# Appendix 10.1: Collision Risk Calculations

## 1 Definition of the Risk Window

The majority of goose flights which crossed the risk zone did so in a south to north direction (Figure 10.4 in ES Chapter 10, Ornithology). The width of the risk window was calculated as the distance between the outer turbine positions plus two blade lengths, at right angles to this flight direction. This gave a risk window width of 2,147m.

The height of the risk zone is taken as 150m, the maximum tip height of the largest turbines (130m), plus a 20m buffer. This height was also the upper limit of one of the height bands used in the field survey. The height of the risk zone, multiplied by its width (above), gave the frontal area of the risk window.

## 2 The Risk of Passing through a Turbine Rotor Disc

It is assumed in the SNH collision risk model (Band *et al*. 2007) that the risk of a goose encountering a turbine rotor disc is proportional to the percentage of the risk window frontal area taken up by all the wind farm rotors combined. This was calculated from the area of a single rotor disc, multiplied by the number of turbines and expressed as a proportion of the area of the risk window.

## 3 The Number of Geese at Risk of Collision

The numbers of geese recorded flying through the risk window were taken from the highlighted records in Tables 10.9 and 10.11 in ES Chapter 10, Ornithology. The geese were recorded during 51 hours of observation during the goose wintering season.

## 4 The Number of Hours when Geese were Active

Data on day length were obtained from standard tables for the latitude of the site and the time of sunrise and sunset determined for the middle of each week between mid September and mid April. The goose active day was taken to start half-an-hour before sunrise and end half-an-hour after sunset. Observations at the Loch of Strathbeg (I.J. Patterson, unpublished data) and measurements made on radio-tagged pink-footed geese at the Ythan estuary, Aberdeenshire (Giroux and Patterson 1995) showed that most geese were active between these times. One hour was therefore added to the sunrise to sunset times to give the length of the goose active day and the total number of goose active hours during the goose wintering season (late September to the end of April).

## 5 Collision Risk

The probability of collision for a greylag goose and a pink-footed goose flying through a turbine rotor disc (9.15% and 8.46% respectively) was calculated from the SNH collision risk model (Band *et al*. 2007), using the following values; turbine variables supplied by the Applicant and bird dimensions from Cramp and Simmons (1977). The turbine variables used were those for the largest candidate model proposed for the site (V105-3.3), since this gave slightly higher values for collision risk than the alternative smaller model (see Table 1). This was considered to be appropriate, since it gave a worst case estimate and because geese flying over the site were likely to encounter the larger turbines (the majority) as well as the smaller ones.

**Table 1: Turbine Variables**

| | Hub Height | Rotor Diameter | Blade Tip Height | Maximum Chord | Pitch | Rotation Period |
|---|---|---|---|---|---|---|
| **V105-3.3** | 77.5m | 105m | 130m | 4.0m | 16 deg | 3.4 sec |

**Table 2: Bird variables**

| | Length | Wing Span | Flight Speed |
|---|---|---|---|
| Greylag Goose | 0.83m | 1.64m | 18m/sec |
| Pink-footed Goose | 0.68m | 1.53m | 18m/sec |

# 6 Calculations

The full workings in the calculation of collision risk are as shown in Table 3:

**Table 3: Collision risk calculations** (variables in blue are supplied; those in black are calculated)

| Variable | Value |
|---|---|
| 1. Height of risk zone (m) | 150 |
| 2. Width of wind farm (m) | 2,147 |
| 3. Area of risk window ($m^2$) | 322,050 |
| 4. Blade length (m) | 52.5 |
| 5. Area of one rotor disc ($m^2$) | 8,659.04 |
| 6. Number of turbines | 16 |
| 7. Total area of rotor discs ($m^2$) | 138,544.56 |
| 8. Proportion of the risk window occupied by rotor discs | 0.4302 |

| | Greylag goose | Pink-footed goose |
|---|---|---|
| 9. Mean number of geese per hour passing through risk window | 1.78 | 11.88 |
| 10. Number of hours in the goose wintering season | 2,349 | 2,349 |
| 11. Total number of geese passing through the risk window | 4,181 | 27,906 |
| 12. Number of geese passing through rotor discs | 1,799 | 12,005 |
| 13. Proportion of geese passing through rotors likely to collide, from SNH model | 0.0915 | 0.0846 |
| 14. Estimated number of collisions per year, in the absence of avoidance | 166 | 1,020 |
| 15. Estimated number of collisions per year, assuming 99.8% avoidance | 0.33 | 2.04 |

# 7 References

Band, W., Madders, M. & Whitfield, D.P. (2007). Developing field and analytical methods to assess avian collision risk at wind farms. In: Birds and Wind Farms. De Lucas, M., Janss, G. & Ferrer, M. (eds). Lynx Edicions, Barcelona.

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