Appendix 8.1 Ornithology

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MacArthur Green

Cumberhead West Wind Farm
Ornithology
Appendix 8.1

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1 INTRODUCTION

MacArthur Green were commissioned by Cumberhead West Wind Farm Ltd to complete ornithological surveys at the proposed Cumberhead West Wind Farm, near Douglas in South Lanarkshire (hereafter referred to as 'the Proposed Development'). The surveys were conducted between May 2019 and March 2020 to inform an assessment of the potential ornithological effects of the Proposed Development on the species assemblage present.

This technical report summarises the methods employed and the results of the field surveys and is supported by the following Annexes.

Annex A	Ornithological Legal Protection
Annex B	Ornithological Survey Methodologies
Annex C	Ornithological Survey Effort & General Information
Annex D	Ornithological Survey Results
Annex E	Collision Risk Assessments
Annex F	Review of The Effects of Artificial Light on Birds in Relation to Deployment of Obstruction Lighting on Wind Turbines

A range of surveys were employed to accurately record baseline conditions within the Proposed Development and appropriate survey areas (detailed in **Annex B**). In this Technical Appendix, associated **Annexes A – F**, and **Chapter 8 (Ornithology)** of the Environmental Impact Assessment Report (EIA Report). Terms referred to are as follows:

- 'the site' refers to the area within the red line boundary, e.g. **Figure 8.3**;
- 'survey area' is defined as the area covered by each survey type for the Proposed Development; and
- 'study area' is defined as the area of consideration of effects on each species at the time of assessment (**Figure 8.3**).

2 LEGAL PROTECTION

With limited exceptions, all wild birds and their eggs are protected by law. Specific levels of protection are determined by a species' inclusion on certain lists. **Annex A** to this report details the various levels of legal protection afforded to UK bird species.

3 METHODS

3.1 Consultations and Desk-Based Study

The following organisations and resources were consulted regarding the ornithological interests on and adjacent to the site:

- The South Strathclyde Raptor Study Group; and
- NatureScot SiteLink (https://sitelink.nature.scot/home).

3.2 Field Surveys

The following surveys were undertaken at the site between May 2019 and March 2020:

- Flight activity surveys (one breeding season and one non-breeding season), from a total of six vantage points (VPs) (**Figure 8.4**);
- Winter walkover surveys (one non-breeding season), 500 m survey buffer; and
- Scarce breeding bird surveys (one breeding season), 2 km survey buffer.

Survey methods followed the recommended NatureScot (2017[i]) guidelines available at the time and methods are described in detail within **Annex B**. Where possible, each survey was carried out beyond the site within a buffer distance specific to that method (e.g. 2 km buffer for the scarce breeding bird surveys) and these are detailed within **Annex B**.

The relative importance of the data collected was determined by the specific level of protection assigned to those species recorded, coupled with their perceived susceptibility to potential effects resulting from the Proposed Development. The resulting 'target species' and 'secondary species' lists are a standard assessment tool for wind farm ornithological studies (see **Annex B**).

Moorland breeding bird surveys were not undertaken due the sub-optimal nature of the prevailing dense Sitka spruce forestry on site however, any breeding waders observed within the survey area during scarce breeding bird surveys were recorded/mapped to indicate any areas of potential wader breeding habitat.

4 FIELD SURVEY RESULTS

All valid surveys were undertaken during suitable weather conditions (as described within **Annex B**). Where weather conditions deteriorated below acceptable conditions (see definitions in **Annex B**), surveys were either suspended or additional surveys were undertaken. In the case of flight activity surveys, any time where the visibility was <1 km was excluded from total survey effort and subsequent analysis (further detail in **Section 4.1**). Schedule 1/Annex 1 surveys were carried out by appropriately licensed surveyors. All survey data were reviewed, inputted, and analysed by MacArthur Green.

A total 75 bird species were recorded within, or adjacent to, the site during the various ornithological surveys conducted. Survey effort and results of the field surveys are detailed within **Annexes C & D** and survey results are also illustrated within **Figure 8.5** to **Figure 8.8** and **Confidential Figures 8.2.1 and 8.2.2**. The following sections summarise the results from each survey undertaken.

4.1 Flight Activity

The flight activity surveys recorded all target species' flight activity within the site and beyond. These data have been used in the collision risk modelling. The flights used included those within the 'Collision Risk Analysis Area' (CRAA) (i.e. the area to be occupied by operational turbines, together with a 500 m buffer).

Flight activity surveys across the 2019 breeding season and 2019/2020 non-breeding season were undertaken across up to six VPs (**Figure 8.4**). A total of five VPs were selected to cover the site in May 2019 (VPs 1 to 5) with VP 1 replaced with VP 6 in August 2019 to provide updated coverage of the site. Valid survey effort[1] is detailed in **Table 8-1-1** and full details of flight activity surveys are contained in **Annex C** with methodology in **Annex B**.

[1] Hours where visibility was <1 km are not considered valid for use in collision risk modelling as less than half the 2 km viewshed can be seen.

Table 8-1-1 Summary of total hours of valid survey per VP in each season

Period	VP 1	VP 2	VP 3	VP 4	VP 5	VP 6
2019 breeding season	28.08	34	36	32	36	8
2019/2020 non-breeding season	0	36.17	36.17	36	38	36.16

A total of eight target species were recorded during the flight activity surveys (further details are provided in **Annex D**). For each species across the whole flight activity survey period, **Table 8-1-2** shows the total number of flights recorded and the total number of birds recorded[2]. The bird seconds are calculated for each observation as the product of flight duration and number of individuals. This is then summed per species to give the total bird seconds recorded across the entire surveyed period.

Table 8-1-2 Target species recorded and total number of flights recorded during flight activity surveys, 2019-2020

Species	Total number of flightlines recorded	Total number of birds recorded	Total bird seconds recorded
Golden plover	5	46	1,097
Goshawk	18	18	2,256
Hen harrier	2	2	115
Herring gull	2	41	3,760
Merlin	1	1	35
Osprey	2	2	230
Peregrine falcon	4	4	275
Pink-footed goose	3	589	43,195

4.1.1 Flightlines Used in Collision Risk Modelling

Only flightlines identified to be within the CRAA and recorded within the 2 km viewshed of the associated VP were considered in the collision risk modelling and **Annex E** provides details of the bird seconds from flights identified to be 'at- risk'.

- 'At-risk' is defined as – a flight having at least part of its duration (i) at Potential Collision Height (PCH)[3]; (ii) within the CRAA; and (iii) recorded within the 2 km viewshed of the associated VP.
- PCH is defined as – the altitude between the minimum and maximum blade height[4] (taken to be from 45 m to 200 m for the Proposed Development).

Hen harrier and merlin were recorded during flight activity surveys but no flights were considered to be 'at-risk'[5]. Full survey results detailing the findings from each survey visit (including target species' flightlines considered not 'at-risk' and secondary species information) can be found within **Annex D**. Only bird seconds for observations identified as within the CRAA and associated viewshed are considered in the following discussions. Full target species results are detailed within **Annex D** and the collision risk calculations are detailed in **Annex E**.

4.1.2 Collision Risk Model Outputs

The bird seconds for target species flights within the CRAA at PCH were then input into a Collision Risk Model (CRM) to calculate the predicted collision rates per season. The CRM calculations for each species can be found in **Annex E. Table 8-1-3** and **Table 8-1-4** provide the estimated collision rates and number of seasons per collision for each species. A dashed line indicates that no "at-risk" flights were identified and estimated collision risk is consequently zero.

Table 8-1-3 Estimated collision rates

Species	2019 breeding season	2019/2020 non-breeding season	Mean annual
Golden plover	-	0.0016	0.0016
Goshawk	-	0.1529	0.1529
Herring gull	0.0493	0.0149	0.0641
Osprey	0.0095	-	0.0095
Peregrine falcon	0.0091	-	0.0091
Pink-footed goose	-	0.3102	0.3102

Table 8-1-4 Estimated number of seasons per collision

Species	2019 breeding season	2019/2020 non-breeding season	Mean annual
Golden plover	-	626	626
Goshawk	-	6.54	6.54
Herring gull	20.3	67.3	15.6
Osprey	105	-	105
Peregrine falcon	110	-	110
Pink-footed goose	-	3.22	3.22

4.2 Breeding Birds

Due to the habitat present within the Proposed Development, targeted surveys for breeding waders were not undertaken[6], however scarce breeding bird surveys recorded curlew, lapwing and snipe, considered to be breeding within the survey area in small numbers (**Table 8-1-5, Figure 8.7**).

Table 8-1-5 Breeding wader territories, 2019

Species	Number of territories 2019 (maximum-minimum)
Curlew	0-2
Lapwing	1-1
Snipe	3-6

[2] This includes flights that would not technically be 'at-risk' of collision (e.g. recorded outwith the CRAA and/or not at rotor height).

[3] In some cases, only part of a total flight duration was recorded at PCH, and it is assumed that this proportion is applicable for that part of the flight within the CRAA and 2 km viewshed area.

[4] Where the actual rotor blade altitude differs from the pre-defined survey height bands, the collision risk model accounts for this difference on the assumption of an even flight distribution within each particular survey height band, and an adjustment can be made to estimate total flight duration at actual rotor blade altitude.

[5] i.e. the flights were outside of the CRAA and associated viewshed and/or were only recorded flying below lower rotor tip height.

[6] Given the prevailing Sitka spruce forestry at Cumberhead West, breeding wader surveys were not undertaken during the 2019 breeding season.

4.3 Winter Walkover

Winter walkover surveys were undertaken during the 2019/2020 non-breeding season. Surveys recorded 22 species, of which only goshawk is considered to be a target species (**Table 8-1-6**). Full details of the winter walkover surveys are provided within **Annexes C and D** and survey methodology is provided within **Annex B**.

Table 8-1-6 Winter walkover: target species records (number of birds recorded per visit), 2019/2019

Species	2019/2020 non-breeding season	
	Number of records	Total number of birds
Goshawk	1	1

4.4 Scarce Breeding Birds

Scarce breeding bird surveys were undertaken during the 2019 (June to August) breeding season. Goshawk was the only target species deemed to have probably bred within the survey area and breeding activity is summarised in **Table 8-1-7** and shown in **Confidential Figure 8.2.2**.

Table 8-1-7 Scarce breeding bird summary

Species	Breeding summary 2019
Goshawk	Probable breeding at one territory, juveniles and adults present

Hen harrier, merlin, osprey and peregrine falcon (target raptor species) were also recorded during surveys (**Confidential Figure 8.2.1**) but were not considered to be breeding/no breeding attempts were located.

Buzzard, kestrel and sparrowhawk (secondary raptor species) were also recorded across the survey area and are likely to have bred within the wider area.

Full details of the scarce breeding bird surveys are provided within **Annexes C and D** and survey methodology is provided within **Annex B**.

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[i] NatureScot/Scottish Natural Heritage (2017) Recommended Bird Survey Methods to inform impact assessment of Onshore Windfarms.

ANNEX A. ORNITHOLOGICAL LEGAL PROTECTION

In Scotland, all wild birds are protected under the Wildlife and Countryside Act 1981 (the 'Act'), as amended by the Nature Conservation (Scotland) Act 2004. This protection also extends to their eggs and nests, with it being an offence to intentionally or recklessly[1]:

- Kill, injure or take any wild bird[2];
- Take, damage, destroy or otherwise interfere with the nest of any wild bird while it is being built or is in use[3];
- At any other time take, damage, destroy or otherwise interfere with any nest habitually used by any wild bird included in Schedule A1 (Protected Nests and Nest Sites for Birds: white-tailed eagle and golden eagle)[4];
- Obstruct or prevent any wild bird from using its nest[5]; or
- Take or destroy an egg of any wild bird[6].

It is also an offence to have in possession or control any live or dead wild bird or any part thereof; or any egg or part of an egg of any wild bird[7].

Further special protection under this legislation is afforded to those species listed on Schedule 1 of the Act. For these species, it is an offence to:

- Intentionally or recklessly disturb any wild bird listed on Schedule 1 while it is nest building, or is in, on or near a nest containing eggs or young, or disturb the dependent young of such a bird[8];
- Intentionally or recklessly disturb any wild birds included on Schedule 1 which leks, while it is doing so[9] (capercaillie is the only bird this offence applies to in Scotland);
- Intentionally or recklessly harass any wild bird included in Schedule 1A[10]. Section 1, subsection 5B states, '*Subject to the provisions of this Part, any person who intentionally or recklessly harasses any wild bird included in Schedule 1A shall be guilty of an offence*'. At this time, Schedule 1A includes golden eagle, hen harrier, red kite and white-tailed eagle. This updated legislation was introduced on 16 March 2013; or
- Intentionally or recklessly take, damage, destroy or otherwise interfere with any nest and/or nest site habitually used by any bird on Schedule A1 at any time. At this time, Schedule 1A includes golden eagle and white-tailed eagle[11];

It is also an offence to knowingly cause or permit to be done an act which is made unlawful by any of the above provisions.

Further protection is described under the EU Birds Directive which requires member states to maintain wild bird species in favourable conservation status[12] and promote the conservation of bird species listed within Annex 1 of the Birds Directive through the protection of their habitat. This is achieved via the designation of Special Protection Areas (SPAs).

Red List bird species are those deemed to be globally threatened and to be suffering population declines within the UK. Although not legally enforceable, the conservation of Red List bird species represents a material consideration, in planning terms.

[1] Exceptions to these offences exist under various circumstances (e.g. controlling pest species; taking birds during specific season; and killing sick or injured birds etc.).
[2] Wildlife and Countryside Act 1981, Section 1(1)(a)
[3] Wildlife and Countryside Act 1981, Section 1(1)(b)
[4] Wildlife and Countryside Act 1981, Section 1(1)(ba)
[5] Wildlife and Countryside Act 1981, Section 1(1)(bb)
[6] Wildlife and Countryside Act 1981, Section 1(1)(c)
[7] Wildlife and Countryside Act 1981, Section 1(2)
[8] Wildlife and Countryside Act 1981, Section 1(5)
[9] Wildlife and Countryside Act 1981, Section 1(5A)
[10] Wildlife and Countryside Act 1981, Section 1(5B)
[11] This reflects the changes introduced by the Wildlife and Countryside Act 1981 (as amended by: Variation of Schedules A1 and 1A (Scotland) Order 2013.
[12] While the term 'favourable conservation status' is not used in the Birds Directive, EU court cases over recent years have progressively interpreted the concept as meaningful in a Birds Directive context (SNH, 2006).

ANNEX B. ORNITHOLOGICAL SURVEY METHODOLOGY

A range of ornithological surveys have been conducted at the Proposed Development. The methodologies used in these surveys are summarised in the sections below; more detailed descriptions are provided in the NatureScot guidance (2017[i]) on which these surveys are based.

Survey Areas

Surveys were undertaken during the 2019 breeding season and the 2019/2020 non-breeding season. All surveys were buffered from the Site boundary provided by Cumberhead West Wind Farm Ltd. at the time of surveys.

For flight activity surveys, Delaunay Triangulation[1] from the proposed turbine locations was used to create a wind farm area[2] and from this the Collision Risk Analysis Area (CRAA) was defined using a 500 metre (m) buffer (**Figure 8.4**). Using the larger 500 m area around the turbines accounts for possible inaccuracies in the recording of flightlines and ensures the assessment is precautionary. Target species' flight activity within this area was used in collision risk modelling.

B.1 Flight Activity Surveys

The aims of the flight activity (vantage point) surveys are: (1) to record flight activity within the vicinity of the site in order to identify areas of importance to birds; and (2) to quantify flight activity within 500 m of proposed turbine locations in order to estimate the likelihood of collision (NatureScot 2017[i] P.14-19).

Timing

- A survey period of 36 hours is recommended as the minimum level of sampling intensity at each VP for each season (breeding, non-breeding, migratory) (NatureScot 2017[i] P.17);
- Watches were spread as evenly throughout the year as possible to ensure that temporally representative data are collected (see **Annex C**). Specific consideration was given to the period around dawn and twilight for breeding waders and to changing raptor behaviour across seasons (NatureScot 2017[i] P.17);
- Watches were suspended and resumed to take account of changes in visibility (e.g. fluctuations in cloud base). Watches were undertaken in conditions of good ground visibility when the cloud base was higher than the most elevated ground being observed; and
- Watches were conducted in a range of weather conditions and were spread throughout the day (see **Annex C** and **Annex D**).

Field Methods

- Viewshed analysis was conducted using Arc GIS to confirm suitable Vantage Point (VP) locations and their associated visible areas at 20 m above ground level[3];
- Reconnaissance surveys were undertaken to refine VP locations;
- The VP locations and associated viewsheds are shown in **Figure 8.4**;
- Care was taken to maximize the area visible whilst minimising disturbance to birds;
- The final six VP locations were selected with the aim of achieving coverage of the whole of each CRAA such that no point was greater than 2 km from a VP. This objective was achieved for the majority of the turbines, with all turbines covered by viewsheds (**Annex E** details how the small gaps in the viewshed coverage of the CRAA is taken into account in the collision modelling);
- A maximum 180° view arc was scanned by surveyors. This rule did not however apply when tracking migratory waterfowl or raptors across the CRAA;
- Each watch lasted a maximum of three hours but was suspended and then resumed to take account of changes in visibility (e.g. fluctuations in the cloud base).

For each target and secondary species, the following data were recorded (NatureScot 2017[i] P.17-18):

- The flightlines by individuals or flocks of birds;
- The time the target bird was detected and the duration (seconds) spent flying over a defined survey area (the viewshed);
- The birds' flight heights, defined into five prescribed height bands (0-20 m, 21-40 m, 41-100 m, 101-150 m and >151 m[4]) were recorded at the point of detection and at 15 second intervals thereafter. From this the proportion of time spent flying below, within (referred to as Potential Collision Height (PCH)) and above approximate rotor height could be estimated. The actual planned rotor height is 45 – 200 m above ground level. This difference is accounted for within the collision risk models on the assumption of even flight distribution within each height band;
- The route followed was plotted in the field onto 1:25,000 scale maps;
- Observations of target species took priority over recording secondary species if both species were present simultaneously;
- The number of birds recorded were the minimum number of individuals that could account for the activity observed; and
- Observers only recorded perched birds and birds on waterbodies once only on arrival at the VP. Thereafter only flying birds and newly noticed perched/swimming birds were included in the activity summaries.

B.2 Winter Walkover

Winter walkovers were performed in the non-breeding seasons to map wintering populations of birds within 500 m of the site.

- The area was surveyed three times during each non-breeding season;
- These surveys involved following a route that optimised ground coverage, such that observers walked within 250 m of every point; and

[1] Delaunay triangulation is a form of mathematical/computational geometry where a given set of points (in this case the turbine locations) are all joined to create discrete triangles. Further information is available here: https://uk.mathworks.com/help/matlab/math/delaunay-triangulation.html

[2] This was adjusted where appropriate depending on the spatial location of the turbines in relation to other turbines.

[3] The viewsheds are based on a 5 m DTM to provide a representation of visibility from the observer locations; this is confirmed and refined through field site visits.

- Observers periodically stopped at appropriate viewing and listening points along the route and longer vantage point watches were included within the walkover to allow potentially important areas to be monitored in greater detail.

B.3 Scarce Breeding Bird Survey

The aim of the scarce breeding bird surveys was to determine the distribution of occupied nests/territories for target raptor and owl species within 2 km of the site and record breeding success. Secondary species such as buzzard, sparrowhawk and kestrel were also noted but location of their nests was not the key focus of the surveys.

Surveys were undertaken by experienced and licensed[4] field ornithologists. Extreme care was taken to avoid unnecessary disturbance to breeding birds.

Guidance from NatureScot (2017[i] P.11-14), '*Bird Monitoring Methods*' (Gilbert *et al.* 1998[ii]) and '*Raptors: a field guide to survey and monitoring*' (Hardey *et al.* 2013[iii]) were all consulted to inform survey methodology and are referenced where appropriate in the species methodologies below.

Barn Owl

- The surveys followed methodology outlined in Gilbert *et al.* (1998[ii]), as mentioned in NatureScot guidance (2017[i] P12-13);
- Surveys were undertaken within 1 km of the site; and
- Surveyors checked for signs of occupation (moulted feathers, pellets) in all suitable buildings within this 1 km buffer.

Goshawk

Methodology outlined in Hardey *et al.* (2013[iii]) was used as guidance for the surveying of areas for potential goshawk breeding. Extreme care was taken not to disturb potential nests especially around the time of year when females were likely to be laying or incubating.

- Areas of suitable woodland were observed for the presence of nests. Searches for goshawk nests were focused on mature forestry blocks, although their presence was not ruled out of other wooded areas;
- Searches carried out between March and April focussed on observing territorial and nest building behaviours;
- Where nests were known to be present, scans were carried out between mid-March and May to confirm breeding. Scans were kept brief – carried out for between 5-10 minutes and from a distance; and
- When breeding was confirmed, searches for further nests were deferred until such a time as the young had hatched. Searches were then undertaken between late May and late June for evidence of provisioning young and then between late July and early August to watch for fledgling activity, this included listening for the begging calls of newly fledged young.

[4] All surveyors hold SNH Schedule 1 Licences.

Hen Harrier

Methodology outlined in Hardey *et al*. (2013[iii]) was used as guidance for the surveying of areas for potential hen harrier breeding. Extreme care was taken not to disturb potential nests especially around the time of year when females were likely to be laying or in cold/wet weather when females were likely to be incubating or brooding. Areas of suitable habitat[5] were visited during four time periods across the breeding season to:

- Check for territory occupancy (between March and mid-April) – this consisted of watching over suitable habitat from a good vantage point for displaying males (and females) and checking all areas of suitable habitat to within 250 m (watching out for signs of kills);
- Locate incubating females (between mid-April and late May) by listening for female begging calls and watching for food passes between the male and female – surveyors watched for at least four hours as Hardey *et al.* (2013[iii]) notes that when the female is incubating it can be up to six hours between feeding visits from the male, but on average it is less than every four hours. Surveys were undertaken between 06:00 to 12:00 or 16:00 to 20:00;
- Check for young or breeding evidence (between late May and late June) again by listening for female begging calls and watching for food passes between male and female when the female is brooding and watching for the male and female provisioning the nest with food once brooding has ended– surveyors should watch for at least two hours as Hardey *et al.* (2013[iii]) notes that an adult bird will visit the nest every 1-2 hours. Surveyors should also watch for display behaviour which could indicate a failed breeding attempt; and
- Check for fledged young (between late June and late August).

Merlin

Methodology outlined in Hardey *et al.* (2013[iii]) was used as guidance for the surveying of areas for potential merlin breeding.

- Areas of suitable nesting habitat (including forest edge where trees are >5 m high) were closely observed between 20th March and 30th April;
- Boulders, fence lines, isolated posts, stone dykes, grouse butts, hummocks, stream banks, crags, trees and recently burnt areas of heather were checked for signs of occupation (e.g. plucked prey, moulted feathers, pellets and faeces);
- If merlin were observed, or signs found, areas were visited at least twice to verify occupation of the territory; and
- Potential nest areas were watched for 4-6 hours if necessary.

Osprey

Methodology outlined in Hardey *et al.* (2013[iii]) and Gilbert *et al.* (1998[ii]) was used as guidance for the surveying of areas for potential osprey breeding. Care was taken when carrying out the searches so as not to disturb any displaying or nesting birds, with nests checked from a distance.

[5] Unsuitable habitat areas include: land above 600 m; improved pasture and arable land; extensive areas of degraded land with no heather cover and low vegetation; the vicinity of cliffs, rocky outcrops, boulder fields and scree; areas within 100 m of hill farms and occupied dwellings.

- All wooded areas within the study area were searched for the possible presence of nests, especially those located close to freshwater lochs and rivers that could provide feeding sites. Artificial platforms were also checked;
- If breeding was suspected within the study area, the location was visited between April and May until nesting was confirmed;
- In line with the methods suggested by Gilbert *et al.* (1998[ii]) and Hardey *et al*. (2013[iii]), proof of occupancy was determined by:
  - Two ospreys seen on the same nest on more than one occasion (with a week separating observations), incubation, or feeding of chicks.
- Further scans were undertaken between late May and early July to try and observe any young in the nests.

Peregrine Falcon

- Potential nest sites were visited and checked for evidence of occupation between March and April;
- Sites checked included crags and steep banks identified from OS maps and searches of the survey area;
- Surveyors checked for signs of occupation (e.g. faecal splash, fresh plucked prey);
- If occupied sites were found they were re-visited to verify incubation; and
- Searches were made for eyries. Where this was not possible sites were watched from a suitable vantage point for 3-4 hours or until a nest was located.

Red Kite

Care was taken not to disturb any birds, especially between mid-March and mid-April when disturbance to displaying red kites can cause them to move to another area (Hardey *et al.* 2013[iii]).

- Wooded areas were scanned from outside for the presence of nests, with signs occupation searched for between February and March;
- Potential territories were watched for 1-2 hours between March and April to observe any breeding or nest-building behaviour; and
- Where breeding was confirmed, nests were scanned to determine the breeding success between late April and late June/early July.

Short-Eared Owl

- At least two visits between early April and the end of May were carried out;
- Suitable habitat was visited and checked for evidence of hunting males, territorial activity and other signs of presence; and
- If breeding was confirmed, a further visit was be made in June to watch birds, locate nest-sites and confirm breeding behaviour wherever possible.

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[i] NatureScot/Scottish Natural Heritage (2017) Recommended bird survey methods to inform impact assessment of onshore windfarms.
[ii] Gilbert, G., Gibbons, D. W. and Evans, J. (1998) Bird Monitoring Methods. RSPB, Sandy.
[iii] Hardey, J., Crick, H., Wernham, C., Riley, H., Etheridge, B. and Thompson, D. (2013) Raptors: a field guide for surveys and monitoring (3rd edition). The Stationery Office, Edinburgh.

ANNEX C. ORNITHOLOGICAL SURVEY EFFORT & GENERAL INFORMATION

Table C-1 shows the system used for recording weather conditions on all the surveys (sections **C.1** to **C.3** below).

Table C-1 Key to meteorological conditions recorded during all surveys

Wind speed				Rain		Cloud cover		Cloud height	
Calm	0	Moderate gale	7	None	0	In eighths		<150m	0
Light air	1	Fresh gale	8	Drizzle/Mist	1	*e.g.*	3/8	150-500m	1
Light breeze	2	Strong gale	9	Light showers	2			>500m	2
Gentle breeze	3	Whole gale	10	Heavy showers	3				
Moderate breeze	4	Storm	11	Heavy rain	4				
Fresh breeze	5	Hurricane	12	**Snow**		**Frost**		**Visibility**	
Strong breeze	6			None	0	None	0	Poor (<1km)	0
				On site	1	Ground	1	Moderate (1-2km)	1
				High ground	2	All day	2	Good (>2km)	2

C.1 Flight Activity Surveys

Flight activity surveys were undertaken during the 2019 breeding season and 2019/2020 non-breeding season. Details of the flight activity surveys undertaken across each Vantage Point (VP) location are supplied in **Table C-2** (survey hours per VP per season are summarised in **Technical Appendix 8.1 Table 8-1-1**) and the associated weather data recorded is detailed in **Table C-3**. Refer to **Annex B** for survey methodology and **Annex D** for survey results.

Table C-2 Summary of flight activity surveys undertaken at Cumberhead West Wind Farm (sorted chronologically)

Date	Season	VP	Observer	Survey start time	Survey finish time	No. hours[1] surveyed
22/05/2019	2019 BR	1	RD	1010	1210	2
22/05/2019	2019 BR	2	RD	1240	1440	2
22/05/2019	2019 BR	2	RD	1240	1440	2
31/05/2019	2019 BR	2	NG	0830	1130	3
31/05/2019	2019 BR	3	SS	0830	1130	3
31/05/2019	2019 BR	1	NG	1130	1415	2.75
31/05/2019	2019 BR	4	SS	1200	1400	2
03/06/2019	2019 BR	1	PN	1000	1300	2.5
03/06/2019	2019 BR	2	AA	1000	1200	2
03/06/2019	2019 BR	2	AA	1200	1400	2
03/06/2019	2019 BR	1	PN	1330	1430	0.83
04/06/2019	2019 BR	4	AA	0715	1015	3
04/06/2019	2019 BR	4	AA	1015	1315	3
10/06/2019	2019 BR	4	JR	0820	1120	3
10/06/2019	2019 BR	1	PN	0835	1135	3
10/06/2019	2019 BR	3	JR	1150	1450	3
10/06/2019	2019 BR	2	PN	1205	1505	3
21/06/2019	2019 BR	4	AA	0530	0830	3
21/06/2019	2019 BR	4	AA	0830	1130	3
18/07/2019	2019 BR	1	MW	0745	1045	3
18/07/2019	2019 BR	1	MW	1115	1415	3
19/07/2019	2019 BR	2	MW	0530	0830	3
19/07/2019	2019 BR	2	MW	0900	1200	3
22/07/2019	2019 BR	4	PN	0815	1115	3
22/07/2019	2019 BR	4	PN	1145	1445	3
24/07/2019	2019 BR	3	MW	0745	1045	3
24/07/2019	2019 BR	3	MW	1115	1415	3
25/07/2019	2019 BR	4	MW	0515	0815	3
25/07/2019	2019 BR	4	MW	0845	1145	3
26/07/2019	2019 BR	1	MW	0500	0800	3
26/07/2019	2019 BR	5	PN	0815	1115	3
26/07/2019	2019 BR	1	MW	0830	1130	3
26/07/2019	2019 BR	5	PN	1145	1445	3
29/07/2019	2019 BR	2	MW	1130	1430	3
29/07/2019	2019 BR	2	MW	1430	1800	3
30/07/2019	2019 BR	3	MW	1400	1700	3
30/07/2019	2019 BR	3	MW	1730	2030	3
31/07/2019	2019 BR	4	MW	0730	1030	3
31/07/2019	2019 BR	3	MW	1100	1400	3
31/07/2019	2019 BR	5	PN	1115	1415	3
31/07/2019	2019 BR	5	PN	1445	1745	3
19/08/2019	2019 BR	5	PN	1335	1635	3
19/08/2019	2019 BR	5	PN	1705	2005	3
20/08/2019	2019 BR	1	MW	1310	1610	3
20/08/2019	2019 BR	1	MW	1640	1940	3
21/08/2019	2019 BR	3	MW	0730	1030	3
21/08/2019	2019 BR	3	MW	1100	1400	3
22/08/2019	2019 BR	5	MW	0715	1015	3
22/08/2019	2019 BR	5	MW	1045	1345	3
23/08/2019	2019 BR	2	MW	0545	0845	3
23/08/2019	2019 BR	2	MW	0915	1215	3
26/08/2019	2019 BR	4	MW	1300	1600	3
26/08/2019	2019 BR	4	MW	1630	1930	3
27/08/2019	2019 BR	5	MW	0730	1030	3
27/08/2019	2019 BR	5	MW	1100	1400	3
28/08/2019	2019 BR	6	MW	0900	1200	3
28/08/2019	2019 BR	6	MW	1230	1530	3
29/08/2019	2019 BR	3	MW	0545	0845	3
29/08/2019	2019 BR	3	MW	0915	1215	3
29/08/2019	2019 BR	2	MW	1245	1345	1
30/08/2019	2019 BR	5	MW	0600	0900	3
30/08/2019	2019 BR	5	MW	0930	1230	3
03/09/2019	2019/2020 NBR	5	MW	0730	1030	3
03/09/2019	2019/2020 NBR	5	MW	1100	1400	3
04/09/2019	2019/2020 NBR	4	MW	0700	1000	3
04/09/2019	2019/2020 NBR	4	MW	1030	1330	3
05/09/2019	2019/2020 NBR	3	MW	0600	0900	3
05/09/2019	2019/2020 NBR	3	MW	0930	1230	3
09/09/2019	2019/2020 NBR	2	MW	1220	1520	3
09/09/2019	2019/2020 NBR	2	MW	1550	1850	3
10/09/2019	2019/2020 NBR	6	MW	0900	1200	3
10/09/2019	2019/2020 NBR	6	MW	1230	1530	3
12/09/2019	2019/2020 NBR	5	MW	0630	0930	3
12/09/2019	2019/2020 NBR	5	MW	1000	1300	3

[1] Note: only valid hours (i.e. where visibility was at least 1 km) are presented in this column.

Date	Season	VP	Observer	Survey start time	Survey finish time	No. hours[1] surveyed
16/09/2019	2019/2020 NBR	4	MW	1200	1500	3
16/09/2019	2019/2020 NBR	3	MW	1540	1840	3
17/09/2019	2019/2020 NBR	6	MW	0745	1045	3
17/09/2019	2019/2020 NBR	2	MW	1115	1415	3
01/10/2019	2019/2020 NBR	5	MW	1120	1420	3
01/10/2019	2019/2020 NBR	5	MW	1450	1750	3
02/10/2019	2019/2020 NBR	2	MW	0900	1200	3
02/10/2019	2019/2020 NBR	2	MW	1230	1530	3
03/10/2019	2019/2020 NBR	6	MW	0730	1030	3
03/10/2019	2019/2020 NBR	6	MW	1100	1400	3
04/10/2019	2019/2020 NBR	4	MW	0730	1030	1
04/10/2019	2019/2020 NBR	4	MW	1100	1400	3
07/10/2019	2019/2020 NBR	3	MW	1110	1410	3
07/10/2019	2019/2020 NBR	3	MW	1440	1740	3
13/11/2019	2019/2020 NBR	4	JRM	0750	1050	3
13/11/2019	2019/2020 NBR	2	JR	0805	1105	2.25
13/11/2019	2019/2020 NBR	3	PN	0810	1110	3
13/11/2019	2019/2020 NBR	4	JRM	1120	1350	2.5
13/11/2019	2019/2020 NBR	2	JR	1135	1350	1.17
13/11/2019	2019/2020 NBR	3	PN	1140	1340	2
28/11/2019	2019/2020 NBR	5	JR	0800	1100	3
28/11/2019	2019/2020 NBR	4	JRM	0940	1240	3
28/11/2019	2019/2020 NBR	6	PN	0955	1155	2
28/11/2019	2019/2020 NBR	5	JR	1130	1330	2
28/11/2019	2019/2020 NBR	6	PN	1225	1525	3
28/11/2019	2019/2020 NBR	4	JRM	1310	1610	3
09/12/2019	2019/2020 NBR	4	MW	0915	1215	3
09/12/2019	2019/2020 NBR	2	JRM	1030	1330	3
09/12/2019	2019/2020 NBR	4	MW	1245	1445	2
16/12/2019	2019/2020 NBR	5	MW	0840	1140	3
16/12/2019	2019/2020 NBR	5	MW	1210	1410	2
20/12/2019	2019/2020 NBR	3	MW	0930	1130	2
20/12/2019	2019/2020 NBR	2	JRM	1000	1300	1.42
20/12/2019	2019/2020 NBR	2	JRM	1300	1400	0
22/01/2020	2019/2020 NBR	2	JRM	0840	1300	0
22/01/2020	2019/2020 NBR	3	PN	0840	1140	2.84
22/01/2020	2019/2020 NBR	3	PN	1210	1410	0.83
29/01/2020	2019/2020 NBR	6	MW	0830	1130	3
29/01/2020	2019/2020 NBR	6	MW	1200	1400	1
30/01/2020	2019/2020 NBR	2	MW	0815	1115	3
30/01/2020	2019/2020 NBR	6	MW	1145	1345	1
31/01/2020	2019/2020 NBR	5	MW	0800	1100	3
31/01/2020	2019/2020 NBR	5	MW	1130	1330	1
25/02/2020	2019/2020 NBR	5	PN	0730	1030	3
25/02/2020	2019/2020 NBR	5	PN	1100	1400	3
26/02/2020	2019/2020 NBR	2	JRM	-	-	0
03/03/2020	2019/2020 NBR	4	JRM	0750	1150	3
03/03/2020	2019/2020 NBR	2	PN	0915	1215	3
03/03/2020	2019/2020 NBR	4	JRM	1220	1520	3
03/03/2020	2019/2020 NBR	2	PN	1245	1445	1.5
06/03/2020	2019/2020 NBR	3	JRM	0800	1100	3
06/03/2020	2019/2020 NBR	3	JRM	1130	1400	2.5
09/03/2020	2019/2020 NBR	4	PN	1035	1105	0.5
09/03/2020	2019/2020 NBR	2	PN	1135	1435	2.58
11/03/2020	2019/2020 NBR	6	JRM	1230	1530	3
11/03/2020	2019/2020 NBR	6	JRM	1600	1710	1.16
12/03/2020	2019/2020 NBR	6	MW	0700	1000	3
12/03/2020	2019/2020 NBR	3	JM	0900	1200	3
12/03/2020	2019/2020 NBR	6	MW	1030	1300	2.5
12/03/2020	2019/2020 NBR	3	JM	1230	1430	2
13/03/2020	2019/2020 NBR	2	JRM	0810	1110	3
13/03/2020	2019/2020 NBR	2	JRM	1140	1155	0.25
13/03/2020	2019/2020 NBR	6	JRM	1225	1355	1.5

Table C-3 Meteorological conditions during flight activity surveys at Cumberhead West Wind Farm (sorted chronologically)

Date	VP	Observer	Survey start time	Survey finish time	Survey hour	Wind speed	Wind direction	Rain	Cloud cover	Cloud height	Visibility	Snow	Frost
22/05/2019	1	RD	1010	1210	1	4	W	0	6	2	2	0	0
22/05/2019	1	RD	1010	1210	2	4	W	0	7	2	2	0	0
22/05/2019	2	RD	1240	1440	1	4	W	0	7	2	2	0	0
22/05/2019	2	RD	1240	1440	2	4	W	0	6	2	2	0	0
31/05/2019	2	NG	0830	1130	1	5	SE	3	8	0	1	0	0
31/05/2019	2	NG	0830	1130	2	5	SE	3	8	0	0	0	0
31/05/2019	2	NG	0830	1130	3	5	SE	2	8	1	1	0	0
31/05/2019	3	SS	0830	1130	1	5	SW	1	8	1	2	0	0
31/05/2019	3	SS	0830	1130	2	5	SW	1	8	1	2	0	0
31/05/2019	3	SS	0830	1130	3	4	SW	3	8	1	1	0	0
31/05/2019	1	NG	1130	1415	1	5	SE	3	8	0	1	0	0
31/05/2019	1	NG	1130	1415	2	6	SE	3	8	0	0	0	0
31/05/2019	1	NG	1130	1415	3	5	SE	2	8	1	1	0	0
31/05/2019	4	SS	1200	1400	1	3	SW	3	8	1	1	0	0
31/05/2019	4	SS	1200	1400	2	3	SW	2	8	1	1	0	0
03/06/2019	1	PN	1000	1300	1	7	SSW	2	8	2	2	0	0
03/06/2019	1	PN	1000	1300	2	7	SSW	2	8	2	2	0	0
03/06/2019	1	PN	1000	1300	3	7	SSW	2	8	2	2	0	0
03/06/2019	2	AA	1000	1400	1	6	W	2	8	2	2	0	0
03/06/2019	2	AA	1000	1400	2	6	W	2	8	2	1	0	0
03/06/2019	2	AA	1000	1400	3	7	W	1	8	2	2	0	0
03/06/2019	2	AA	1000	1400	4	6	W	2	8	2	2	0	0
03/06/2019	1	PN	1330	1430	1	6	SSW	2	8	2	2	0	0
04/06/2019	4	AA	0715	1015	1	2	SSW	0	2	2	2	0	0
04/06/2019	4	AA	0715	1015	2	2	S	0	6	2	2	0	0
04/06/2019	4	AA	0715	1015	3	1	SW	0	6	2	2	0	0
04/06/2019	4	AA	1015	1315	4	2	S	0	7	2	2	0	0
04/06/2019	4	AA	1015	1315	5	2	SE	0	7	2	2	0	0
10/06/2019	4	JR	0820	1120	1	1	NE	0	2	2	2	0	0
10/06/2019	4	JR	0820	1120	2	1	NNE	0	2	2	2	0	0
10/06/2019	4	JR	0820	1120	3	2	NE	0	3	2	2	0	0
10/06/2019	1	PN	0835	1135	1	3	NW	0	3	2	2	0	0
10/06/2019	1	PN	0835	1135	2	3	NW	0	4	2	2	0	0
10/06/2019	1	PN	0835	1135	3	4	NNE	0	4	2	2	0	0
10/06/2019	3	JR	1150	1430	1	2	NE	0	4	2	2	0	0
10/06/2019	3	JR	1150	1430	2	2	NE	0	4	2	2	0	0
10/06/2019	3	JR	1150	1430	3	3	NE	0	3	2	2	0	0
10/06/2019	2	PN	1205	1505	1	3	NNE	0	6	2	2	0	0
10/06/2019	2	PN	1205	1505	2	2	NE	0	6	2	2	0	0
10/06/2019	2	PN	1205	1505	3	4	NW	0	6	2	2	0	0
21/06/2019	4	AA	0530	0830	1	4	W	0	5	1	2	0	0
21/06/2019	4	AA	0530	0830	2	4	WSW	0	5	2	2	0	0
21/06/2019	4	AA	0530	0830	3	4	SW	2	7	2	2	0	0

Date	VP	Observer	Survey start time	Survey finish time	Survey hour	Wind speed	Wind direction	Rain	Cloud cover	Cloud height	Visibility	Snow	Frost
21/06/2019	4	AA	0830	1130	4	4	SW	2	7	2	2	0	0
21/06/2019	4	AA	0830	1130	5	4	SW	2	7	2	2	0	0
21/06/2019	4	AA	0830	1130	6	4	SW	2	6	2	2	0	0
18/07/2019	1	MW	0745	1045	1	6	WSW	1	8	0	0	0	0
18/07/2019	1	MW	0745	1045	2	6	WSW	2	8	1	1	0	0
18/07/2019	1	MW	0745	1045	3	6	WSW	2	8	2	2	0	0
18/07/2019	1	MW	1115	1415	1	6	WSW	2	8	2	2	0	0
18/07/2019	1	MW	1115	1415	2	7	WSW	2	8	2	2	0	0
18/07/2019	1	MW	1115	1415	3	7	WSW	2	8	2	2	0	0
19/07/2019	2	MW	0530	0830	1	2	S	2	8	2	2	0	0
19/07/2019	2	MW	0530	0830	2	3	S	2	8	2	2	0	0
19/07/2019	2	MW	0530	0830	3	4	SSW	0	7	2	2	0	0
19/07/2019	2	MW	0900	1200	1	4	SSW	0	7	2	2	0	0
19/07/2019	2	MW	0900	1200	2	4	SSW	0	7	2	2	0	0
19/07/2019	2	MW	0900	1200	3	5	SSW	0	7	2	2	0	0
22/07/2019	4	PN	0815	1115	1	4	SW	0	8	2	2	0	0
22/07/2019	4	PN	0815	1115	2	4	SW	0	8	2	2	0	0
22/07/2019	4	PN	0815	1115	3	4	SW	0	8	2	2	0	0
22/07/2019	4	PN	1145	1445	1	4	SW	0	8	2	2	0	0
22/07/2019	4	PN	1145	1445	2	4	SW	0	8	2	2	0	0
22/07/2019	4	PN	1145	1445	3	4	SW	0	7	2	2	0	0
24/07/2019	3	MW	0745	1045	1	7	SW	0	8	2	2	0	0
24/07/2019	3	MW	0745	1045	2	7	SW	0	8	2	2	0	0
24/07/2019	3	MW	0745	1045	3	7	SW	0	7	2	2	0	0
24/07/2019	3	MW	1115	1415	1	6	SW	0	7	2	2	0	0
24/07/2019	3	MW	1115	1415	2	6	SW	0	7	2	2	0	0
24/07/2019	3	MW	1115	1415	3	6	SW	0	7	2	2	0	0
25/07/2019	4	MW	0515	0815	1	4	SSE	0	2	2	2	0	0
25/07/2019	4	MW	0515	0815	2	4	SSE	0	3	2	2	0	0
25/07/2019	4	MW	0515	0815	3	5	SSE	0	2	2	2	0	0
25/07/2019	4	MW	0845	1145	1	5	SSE	0	3	2	2	0	0
25/07/2019	4	MW	0845	1145	2	5	SSE	0	3	2	2	0	0
25/07/2019	4	MW	0845	1145	3	5	SSE	0	3	2	2	0	0
26/07/2019	1	MW	0500	0800	1	7	S	0	8	2	2	0	0
26/07/2019	1	MW	0500	0800	2	6	S	0	8	2	2	0	0
26/07/2019	1	MW	0500	0800	3	7	S	0	8	2	2	0	0
26/07/2019	5	PN	0815	1115	1	3	SSE	0	7	2	2	0	0
26/07/2019	5	PN	0815	1115	2	4	SSW	0	7	2	2	0	0
26/07/2019	5	PN	0815	1115	3	4	SSW	0	7	2	2	0	0
26/07/2019	1	MW	0830	1130	1	6	S	0	8	2	2	0	0
26/07/2019	1	MW	0830	1130	2	7	S	0	7	2	2	0	0
26/07/2019	1	MW	0830	1130	3	7	S	0	7	2	2	0	0
26/07/2019	5	PN	1145	1445	1	4	S	0	7	2	2	0	0
26/07/2019	5	PN	1145	1445	2	4	S	0	7	2	2	0	0

Date	VP	Observer	Survey start time	Survey finish time	Survey hour	Wind speed	Wind direction	Rain	Cloud cover	Cloud height	Visibility	Snow	Frost
26/07/2019	5	PN	1145	1445	3	4	S	0	7	2	2	0	0
29/07/2019	2	MW	1130	1430	1	2	SSE	0	8	2	2	0	0
29/07/2019	2	MW	1130	1430	2	2	SSE	0	8	2	2	0	0
29/07/2019	2	MW	1130	1430	3	3	SSE	0	8	2	2	0	0
29/07/2019	2	MW	1430	1800	1	2	SSE	0	7	2	2	0	0
29/07/2019	2	MW	1430	1800	2	2	SSE	0	8	2	2	0	0
29/07/2019	2	MW	1430	1800	3	2	SSE	1	8	0	2	0	0
30/07/2019	3	MW	1400	1700	1	2	NW	0	8	2	2	0	0
30/07/2019	3	MW	1400	1700	2	2	NW	0	8	2	2	0	0
30/07/2019	3	MW	1400	1700	3	3	NW	3	8	2	2	0	0
30/07/2019	3	MW	1730	2030	1	3	NW	3	7	2	2	0	0
30/07/2019	3	MW	1730	2030	2	2	NW	3	8	2	2	0	0
30/07/2019	3	MW	1730	2030	3	3	NW	3	8	2	2	0	0
31/07/2019	4	MW	0730	1030	1	4	N	0	8	1	1	0	0
31/07/2019	4	MW	0730	1030	2	4	N	0	8	2	2	0	0
31/07/2019	4	MW	0730	1030	3	4	NNE	0	8	2	2	0	0
31/07/2019	3	MW	1100	1400	1	3	NNE	0	7	2	2	0	0
31/07/2019	3	MW	1100	1400	2	3	NNE	3	8	2	2	0	0
31/07/2019	3	MW	1100	1400	3	3	NNE	3	7	2	2	0	0
31/07/2019	5	PN	1115	1415	1	3	NE	0	6	2	2	0	0
31/07/2019	5	PN	1115	1415	2	3	NE	2	7	2	2	0	0
31/07/2019	5	PN	1115	1415	3	3	NE	3	7	2	2	0	0
31/07/2019	5	PN	1445	1745	1	3	NE	2	7	2	2	0	0
31/07/2019	5	PN	1445	1745	2	2	NE	3	8	2	2	0	0
31/07/2019	5	PN	1445	1745	3	2	NW	0	8	2	2	0	0
19/08/2019	5	PN	1335	1635	1	5	WSW	2	7	2	2	0	0
19/08/2019	5	PN	1335	1635	2	5	WSW	0	7	2	2	0	0
19/08/2019	5	PN	1335	1635	3	5	WSW	2	7	2	2	0	0
19/08/2019	5	PN	1705	2005	1	5	WSW	0	6	2	2	0	0
19/08/2019	5	PN	1705	2005	2	5	WSW	0	4	2	2	0	0
19/08/2019	5	PN	1705	2005	3	5	WSW	0	6	2	2	0	0
20/08/2019	1	MW	1310	1610	1	4	WSW	0	7	2	2	0	0
20/08/2019	1	MW	1310	1610	2	5	WSW	0	8	2	2	0	0
20/08/2019	1	MW	1310	1610	3	5	WSW	0	6	2	2	0	0
20/08/2019	1	MW	1640	1940	1	5	WSW	0	5	2	2	0	0
20/08/2019	1	MW	1640	1940	2	5	WSW	0	4	2	2	0	0
20/08/2019	1	MW	1640	1940	3	5	WSW	0	3	2	2	0	0
21/08/2019	3	MW	0730	1030	1	6	SW	0	8	2	2	0	0
21/08/2019	3	MW	0730	1030	2	6	SW	0	8	2	2	0	0
21/08/2019	3	MW	0730	1030	3	6	SW	0	8	2	2	0	0
21/08/2019	3	MW	1100	1400	1	7	SW	0	7	2	2	0	0
21/08/2019	3	MW	1100	1400	2	7	SW	0	7	2	2	0	0
21/08/2019	3	MW	1100	1400	3	7	SW	0	7	2	2	0	0
22/08/2019	5	MW	0715	1015	1	6	SSW	0	7	2	2	0	0

Date	VP	Observer	Survey start time	Survey finish time	Survey hour	Wind speed	Wind direction	Rain	Cloud cover	Cloud height	Visibility	Snow	Frost
22/08/2019	5	MW	0715	1015	1	6	SSW	0	8	2	2	0	0
22/08/2019	5	MW	0715	1015	2	6	SSW	0	8	2	2	0	0
22/08/2019	5	MW	0715	1015	2	7	SSW	3	8	2	2	0	0
22/08/2019	5	MW	0715	1015	3	6	SSW	0	8	2	2	0	0
22/08/2019	5	MW	0715	1015	3	7	SSW	4	4	2	2	0	0
23/08/2019	2	MW	0545	0845	1	5	SW	0	6	2	2	0	0
23/08/2019	2	MW	0545	0845	2	6	SW	0	7	2	2	0	0
23/08/2019	2	MW	0545	0845	3	7	SW	0	8	2	2	0	0
23/08/2019	2	MW	0915	1215	1	7	SW	0	7	2	2	0	0
23/08/2019	2	MW	0915	1215	2	6	SW	0	6	2	2	0	0
23/08/2019	2	MW	0915	1215	3	6	SW	0	6	2	2	0	0
26/08/2019	4	MW	1300	1600	1	4	SSW	0	5	2	2	0	0
26/08/2019	4	MW	1300	1600	2	4	SSW	0	5	2	2	0	0
26/08/2019	4	MW	1300	1600	3	5	SSW	0	4	2	2	0	0
26/08/2019	4	MW	1630	1930	1	5	SSW	0	5	2	2	0	0
26/08/2019	4	MW	1630	1930	2	5	SSW	0	4	2	2	0	0
26/08/2019	4	MW	1630	1930	3	4	S	0	3	2	2	0	0
27/08/2019	5	MW	0730	1030	1	3	S	0	8	2	2	0	0
27/08/2019	5	MW	0730	1030	2	3	S	0	8	2	2	0	0
27/08/2019	5	MW	0730	1030	3	4	S	0	8	2	2	0	0
27/08/2019	5	MW	1100	1400	1	4	S	0	6	2	2	0	0
27/08/2019	5	MW	1100	1400	2	4	S	0	7	2	2	0	0
27/08/2019	5	MW	1100	1400	3	4	S	0	6	2	2	0	0
28/08/2019	2	MW	0900	1200	1	5	S	0	8	2	2	0	0
28/08/2019	2	MW	0900	1200	2	5	S	0	7	2	2	0	0
28/08/2019	2	MW	0900	1200	3	6	S	0	8	2	2	0	0
28/08/2019	2	MW	1230	1530	1	6	S	3	8	2	2	0	0
28/08/2019	2	MW	1230	1530	2	6	S	3	8	2	2	0	0
28/08/2019	2	MW	1230	1530	3	6	S	3	8	2	2	0	0
29/08/2019	3	MW	0545	0845	1	4	SSW	0	6	2	2	0	0
29/08/2019	3	MW	0545	0845	2	5	SSW	0	5	2	2	0	0
29/08/2019	3	MW	0545	0845	3	6	SSW	3	7	2	2	0	0
29/08/2019	3	MW	0915	1215	1	7	S	3	8	2	2	0	0
29/08/2019	3	MW	0915	1215	2	7	S	3	8	2	2	0	0
29/08/2019	3	MW	0915	1215	3	7	S	3	8	2	2	0	0
29/08/2019	2	MW	1245	1345	1	8	S	3	8	2	2	0	0
30/08/2019	5	MW	0600	0900	1	7	SSW	0	8	2	2	0	0
30/08/2019	5	MW	0600	0900	2	7	SSW	3	8	2	2	0	0
30/08/2019	5	MW	0600	0900	3	8	SSW	3	8	1	1	0	0
30/08/2019	5	MW	0930	1230	1	8	SSW	3	8	2	2	0	0
30/08/2019	5	MW	0930	1230	2	8	SSW	3	8	2	2	0	0
30/08/2019	5	MW	0930	1230	3	9	SSW	3	8	2	2	0	0
03/09/2019	5	MW	0730	1030	1	4	SW	4	8	1	1	0	0
03/09/2019	5	MW	0730	1030	2	4	SW	4	8	1	1	0	0

Date	VP	Observer	Survey start time	Survey finish time	Survey hour	Wind speed	Wind direction	Rain	Cloud cover	Cloud height	Visibility	Snow	Frost
03/09/2019	5	MW	0730	1030	3	5	SW	4	8	1	1	0	0
03/09/2019	5	MW	1100	1400	1	5	SW	4	8	1	1	0	0
03/09/2019	5	MW	1100	1400	2	5	SW	4	8	1	1	0	0
03/09/2019	5	MW	1100	1400	3	6	SW	4	8	0	0	0	0
04/09/2019	4	MW	0700	1000	1	5	SW	0	8	2	2	0	0
04/09/2019	4	MW	0700	1000	2	5	SW	0	8	2	2	0	0
04/09/2019	4	MW	0700	1000	3	6	SW	0	8	2	2	0	0
04/09/2019	4	MW	1030	1330	1	6	SW	4	8	1	1	0	0
04/09/2019	4	MW	1030	1330	2	7	SW	4	8	1	1	0	0
04/09/2019	4	MW	1030	1330	3	8	SW	4	8	1	1	0	0
05/09/2019	3	MW	0600	0900	1	3	WNW	0	8	2	2	0	0
05/09/2019	3	MW	0600	0900	2	4	WNW	0	8	2	2	0	0
05/09/2019	3	MW	0600	0900	3	5	WNW	0	8	2	2	0	0
05/09/2019	3	MW	0930	1230	1	5	WNW	3	8	2	2	0	0
05/09/2019	3	MW	0930	1230	2	5	WNW	0	8	2	2	0	0
05/09/2019	3	MW	0930	1230	3	5	WNW	0	8	2	2	0	0
09/09/2019	2	MW	1220	1520	1	2	SSE	4	8	2	2	0	0
09/09/2019	2	MW	1220	1520	2	2	SSE	4	8	2	2	0	0
09/09/2019	2	MW	1220	1520	3	2	S	4	8	2	2	0	0
09/09/2019	2	MW	1550	1850	1	3	S	4	8	2	2	0	0
09/09/2019	2	MW	1550	1850	2	3	SSW	3	8	2	2	0	0
09/09/2019	2	MW	1550	1850	3	3	SW	3	8	2	2	0	0
10/09/2019	6	MW	0900	1200	1	3	WNW	0	7	2	2	0	0
10/09/2019	6	MW	0900	1200	2	3	WNW	0	7	2	2	0	0
10/09/2019	6	MW	0900	1200	3	4	WNW	0	6	2	2	0	0
10/09/2019	6	MW	1230	1530	1	4	WNW	0	7	2	2	0	0
10/09/2019	6	MW	1230	1530	2	5	WNW	0	8	2	2	0	0
10/09/2019	6	MW	1230	1530	3	5	WNW	0	8	2	2	0	0
12/09/2019	5	MW	0630	0930	1	5	SSW	4	8	2	2	0	0
12/09/2019	5	MW	0630	0930	2	5	SSW	1	8	1	1	0	0
12/09/2019	5	MW	0630	0930	3	5	SSW	4	8	2	2	0	0
12/09/2019	5	MW	1000	1300	1	4	SSW	4	8	2	2	0	0
12/09/2019	5	MW	1000	1300	2	3	SSW	4	8	2	2	0	0
12/09/2019	5	MW	1000	1300	3	3	SSW	4	8	2	2	0	0
16/09/2019	4	MW	1200	1500	1	3	WNW	0	7	2	2	0	0
16/09/2019	4	MW	1200	1500	2	4	WNW	0	8	2	2	0	0
16/09/2019	4	MW	1200	1500	3	5	WNW	0	7	2	2	0	0
16/09/2019	3	MW	1540	1840	1	5	WNW	0	7	2	2	0	0
16/09/2019	3	MW	1540	1840	2	5	WNW	0	8	2	2	0	0
16/09/2019	3	MW	1540	1840	3	5	WNW	3	8	2	2	0	0
17/09/2019	6	MW	0745	1045	1	4	WNW	0	5	2	2	0	0
17/09/2019	6	MW	0745	1045	2	5	WNW	0	6	2	2	0	0
17/09/2019	6	MW	0745	1045	3	5	WNW	0	7	2	2	0	0
17/09/2019	3	MW	1115	1415	1	6	WNW	0	5	2	2	0	0

Date	VP	Observer	Survey start time	Survey finish time	Survey hour	Wind speed	Wind direction	Rain	Cloud cover	Cloud height	Visibility	Snow	Frost
17/09/2019	3	MW	1115	1415	2	6	WNW	0	5	2	2	0	0
17/09/2019	3	MW	1115	1415	3	7	WNW	0	4	2	2	0	0
01/10/2019	5	MW	1120	1420	1	5	NE	0	8	2	2	0	0
01/10/2019	5	MW	1120	1420	2	5	NE	0	8	2	2	0	0
01/10/2019	5	MW	1120	1420	3	5	NE	0	8	2	2	0	0
01/10/2019	5	MW	1450	1750	1	5	NE	0	8	2	2	0	0
01/10/2019	5	MW	1450	1750	2	5	NE	0	8	2	2	0	0
01/10/2019	5	MW	1450	1750	3	5	NE	0	8	2	2	0	0
02/10/2019	2	MW	0900	1200	1	3	NNW	0	3	2	2	0	0
02/10/2019	2	MW	0900	1200	2	4	NNW	0	3	2	2	0	0
02/10/2019	2	MW	0900	1200	3	4	NNW	0	3	2	2	0	0
02/10/2019	2	MW	1230	1530	1	4	NNW	0	3	2	2	0	0
02/10/2019	2	MW	1230	1530	2	5	NNW	0	4	2	2	0	0
02/10/2019	2	MW	1230	1530	3	5	NNW	0	6	2	2	0	0
03/10/2019	6	MW	0730	1100	1	2	SE	0	8	2	2	1	0
03/10/2019	6	MW	0730	1100	2	2	SE	0	8	2	2	0	0
03/10/2019	6	MW	0730	1100	3	3	SE	0	8	2	2	0	0
03/10/2019	6	MW	1030	1400	1	3	SE	0	8	2	2	0	0
03/10/2019	6	MW	1030	1400	2	4	SE	0	8	2	2	0	0
03/10/2019	6	MW	1030	1400	3	5	SE	0	8	2	2	0	0
04/10/2019	4	MW	0730	1030	1	3	NE	0	8	0	0	0	0
04/10/2019	4	MW	0730	1030	2	3	NE	0	8	0	0	0	0
04/10/2019	4	MW	0730	1030	3	3	NE	0	8	1	1	0	0
04/10/2019	4	MW	1100	1400	1	4	NE	0	8	2	2	0	0
04/10/2019	4	MW	1100	1400	2	4	NE	0	8	2	2	0	0
04/10/2019	4	MW	1100	1400	3	4	NE	0	8	2	2	0	0
07/10/2019	3	MW	1110	1410	1	7	SSE	1	8	1	1	0	0
07/10/2019	3	MW	1110	1410	2	8	SSE	1	8	1	1	0	0
07/10/2019	3	MW	1110	1410	3	7	SSE	1	8	2	2	0	0
07/10/2019	3	MW	1440	1740	1	6	S	0	8	2	2	0	0
07/10/2019	3	MW	1440	1740	2	6	S	0	8	2	2	0	0
07/10/2019	3	MW	1440	1740	3	6	S	0	7	2	2	0	0
13/11/2019	4	JRM	0750	1050	1	3	SW	0	6	2	2	0	0
13/11/2019	4	JRM	0750	1050	2	3	SW	1	6	2	2	0	0
13/11/2019	4	JRM	0750	1050	3	3	WSW	1	8	1	2	0	0
13/11/2019	2	JR	0805	1105	1	2	SW	1	6	1	2	2	1
13/11/2019	2	JR	0805	1105	2	2	SW	2	7	1	1	2	1
13/11/2019	2	JR	0805	1105	3	2	SSW	2	8	2	2	2	1
13/11/2019	3	PN	0810	1110	1	2	SSW	0	7	2	2	1	0
13/11/2019	3	PN	0810	1110	2	3	SSW	0	7	2	2	1	0
13/11/2019	3	PN	0810	1110	3	2	S	0	7	2	2	0	0
13/11/2019	4	JRM	1120	1350	1	2	SW	0	8	1	2	0	0
13/11/2019	4	JRM	1120	1350	2	3	SW	0	5	1	2	0	0
13/11/2019	4	JRM	1120	1350	3	3	SSW	0	4	2	2	0	0

Date	VP	Observer	Survey start time	Survey finish time	Survey hour	Wind speed	Wind direction	Rain	Cloud cover	Cloud height	Visibility	Snow	Frost
13/11/2019	2	JR	1135	1350	1	2	S	2	8	1	0	1	1
13/11/2019	2	JR	1135	1350	2	2	S	2	8	1	0	0	1
13/11/2019	2	JR	1135	1350	3	2	S	1	4	2	2	0	0
13/11/2019	3	PN	1140	1340	1	2	S	1	8	1	2	0	0
13/11/2019	3	PN	1140	1340	2	3	S	0	7	1	2	0	0
28/11/2019	5	JR	0800	1100	1	3	NNE	0	7	2	2	0	0
28/11/2019	5	JR	0800	1100	2	4	NNE	0	4	2	2	0	0
28/11/2019	5	JR	0800	1100	3	3	NE	0	2	2	2	0	0
28/11/2019	4	JRM	0940	1240	1	5	NNW	0	3	2	2	0	0
28/11/2019	4	JRM	0940	1240	2	5	NW	0	4	2	2	0	0
28/11/2019	4	JRM	0940	1240	3	6	NNW	0	3	2	2	0	0
28/11/2019	6	PN	0955	1155	1	5	NNE	0	6	2	2	0	0
28/11/2019	6	PN	0955	1155	2	5	NNE	0	6	2	2	0	0
28/11/2019	5	JR	1130	1330	1	3	NE	0	4	2	2	0	0
28/11/2019	5	JR	1130	1330	2	3	NE	0	3	2	2	0	0
28/11/2019	6	PN	1225	1525	1	5	NNE	0	2	2	2	0	0
28/11/2019	6	PN	1225	1525	2	4	NE	0	5	2	2	0	0
28/11/2019	6	PN	1225	1525	3	4	NE	0	2	2	2	0	0
28/11/2019	4	JRM	1310	1610	1	4	N	0	2	2	2	0	0
28/11/2019	4	JRM	1310	1610	2	4	NW	0	3	2	2	0	0
28/11/2019	4	JRM	1310	1610	3	4	NNW	0	3	2	2	0	0
09/12/2019	4	MW	0915	1215	1	3	NW	0	1	2	2	1	0
09/12/2019	4	MW	0915	1215	2	3	NW	0	1	2	2	1	0
09/12/2019	4	MW	0915	1215	3	3	NW	0	1	2	2	1	0
09/12/2019	2	JRM	1030	1330	1	4	WSW	0	1	2	2	0	0
09/12/2019	2	JRM	1030	1330	2	4	WSW	0	1	2	2	0	0
09/12/2019	2	JRM	1030	1330	3	5	WSW	0	2	2	2	0	0
09/12/2019	4	MW	1245	1445	1	4	NW	0	1	2	2	1	0
09/12/2019	4	MW	1245	1445	2	4	NW	0	1	2	2	1	0
16/12/2019	5	MW	0840	1140	1	4	SW	3	8	1	1	1	1
16/12/2019	5	MW	0840	1140	2	4	SW	3	8	1	1	1	1
16/12/2019	5	MW	0840	1140	3	5	SW	0	8	2	2	1	1
16/12/2019	5	MW	1210	1410	1	5	SW	0	8	2	2	1	1
16/12/2019	5	MW	1210	1410	2	5	SW	0	7	2	2	1	1
20/12/2019	3	MW	0930	1130	1	3	S	1	8	1	1	0	0
20/12/2019	3	MW	0930	1130	2	4	S	1	8	1	1	0	0
20/12/2019	2	JRM	1000	1300	1	3	NE	2	8	0	0	0	0
20/12/2019	2	JRM	1000	1300	2	3	NE	1	8	0	0	0	0
20/12/2019	2	JRM	1000	1300	3	3	NE	0	8	1	2	0	0
20/12/2019	2	JRM	1300	1400	1	4	SW	1	8	1	0	0	0
22/01/2020	2	JRM	0840	1300	1	4	WNW	1	8	0	0	0	0
22/01/2020	2	JRM	0840	1300	2	4	WNW	1	8	0	0	0	0
22/01/2020	2	JRM	0840	1300	3	4	WNW	1	8	0	0	0	0
22/01/2020	2	JRM	0840	1300	4	4	WNW	1	8	0	0	0	0

Date	VP	Observer	Survey start time	Survey finish time	Survey hour	Wind speed	Wind direction	Rain	Cloud cover	Cloud height	Visibility	Snow	Frost
22/01/2020	3	PN	0840	1140	1	3	WNW	0	8	1	1	0	0
22/01/2020	3	PN	0840	1140	2	3	WNW	0	8	1	1	0	0
22/01/2020	3	PN	0840	1140	3	3	WNW	0	8	1	2	0	0
22/01/2020	3	PN	1210	1410	1	2	WNW	0	8	1	1	0	0
22/01/2020	3	PN	1210	1410	2	2	WNW	0	8	0	0	0	0
29/01/2020	6	MW	0830	1130	1	3	SW	0	8	1	1	1	1
29/01/2020	6	MW	0830	1130	2	3	SW	0	8	1	1	1	1
29/01/2020	6	MW	0830	1130	3	3	SW	0	8	1	1	1	1
29/01/2020	6	MW	1200	1400	1	3	SW	0	8	1	1	1	1
29/01/2020	6	MW	1200	1400	2	3	SW	0	8	0	0	1	1
30/01/2020	2	MW	0815	1115	1	6	SW	4	8	1	1	0	1
30/01/2020	2	MW	0815	1115	2	6	SW	4	8	1	1	0	1
30/01/2020	2	MW	0815	1115	3	7	SW	3	8	1	1	0	1
30/01/2020	6	MW	1145	1345	1	7	SW	3	8	0	0	0	1
30/01/2020	6	MW	1145	1345	2	7	SW	4	8	1	1	0	1
31/01/2020	5	MW	0800	1100	1	5	SSW	4	8	1	1	0	0
31/01/2020	5	MW	0800	1100	2	6	SSW	3	8	2	2	0	0
31/01/2020	5	MW	0800	1100	3	6	SSW	4	8	2	2	0	0
31/01/2020	5	MW	1130	1330	1	6	SSW	4	8	1	1	0	0
31/01/2020	5	MW	1130	1330	2	6	SSW	4	8	0	0	0	0
25/02/2020	5	PN	0730	1030	1	4	WNW	2	7	2	2	2	1
25/02/2020	5	PN	0730	1030	2	4	WNW	2	7	2	2	2	1
25/02/2020	5	PN	0730	1030	3	4	WNW	0	6	2	2	2	1
25/02/2020	5	PN	1100	1400	1	5	WNW	0	3	2	2	2	1
25/02/2020	5	PN	1100	1400	2	5	WNW	0	2	2	2	2	1
25/02/2020	5	PN	1100	1400	3	4	WNW	2	4	2	2	2	1
03/03/2020	4	JRM	0750	1150	1	3	SSW	1	8	0	0	0	1
03/03/2020	4	JRM	0750	1150	2	3	SW	0	3	1	2	0	1
03/03/2020	4	JRM	0750	1150	3	5	WSW	0	6	1	2	0	1
03/03/2020	2	PN	0915	1215	1	4	W	0	7	2	2	0	1
03/03/2020	2	PN	0915	1215	2	4	W	0	7	2	2	0	1
03/03/2020	2	PN	0915	1215	3	4	W	2	7	2	2	0	1
03/03/2020	4	JRM	1220	1520	1	5	SW	0	5	1	2	0	1
03/03/2020	4	JRM	1220	1520	2	5	WSW	0	6	2	2	0	1
03/03/2020	4	JRM	1220	1520	3	5	SW	3	7	1	2	0	1
03/03/2020	2	PN	1245	1445	1	4	W	2	7	2	2	0	1
03/03/2020	2	PN	1245	1445	2	4	W	1	7	2	1	0	1
06/03/2020	3	JRM	0800	1100	1	3	S	0	4	2	2	0	2
06/03/2020	3	JRM	0800	1100	2	4	S	0	8	2	2	0	2
06/03/2020	3	JRM	0800	1100	3	4	S	2	8	2	2	0	2
06/03/2020	3	JRM	1130	1400	1	4	S	2	6	2	2	0	2
06/03/2020	3	JRM	1130	1400	2	5	S	0	6	2	2	0	2
06/03/2020	3	JRM	1130	1400	3	5	S	2	8	2	2	0	2
09/03/2020	4	PN	1035	1105	1	4	SW	1	8	2	1	0	0

Date	VP	Observer	Survey start time	Survey finish time	Survey hour	Wind speed	Wind direction	Rain	Cloud cover	Cloud height	Visibility	Snow	Frost
09/03/2020	2	PN	1135	1435	1	5	SW	1	8	2	2	0	0
09/03/2020	2	PN	1135	1435	2	5	SW	1	8	2	2	0	0
09/03/2020	2	PN	1135	1435	3	5	SW	1	8	2	2	0	0
11/03/2020	6	JRM	1230	1530	1	7	WSW	3	8	2	2	0	0
11/03/2020	6	JRM	1230	1530	2	7	W	2	8	2	2	0	0
11/03/2020	6	JRM	1230	1530	3	7	W	0	8	2	2	0	0
11/03/2020	6	JRM	1600	1710	1	7	W	2	8	2	2	0	0
11/03/2020	6	JRM	1600	1710	2	6	W	4	8	2	2	0	0
12/03/2020	6	MW	0700	1000	1	6	SW	3	8	2	2	1	1
12/03/2020	6	MW	0700	1000	2	6	SW	0	8	2	2	1	1
12/03/2020	6	MW	0700	1000	3	6	SW	0	8	2	2	1	1
12/03/2020	3	JM	0900	1200	1	6	SSW	0	8	2	2	2	1
12/03/2020	3	JM	0900	1200	2	6	SSW	0	8	2	2	2	1
12/03/2020	3	JM	0900	1200	3	6	SSW	0	8	2	2	2	1
12/03/2020	6	MW	1030	1300	1	7	SW	0	8	2	2	1	1
12/03/2020	6	MW	1030	1300	2	7	SW	0	8	2	2	0	1
12/03/2020	6	MW	1030	1300	3	7	SW	0	8	2	2	0	1
12/03/2020	3	JM	1230	1430	1	7	SSW	2	8	2	2	0	1
12/03/2020	3	JM	1230	1430	2	6	SSW	3	8	2	2	0	1
13/03/2020	2	JRM	0810	1110	1	4	NNE	0	2	2	2	0	1
13/03/2020	2	JRM	0810	1110	2	5	NE	0	3	2	2	0	1
13/03/2020	2	JRM	0810	1110	3	5	ENE	0	3	2	2	0	1
13/03/2020	2	JRM	1140	1155	1	5	ENE	0	4	2	2	0	1
13/03/2020	6	JRM	1225	1355	1	3	ENE	0	4	2	2	0	1
13/03/2020	6	JRM	1225	1355	2	4	ENE	0	8	2	2	0	1

C.2 Winter Walkover Surveys

Winter walkover surveys were undertaken during the 2019/2020 non-breeding season. **Table C-4** details survey dates and weather data recorded. Refer to **Annex B** for survey methodology and **Annex D** for survey results.

Table C-4 Meteorological conditions during winter walkover surveys at Cumberhead West Wind Farm (sorted chronologically)

Date	Survey visit	Observer	Survey start time	Survey finish time	Survey hour	Wind speed	Wind direction	Rain	Cloud cover	Cloud height	Visibility	Snow	Frost
26/11/2019	1	MW	0800	1300	1	2	SSE	0	8	1	1	0	0
26/11/2019	1	MW	0800	1300	2	3	ESE	0	8	0	0	0	0
26/11/2019	1	MW	0800	1300	3	3	ESE	0	8	0	0	0	0
26/11/2019	1	MW	0800	1300	4	3	ESE	0	8	1	1	0	0
26/11/2019	1	MW	0800	1300	5	4	E	4	8	1	1	0	0
27/11/2019	1	MW	0800	1300	1	1	ESE	0	8	1	1	0	0
27/11/2019	1	MW	0800	1300	2	1	E	0	8	0	0	0	0
27/11/2019	1	MW	0800	1300	3	1	E	0	8	1	1	0	0
27/11/2019	1	MW	0800	1300	4	1	ENE	0	8	0	0	0	0
27/11/2019	1	MW	0800	1300	5	2	ENE	0	8	0	0	0	0
20/01/2020	2	MW	0830	1330	1	5	WSW	0	8	2	2	0	0
20/01/2020	2	MW	0830	1330	2	5	WSW	0	8	2	2	0	0

Date	Survey visit	Observer	Survey start time	Survey finish time	Survey hour	Wind speed	Wind direction	Rain	Cloud cover	Cloud height	Visibility	Snow	Frost
20/01/2020	2	MW	0830	1330	3	6	WSW	0	8	2	2	0	0
20/01/2020	2	MW	0830	1330	4	5	WSW	0	8	2	2	0	0
20/01/2020	2	MW	0830	1330	5	5	WSW	0	8	2	2	0	0
22/01/2020	2	MW	0815	1315	1	3	WSW	0	8	1	1	0	0
22/01/2020	2	MW	0815	1315	2	4	WSW	0	8	1	1	0	0
22/01/2020	2	MW	0815	1315	3	4	WSW	0	8	1	1	0	0
22/01/2020	2	MW	0815	1315	4	4	WSW	0	8	1	1	0	0
22/01/2020	2	MW	0815	1315	5	4	WSW	3	8	1	1	0	0
10/02/2020	3	MW	0830	1200	1	6	SW	3	8	1	1	1	1
10/02/2020	3	MW	0830	1200	2	6	SW	3	8	1	1	1	1
10/02/2020	3	MW	0830	1200	3	6	SW	3	8	1	1	1	1
10/02/2020	3	MW	0830	1200	4	7	SW	3	8	1	1	1	1
18/02/2020	3	MW	0800	1300	1	5	SW	0	8	2	2	0	1
18/02/2020	3	MW	0800	1300	2	6	SW	0	8	2	2	0	1
18/02/2020	3	MW	0800	1300	3	6	SW	0	8	2	2	0	1
18/02/2020	3	MW	0800	1300	4	7	SW	3	8	2	2	0	1
18/02/2020	3	MW	0800	1300	5	7	SW	3	8	2	2	0	1
26/11/2019	1	MW	0800	1300	1	2	SSE	0	8	1	1	0	0
26/11/2019	1	MW	0800	1300	2	3	ESE	0	8	0	0	0	0
26/11/2019	1	MW	0800	1300	3	3	ESE	0	8	0	0	0	0
26/11/2019	1	MW	0800	1300	4	3	ESE	0	8	1	1	0	0
26/11/2019	1	MW	0800	1300	5	4	E	4	8	1	1	0	0
27/11/2019	1	MW	0800	1300	1	1	ESE	0	8	1	1	0	0
27/11/2019	1	MW	0800	1300	2	1	E	0	8	0	0	0	0
27/11/2019	1	MW	0800	1300	3	1	E	0	8	1	1	0	0
27/11/2019	1	MW	0800	1300	4	1	ENE	0	8	0	0	0	0
27/11/2019	1	MW	0800	1300	5	2	ENE	0	8	0	0	0	0
20/01/2020	2	MW	0830	1330	1	5	WSW	0	8	2	2	0	0
20/01/2020	2	MW	0830	1330	2	5	WSW	0	8	2	2	0	0
20/01/2020	2	MW	0830	1330	3	6	WSW	0	8	2	2	0	0
20/01/2020	2	MW	0830	1330	4	5	WSW	0	8	2	2	0	0
20/01/2020	2	MW	0830	1330	5	5	WSW	0	8	2	2	0	0
22/01/2020	2	MW	0815	1315	1	3	WSW	0	8	1	1	0	0
22/01/2020	2	MW	0815	1315	2	4	WSW	0	8	1	1	0	0
22/01/2020	2	MW	0815	1315	3	4	WSW	0	8	1	1	0	0
22/01/2020	2	MW	0815	1315	4	4	WSW	0	8	1	1	0	0
22/01/2020	2	MW	0815	1315	5	4	WSW	3	8	1	1	0	0
10/02/2020	3	MW	0830	1200	1	6	SW	3	8	1	1	1	1
10/02/2020	3	MW	0830	1200	2	6	SW	3	8	1	1	1	1
10/02/2020	3	MW	0830	1200	3	6	SW	3	8	1	1	1	1
10/02/2020	3	MW	0830	1200	4	7	SW	3	8	1	1	1	1
18/02/2020	3	MW	0800	1300	1	5	SW	0	8	2	2	0	1
18/02/2020	3	MW	0800	1300	2	6	SW	0	8	2	2	0	1
18/02/2020	3	MW	0800	1300	3	6	SW	0	8	2	2	0	1

Date	Survey visit	Observer	Survey start time	Survey finish time	Survey hour	Wind speed	Wind direction	Rain	Cloud cover	Cloud height	Visibility	Snow	Frost
18/02/2020	3	MW	0800	1300	4	7	SW	3	8	2	2	0	1
18/02/2020	3	MW	0800	1300	5	7	SW	3	8	2	2	0	1

C.3 Scarce Breeding Bird Surveys

Scarce breeding bird surveys were undertaken during the 2019 breeding season. **Table C-5** details survey dates and weather data recorded. Refer to **Annex B** for survey methodology and **Annex D** for survey results.

Table C-5 Meteorological conditions during scarce breeding bird surveys at Cumberhead West Wind Farm (sorted chronologically)

Date	Survey visit	Observer	Survey start time	Survey finish time	Survey hour	Wind speed	Wind direction	Rain	Cloud cover	Cloud height	Visibility	Snow	Frost
03/06/2019	1	JR	0950	1410	1	5	WSW	1	8	2	2	0	0
03/06/2019	1	JR	0950	1410	2	6	WSW	2	8	2	2	0	0
03/06/2019	1	JR	0950	1410	3	6	SW	2	8	1	1	0	0
03/06/2019	1	JR	0950	1410	4	6	SW	2	8	1	2	0	0
03/06/2019	1	JR	0950	1410	5	6	SW	2	8	1	2	0	0
04/06/2019	1	JR	0700	1300	1	2	SW	0	3	2	2	0	0
04/06/2019	1	JR	0700	1300	2	2	SW	0	3	2	2	0	0
04/06/2019	1	JR	0700	1300	3	2	SW	0	5	2	2	0	0
04/06/2019	1	JR	0700	1300	4	2	SW	0	6	2	2	0	0
04/06/2019	1	JR	0700	1300	5	2	SSW	0	7	2	2	0	0
04/06/2019	1	JR	0700	1300	6	2	SW	0	8	2	2	0	0
05/06/2019	1	JR	0740	1340	1	2	N	4	8	1	0	0	0
05/06/2019	1	JR	0740	1340	2	2	NE	3	8	1	0	0	0
05/06/2019	1	JR	0740	1340	3	1	NE	1	8	1	1	0	0
05/06/2019	1	JR	0740	1340	4	0	N/A	2	8	2	2	0	0
05/06/2019	1	JR	0740	1340	5	0	N/A	3	8	2	2	0	0
05/06/2019	1	JR	0740	1340	6	1	SW	3	8	2	2	0	0
13/07/2019	2	KS	0745	1500	1	3	W	0	6	1	2	0	0
13/07/2019	2	KS	0745	1500	2	3	W	0	6	1	2	0	0
13/07/2019	2	KS	0745	1500	3	3	W	0	6	1	2	0	0
13/07/2019	2	KS	0745	1500	4	3	W	0	6	1	2	0	0
13/07/2019	2	KS	0745	1500	5	3	W	0	4	2	2	0	0
13/07/2019	2	KS	0745	1500	6	3	W	0	4	2	2	0	0
13/07/2019	2	KS	0745	1500	7	3	W	0	4	2	2	0	0
13/07/2019	2	KS	0745	1500	8	3	W	0	4	2	2	0	0
14/07/2019	2	KS	0730	1500	1	4	NW	0	7	2	2	0	0
14/07/2019	2	KS	0730	1500	2	4	NW	0	7	2	2	0	0
14/07/2019	2	KS	0730	1500	3	4	NW	0	7	2	2	0	0
14/07/2019	2	KS	0730	1500	4	4	NW	0	7	2	2	0	0
14/07/2019	2	KS	0730	1500	5	4	NW	0	5	2	2	0	0
14/07/2019	2	KS	0730	1500	6	4	NW	0	5	2	2	0	0
14/07/2019	2	KS	0730	1500	7	4	NW	0	5	2	2	0	0
14/07/2019	2	KS	0730	1500	8	4	NW	0	5	2	2	0	0
16/07/2019	2	JR	1030	1630	1	3	SW	0	7	2	2	0	0
16/07/2019	2	JR	1030	1630	2	3	W	0	8	2	2	0	0

Date	Survey visit	Observer	Survey start time	Survey finish time	Survey hour	Wind speed	Wind direction	Rain	Cloud cover	Cloud height	Visibility	Snow	Frost
16/07/2019	2	JR	1030	1630	3	3	W	0	8	2	2	0	0
16/07/2019	2	JR	1030	1630	4	2	W	3	7	2	2	0	0
16/07/2019	2	JR	1030	1630	5	4	W	0	5	2	2	0	0
16/07/2019	2	JR	1030	1630	6	4	W	0	6	2	2	0	0
22/07/2019	2	JR	0815	1415	1	6	SW	1	8	2	2	0	0
22/07/2019	2	JR	0815	1415	2	6	SW	0	8	2	2	0	0
22/07/2019	2	JR	0815	1415	3	7	SW	0	8	2	2	0	0
22/07/2019	2	JR	0815	1415	4	7	SW	0	7	2	2	0	0
22/07/2019	2	JR	0815	1415	5	6	SW	0	6	2	2	0	0
22/07/2019	2	JR	0815	1415	6	7	SW	0	5	2	2	0	0
19/08/2019	3	MW	0800	1400	1	5	SW	2	8	2	2	0	0
19/08/2019	3	MW	0800	1400	2	6	SW	2	8	2	2	0	0
19/08/2019	3	MW	0800	1400	3	5	SW	0	8	2	2	0	0
19/08/2019	3	MW	0800	1400	4	5	SW	0	7	2	2	0	0
19/08/2019	3	MW	0800	1400	5	5	SW	2	6	2	2	0	0
19/08/2019	3	MW	0800	1400	6	5	SW	0	5	2	2	0	0

ANNEX D. ORNITHOLOGICAL SURVEY RESULTS

D.1 Flight Activity Records: Target Species

In accordance with NatureScot guidance (2017), target species are those which may be considered to be at risk from the potential effects of wind farms. All flights of target species within the turbine area and the surrounding area were mapped and are detailed in **Table D-1**.

Table D-1 Details of target species recorded during flight activity surveys (sorted by species)

Date	VP	Observer	Flight start time	Species	No. of birds	Duration (s)	Inside CRAA (seconds)					Outside CRAA (seconds)				
							0-20m	21-40m	41-100m	101-150m	>150m	0-20m	21-40m	41-100m	101-150m	>150m
12/9/2019	5	MW	0749	Golden plover	1	28	6.77	0.00	0.00	0.00	0.00	21.23	0.00	0.00	0.00	0.00
17/9/2019	2	MW	1214	Golden plover	3	35	0.00	21.09	0.00	0.00	0.00	0.00	13.91	0.00	0.00	0.00
17/9/2019	6	MW	1030	Golden plover	1	16	0.00	0.00	12.39	0.00	0.00	0.00	0.00	3.61	0.00	0.00
1/10/2019	5	MW	1130	Golden plover	36	18	3.08	0.00	0.00	0.00	0.00	14.92	0.00	0.00	0.00	0.00
7/10/2019	3	MW	1214	Golden plover	5	60	0.00	32.39	0.00	0.00	0.00	0.00	27.61	0.00	0.00	0.00
30/7/2019	3	MW	1648	Goshawk	1	35	16.51	12.38	0.00	0.00	0.00	3.49	2.62	0.00	0.00	0.00
30/7/2019	3	MW	1750	Goshawk	1	61	16.00	45.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31/7/2019	3	MW	1114	Goshawk	1	112	36.34	73.66	0.00	0.00	0.00	0.66	1.34	0.00	0.00	0.00
31/7/2019	3	MW	1150	Goshawk	1	50	20.00	30.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21/8/2019	3	MW	0911	Goshawk	1	40	8.04	24.13	0.00	0.00	0.00	1.96	5.87	0.00	0.00	0.00
26/8/2019	4	MW	1314	Goshawk	1	45	23.30	0.00	0.00	0.00	0.00	21.70	0.00	0.00	0.00	0.00
26/8/2019	6	PN	1453	Goshawk	1	8	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5/9/2019	3	MW	0600	Goshawk	1	5	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00
5/9/2019	3	MW	0730	Goshawk	1	35	35.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1/10/2019	5	MW	1310	Goshawk	1	150	0.00	98.07	24.52	0.00	0.00	0.00	21.93	5.48	0.00	0.00
1/10/2019	5	MW	1310	Goshawk	1	38	8.00	30.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28/11/2019	5	JR	0948	Goshawk	1	68	0.00	68.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9/12/2019	4	MW	1111	Goshawk	1	35	17.44	0.00	0.00	0.00	0.00	17.56	0.00	0.00	0.00	0.00
20/12/2019	2	JMR	1322	Goshawk	1	5	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6/3/2020	3	JRM	1231	Goshawk	1	1200	20.81	20.81	52.02	738.63	0.00	9.19	9.19	22.98	326.37	0.00
6/3/2020	3	JRM	1256	Goshawk	1	40	0.00	22.72	13.63	0.00	0.00	0.00	2.28	1.37	0.00	0.00
6/3/2020	3	JRM	1314	Goshawk	1	29	0.00	14.00	15.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13/3/2020	6	JRM	1245	Goshawk	1	300	0.00	0.00	20.29	30.43	152.15	0.00	0.00	9.71	14.57	72.85
31/1/2020	5	MW	0848	Hen harrier	1	65	11.83	3.55	0.00	0.00	0.00	38.17	11.45	0.00	0.00	0.00
3/3/2020	4	JRM	0946	Hen harrier	1	50	35.00	15.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10/6/2019	4	JR	0901	Herring gull	40	90	0.00	26.70	5.34	0.00	0.00	0.00	48.30	9.66	0.00	0.00
13/11/2019	3	PN	1019	Herring gull	1	160	0.00	0.00	16.99	73.64	0.00	0.00	0.00	13.01	56.36	0.00
3/9/2019	5	MW	0953	Merlin	1	35	14.80	0.00	0.00	0.00	0.00	20.20	0.00	0.00	0.00	0.00
19/8/2019	5	PN	1915	Osprey	1	110	0.00	30.35	43.84	0.00	0.00	0.00	14.65	21.16	0.00	0.00
16/9/2019	4	MW	1311	Osprey	1	120	11.37	3.79	0.00	0.00	0.00	78.63	26.21	0.00	0.00	0.00
25/7/2019	4	MW	0758	Peregrine falcon	1	25	6.59	0.00	0.00	0.00	0.00	18.41	0.00	0.00	0.00	0.00
25/7/2019	4	MW	0847	Peregrine falcon	1	20	0.00	0.00	0.00	0.00	0.00	20.00	0.00	0.00	0.00	0.00
26/7/2019	5	PN	1421	Peregrine falcon	1	120	0.00	43.93	21.96	21.96	0.00	0.00	16.07	8.04	8.04	0.00
30/8/2019	5	MW	1009	Peregrine falcon	1	110	28.51	41.19	0.00	0.00	0.00	16.49	23.81	0.00	0.00	0.00
1/10/2019	5	MW	1210	Pink-footed goose	75	65	11.96	8.97	17.94	0.00	0.00	8.04	6.03	12.06	0.00	0.00

Date	VP	Observer	Flight start time	Species	No. of birds	Duration (s)	Inside CRAA (seconds)					Outside CRAA (seconds)				
							0-20m	21-40m	41-100m	101-150m	>150m	0-20m	21-40m	41-100m	101-150m	>150m
1/10/2019	5	MW	1230	Pink-footed goose	140	60	0.00	0.00	34.38	0.00	0.00	0.00	0.00	25.62	0.00	0.00
1/10/2019	5	MW	1455	Pink-footed goose	374	80	0.00	10.63	17.72	0.00	0.00	0.00	19.37	32.28	0.00	0.00

D.2 Flight Activity Records: Secondary Species

Table D-2 details secondary species recorded per season during flight activity surveys. Secondary species were recorded to give an indication of the use of the site by these species. Refer to **Annex B** for survey methodology and **Annex C** for weather data.

Table D-2 Summary of secondary species recorded during flight activity surveys

Species	2019 breeding season		2019/2020 non-breeding season	
	No. of records	No. of birds	No. of records	No. of birds
Buzzard	59	77	47	67
Common gull	4	4	0	0
Great black-backed gull	1	1	0	0
Kestrel	25	31	18	22
Lesser black-backed gull	5	50	0	0
Red grouse	2	2	8	9
Sparrowhawk	19	32	10	11

D.3 Winter Walkover Records

Table D-3 details all the species recorded. Refer to **Annex B** for survey methodology and **Annex C** for weather data.

Table D-3 Winter walkover survey records: 2019/2020 non-breeding season

Date	Survey visit	Observer	Species	Number recorded	Notes
18/02/2020	3	MW	Goshawk	1	Adult female

D.4 Scarce Breeding Bird Records

Table D-4 details all records of raptors recorded during surveys, however only Annex 1[1] or Schedule 1[2] species are considered to be scarce breeding birds (i.e. target species). Refer to **Annex B** for survey methodology, **Annex C** for weather data and **Confidential Figure 8.2.2** for confidential data relating to breeding goshawk in 2019 and 2020.

Table D-4 Raptor records: 2019 breeding season

Date	Species	Protection status	Number recorded	Age/sex	Notes
14/07/2019	Merlin	Annex 1[1], Schedule 1[2], BoCC[3] Red	1	Adult	-
19/08/2019	Osprey	Annex 1, Schedule 1, BoCC Amber	1	Adult	Sitting on stumps, either with half a fish or a whole fish

D.5 Bird Species Index

A total of 75 bird species or signs was recorded at, or adjacent, to the site during the ornithological surveys. **Table D-5** comprises a list of all these species along with their conservation status.

Table D-5 All bird species recorded at Cumberhead West Wind Farm (May 2019 to March 2020)

Species	Conservation status	Species	Conservation status
Blackbird	BoCC Green	Long-tailed tit	BoCC Green
Blackcap	BoCC Green	Magpie	BoCC Green
Blue tit	BoCC Green	Mallard	BoCC Amber
Brambling	Schedule 1, BoCC Green	Meadow pipit	BoCC Amber
Bullfinch	BoCC Amber	Merlin	Annex 1, Schedule 1, BoCC Red
Buzzard	BoCC Green	Mistle thrush	BoCC Red
Canada goose	Not assessed	Osprey	Annex 1, Schedule 1, BoCC Amber
Carrion crow	BoCC Green	Peregrine falcon	Annex 1, Schedule 1, BoCC Green
Chaffinch	BoCC Green	Pheasant	No Status
Coal tit	BoCC Green	Pied wagtail	BoCC Green
Common crossbill	Schedule 1, BoCC Green	Pink-footed goose	BoCC Amber
Common gull	BoCC Amber	Raven	BoCC Green
Cormorant	BoCC Green	Red grouse	BoCC Amber
Cuckoo	BoCC Red	Redstart	BoCC Amber
Curlew	BoCC Red	Redwing	Schedule 1, BoCC Red
Dunnock	BoCC Amber	Reed bunting	BoCC Amber
Fieldfare	Schedule 1, BoCC Red	Robin	BoCC Green
Goldcrest	BoCC Green	Rook	BoCC Green
Golden plover	Annex 1, BoCC Green	Sand martin	BoCC Green
Goldfinch	BoCC Green	Siskin	BoCC Green
Goosander	BoCC Green	Skylark	BoCC Red
Goshawk	Schedule 1, BoCC Green	Snipe	BoCC Amber
Great black-backed gull	BoCC Amber	Song thrush	BoCC Red
Great spotted woodpecker	BoCC Green	Sparrowhawk	BoCC Green
Great tit	BoCC Green	Spotted flycatcher	BoCC Red
Grey wagtail	BoCC Red	Starling	BoCC Red
Greylag goose	BoCC Amber	Stock dove	BoCC Amber
Hen harrier	Annex 1, Schedule 1, BoCC Red	Stonechat	BoCC Green
Herring gull	BoCC Red	Swallow	BoCC Green
House martin	BoCC Amber	Swift	BoCC Amber
House sparrow	BoCC Red	Tree pipit	BoCC Red
Jackdaw	BoCC Green	Twite	BoCC Red
Jay	BoCC Green	Wheatear	BoCC Green
Kestrel	BoCC Amber	Whinchat	BoCC Red
Lapwing	BoCC Red	Willow warbler	BoCC Amber
Lesser black-backed gull	BoCC Amber	Woodpigeon	BoCC Green
Lesser redpoll	BoCC Red	Wren	BoCC Green
Linnet	BoCC Red	-	-

[1] Annex 1 of the EU Birds Directive.
[2] Schedule 1 of the Wildlife and Countryside Act 1981, as amended by the Nature Conservation Act (Scotland) 2004.
[3] BoCC – Birds of Conservation Concern (Eaton *et al.* 2015).

ANNEX E. COLLISION RISK ASSESSMENTS

Delaunay Triangulation[1] from the proposed turbine locations was used to create a wind farm area[2] and from this the Collision Risk Analysis Area (CRAA) was created using a 500 metre (m) buffer (**Figure 8.4**). Using the larger 500 m area around the turbines accounts for possible inaccuracies in the recording of flightlines and ensures the assessment is precautionary.

The aim is to have 100 % coverage of the turbines and associated CRAA by the viewsheds, however in practice this is often unachievable as a result of the topography of the site, presence of mature forestry and limited to no access outwith the site boundary. For the Proposed Development, although some small areas of the CRAA remain 'invisible' at 20 m above ground level (**Figure 8.4**), the habitat within these areas is of sufficient similarity such that the survey data collected and subsequently assessed are considered to be representative of the whole CRAA. In addition, there were no records made during any of the surveys which would suggest that this area was of any particular importance to target species. Furthermore, the flying time at risk height ($secsHahr^{-1}$) for each species is calculated as a single mean activity rate within the entirety of the CRAA.

Table E-1, **Table E-2** and

Table E-3 present the parameters which apply to each Collision Risk Model (CRM).

Table E-1 Wind farm parameters

Size of wind farm envelope	1,035.66	hectares (ha)
Number of turbines	21	turbines
Rotor diameter	155	metres (m)
Hub height	122.5	m
Max. rotor depth	0.83	m (at 15° pitch angle)
Max. chord	3.4	m
Pitch	15	degrees (°)
Rotation period	3.16	seconds (secs)
Turbine operation time	85	percent (%)
Risk height: lowest	45	m
Risk height: highest	200	m
Flight risk volume	1,605,272,457	m^3

Table E-2 CRM parameters per species

Species	Length (m)	Wingspan (m)	Assumed flight speed, v (ms^{-1})	Avoidance rate	Probability of collision	Bird transit time (secs)
Golden plover	0.28	0.72	17.9	0.98	0.0485	0.0618
Goshawk	0.62	1.65	9.7	0.98	0.1127	0.1491
Herring gull	0.64	1.5	12.8	0.98	0.0893	0.1146
Osprey	0.58	1.7	11.4	0.98	0.0944	0.1234
Peregrine falcon	0.48	1.1	12.1	0.98	0.0810	0.1080
Pink-footed goose	0.675	1.525	17.3	0.998	0.0719	0.0868

[1] Delaunay triangulation is a form of mathematical/computational geometry where a given set of points (in this case the turbine locations) are all joined to create discrete triangles. Further information is available here: https://uk.mathworks.com/help/matlab/math/delaunay-triangulation.html

[2] This was adjusted where appropriate depending on the spatial location of the turbines in relation to other turbines.

Table E-3 Visible area within the CRAA per vantage point

VP	Area (ha)	VP	Area (ha)
1	241.11	4	277.26
2	178.33	5	299.62
3	490.97	6	264.56

Birds are assumed to be active during all the daylight hours and this is estimated by calculating the number of hours per day between sunrise and sunset (adjusting for correct latitude) for the survey seasons as defined in **Table E-4** below.

Table E-4 Season definitions per species/species group

Species	Breeding season			Non-breeding season		
	Start date	End date	Hours presumed present	Start date	End date	Hours presumed present
Geese and swans	15th May	31st August	1,795	1st September	14th May	2,701
Raptors	15th March	31st August	2,648	1st September	14th March	1,848
Waders	1st April	31st July	2,438	1st August	31st March	2,058
Other	15th March	31st August	2,648	1st September	14th March	1,848

Outputs for the CRM for the following species are presented in the following order below:

- Golden plover;
- Goshawk;
- Herring gull;
- Osprey;
- Peregrine falcon; and
- Pink-footed goose.

E.1 Golden Plover

Non-Breeding Season 2019/2020

Table E-5 Golden plover flight activity

VP	Seconds at risk height	Observation effort (HaHr)	Flying time at risk height (secsHahr^{-1})
6	11.35	9,566.4140	0.000000057

Table E-6 Golden plover mortality estimates

Mean activity in wind farm at rotor height	0.00006	hr^{-1}
Total Combined rotor swept volume	438,381	m^3
Bird occupancy	0.1219	hrs/season
Bird occupancy of rotor swept volume	0.1199	bird-sec
No. of transits through rotors	1.9393	per season
Estimated collisions	0.0940	per season
Estimated collisions after correction for operation	0.0799	per season
Estimated collisions after avoidance factor	0.0016	per season
Equivalent to 1 bird every	626.02	seasons

E.2 Goshawk

Non-Breeding Season 2019/2020

Table E-7 Goshawk flight activity

VP	Seconds at risk height	Observation effort (HaHr)	Flying time at risk height (secsHahr^{-1})
3	812.55	17,758.1937	0.0000041

Table E-8 Goshawk mortality estimates

Mean activity in wind farm at rotor height	0.005	hr^{-1}
Total Combined rotor swept volume	573,107	m^3
Bird occupancy	9.2586	hrs/season
Bird occupancy of rotor swept volume	11.8997	bird-sec
No. of transits through rotors	79.8075	per season
Estimated collisions	8.9964	per season
Estimated collisions after correction for operation	7.6470	per season
Estimated collisions after avoidance factor	0.1529	per season
Equivalent to 1 bird every	6.54	seasons

E.3 Herring Gull

Breeding Season 2019

Table E-9 Herring gull flight activity

VP	Seconds at risk height	Observation effort (HaHr)	Flying time at risk height (secsHahr^{-1})
4	195.78	8,872.2519	0.000001

Table E-10 Herring gull mortality estimates

Mean activity in wind farm at rotor height	0.0011	hr^{-1}
Total Combined rotor swept volume	581,032	m^3
Bird occupancy	2.8523	hrs/season
Bird occupancy of rotor swept volume	3.7167	bird-sec
No. of transits through rotors	32.4442	per season
Estimated collisions	2.8982	per season
Estimated collisions after correction for operation	2.4635	per season
Estimated collisions after avoidance factor	0.0493	per season
Equivalent to 1 bird every	20.30	seasons

Non-Breeding Season 2019/2020

Table E-11 Herring gull flight activity

VP	Seconds at risk height	Observation effort (HaHr)	Flying time at risk height (secsHahr^{-1})
3	89.22	17,758.1937	0.00000045

Table E-12 Herring gull mortality estimates

Mean activity in wind farm at rotor height	0.00047	hr^{-1}
Total Combined rotor swept volume	581,032	m^3
Bird occupancy	0.8603	hrs/season
Bird occupancy of rotor swept volume	1.1210	bird-sec
No. of transits through rotors	9.7856	per season
Estimated collisions	0.8741	per season
Estimated collisions after correction for operation	0.7430	per season
Estimated collisions after avoidance factor	0.0149	per season
Equivalent to 1 bird every	67.29	seasons

E.4 Osprey

Breeding Season 2019

Table E-13 Osprey flight activity

VP	Seconds at risk height	Observation effort (HaHr)	Flying time at risk height (secsHahr^{-1})
5	40.19	10,786.2771	0.00000021

Table E-14 Osprey mortality estimates

Mean activity in wind farm at rotor height	0.00022	hr^{-1}
Total Combined rotor swept volume	557,257	m^3
Bird occupancy	0.5855	hrs/season
Bird occupancy of rotor swept volume	0.7318	bird-sec
No. of transits through rotors	5.9318	per season
Estimated collisions	0.5597	per season
Estimated collisions after correction for operation	0.4758	per season
Estimated collisions after avoidance factor	0.0095	per season
Equivalent to 1 bird every	105.09	seasons

E.5 Peregrine Falcon

Breeding Season 2019

Table E-15 Peregrine falcon flight activity

VP	Seconds at risk height	Observation effort (HaHr)	Flying time at risk height (secsHahr^{-1})
5	42.09	10,786.2771	0.00000022

Table E-16 Peregrine falcon mortality estimates

Mean activity in wind farm at rotor height	0.00023	hr^{-1}
Total Combined rotor swept volume	517,632	m^3
Bird occupancy	0.6133	hrs/season
Bird occupancy of rotor swept volume	0.7120	bird-sec
No. of transits through rotors	6.5950	per season
Estimated collisions	0.5341	per season
Estimated collisions after correction for operation	0.4540	per season
Estimated collisions after avoidance factor	0.0091	per season
Equivalent to 1 bird every	110.13	seasons

E.6 Pink-Footed Goose

Non-Breeding Season 2019/2020

Table E-17 Pink-footed goose flight activity

VP	Seconds at risk height	Observation effort (HaHr)	Flying time at risk height (secsHahr^{-1})
5	11,720.88	11,385.5147	0.000059

Table E-18 Pink-footed goose mortality estimates

Mean activity in wind farm at rotor height	0.06115	hr^{-1}
Total Combined rotor swept volume	594,901	m^3
Bird occupancy	165.1755	hrs/season
Bird occupancy of rotor swept volume	220.3658	bird-sec
No. of transits through rotors	2539.3235	per season
Estimated collisions	182.4993	per season
Estimated collisions after correction for operation	155.1244	per season
Estimated collisions after avoidance factor	0.3102	per season
Equivalent to 1 bird every	3.22	seasons

ANNEX F. REVIEW OF THE EFFECTS OF ARTIFICIAL LIGHT ON BIRDS IN RELATION TO DEPLOYMENT OF OBSTRUCTION LIGHTING ON WIND TURBINES

Introduction

With the increase in height of wind turbines, it is now a requirement for obstruction lighting to be added to tall turbines (>150 m) to make the structures more visible to pilots of aircraft. This review summarises the impacts of artificial light on birds and considers whether any of the known impacts might arise in birds as a consequence of deployment of obstruction lighting on wind turbines. This review was undertaken by Professor Bob Furness in September 2017.

Methods

A literature search was carried out, using tools such as Web of Knowledge and Google scholar, to identify relevant published work. Identified publications were obtained and read, in order to prepare this review paper.

Results Obtained from Literature Search

There is a large literature identifying a wide range of impacts of artificial lights on birds. The identified impacts all relate to effects occurring at night. These include:

- Disruption of photoperiod physiology of birds due to artificial light;
- Extension of daytime activity (earlier start at dawn, later end at dusk);
- Phototaxis of seabirds (birds attracted to light sources and grounded on land);
- Phototaxis of nocturnal migrants (birds attracted to light sources and grounded or killed);
- Ability of some birds to use nocturnal feeding assisted by artificial light;
- Increased predation risk for nocturnal birds resulting from artificial lighting;
- Birds better able to avoid collision when structures are illuminated; and
- Displacement of birds due to avoidance of lights.

These impacts are considered in turn below.

Disruption of photoperiod physiology of birds due to artificial light

In theory, low levels of artificial light have the potential to affect the physiological photoperiod experienced by birds, and thereby to affect the timing of their onset of activity in the morning and end of activity in the evening, as well as potentially affecting the seasonal triggers for activities such as deposition or shedding of fat stores, moult, breeding and migration (Titulaer *et al.* 2012[i], Gaston *et al.* 2013[ii], 2015[iii], De Jong *et al.* 2017[iv], Da Silva *et al.* 2017[v]). However, there are no published studies or observations reporting clear examples of any seasonal activities of birds being affected by exposure to artificial light. There are a few anecdotal examples of urban birds starting to nest in winter, and this could possibly be interpreted as birds coming into breeding condition early because their photoperiod had been affected by artificial light. However, such early breeding is generally seen only in a few bird species that are often able to breed successfully in winter if weather conditions permit. That suggests that such cases represent opportunistic breeding in urban environments rather than disruption of natural photoperiod responses. De Jong *et al*. (2017)[iv] experimented with birds in captivity, exposing them to different colours of light at night. Birds advanced their onset of activity in the morning when exposed to light at night, and advanced timing more in response to red and white light than to green light. Birds advanced timing more in response to higher intensity of artificial light. However, there have not been similar experiments with free-living wild birds, so it is uncertain if such effects occur in wild birds. Since such effects have not been reported, it seems more likely that there is very little, if any, effect of artificial light on photoperiod responses of wild birds.

Extension of daytime activity

Da Silva *et al.* (2017)[vi] used an experimental approach with wild birds, exposing the area around an automated feeding station in a forest to artificial light at night. They found a small response in some bird species, with blue tit and great tit starting to forage earlier during experimentally lighted mornings. However, no response was shown by willow/marsh tit, nuthatch, jay or blackbird, and the response of great tits was weak. The authors concluded that '*our results suggest that artificial light during winter has only small effects on timing of foraging*'. Da Silva *et al.* (2017)[vi] used an experimental approach to test whether birds start singing earlier in the morning when their forest habitat was illuminated with artificial light. They found no effect of artificial light (testing a variety of different light colours) on the timing of the dawn chorus. These results suggest that artificial light has very little, if any, impact on the available daylength for day-active birds, possibly because the natural variation in light levels is so large that artificial light makes very little difference to the natural diurnal cycle of light levels.

Phototaxis of seabirds

Most burrow-nesting shearwaters and petrels are nocturnally active. Adults rear a single chick, and 'desert' the fully-grown chick to leave it to fledge independently. Chicks fledge at night, usually just after dark, and show strong positive phototaxis; they are attracted to light. This allows them to navigate from the dark burrows at the colony to the sea, as light intensity is naturally higher over the sea than onshore. This phototaxic response is therefore important to allow fledglings to find the sea when they first leave their burrow (especially important for those petrel species that breed at colonies some distance inland from the sea). This phototaxis behavioural response is also seen, for example, in hatchling sea turtles and has the same function. Puffins also show this same response as petrels. There are numerous examples of shearwater, petrel, and puffin chicks being attracted to artificial lights at fledging, and being grounded (Wilhelm *et al*. 2013[vii], Rodriguez *et al.* 2014[viii], Gineste *et al.* 2017[ix]). This is well known, for example, at colonies in the Hawaii, Balearic Islands, Canary Islands and Azores where fledglings will collide with street lights and car headlights (Fontaine *et al.* 2011[x], Troy *et al.* 2011[xi], 2013[xii], Rodriguez *et al.* 2012a[xiii],b[xiv],c[xv], 2015a[xvi],b[xvii]). It also occurs in Scotland, for example at the islands of Rum and St Kilda (Miles *et al.* 2010[xviii]) where Manx shearwaters, European storm-petrels, Leach's storm-petrels and Atlantic puffin fledglings are grounded at street lights and illuminated windows. In virtually all of these examples, only fledglings are attracted and grounded, during the short period in late summer when chicks are departing from nesting burrows. Adults appear to be unaffected by artificial lights. Although for most colonies the numbers of fledglings distracted by artificial lights is trivial, the impact on survival of fledglings can be significant in a few cases where large colonies are close to extensive artificial lighting. In Reunion Island, 13,200 tropical shearwater fledglings were found grounded due to artificial lights, with numbers increasing from 1996 to 2015 (Gineste *et al.* 2017[ix]). At Phillip Island, Australia, 8,871 short-tailed shearwater fledglings were found grounded by lights along the roadsides, with at least 40% of these dead or dying (Rodriguez *et al.* 2014[viii]). Turning off the street lights mitigated this mortality (Rodriguez *et al*. 2014[viii]). In Kauai, Hawaii, more than 30,000 grounded fledglings of the federally threatened Newell's shearwater have been collected under lights, an impact that may be contributing to the decline of this population (Troy *et al*. 2011[xi]).

Lights on wind farm turbines in Scotland are unlikely to affect fledging puffins, shearwaters or petrels from Scottish colonies, as most of those colonies are on offshore islands immediately overlooking the sea. Fledglings are likely to disperse over the sea without seeing lights on wind turbines. Exceptions to this might be puffins from Isle of May fledging past offshore wind farms in the Forth and Tay area, Manx shearwaters and European storm petrels fledging from Sanda Islands, Kintyre, past terrestrial wind farms on the Kintyre peninsula, puffins fledging from the Shiants Islands passing terrestrial wind farms in the Western Isles, Manx shearwaters fledging from the small isles (especially Rum) and the Treshnish Isles passing terrestrial wind farms on Skye or Mull. However, the lights involved on wind turbines would be likely to represent a trivial amount of lighting relative to the street lights and house lights of local towns, villages, lighthouses, ships and fishing vessels. These fledglings are also thought to tend to fly low rather than at high altitudes, and so would not be likely to be particularly close to lights at the tops of turbines. Phototaxis of fledging seabirds in Scotland is, therefore, very unlikely to be a problem in relation to obstruction lighting on wind turbines.

Phototaxis of nocturnal migrants

It has been recognised for a very long time that nocturnal migrant birds are attracted to artificial light while migrating (Harvie Brown *et al.* 1881[xix], Horring 1926[xx], Mehlum 1977[xxi], Jones and Francis 2003[xxii]). This topic has recently received considerable attention specifically in relation to lighting at communication towers (Longcore *et al.* 2008[xxiii], Gehring *et al.* 2009[xxiv]), wind farms (Kerlinger *et al.* 2010[xxv], Hüppop and Hilgerloh 2012[xxvi]), oil and gas production platforms (Day *et al.* 2015[xxvii], Ronconi et al. 2015[xxviii]), cruise ships (Bocetti 2011)[xxix], and in general in relation to bird ecology (Zhao *et al*. 2014[xxx], Watson *et al.* 2016[xxxi]).

The strongest and most dramatic examples of phototaxis in nocturnal migration birds are the 'falls' of migrants that can occur at lighthouses and lightships, especially during foggy weather in autumn. These were studied in detail in the 1880s to 1920s. For example, Harvie Brown and Alfred Newton established a committee of the British Association for the Advancement of Science in the 1870s and sent questionnaires to lighthouse keepers throughout the British Isles to obtain data on nocturnal bird migration and the numbers of birds killed by collision with lights. As long ago as 1881, they reported that '*the brightest, whitest, fixed lights attract the most birds*', that most collisions occurred during autumn migration rather than during spring migration, and that most collisions occurred when the weather was foggy and windy (as also concluded over 100 years later by Mehlum 1977[xxi]). These same factors were identified as affecting collision rates in a study by Zhao *et al.* (2014)[xxx]. The British association annual reports show the large numbers of birds that can be killed; for example, 600 thrushes killed by collision with Skerryvore lighthouse in October 1877. A high proportion of the birds killed were juveniles, which probably at least in part explains why numbers killed tended to be much higher in autumn than in spring. Similar surveys were conducted around the same period in many different European countries. For example, the 41st annual report on birds at Danish lighthouses, for the year 1923, was published in 1926 (Horring 1926[xx]). That report mentions that at least 4,600 birds, mostly thrushes and starlings, were killed by collision at Danish lighthouses and lightships in 1923. Study of birds at lighthouses fell out of favour around the 1930s, and there is very little literature on this topic after that period, although it was recognised that large numbers of migrating birds were still being killed by collision at lighthouses (e.g. Mehlum 1977[xxi], Jones and Francis 2003[xxii]). Jones and Francis (2003)[xxii] reported that from 1960-1989 there were kills of up to 2,000 birds in a single night in autumn at Long Point lighthouse (Ontario, Canada). However, this light was fitted with a new beam in 1989, which was narrower and less powerful, and this resulted in a huge decrease in numbers of migrant birds killed. From 1990 to 2002 the mean numbers known to be killed were reduced to only about 30 birds per year. The authors point out that this highlights the '*effectiveness of simple changes in light signatures in reducing avian light attraction and mortality during migration*'.

Ronconi *et al.* (2015)[xxviii] and Day *et al.* (2015)[xxvii] both report that poor weather (e.g. fog, rain, low cloud cover) exacerbate nocturnal attraction of bird migrants to lights at oil and gas production platforms, with on occasions thousands of birds being killed in a night, especially where gas is being flared. Kerlinger *et al*. (2010) report that bright artificial lighting may have caused '*multi-bird fatality events*' at wind farms in North America, but that obstruction lighting at turbines as recommended by the Federal Aviation Administration (FAA) (flashing red lights) had no influence on bird collisions compared with turbines at the same wind farm, where there was no obstruction lighting (see also this same conclusion in Manville 2009[xxxii]). Gehring *et al.* (2009)[xxiv] reported that communication towers equipped with non-flashing/steady-burning lights in addition to red or white flashing obstruction lights were responsible for much higher numbers of bird collisions; towers with fixed lights and flashing lights were responsible for 13 bird fatalities per season, whereas towers with only flashing obstruction lights were responsible for 3.7 bird fatalities per season. They concluded that having only flashing obstruction lights reduced bird collisions significantly, a conclusion supported by Patterson (2012)[xxxiii]. Longcore *et al.* (2008)[xxiii] reported that steady-burning lights increased the numbers of birds colliding with communication towers.

Watson *et al.* (2016)[xxxi] report that more nocturnal flight calls can be detected over artificially lit areas than over dark areas. They conclude that artificial lighting changes behaviour of nocturnal migrant birds, either by changing their flight paths to pass over lit areas, by flying at lower altitudes over lit areas, by increasing their call rates over lit areas, or by remaining longer over lit areas. Hüppop and Hilgerloh (2012)[xxvi] suggest that nocturnal migrants are more vocal when conditions are adverse, so that vocalisations do not indicate bird numbers but rather the stress levels of the birds. Bocetti (2011)[xxix] identified that cruise ships, which often have bright external lighting during the night, also represent a collision hazard for nocturnal migrant birds, although it seems likely that the numbers of birds killed at cruise ships are rather small compared to numbers killed at lighthouses.

The evidence indicates that lights on wind turbines are likely to increase numbers of nocturnal migrant birds that collide. However, that increase is mainly seen if lights are steady-burning, whereas there is very little increase in collisions when lights are flashing. Obstruction lighting on wind turbines appears to be several orders of magnitude less effective than the light from lighthouses and lightships in attracting nocturnal migrant birds. Survival rates of small birds are low, and it is recognised that many birds die during migration, especially juvenile birds during autumn migration (Newton 2008)[xxxiv]. Birds that are attracted by artificial light are likely to be birds that are already at high risk of mortality because they are facing adverse weather conditions and are lost or exhausted (Newton 2008)[xxxiv]. Furthermore, Welcker *et al.* (2017)[xxxv] reported that, despite the apparent attraction of nocturnal migrating birds to lights, nocturnal migrants represented only 8.6% of all fatalities at a sample of German wind farms. They concluded that '*nocturnal migrants do not have a higher risk of collision with wind energy facilities than do diurnally active species, but rather appear to circumvent collision more effectively*'.

Phototaxis of other birds

Attraction of fledgling shearwaters, petrels and puffins, and attraction of nocturnal migrating birds to lights is well established and has been studied in detail. In contrast, there is no clear evidence from research studies or observations to suggest that other kinds of birds show attraction to lights. There seems to be little or no phototaxis shown by adult shearwaters, petrels or puffins around the British Isles, despite the strong response seen in fledglings. There is some evidence of adult petrels being attracted to bright artificial lights at night at colonies in the sub-Antarctic (e.g. Furness, pers. obvs.), but that may simply be a disorientation and grounding of birds that fly into strong beams of light such that they are unable to see where they are going. There is little evidence to suggest that those birds are attracted towards artificial light. There is little or no evidence to suggest that birds that are not undertaking migration are attracted to artificial light. While nocturnal migrants are found as collision casualties at lighthouses during the migration seasons, resident birds in summer or winter, wintering birds in winter or breeding birds in summer are not found as collision casualties in summer or winter. Seabirds breeding close to lighthouses are not found as collision casualties at lighthouses. The evidence strongly indicates that resident, breeding and wintering birds do not show phototaxis. Therefore, there is no risk due to phototaxis for resident birds, breeding or wintering birds in the vicinity of wind farms as a direct consequence of deployment of obstruction lighting on wind turbines.

Ability of some birds to use nocturnal feeding assisted by artificial light

Birds that are visual feeders and feed only during the day may benefit from artificial light that allows them to feed visually at night. This has been reported, for example, in intertidal waders. Santos *et al.* (2010)[xxxvi] found that visual feeding shorebirds fed at night in areas of the Tagus Estuary (Portugal) where artificial light allowed them to see prey. Tactile-feeding waders did not show any change in distribution attributable to the distribution of artificial light. Similarly, Da Silva *et al.* (2017)[v] found that blue tits and great tits started foraging earlier in the morning when artificial light was available. The availability of artificial light did not alter feeding times of willow/marsh tits, nuthatches, jays or blackbirds, and the effect on great tits was weak and only evident during nights when weather was poor. There are anecdotal observations of birds such as robins feeding under street lights during winter darkness in urban environments.

In the context of obstruction lighting on wind turbines, it is highly unlikely that the amount of light provided would allow birds to feed at times when natural light levels were low, so this effect is very unlikely to be seen at wind farms.

Increased predation risk for nocturnal birds resulting from artificial lighting

Canario *et al.* (2012)[xxxvii] observed short-eared owls and long-eared owls catching migrating songbirds that had been attracted to artificial lights. Oro *et al.* (2005)[xxxviii] found significantly lower survival rates of breeding adult European storm-petrels at a colony in Benidorm Island (Spain) that was illuminated by artificial lighting shining across the sea from Benidorm city compared to a control colony on the dark side of Benidorm Island. The low survival of the population exposed to artificial light was due to yellow-legged gull predation on the storm petrels which was facilitated by the artificial light allowing gulls to see, and catch, storm petrels attending the colony at night.

Amounts of light produced by obstruction lighting at the top of wind turbines will be far less than produced by the lights in the studies reported above. It is, therefore, extremely unlikely that the lighting on wind turbines would affect predation risk for nocturnal birds in the vicinity of wind farms.

Ability to avoid collision when structures are illuminated

Blackwell *et al.* (2012)[xxxix] showed that artificial lights on aircraft reduced the risk of bird strike because lights made the aircraft more detectable to birds so allowed earlier avoidance behaviour. A study of bat collisions at wind farms in Texas found that bat fatalities were more frequent at turbines without aviation lights compared with turbines with synchronised red flashing aviation lights. The lower mortality at turbines with lights applied for only one species of bat, the other species showing no difference in mortality between turbines with or without aviation lights. However, the study suggests that at least one of the bat species avoided turbines more successfully when the turbine was equipped with obstruction lighting.

Displacement of birds due to avoidance of lights

Day *et al.* (2017)[xl] reported that migrating eiders showed higher avoidance at night of an oil-production facility in Alaska when it was illuminated with a hazing light system. However, this seems to be a rare example of birds being displaced by artificial lights, and there seem to be more examples of birds using artificial lights to their benefit, such as the use by shorebirds of artificial lights to allow them to feed visually at night.

Cumulative assessment

Loss *et al.* (2015)[xli] assessed the scale of anthropogenic mortality of birds in the United States and concluded that cause-specific annual mortality was billions due to predation by domestic cats, hundreds of millions due to collisions with buildings (mainly windows) and vehicles, tens of millions due to collisions with power lines, millions due to collisions with communication towers and electrocution at power lines, and hundreds of thousands due to collisions with wind turbines. These relative impacts are likely to be in a similar ranking in Scotland, and indeed throughout most of Europe.

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