the predicted collision mortality.**

| Parameter | Description | Source / Calculation | Golden Plover | | Kestrel | | Buzzard | | Lapwing | | Lesser Black-backed gull | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | National Population | Dungarvan Harbour SPA Population | National Population | County Population | National Population | County Population | National Population | Dungarvan Harbour SPA Population | National Population | Dungarvan Harbour SPA Population |
| pop | Population size | Various sources (see sources/notes row below) | 80,707 | 4,980 | 16,470 | 435.23 | 3,000 | 79.28 | 69,823 | 3,233 | 7,112 | 269 |
| surv | Annual survival rate | Source 1. | 0.73 | 0.73 | 0.69 | 0.69 | 0.9 | 0.9 | 0.705 | 0.705 | 0.913 | 0.913 |
| mort(back) | Annual background mortality | pop*(1-surv) | 21790.89 | 1344.6 | 5105.7 | 134.9213 | 300 | 7.928 | 20597.785 | 953.735 | 618.744 | 23.403 |
| mort(coll) | Predicted annual collision mortality | Predicted collision rates from CRM | 6.21 | 6.21 | 2.72 | 2.72 | 3.66 | 3.66 | 0.002 | 0.002 | 0.22 | 0.22 |
| % of population | Percentage of population | | 0.01 | 0.12 | 0.02 | 0.62 | 0.12 | 4.62 | 0.00 | 0.00 | 0.00 | 0.08 |
| Magnitude (Percival, 2003) | | | <1% (Negligible) | <1% (Negligible) | <1% (Negligible) | <1% (Negligible) | <1% (Negligible) | 1-5% (Low) | <1% (Negligible) | <1% (Negligible) | <1% (Negligible) | <1% (Negligible) |
| Sources/Notes: | | | Source 2 | Source 3 | Source 4 | Source 5 | Source 4 | Source 5 | Source 2 | Source 3 | Source 6 | Source 7 |

**Source 1**: Adult survival rates from www.bto.org/understanding-birds/birdfacts accessed 17/05/23
**Source 2**: IWM 106 (2019) Irish Wetland Bird Survey 2009/10 – 2015/16
**Source 3**: Site (europa.eu) - https://biodiversity.europa.eu/sites/natura2000/IE0004032 accessed May 2023
**Source 4**: NPWS (2012) Article 12 Report - Ireland's bird species' status and trends for the period 2008-2012

**Source 5**: Estimate based on proportion of population split by county area, used due to a lack of a county estimate
**Source 6**: JNCC website accessed May 2023 - https://jncc.gov.uk/our-work/lesser-black-backed-gull-larus-fuscus/#annual-abundance-and-productivity-by-geographical-area-republic-of-ireland.
**Source 7**: Site (europa.eu) - https://biodiversity.europa.eu/sites/natura2000/IE0004032 accessed May 2023

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