LOMOND ENERGY

MERKINS WINDFARM
ORNITHOLOGY TECHNICAL REPORT

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ORNITHOLOGY TECHNICAL REPORT

INTRODUCTION

1. This Technical Report presents the following information in support of **Chapter 10: Ornithology** of the Merkins Windfarm Environmental Statement:

   - Desk Study: information on bird distribution at the site and surrounding area, collected from various sources;
   - Baseline Survey Methods: the survey methods used between September 2008 and August 2009 in order to provide baseline information on the breeding and non-breeding bird interest at the site;
   - Baseline Survey Results: the results of baseline surveys carried out in 2008-09; and
   - Collision Risk Modelling: calculating the estimated theoretical collision risk to key species.

DESK STUDY

Protected Sites

Statutory Designations

2. The Scottish Natural Heritage Information Service (SNHi) SiteLink website was queried to find details of statutory designated sites for nature conservation near the proposed windfarm. **Table 1** provides a summary of Special Protection Areas (SPA) and Ramsar sites within 20km of the windfarm site and of Sites of Special Scientific Interest (SSSI) within 5km (**Figure 10.1**).

Table 1: Statutory designated sites.

Site	Designation	Distance	Qualifying features
Dumbarton Muir	SSSI	Adjacent to E of site	Raised bog; blanket bog. No cited ornithological interest features.
Auchenreoch Glen	SSSI	1.3km SW	Woodland/grassland habitats and Carboniferous geological features. No cited ornithological features.
Lang Craigs	SSSI	1.8km S	Upland habitat: tall herb ledge. No cited ornithological features.
Blairbeich Bog	SSSI	2.4km N	Raised bog. No cited ornithological features.

Site	Designation	Distance	Qualifying features
Caldarvan Loch	SSSI	1.8km NW	Eutrophic Loch. No cited ornithological features.
Aucheneck	SSSI	3.5km NE	Geological features. No cited ornithological features.
Hawcraig – Glenarbuck	SSSI	4.5km SSE	Rocky slope and woodland habitats. No cited ornithological features.
Glenarbuck	SSSI	4.5km SSE	Geological features. No cited ornithological features.
Loch Humphrey Burn	SSSI	4.7km SE	Geological features. No cited ornithological features.
Inner Clyde	SPA, Ramsar (and SSSI)	5.1km S	Internationally important population of wintering redshank.
Loch Lomond	SPA, Ramsar (and includes Endrick Mouth and Islands SSSI)	6km N	Internationally important population of wintering Greenland white-fronted geese. Internationally important population of breeding capercaillie.
Black Cart	SPA (and SSSI)	12km SSE	Internationally important population of wintering whooper swans.
Renfrewshire Heights	SPA (and SSSI)	16km SW	Internationally important population of breeding hen harriers.

Non-statutory Designations

3. **Chapter 9: Ecology** provides details of eight proposed Local Nature Conservation Sites (pLNCS) within 2km of the proposed windfarm.

Local Biodiversity Action Plan (LBAP)

4. The Dunbartonshire Local Biodiversity Action Plan[i] sets out key objectives to reach the aim of conserving biodiversity for the health, enjoyment and wellbeing of the people of Scotland now and in the future. One of these objectives is to halt the loss of biodiversity and continue to reverse previous losses through targeted action for species and habitats. Habitat Action Plans are set out for different types of habitat that will have benefit for the following priority bird species (**Table 2**):

Table 2: LBAP priority species benefitting from the Dunbartonshire LBAP. Group A - denotes species for which action plans were written in the EDC LBAP; Group B - denotes new LBAP priority species to East and West Dunbartonshire; Group C - denotes species of particular conservation concern, either at the UK or local level, or are known to be vulnerable

Group A	Group B	Group C
Black Grouse *Tetrao tetrix*	Barn Owl *Tyto alba*	Bullfinch *Pyrrhula pyrrhula*
Curlew *Numenius arquata*		Dipper *Cinclus cinclus*
Grey Partridge *Perdix perdix*		Golden Plover *Pluvialis apricaria*
Lapwing *Vanellus vanellus*		Goldeneye *Bucephala clangula*
Linnet *Carduelis cannabina*		Goosander *Mergus merganser*
Redshank *Tringa totanus*		Grasshopper Warbler *Locustella naevia*
Reed Bunting *Emberiza schoeniclus*		Great Spotted Woodpecker *Dendrocopos major*
Skylark *Alauda arvensis*		Green Woodpecker *Picus viridis*
Snipe *Gallinago gallinago*		Greylag Goose *Anser anser*
Tree Sparrow *Passer montanus*		Hen Harrier *Circus cyaneus*
Yellowhammer *Emberiza citrinella*		House Martin *Delichon urbica*
		House Sparrow *Passer domesticus*
		Kestrel *Falco tinnunculus*
		Kingfisher *Alcedo atthis*
		Lesser Redpoll *Carduelis cabaret*
		Lesser Whitethroat *Sylvia curruca*
		Merlin *Falco columbarius*
		Peregrine *Falco peregrinus*
		Pink-footed Goose *Anser brachyrhynchus*
		Pintail *Anas acuta*
		Pochard *Aythya ferina*
		Red-breasted Merganser *Mergus serrator*
		Redstart *Phoenicurus phoenicurus*
		Ringed Plover *Charadrius hiaticula*
		Sand Martin *Riparia riparia*

Group A	Group B	Group C
		Sedge Warbler *Acrocephalus schoenobaenus* Short-eared Owl *Asio flammeus* Song Thrush *Turdus philomelos* Sparrowhawk *Accipiter nisus* Spotted Flycatcher *Muscicapa striata* Swallow *Hirundo rustica* Swift *Apus apus* Teal *Anas crecca* Twite *Carduelis flavirostris* Tree Pipit *Anthus trivialis* Water Rail *Rallus aquaticus* Wigeon *Anas penelope* Woodcock *Scolopax rusticola*

Data Sources

5. Data requests for records of birds of conservation concern (e.g. Schedule 1, Annex I, red list, LBAP) within 2km of the site (up to 6km for golden eagle) were made to:

- Glasgow Museums Resource Centre;
- Scottish Ornithologists Club (Clyde Branch);
- Scottish Raptor Study Group;
- Central Scotland Black Grouse and Capercaillie Group; and
- Royal Society for the Protection of Birds (RSPB).

Glasgow Museums Resource Centre

6. Glasgow Museums Resource Centre provided records of birds from the Clyde Bird Reports (**Table 3**). The status and type of record was not provided (e.g. breeding, non-breeding etc.). The paucity of records highlights that the area within 2km of the site is not frequently visited by birdwatchers.

Table 3: Glasgow Museums Resource Centre records of birds.

Species	Records
Buzzard *Buteo buteo*	One record in 2003, approximately 2km north of the site.
Golden eagle *Aquila chrysaetos*	Two records from 1983 and 1985 in the Clyde Bird Report, both from the edge of the 6km search zone. There are no breeding records within the 6km search area.
Osprey *Pandion haliaetus*	One record in 2003 of a bird flying over Gallangad Plantation 2km to the northeast of the site. There are no breeding records within the 2km search area.
Red grouse *Lagopus lagopus*	One record in 2004 from Blairquhomrie Muir to the north of the site.
Grey partridge *Perdix perdix*	One record in 2004 from Gallangad Farm 2km north of the site.
Great spotted woodpecker *Dendrocopos major*	One record in 2003 from Gallangad Plantation 2km to the northeast of the site.
Skylark *Alauda arvensis*	Two records in 2003 and 2004 of birds outside the windfarm site, at Blairquhomrie Muir and Doughnot Hill.
Treecreeper *Certhia familiaris*	One record in 2004 from Gallangad Burn in woodland 2km to the northeast of the site.
Linnet *Carduelis cannabina*	One record in 2004 from Blairquhomrie Muir to the north of the site.
Snow Bunting *Plectrophenax nivalis*	One record in 2004 at Meikle White Hill approximately 1km southeast of the site.

Scottish Ornithologists Club

7. The Scottish Ornithologists Club holds no records from the search area within the last five years (response dated December 2010).

Scottish Raptor Study Group

8. No response to the data requests was received from the Scottish Raptor Study Group.

Central Scotland Black Grouse and Capercaillie Group

9. Records of black grouse numbers at eight lek sites in the Kilpatrick Hills between 1998 and 2009 were provided. Due to the sensitive nature of lek sites that may suffer adversely as a result of disturbance, full details are restricted to the **Ornithology Confidential Annex**.

10. Only two of the records were within 2km of the proposed windfarm, both records from 2009, which are the same records as those provided by the Black Grouse Survey results of this study: a lek of four birds at Auchenreoch ruins approximately 825m to the south-west of the proposed windfarm and a record of a single male on Blairquhomrie Muir, approximately 1km north of the proposed windfarm.

Royal Society for the Protection of Birds

11. The RSPB provided four records for the search area. Detailed information for three records is classified as confidential and/or sensitive. The fourth record is of probable breeding swifts at Bonhill several kilometres west of the site. RSPB hold no probable or confirmed breeding records of Annex 1 or Schedule 1 raptors within the search area.

12. Confidential records provided by RSPB, along with supplementary information obtained through consultation with RSPB area officer Yvonne Boles, are presented in the **Ornithology Confidential Annex**.

BASELINE SURVEY METHODS

13. Baseline surveys were carried out between September 2008 and August 2009 to quantify the use of the area at the site by breeding and non-breeding birds, and to allow an estimate of the theoretical risk of bird collision with the turbine rotors. All field surveys were undertaken by the experienced ornithological surveyors from Arcus Renewable Energy Consulting Ltd and RPS Group plc.

14. Survey areas were initially based on a 12-turbine layout. The scope of the proposed development was revised in March 2009 to an interim, extended 20-turbine layout, which resulted in the need to increase the size of the survey areas north of the initial 12-turbine layout. The final turbine layout was reduced in size again to a 10-turbine layout, but turbines are positioned further south than the initial 12-turbine layout. These are hereafter referred to as the "initial layout" of 12 turbines, the "interim layout" of 20 turbines, and the "final layout" of 10 turbines, which is the subject of this application. Survey area boundaries for each type of survey are displayed in **Figure 10.2** in relation to the final layout.

Breeding Bird Survey

15. Breeding bird surveys followed a modified Brown and Shepherd methodology, as detailed in Gilbert et al. (1998)[ii]. Three survey visits were made between April and June 2009, covering all areas within 500m of the interim turbine layout (**Figure 10.2**). As the final layout has turbines located further south than the interim layout, survey coverage of a full 500m buffer zone of the final layout in areas around the southernmost turbine locations was not achieved. The minimum extent of the buffer zone was of approximately 210m around Turbine 8, 300m around Turbine 5, 350m around Turbine 9 and 425m around Turbine 10. The effect of this in terms of the impact assessment is discussed in **Chapter 10: Ornithology**.

16. The Brown and Shepherd methodology is used to census upland breeding waders and was adapted to record other breeding bird species within the survey area. The

surveyors walked a predetermined transect through 500m × 500m grid squares ensuring that all points within the survey area were approached to within 100m. 20-25 minutes were spent surveying each 500m × 500m grid square. All species seen or heard were recorded accurately onto large-scale field maps, using standard British Trust for Ornithology (BTO) Common Bird Census (CBC) notation. This allowed distinction between different species and between different behaviours – particularly between behaviours indicative of breeding (e.g. singing, alarm calling, aggressive interactions, distraction displays etc.) and those not related to breeding.

17. **Table 4** provides details of the dates and weather conditions of the breeding bird surveys.

Table 4: Timing and weather conditions of breeding bird surveys.

Visit	Date	Start Time	End Time	Visibility	Wind direction	Wind speed	Cloud cover	Cloud height	Rain	Frost	Snow
1	16-Apr-09	08:50	14:30	1	E	4	8	1	0	0	0
1	17-Apr-09	08:40	14:00	2	E	4	8	2	0	0	0
2	13-May-08	08:30	10:30	2	E	3	0	-	0	0	0
2	15-May-08	10:00	15:00	2	E	4	8	2	1	0	0
3	09-Jun-09	08:30	14:30	2	W	4	7	2	1	0	0
3	10-Jun-09	09:30	14:30	2	SW	3	5	2	0	0	0

Visibility; 0 = <1km; 1 = ≥1km; 2 = ≥2km
Wind direction: according to 16-point compass
Wind speed: according to the Beaufort scale
Cloud cover: in eighths of sky
Cloud height: 0 = <150m; 1 = 150-500m; 2 = >500m
Rain: 0 = None; 1 = Drizzle/Mist; 2 = Light showers; 3 = Heavy showers; 4 = Heavy rain
Frost: 0 = None; 1 = Ground; 2 = All day
Snow: 0 = None; 1 = Onsite; 2 = On high ground only

18. For the analysis of breeding bird locations, species maps were compiled displaying records of the species from each of the three survey visits. Territories were analysed by identifying clusters of records of birds displaying breeding behaviour. A territory was defined where there was a cluster of two or more records of a bird displaying breeding behaviour and the centre of the territory was plotted at the approximate central location of the cluster. A 'probable' territory was identified at locations where there was a single record between the three visits of a bird showing some evidence of breeding behaviour at a location that did not form part of a cluster. Analysis of territory locations of target species was supplemented by data collected during the flight activity surveys (e.g. for curlew).

Breeding Raptor Survey

19. In addition to the general breeding bird survey, surveys of all suitable areas within 2km of the interim layout were carried out between March and July 2009 to establish whether any raptors of conservation concern bred within or close to the site, following methodologies detailed in Hardey *et al.* (2009)[iii]. Target species were Annex 1 (EU Birds Directive) and Schedule 1 (Wildlife and Countryside Act) listed species, including short-eared owl, and observations of buzzard, sparrowhawk and kestrel were also noted. Records of breeding raptor behaviour were supplemented by observations made during flight activity surveys (VP watches), which together, provided a robust data set to assess the presence/absence of breeding raptors near the proposed windfarm in 2009.

20. **Table 5** provides details of the dates and weather conditions of the breeding raptor surveys.

Table 5: Timing and weather conditions of breeding raptor surveys.

Date	Start Time	End Time	Visibility	Wind direction	Wind speed	Cloud cover	Cloud height	Rain	Frost	Snow
24-Mar-09	10:00	12:00	Weather became poor							
26-Mar-09	08:00	14:00	2	W	5	3	2	0/3	0	0
29-Apr-09	10:00	15:00	2	SW	3	8	2	0	0	0
29-May-09	10:15	15:40	2	S/SE/E	1-2	1-8	1-2	0	0	0
08-Jun-09	08:40	15:00	2	E	4	6	2	0	0	0
17-Jul-09	09:15	13:45	2	N	2-4	3-7	2	0	0	0

Visibility; 0 = <1km; 1 = ≥1km; 2 = ≥2km
Wind direction: according to 16-point compass
Wind speed: according to the Beaufort scale
Cloud cover: in eighths of sky
Cloud height: 0 = <150m; 1 = 150-500m; 2 = >500m
Rain: 0 = None; 1 = Drizzle/Mist; 2 = Light showers; 3 = Heavy showers; 4 = Heavy rain
Frost: 0 = None; 1 = Ground; 2 = All day
Snow: 0 = None; 1 = Onsite; 2 = On high ground only

21. The surveys in June and July focussed mainly on searching for evidence of merlin nesting in areas to the west of the site, where there is a historical record of a breeding pair (see **Ornithology Confidential Annex**).

Barn owl survey

22. Reconnaissance survey was undertaken between 08:40 and 16:00 on 29th January 2009 to identify potential barn owl nest-sites within 1km of the initial layout of the proposed windfarm. All suitable, accessible structures (barns and other buildings) and quarries within the search area would then be subject to further searches to

assess occupancy during the summer. However, there were no such structures within the initial search area. In March 2009, the search area for potential nest sites was extended to cover a 1km buffer of the interim layout, which identified buildings to the north of the site near 'The Merkins'. These buildings were not surveyed for occupancy by barn owls due to access restrictions at the time. However, they are beyond 1km from the final layout.

Long-eared owl survey

23. Long-eared owls were known to be present in the woodland to the east of the windfarm, as they were observed when leaving the site after flight activity surveys at dusk. Pellets were also found at forest edges.

24. A survey was conducted for this species between 18:30 and 21:30 on 19th March 2009. All woodland edges within 500m of the interim layout were walked between one hour before and two hours after sunset, listening for calling males. The specific survey results were supplemented by additional records of the species made during the course of other surveys.

25. Weather conditions were ideal for the survey, with no wind and no precipitation or cloud cover. The temperature was between 5-8°C.

Black grouse survey

26. Black grouse were observed when walking to VP locations and during flight activity surveys. Black grouse lek surveys were therefore conducted within 1.5km of the interim layout (**Figure 10.2**), following methodology detailed in Gilbert *et al.* (1998)[ii] in order to identify the location of lek sites in the area.

27. The surveys were carried out covering all suitable habitats within the survey area between 05:40 and 08:00 on 31st March and 1st April 2009 during suitable weather conditions. Surveyors walked through the survey area to within a minimum of 500m from every point, stopping frequently to scan the surrounding land for black grouse and to listen for their distinctive bubbling song. Locations of any lek sites detected were mapped accurately onto large-scale field maps and the lek site was revisited to count attending male and female birds.

28. The specific survey records were supplemented by additional records of black grouse made during other survey routines and when accessing and leaving the site.

29. **Table 6** provides details of the dates and weather conditions of the black grouse surveys.

Table 6: Timing and weather conditions of black grouse surveys.

Date	Start Time	End Time	Visibility	Wind direction	Wind speed	Cloud cover	Cloud height	Rain	Frost	Snow
31-Mar-09	05:30	08:00	0-1	W	3	8	0	0	0	0
01-Apr-09	05:40	08:20	0-1	W	1	0	-	0	0	0

Visibility; 0 = <1km; 1 = ≥1km; 2 = ≥2km
Wind direction: according to 16-point compass
Wind speed: according to the Beaufort scale
Cloud cover: in eighths of sky
Cloud height: 0 = <150m; 1 = 150-500m; 2 = >500m
Rain: 0 = None; 1 = Drizzle/Mist; 2 = Light showers; 3 = Heavy showers; 4 = Heavy rain
Frost: 0 = None; 1 = Ground; 2 = All day
Snow: 0 = None; 1 = Onsite; 2 = On high ground only

Breeding diver survey

30. Red-throated divers are known to be present in the local area. Specific surveys at a known location (see **Ornithology Confidential Annex** for further details) were undertaken to assess their breeding status and to assess the potential for birds to fly over the windfarm site. The potential breeding location was visited (under Schedule 1 Licence) on 2nd June 2009 between 06:00 and 08:10 and again during the early morning of 29th July 2009.

31. The surveys concluded that red-throated divers were present in 2009 and made a breeding attempt; however, no young birds were observed and it is considered that the nesting attempt was unsuccessful. Consultations were carried out with RSPB Scotland to determine the need for any additional flight activity surveys. It was agreed that no additional survey would be required as it was highly unlikely that birds would fly over the proposed windfarm site. It was considered much more likely that divers would fly between lochs and reservoirs and to the Clyde Estuary/Firth which would not result in birds flying over the windfarm site.

Winter walkover survey

32. Monthly walkovers of all areas within 500m of the initial layout were carried out between November 2008 and February 2009 to record wintering birds, in order to allow assessment of potential displacement impacts on birds that may use the site during the non-breeding season. A winter walkover of all areas within 500m of the interim layout was carried out in March 2009. The walkover method followed a similar protocol to the breeding bird survey, but ground coverage was less intensive, with transects walked approximately 300-400m apart, thus ensuring that all parts of the survey area were accessed to within 200m.

33. As the final layout has turbines located further south than the initial layout and the interim layout, survey coverage of the entire final layout and a full 500m buffer zone in areas around the southernmost turbine locations was not achieved. The effect of this in terms of the impact assessment is discussed in **Chapter 10: Ornithology**.

34. **Table 7** provides details of the dates and weather conditions of the winter walkover surveys.

Table 7: Timing and weather conditions of winter walkover surveys.

Date	Start Time	End Time	Visibility	Wind direction	Wind speed	Cloud cover	Cloud height	Rain	Frost	Snow
13-Nov-08	09:12	15:26	1/2	SW	3-5	8	1	1-3	0	0
10-Dec-08	09:40	14:40	2	W	2-3	0-1	2	0	2	2
21-Jan-09	08:50	13:50	2	SW	3	3-8	2	0-2	0	1
11-Feb-09	10:30	15:15	2	-	0	2	2	0	2	1
24-Mar-09	09:40	11:30	1	SW	3	8	1	2	0	0
26-Mar-09	09:30	12:40	2	W	4-5	5-7	2	0-2	0	0

Visibility; 0 = <1km; 1 = ≥1km; 2 = ≥2km
Wind direction: according to 16-point compass
Wind speed: according to the Beaufort scale
Cloud cover: in eighths of sky
Cloud height: 0 = <150m; 1 = 150-500m; 2 = >500m
Rain: 0 = None; 1 = Drizzle/Mist; 2 = Light showers; 3 = Heavy showers; 4 = Heavy rain
Frost: 0 = None; 1 = Ground; 2 = All day
Snow: 0 = None; 1 = Onsite; 2 = On high ground only

Flight Activity Survey

35. Vantage Point (VP) watches were undertaken between September 2008 and August 2009, using a standard methodology described in SNH guidelines (2005)[iv].

36. Two VP locations (VP1 and VP2) were initially selected to provide coverage of the initial layout and surrounding buffer zone between September 2008 and March 2009; however, a third VP location (VP3) was introduced in March 2009, at the beginning of the spring migration season, in order to provide the most efficient coverage of the extended interim layout. VP3 provides coverage of a buffer zone to the north of the final layout, which is of similar habitat to that within the final layout, therefore data collected from VP3 are included in the analyses of flight activity (for the breeding season only, as no data were collected from VP3 during the non-breeding season).

37. Non-breeding season and autumn migration watches were completed from the original two VP locations. Spring and breeding season watches were completed from all three VPs.

38. Grid references of the VP locations are:

- VP1 – NS 44007 79244; 180° arc centred on bearing 328°.
- VP2 – NS 44449 80623; 180° arc centred on bearing 270°.
- VP3 – NS 42359 81572; 180° arc centred on bearing 135°.

39. Theoretical viewsheds of the visible area from each of the VP locations are shown in **Figure 10.3**. These viewsheds were calculated assuming the surveyor was sitting at the VP location (placing head height at approximately 1m above ground), and show the area visible at 20m above ground level, which is the lowest elevation of the potential collision risk height band used during the surveys, and at 28m above ground level, which is the lowest sweep height of any of the operational rotors. It is evident that there are some small gaps in the visual coverage of the 200m buffer area around the final layout, but any birds actually at risk height (between the lowest and highest span of the rotors) at the turbine locations would be visible. Due to the nature of the terrain, it was not possible to comprehensively cover the 200m buffer areas from realistic vantage points. It is considered that flight activity at the locations adjacent to the site that are not theoretically visible would not differ significantly from the rest of the site that is visible, therefore the observations of bird flight activity achieved from the VPs provide a representative sample of bird flight activity in the area on which to base a robust assessment of collision risk and use of the site by foraging birds.

40. Each survey consisted of two 2-hour watches, with a break of at least 15 minutes between each 2-hour session to maintain observer alertness. Surveyors did not move around during the break in a way which might have caused disturbance to birds resulting in any effect on subsequent VP watches. Watches were carried out at various times of day, including at dawn and dusk, and were usually carried out during conditions of at least moderate visibility. On occasions when visibility was poor (<1km), only auditory records of vocal species would be valid for inclusion in the assessment of collision risk. The duration of VP observations during conditions of poor visibility has been excluded from analyses of flight activity of waders and raptors, but has been retained in analyses of collision risk for geese. It is considered that a representative sample of flight activity of target species has been collected during each season within the twelve-month survey period. The duration of observations made during each season exceeds the minimum recommendations as set out in SNH guidelines (**Table 8**). Full details of timing and weather conditions during each survey are provided in **Table 9**.

Table 8: Summary of flight activity survey duration each season.

Season	Period	Observation duration at each VP
Autumn migration	Sep – Nov 2008	40 hours at each of VP1 and VP2. [One hour at VP2 during poor visibility]
Non-breeding	Sep 2008 – Feb 2009	64 hours at each of VP1 and VP2. [Three hours at VP2 during poor visibility]

Season	Period	Observation duration at each VP
Spring migration	Mar – mid-May 2009	44 hours at each of VP1, VP2 and VP3. [Three, two and four hours during poor visibility at VP1, VP2 and VP3 respectively]
Breeding season	Mar – Aug 2009	72 hours at each of VP1, VP2 and VP3. [Four, three and four hours during poor visibility at VP1, VP2 and VP3]

41. Target species included all diver species, all grebe species, all swan species, all wild geese (excluding feral Canada and feral greylag geese), all ducks, all herons, all raptors and owls listed on Annex 1 of the Birds Directive or Schedule 1 of the Wildlife and Countryside Act, all terns and all waders. Secondary species included all other raptors, gulls and raven. Discrete flight-lines or movements of gulls across the site were recorded separately.

42. For target species, focal sampling was carried out. The area in view from each VP was scanned until a target species was observed, at which point it was followed until it landed or flew out of sight. The flight lines of target bird species observed were recorded onto large-scale field maps. The time and duration of each flight were recorded, and the altitude of the target bird(s) was recorded at the start of the observation and at 15 second intervals thereafter in one of three height bands: <20m (below rotor height), 20-125m (at rotor height: potential collision height) and >125m (above rotor height).

43. All observed flight lines of target species were digitised in a GIS and superimposed onto a map of the windfarm. Other details of each flight, including time, number of birds, flight duration and height were entered into a database and cross-referenced by a unique numerical code to the mapped flight line.

44. Secondary species were recorded using 5-minute summaries. Each watch was sub-divided into 5-minute periods. At the end of each 5-minute period, the number and activity of all secondary species observed was recorded. The number of birds recorded in a 5-minute period was the minimum number of individuals that could account for the activity observed. If a target species was being tracked during a 5-minute period, then the activity summary for that period was abandoned and a new one started once observations of the target species had ended. Observation of target species took priority over the recording of secondary species.

45. There was no evidence of any flight activity over the site by red-throated divers that may breed in the general area, therefore additional specific watches targeting diver flight activity were not undertaken.

Table 9: Timing and weather conditions of each flight activity survey.

Date	VP	Start Time	End Time	Hour	Visibility	Wind direction	Wind speed	Cloud cover	Cloud height	Rain	Frost	Snow
26-Sep-08	2	16:15	18:15	1	1	SW	5	8	1	0	0	0
26-Sep-08	2	16:15	18:15	2	1	SW	5	8	1	0	0	0
26-Sep-08	2	18:30	20:30	1	1	SW	4	8	1	0	0	0
26-Sep-08	2	18:30	20:30	2	1	SW	4	8	1	0	0	0
30-Sep-08	1	11:40	13:40	1	2	NW	4	6	1	2	0	0
30-Sep-08	1	11:40	13:40	2	2	NW	5	6	1	1	0	0
30-Sep-08	1	13:55	15:55	1	2	NW	5	6	1	1	0	0
30-Sep-08	1	13:55	15:55	2	2	NW	5	5	2	1	0	0
14-Oct-08	1	10:10	12:10	1	2		0	6	2	0	0	0
14-Oct-08	1	10:10	12:10	2	2	SW	2	7	1	1	0	0
14-Oct-08	1	12:25	14:25	1	2	SSW	2	7	1	0	0	0
14-Oct-08	1	12:25	14:25	2	2	SW	1	6	1	0	0	0
15-Oct-08	2	06:50	08:50	1	0	SW	5	8	1	1	0	0
15-Oct-08	2	06:50	08:50	2	2	SW	6	8	0	2	0	0
15-Oct-08	2	09:05	11:05	1	2	SW	5	8	0	0	0	0
15-Oct-08	2	09:05	11:05	2	2	SW	5	8	0	0	0	0
23-Oct-08	1	11:05	13:05	1	1	SW	7	8	0	4	0	0
23-Oct-08	1	11:05	13:05	2	1	SW	8	8	0	4	0	0
23-Oct-08	1	13:20	15:20	1	1	SW	8	8	1	4	0	0
23-Oct-08	1	13:20	15:20	2	2	SW	8	8	1	4	0	0
23-Oct-08	2	11:05	13:05	1	1	S	7	8	1	4	0	0
23-Oct-08	2	11:05	13:05	2	1	S	8	8	1	4	0	0
23-Oct-08	2	13:20	15:20	1	1	S	8	8	1	4	0	0
23-Oct-08	2	13:20	15:20	2	2	S	8	8	1	4	0	0
24-Oct-08	1	14:45	16:45	1	2	SSW	6	7	2	2	0	0
24-Oct-08	1	14:45	16:45	2	2	SSW	7	2	2	1	0	0
24-Oct-08	1	17:00	19:00	1	2	SSW	7	7	2	0	0	0
24-Oct-08	1	17:00	19:00	2	2	SSW	7	6	3	3	0	0
24-Oct-08	2	14:45	16:45	1	2	SW	6	7	2	1	0	0
24-Oct-08	2	14:45	16:45	2	2	SW	7	2	2	1	0	0
24-Oct-08	2	17:00	19:00	1	2	SW	7	7	2	1	0	0
24-Oct-08	2	17:00	19:00	2	2	SW	7	6	2	1	0	0
28-Oct-08	1	09:15	11:15	1	2	NE	2	2	2	0	1	0
28-Oct-08	1	09:15	11:15	2	2	NE	3	2	2	0	0	0
28-Oct-08	1	11:30	13:30	1	2	N	4	2	2	0	0	0
28-Oct-08	1	11:30	13:30	2	2	N	4	2	2	0	0	0
28-Oct-08	2	09:15	11:15	1	2	NE	2	2	2	0	1	0

Date	VP	Start Time	End Time	Hour	Visibility	Wind direction	Wind speed	Cloud cover	Cloud height	Rain	Frost	Snow
28-Oct-08	2	09:15	11:15	2	2	NE	3	2	2	0	0	0
28-Oct-08	2	11:30	13:30	1	2	N	4	2	2	0	0	0
28-Oct-08	2	11:30	13:30	2	2	N	4	2	2	0	0	0
29-Oct-08	1	06:15	08:15	1	2	W	3	7	2	0	1	2
29-Oct-08	1	06:15	08:15	2	2	W	3	4	2	0	1	2
29-Oct-08	1	08:30	10:30	1	2	SW	3	7	2	0	1	2
29-Oct-08	1	08:30	10:30	2	2	SW	3	5	2	0	1	2
29-Oct-08	2	06:15	08:15	1	2	W	3	7	2	0	1	2
29-Oct-08	2	06:15	08:15	2	2	W	3	4	2	0	1	2
29-Oct-08	2	08:30	10:30	1	2	SW	3	7	2	0	1	2
29-Oct-08	2	08:30	10:30	2	2	SW	3	5	2	0	0	2
04-Nov-08	1	13:20	15:20	1	2	ENE	4	3	2	0	0	0
04-Nov-08	1	13:20	15:20	2	2	ENE	4	6	2	0	0	0
04-Nov-08	1	15:35	17:35	1	2	ENE	3	8	2	0	0	0
04-Nov-08	1	15:35	17:35	2	1	NE	2	4	2	0	0	0
04-Nov-08	2	13:20	15:20	1	2	NE	4	3	2	0	0	0
04-Nov-08	2	13:20	15:20	2	2	NE	4	6	2	0	0	0
04-Nov-08	2	15:35	17:35	1	2	NE	3	8	2	0	0	0
04-Nov-08	2	15:35	17:35	2	2	NE	2	4	2	0	0	0
11-Nov-08	1	09:15	11:15	1	2	W	7	6	2	0	0	0
11-Nov-08	1	09:15	11:15	2	2	W	7	6	2	0	0	0
11-Nov-08	1	11:30	13:30	1	2	W	8	6	2	0	0	2
11-Nov-08	1	11:30	13:30	2	2	W	7	6	2	1	0	2
11-Nov-08	2	09:15	11:15	1	2	WNW	7	6	2	0	0	2
11-Nov-08	2	09:15	11:15	2	2	WNW	7	6	2	0	0	2
11-Nov-08	2	11:30	13:30	1	2	WNW	8	6	2	0	0	2
11-Nov-08	2	11:30	13:30	2	2	WNW	7	6	2	1	0	2
18-Nov-08	1	07:00	09:00	1	2	W	3	3	2	0	0	0
18-Nov-08	1	07:00	09:00	2	2	W	3	4	2	0	0	0
18-Nov-08	1	09:20	11:20	1	2	W	3	3	2	0	0	0
18-Nov-08	1	09:20	11:20	2	2	W	3	2	2	0	0	0
18-Nov-08	2	07:00	09:00	1	2	W	3	1	1	0	0	0
18-Nov-08	2	07:00	09:00	2	2	SW	2	1	1	0	0	0
18-Nov-08	2	09:20	11:20	1	2	SW	2	5	1	0	0	0
18-Nov-08	2	09:20	11:20	2	2	W	3	1	2	0	0	0
25-Nov-08	1	09:20	11:20	1	2	S	1	2	2	0	1	2
25-Nov-08	1	09:20	11:20	2	2	S	1	1	2	0	1	2
25-Nov-08	1	11:35	13:35	1	2	W	2	3	2	0	0	2

Date	VP	Start Time	End Time	Hour	Visibility	Wind direction	Wind speed	Cloud cover	Cloud height	Rain	Frost	Snow
25-Nov-08	1	11:35	13:35	2	2	SW	1	4	2	0	0	2
25-Nov-08	2	09:20	11:20	1	2	W	2	1	2	0	1	0
25-Nov-08	2	09:20	11:20	2	2	W	2	3	2	0	2	0
25-Nov-08	2	11:35	13:35	1	2	W	2	4	2	0	0	0
25-Nov-08	2	11:35	13:35	2	2	W	2	5	2	0	0	0
12-Dec-08	1	09:30	11:30	1	1	SSE	4	8	1	0	1	1
12-Dec-08	1	09:30	11:30	2	2	SSE	5	8	1	0	1	1
12-Dec-08	1	11:45	13:45	1	2	S	5	6	1	0	0	1
12-Dec-08	1	11:45	13:45	2	1	S	5	8	1	2	0	1
12-Dec-08	2	09:30	11:30	1	1	SE	4	8	1	1	1	2
12-Dec-08	2	09:30	11:30	2	2	S	4	8	1	0	1	2
12-Dec-08	2	11:45	13:45	1	2	S	5	8	2	0	1	2
12-Dec-08	2	11:45	13:45	2	2	S	5	8	2	0	1	2
17-Dec-08	1	11:10	13:10	1	2	SW	5	7	2	2	0	0
17-Dec-08	1	11:10	13:10	2	2	SW	5	8	1	2	0	0
17-Dec-08	1	13:25	15:25	1	1	SW	6	8	1	3	0	0
17-Dec-08	1	13:25	15:25	2	1	SW	6	8	1	2	0	0
17-Dec-08	2	11:10	13:10	1	2	SW	7	6	2	1	0	0
17-Dec-08	2	11:10	13:10	2	2	SW	8	8	1	2	0	0
17-Dec-08	2	13:25	15:25	1	2	SSW	8	8	1	3	0	0
17-Dec-08	2	13:25	15:25	2	2	SSW	8	8	0	3	0	0
06-Jan-09	1	11:35	13:35	1	2	SW	4	8	1	1	2	1
06-Jan-09	1	11:35	13:35	2	2	SW	3	8	1	1	2	1
06-Jan-09	1	13:50	15:50	1	2	SW	3	7	1	1	2	1
06-Jan-09	1	13:50	15:50	2	2	SW	4	7	1	0	2	2
06-Jan-09	2	11:35	13:35	1	2	SW	4	8	2	1	2	2
06-Jan-09	2	11:35	13:35	2	2	SW	3	8	2	1	2	2
06-Jan-09	2	13:50	15:50	1	2	SW	3	7	2	0	2	2
06-Jan-09	2	13:50	15:50	2	2	SW	4	7	2	0	2	2
20-Jan-09	1	08:40	10:40	1	2	SW	3	5	2	0	0	1
20-Jan-09	1	08:40	10:40	2	2	SW	3	7	1	1	0	1
20-Jan-09	1	10:55	12:55	1	2	SW	4	8	1	1	0	1
20-Jan-09	1	10:55	12:55	2	2	SW	3	8	1	1	0	1
20-Jan-09	2	08:40	10:40	1	2	SW	4	7	1	1	0	1
20-Jan-09	2	08:40	10:40	2	2	SW	5	6	1	2	0	1
20-Jan-09	2	10:55	12:55	1	2	SW	5	8	0	2	0	1
20-Jan-09	2	10:55	12:55	2	2	SW	4	8	0	1	0	1
12-Feb-09	1	11:25	13:25	1	1	SSE	4	8	0	2	1	1

Date	VP	Start Time	End Time	Hour	Visibility	Wind direction	Wind speed	Cloud cover	Cloud height	Rain	Frost	Snow
12-Feb-09	1	11:25	13:25	2	1	S	3	8	0	2	0	0
12-Feb-09	1	13:40	15:40	1	1	S	2	8	0	1	0	1
12-Feb-09	1	13:40	15:40	2	1	S	2	8	0	1	0	1
12-Feb-09	2	11:25	13:25	1	1	SE	3	8	1	1	1	1
12-Feb-09	2	11:25	13:25	2	1	S	3	8	1	1	0	1
12-Feb-09	2	13:40	15:40	1	0	SW	3	8	1	1	0	1
12-Feb-09	2	13:40	15:40	2	0	S	3	8	1	1	0	1
24-Feb-09	1	06:25	08:25	1	2	SW	2	4	2	0	0	0
24-Feb-09	1	06:25	08:25	2	2	SW	2	5	2	0	0	0
24-Feb-09	1	08:40	10:40	1	1	SW	3	8	1	1	0	0
24-Feb-09	1	08:40	10:40	2	2	SW	2	8	1	1	0	0
24-Feb-09	2	06:25	08:25	1	2	WNW	1	5	2	0	0	0
24-Feb-09	2	06:25	08:25	2	2	W	1	4	0	0	0	0
24-Feb-09	2	08:40	10:40	1	2	W	2	7	0	0	0	0
24-Feb-09	2	08:40	10:40	2	2	WNW	2	8	1	1	0	0
03-Mar-09	1	14:40	16:40	1	2	SSW	6	8	1	2	0	0
03-Mar-09	1	14:40	16:40	2	2	SW	6	8	1	3	0	0
03-Mar-09	1	16:55	18:55	1	2	SW	6	8	0	3	0	0
03-Mar-09	1	16:55	18:55	2	1	SW	7	8	0	4	0	0
03-Mar-09	2	14:40	16:40	1	2	S	4	8	2	2	0	0
03-Mar-09	2	14:40	16:40	2	2	S	5	8	2	3	0	0
03-Mar-09	2	16:55	18:55	1	2	S	4	8	1	3	0	0
03-Mar-09	2	16:55	18:55	2	1	S	4	8	1	3	0	0
10-Mar-09	1	05:45	07:45	1	2	SW	1	1	2	0	1	0
10-Mar-09	1	05:45	07:45	2	2	SW	1	1	2	0	1	0
10-Mar-09	1	08:00	10:00	1	2	SW	1	1	2	0	0	0
10-Mar-09	1	08:00	10:00	2	2	SW	3	0	2	0	0	0
10-Mar-09	2	05:45	07:45	1	2		0		0	0	1	0
10-Mar-09	2	05:45	07:45	2	2		0		0	0	1	0
10-Mar-09	2	08:00	10:00	1	2	SE	1	0	0	0	1	0
10-Mar-09	2	08:00	10:00	2	2	SW	2	0	0	0	0	0
10-Mar-09	3	05:45	07:45	1	2		0	1	2	0	1	2
10-Mar-09	3	05:45	07:45	2	2		0	1	2	0	1	2
10-Mar-09	3	08:00	10:00	1	2	NW	1	1	2	0	1	2
10-Mar-09	3	08:00	10:00	2	2	NW	2	1	2	0	0	2
13-Mar-09	3	15:00	17:00	1	2	W	8	6	2	2	0	0
13-Mar-09	3	15:00	17:00	2	2	WNW	6	7	2	2	0	0
13-Mar-09	3	17:15	19:15	1	2	WNW	6	7	1	3	0	0

Date	VP	Start Time	End Time	Hour	Visibility	Wind direction	Wind speed	Cloud cover	Cloud height	Rain	Frost	Snow
13-Mar-09	3	17:15	19:15	2	2	WNW	7	6	1	2	0	0
24-Mar-09	1	05:15	07:15	1	2	SW	2	6	2	0	1	0
24-Mar-09	1	05:15	07:15	2	2	SW	2	7	2	0	1	0
24-Mar-09	1	07:30	09:30	1	2	SW	3	8	2	0	1	0
24-Mar-09	1	07:30	09:30	2	2	SW	3	8	2	0	0	0
24-Mar-09	2	05:15	07:15	1	2	S	1	0	0	0	1	0
24-Mar-09	2	05:15	07:15	2	2	S	1	8	1	0	1	0
24-Mar-09	2	07:30	09:30	1	2	SW	2	8	1	0	1	0
24-Mar-09	2	07:30	09:30	2	2	SW	3	8	1	0	0	0
24-Mar-09	3	05:15	07:15	1	2	W	1	2	2	0	1	0
24-Mar-09	3	05:15	07:15	2	2	W	2	6	2	0	1	0
24-Mar-09	3	07:30	09:30	1	2	W	2	8	2	0	0	0
24-Mar-09	3	07:30	09:30	2	2	W	3	8	2	0	0	0
27-Mar-09	1	09:05	11:05	1	2	W	5	8	2	2	0	0
27-Mar-09	1	09:05	11:05	2	2	W	6	8	2	2	0	0
27-Mar-09	1	11:20	13:20	1	1	W	5	8	2	2	0	0
27-Mar-09	1	11:20	13:20	2	1	W	5	8	2	2	0	0
27-Mar-09	2	09:05	11:05	1	2	NW	6	8	2	3	0	0
27-Mar-09	2	09:05	11:05	2	2	NW	6	8	2	3	0	0
27-Mar-09	2	11:20	13:20	1	2	NW	6	7	2	2	0	0
27-Mar-09	2	11:20	13:20	2	2	NW	6	8	2	3	0	0
27-Mar-09	3	09:05	11:05	1	2	W	6	7	2	3	0	0
27-Mar-09	3	09:05	11:05	2	2	W	5	8	2	3	0	0
27-Mar-09	3	11:20	13:20	1	1	W	5	8	1	3	0	0
27-Mar-09	3	11:20	13:20	2	1	W	6	8	1	3	0	0
31-Mar-09	1	08:00	10:00	1	1	SW	4	8	1	1	0	0
31-Mar-09	1	08:00	10:00	2	2	SW	4	8	1	0	0	0
31-Mar-09	1	10:15	12:15	1	2	SW	4	6	2	0	0	0
31-Mar-09	1	10:15	12:15	2	2	SW	4	5	2	0	0	0
31-Mar-09	2	08:00	10:00	1	1	WSW	4	8	0	1	0	0
31-Mar-09	2	08:00	10:00	2	2	WSW	4	7	1	0	0	0
31-Mar-09	2	10:15	12:15	3	2	WSW	4	3	1	0	0	0
31-Mar-09	2	10:15	12:15	4	2	WSW	4	6	1	0	0	0
31-Mar-09	3	08:00	10:00	1	1	W	4	8	1	1	0	0
31-Mar-09	3	08:00	10:00	2	2	W	4	6	1	0	0	0
31-Mar-09	3	10:15	12:15	1	2	W	4	4	1	0	0	0
31-Mar-09	3	10:15	12:15	2	2	W	3	3	1	0	0	0
01-Apr-09	1	08:30	10:30	1	2	S	2	1	2	0	0	0

Date	VP	Start Time	End Time	Hour	Visibility	Wind direction	Wind speed	Cloud cover	Cloud height	Rain	Frost	Snow
01-Apr-09	1	08:30	10:30	2	2	SW	3	4	2	0	0	0
01-Apr-09	1	10:45	12:45	1	2	SW	3	8	2	0	0	0
01-Apr-09	1	10:45	12:45	2	2	SW	3	8	2	0	0	0
01-Apr-09	2	08:30	10:30	1	2		1	4	2	0	0	0
01-Apr-09	2	08:30	10:30	2	2	SW	4	7	1	0	0	0
01-Apr-09	2	10:45	12:45	1	2	SW	5	8	1	0	0	0
01-Apr-09	2	10:45	12:45	2	2	SW	4	8	1	0	0	0
01-Apr-09	3	08:30	10:30	1	1	SW	1	0	0	0	0	0
01-Apr-09	3	08:30	10:30	2	2	SW	2	3	1	0	0	0
01-Apr-09	3	10:45	12:45	1	2	SW	3	8	2	0	0	0
01-Apr-09	3	10:45	12:45	2	2	SW	3	8	2	0	0	0
03-Apr-09	1	08:15	10:15	1	0	S	2	8	0	0	0	0
03-Apr-09	1	08:15	10:15	2	0	S	2	8	0	0	0	0
03-Apr-09	1	10:30	12:30	1	0	S	2	8	0	0	0	0
03-Apr-09	1	10:30	12:30	2	1	S	1	8	0	0	0	0
03-Apr-09	2	08:15	10:15	1	0	SE	3	8	0	0	0	0
03-Apr-09	2	08:15	10:15	2	1	SE	3	8	0	0	0	0
03-Apr-09	2	10:30	12:30	1	0	SE	2	8	1	0	0	0
03-Apr-09	2	10:30	12:30	2	2	E	2	8	1	0	0	0
03-Apr-09	3	08:15	10:15	1	1	SW	1	8	0	0	0	0
03-Apr-09	3	08:15	10:15	2	0	SW	1	8	0	0	0	0
03-Apr-09	3	10:30	12:30	1	0	SW	1	8	0	0	0	0
03-Apr-09	3	10:30	12:30	2	1	SW	1	8	0	0	0	0
15-Apr-09	1	08:35	10:35	1	1	E	4	8	1	0	0	0
15-Apr-09	1	08:35	10:35	2	2	E	4	6	2	0	0	0
15-Apr-09	1	10:50	12:50	1	2	E	4	7	2	0	0	0
15-Apr-09	1	10:50	12:50	2	2	E	4	8	2	0	0	0
15-Apr-09	2	08:35	10:35	1	1	NE	3	7	1	0	0	0
15-Apr-09	2	08:35	10:35	2	1	NE	4	7	2	0	0	0
15-Apr-09	2	10:50	12:50	1	1	Ne	4	8	2	0	0	0
15-Apr-09	2	10:50	12:50	2	1	Ne	4	8	2	0	0	0
15-Apr-09	3	08:35	10:35	1	1	SE	7	8	0	0	0	0
15-Apr-09	3	08:35	10:35	2	1	SE	6	8	0	0	0	0
15-Apr-09	3	10:50	12:50	3	1	SE	6	8	1	0	0	0
15-Apr-09	3	10:50	12:50	4	1	SE	5	8	1	0	0	0
29-Apr-09	1	04:35	06:35	1	2	E	2	8	2	0	0	0
29-Apr-09	1	04:35	06:35	2	2	E	3	8	2	0	0	0
29-Apr-09	1	06:50	08:50	1	2	E	2	8	1	0	0	0

Date	VP	Start Time	End Time	Hour	Visibility	Wind direction	Wind speed	Cloud cover	Cloud height	Rain	Frost	Snow
29-Apr-09	1	06:50	08:50	2	2	E	2	8	0	1	0	0
29-Apr-09	2	04:35	06:35	1	2	E	2	8	2	0	0	0
29-Apr-09	2	04:35	06:35	2	2	E	2	8	2	0	0	0
29-Apr-09	2	06:50	08:50	1	2	E	4	8	2	0	0	0
29-Apr-09	2	06:50	08:50	2	2	E	5	8	2	0	0	0
29-Apr-09	3	04:35	06:35	1	2	NE	3	8	1	0	0	0
29-Apr-09	3	04:35	06:35	2	2	NE	2	8	1	0	0	0
29-Apr-09	3	06:50	08:50	1	2	NE	2	8	1	0	0	0
29-Apr-09	3	06:50	08:50	2	2	E	4	8	1	0	0	0
07-May-09	1	04:20	06:20	1	1	SW	6	8	0	3	0	0
07-May-09	1	04:20	06:20	2	2	SW	6	5	1	0	0	0
07-May-09	1	06:35	08:35	1	1	SW	7	7	1	2	0	0
07-May-09	1	06:35	08:35	2	1	SW	6	8	1	3	0	0
07-May-09	2	04:15	06:15	1	1	W	5	7	1	0	0	0
07-May-09	2	04:15	06:15	2	1	S	6	8	1	3	0	0
07-May-09	2	06:30	08:30	3	1	S	7	8	1	1	0	0
07-May-09	2	06:30	08:30	4	1	S	7	7	1	1	0	0
07-May-09	3	04:20	06:20	1	0	W	6	6	2	3	0	0
07-May-09	3	04:20	06:20	2	0	W	6	5	2	3	0	0
07-May-09	3	06:35	08:35	1	2	SW	7	7	2	2	0	0
07-May-09	3	06:35	08:35	2	1	SW	6	8	2	3	0	0
14-May-09	1	18:10	20:10	1	2	E	4	3	2	0	0	0
14-May-09	1	18:10	20:10	2	2	E	5	3	2	0	0	0
14-May-09	1	20:25	22:25	1	2	E	5	2	2	0	0	0
14-May-09	1	20:25	22:25	2	2	E	5	2	2	0	0	0
14-May-09	2	18:10	20:10	1	2	E	4	3	2	0	0	0
14-May-09	2	18:10	20:10	2	2	E	4	3	2	0	0	0
14-May-09	2	20:25	22:25	1	2	E	3	2	2	0	0	0
14-May-09	2	20:25	22:25	2	2	E	2	2	2	0	0	0
14-May-09	3	18:10	20:10	1	2	NE	7	4	2	0	0	0
14-May-09	3	18:10	20:10	2	2	NE	8	2	2	0	0	0
14-May-09	3	20:25	22:25	1	2	NE	7	1	2	0	0	0
14-May-09	3	20:25	22:25	2	2	NE	7	4	2	0	0	0
20-May-09	1	09:15	11:15	1	2	SW	3	7	2	0	0	0
20-May-09	1	09:15	11:15	2	2	SW	3	7	2	0	0	0
20-May-09	1	11:30	13:30	1	2	SW	4	7	2	0	0	0
20-May-09	1	11:30	13:30	2	2	SW	4	8	2	0	0	0
20-May-09	2	09:15	11:15	1	2	SW	2	8	1	0	0	0

Date	VP	Start Time	End Time	Hour	Visibility	Wind direction	Wind speed	Cloud cover	Cloud height	Rain	Frost	Snow
20-May-09	2	09:15	11:15	2	2	SW	3	8	1	0	0	0
20-May-09	2	11:30	13:30	1	1	SW	4	8	2	0	0	0
20-May-09	2	11:30	13:30	2	1	SW	3	6	2	0	0	0
20-May-09	3	09:15	11:15	1	2	SW	4	8	2	0	0	0
20-May-09	3	09:15	11:15	2	2	SW	4	7	2	0	0	0
20-May-09	3	11:30	13:30	1	2	SW	5	7	2	0	0	0
20-May-09	3	11:30	13:30	2	2	SW	5	8	2	0	0	0
03-Jun-09	1	03:55	05:55	1	2	E	3	8	2	0	0	0
03-Jun-09	1	03:55	05:55	2	2	E	3	7	2	0	0	0
03-Jun-09	1	06:10	08:10	1	2	E	3	8	2	0	0	0
03-Jun-09	1	06:10	08:10	2	2	E	3	7	2	0	0	0
03-Jun-09	2	03:55	05:55	1	2	NNE	2	8	2	0	0	0
03-Jun-09	2	03:55	05:55	2	2	NNE	2	7	2	0	0	0
03-Jun-09	2	06:10	08:10	1	2	ENE	2	7	2	0	0	0
03-Jun-09	2	06:10	08:10	2	2	ENE	2	7	2	0	0	0
03-Jun-09	3	03:55	05:55	1	2	E	2	8	2	0	0	0
03-Jun-09	3	03:55	05:55	2	2	E	2	7	2	0	0	0
03-Jun-09	3	06:10	08:10	1	2	E	1	7	2	0	0	0
03-Jun-09	3	06:10	08:10	2	2	E	2	7	2	0	0	0
01-Jul-09	1	10:25	12:25	1	2	S	2	6	2	0	0	0
01-Jul-09	1	10:25	12:25	2	2	SW	2	6	2	0	0	0
01-Jul-09	1	12:40	14:40	1	2	SW	2	8	2	0	0	0
01-Jul-09	1	12:40	14:40	2	2	SW	3	8	2	0	0	0
01-Jul-09	2	10:25	12:25	1	2	S	1	6	2	0	0	0
01-Jul-09	2	10:25	12:25	2	2	S	2	8	2	0	0	0
01-Jul-09	2	12:40	14:40	1	2	S	3	8	1	0	0	0
01-Jul-09	2	12:40	14:40	2	2	S	2	8	1	2	0	0
01-Jul-09	3	10:25	12:25	1	2	S	1	5	2	0	0	0
01-Jul-09	3	10:25	12:25	2	2	S	2	8	2	0	0	0
01-Jul-09	3	12:40	14:40	1	2	SW	2	8	2	0	0	0
01-Jul-09	3	12:40	14:40	2	2	SW	2	8	2	2	0	0
14-Jul-09	1	09:05	11:05	1	2	SW	3	7	2	0	0	0
14-Jul-09	1	09:05	11:05	2	2	SW	4	7	2	0	0	0
14-Jul-09	1	11:20	13:20	1	2	SW	4	6	2	0	0	0
14-Jul-09	1	11:20	13:20	2	2	SW	4	6	2	0	0	0
14-Jul-09	2	09:05	11:05	1	2	SSW	6	6	2	0	0	0
14-Jul-09	2	09:05	11:05	2	2	SSW	6	5	2	0	0	0
14-Jul-09	2	11:20	13:20	1	2	SSW	5	4	2	0	0	0

Date	VP	Start Time	End Time	Hour	Visibility	Wind direction	Wind speed	Cloud cover	Cloud height	Rain	Frost	Snow
14-Jul-09	2	11:20	13:20	2	2	SSW	4	4	2	0	0	0
14-Jul-09	3	09:05	11:05	1	1	SW	3	8	1	0	0	0
14-Jul-09	3	09:05	11:05	2	2	SW	3	7	1	0	0	0
14-Jul-09	3	11:20	13:20	1	2	SW	3	7	2	0	0	0
14-Jul-09	3	11:20	13:20	2	2	SW	2	6	2	0	0	0
22-Jul-09	1	09:50	11:50	1	1	SW	3	8	2	2	0	0
22-Jul-09	1	09:50	11:50	2	1	SW	3	8	1	3	0	0
22-Jul-09	1	12:05	14:05	1	0	SW	1	8	1	2	0	0
22-Jul-09	1	12:05	14:05	2	1	SW	2	8	1	2	0	0
22-Jul-09	2	09:50	11:50	1	1	SSE	2	8	1	3		
22-Jul-09	2	09:50	11:50	2	1	S	2	8	1	3	0	0
22-Jul-09	2	12:05	14:05	1	1	W	1	8	1	3	0	0
22-Jul-09	2	12:05	14:05	2	1	W	1	7	1	3	0	0
22-Jul-09	3	09:50	11:50	1	1	SE	2	8	1	3	0	0
22-Jul-09	3	09:50	11:50	2	1	S	1	8	1	3	0	0
22-Jul-09	3	12:05	14:05	1	1	W	1	8	1	3	0	0
22-Jul-09	3	12:05	14:05	2	1	W	1	7	1	3	0	0
07-Aug-09	1	04:30	06:30	1	2	S	2	2	2	0	0	0
07-Aug-09	1	04:30	06:30	2	2	S	1	5	2	0	0	0
07-Aug-09	1	06:45	08:45	1	2	S	1	7	2	0	0	0
07-Aug-09	1	06:45	08:45	2	2	S	1	8	2	0	0	0
07-Aug-09	2	04:30	06:30	1	0	SSW	1	8	2	0	0	0
07-Aug-09	2	04:30	06:30	2	2	S	2	7	2	0	0	0
07-Aug-09	2	06:45	08:45	1	2	S	1	7	2	0	0	0
07-Aug-09	2	06:45	08:45	2	2	W	1	7	2	0	0	0
07-Aug-09	3	04:30	06:30	1	1	S	1	8	1	0	0	0
07-Aug-09	3	04:30	06:30	2	2	S	1	7	2	0	0	0
07-Aug-09	3	06:45	08:45	1	2	S	1	7	2	0	0	0
07-Aug-09	3	06:45	08:45	2	2	W	1	7	2	0	0	0
27-Aug-09	1	09:30	11:30	1	2	SW	1	8	2	0	0	0
27-Aug-09	1	09:30	11:30	2	2	SW	2	8	2	0	0	0
27-Aug-09	1	11:45	13:45	1	2	SW	2	8	2	0	0	0
27-Aug-09	1	11:45	13:45	2	2	SW	3	8	2	0	0	0
27-Aug-09	2	09:30	11:30	1	2	S	4	7	2	0	0	0
27-Aug-09	2	09:30	11:30	2	2	S	5	7	2	0	0	0
27-Aug-09	2	11:45	13:45	1	2	S	5	4	2	0	0	0
27-Aug-09	2	11:45	13:45	2	2	S	6	7	2	0	0	0
27-Aug-09	3	09:30	11:30	1	2	NW	3	6	2	1	0	0

Date	VP	Start Time	End Time	Hour	Visibility	Wind direction	Wind speed	Cloud cover	Cloud height	Rain	Frost	Snow
27-Aug-09	3	09:30	11:30	2	2	SW	4	7	2	0	0	0
27-Aug-09	3	11:45	13:45	1	2	SW	4	6	2	0	0	0
27-Aug-09	3	11:45	13:45	2	2	SW	4	8	2	0	0	0

Visibility; 0 = <1km; 1 = ≥1km; 2 = ≥2km
Wind direction: according to 16-point compass
Wind speed: according to the Beaufort scale
Cloud cover: in eighths of sky
Cloud height: 0 = <150m; 1 = 150-500m; 2 = >500m
Rain: 0 = None; 1 = Drizzle/Mist; 2 = Light showers; 3 = Heavy showers; 4 = Heavy rain
Frost: 0 = None; 1 = Ground; 2 = All day
Snow: 0 = None; 1 = Onsite; 2 = On high ground only

BASELINE SURVEY RESULTS

Breeding Bird Survey

46. A total of 25 species was recorded during the BBS surveys, of which ten species bred or held territory within the survey area. One additional species is likely to have bred within the survey area but wasn't recorded during the BBS. Five breeding species are considered to be species of conservation concern (UKBAP, LBAP, Red and Amber listed species); six others are not listed as species of conservation concern (**Table 10**). No Annex 1 or Schedule 1 species were proven to have bred within the survey area.

Table 10: Species recorded breeding in the Breeding Bird Survey area in 2009

Species	Conservation Status	Details
Red grouse	Amber listed, UKBAP	No breeding behaviour recorded during the BBS, but presence of birds during the survey, coupled with observations made during flight activity surveys indicate that two or three pairs may breed within the survey area.
Common snipe (**Figure 10.4**)	Amber listed, LBAP	Between two and five territories within the survey area. One territory and two probable territories were held in the area within 500m of the final layout. One territory and one probable territory were further to the north of the final layout.

Species	Conservation Status	Details
Curlew (**Figure 10.4**)	Amber listed, UKBAP, LBAP	BBS results indicate that there were up to 11 territories held within the survey area, although many of these locations are based on detection of breeding behaviour during a single survey visit. Curlews range across a large area during the breeding season, calling and display-flighting. Based on observed flights during flight activity surveys, it is likely that there were up to two or three territories held within 500m of the final layout and probably another held within 500m of the access track route. A fifth territory may have been held beyond 500m to the north-east of the final layout.
Skylark (**Figure 10.5**)	Red listed, UKBAP, LBAP	Ubiquitous in the open habitats within the survey area, with between 90 and 120 territories estimated.
Meadow Pipit	Amber listed	Ubiquitous in the open parts of the survey area; individuals were not mapped during the survey, but estimates were made of the number of birds per 500m × 500m survey square. It is likely that 60 – 100 pairs were present within the survey area.
Wren		A low density of breeding birds, with between four and nine territories held within the survey area, typically associated with scrub or marshy grassland areas along burns.
Robin		Not recorded in the survey area during the BBS, but singing birds recorded at the edge of Nobleston Wood during the winter walkover survey.
Stonechat		Up to four territories held within the survey area, near burns or stone walls.
Blackbird		Two territories held within the survey area at the edge of Nobleston Wood.
Carrion crow		Two territories held within the survey area to the north of the final layout.
Chaffinch		Up to five territories at the eastern periphery of Nobleston Wood and another in riparian woodland at the northwest edge of the survey area.

47. A further ten species of conservation concern were recorded during the BBS; these were not considered to be breeding within the survey area, although some species may have bred within 1km of the survey area. They included: mallard, wigeon, black grouse, common gull, herring gull, lesser black-backed gull, swallow, whinchat, wheatear and mistle thrush.

48. Other common species recorded within the breeding bird survey area, but not exhibiting any behaviour indicative of breeding, included: buzzard, woodpigeon, coal tit, rook and raven.

Breeding Raptor Survey

49. The area around the windfarm provides suitable habitat for breeding hen harrier and merlin. However, no Annex 1 or Schedule 1 species were found breeding within the 2km raptor survey area. Flight activity of target raptor species, including peregrine, merlin and hen harrier, was very infrequent at the site during the breeding season, providing additional evidence to support that conclusion.

50. There is a known peregrine territory distantly to the south of the site, beyond 2km from any part of the windfarm.

51. Merlin are known to have bred within 2km north of the final layout. There is also a record of breeding merlin on the periphery of a woodland block to the east of the windfarm, although communication with a Raptor Study Group member suggested that this record was erroneous (C. Cathrine pers. comm.). Despite targeted searches of these areas in 2009, no evidence of breeding could be found. Further details of the historical records are provided in the **Ornithology Confidential Annex**.

52. A male hen harrier was observed very occasionally during flight activity surveys during the breeding season in 2009, but there was no evidence of breeding within the survey area.

53. Small numbers of buzzard (2-3 pairs), sparrowhawk (1-2 pairs) and kestrel (possibly 1 pair) bred within the 2km survey area.

Barn owl survey

54. There were no man-made structures or natural features with potential to support nesting barn owl within the barn owl survey area, and no signs of barn owl were found. No barn owls have been observed during flight activity surveys.

Long-eared owl survey

55. Long-eared owls were known to be present in the woodland to the east of the windfarm, as they were observed when walking offsite after flight activity surveys at dusk. Pellets were also found at forest edges. There were potentially two territories being held in two different woodland blocks to the east of the site: one approximately 825m away from the final layout, the other beyond 2km.

56. Survey results indicate that there was a long-eared owl territory located within Nobleston Wood, centred approximately 1km west of the final layout. Mating calls were heard around a clearing at Pappert Hill and alarm calls were made by a bird seen in the woodland approximately 500m south of the clearing.

57. Tawny owls were heard occasionally during walks on and offsite when accessing VP locations before dawn and after dusk. There are likely to be 1-2 pairs within 1km of the windfarm.

Black grouse survey

58. There was a lek of four males (but possibly up to six birds) in attendance at the ruins at Auchenreoch at approximately NS 42475 78785 (**Figure 10.6**). One female was also observed in attendance at the lek on one occasion. When disturbed, birds flew west and north-west into woodland areas away from the site. This lek site is 825m away from the nearest part of the windfarm.

59. A single male was observed further south-west, approximately 1.8km away from the final layout, but this was likely to have been a bird disturbed from the main lek and is not considered to be a separate lek site.

60. A single male was observed 1km north of the final layout but was not lekking.

61. A separate lek of two males was observed approximately 2.5km northeast of the site.

Breeding diver survey

62. An unsuccessful breeding attempt was made at a location over 2km to the east of the site. No flights over the site were observed during breeding season flight activity surveys (which included dawn and dusk watches) or during any other survey.

Winter walkover survey

63. A total of 21 species was recorded during the winter walkover surveys between November 2008 and March 2009 (**Table 11**). Ten of these are considered to be species of conservation concern (Annex 1, Schedule 1, UKBAP, LBAP, Red and Amber listed species).

Table 11: Species recorded in the survey area during the 2008/09 Winter Walkover Survey

Species	Conservation Status	Details
Canada Goose		A single bird flying high south-east to north-west over the survey area in December.
Buzzard		Single birds over the north-eastern part of the survey area in November and over the southern edge of the survey area in March.
Kestrel	Amber Listed, LBAP	A single bird in the north-western part of the survey area in November.
Peregrine	Annex 1, Schedule 1, LBAP	A female bird resting by the cairn at the summit of the Hill of Standing Stones in December.

Species	Conservation Status	Details
Red Grouse	Amber listed, UKBAP	Present in small numbers across the survey area between November and March, with the largest count of 20 individuals made in November. Between seven and ten individuals present during December to March, thinly scattered throughout the survey area.
Black Grouse	Red listed, UKBAP, LBAP	Single males present in the north-western and northern parts of the survey area in February and March respectively. Both records probably relate to the same individual.
Common Snipe	Amber listed, LBAP	Occasionally recorded during the winter period, with three single birds in the northern and eastern parts of the survey area in November, a single bird in the north-eastern sector in January, and three single individuals within the south-eastern and southern sectors of the survey area in March.
Skylark	Red listed, UKBAP, LBAP	Thinly but widely distributed across the survey area in November, but no further records until March, when 17 singing individuals were present across the entire survey area. It is apparent that the local breeding population move from the site during the colder months of the year, probably relocating to other habitats such as farmland closer to the coast and/or further to the south of the site, where weather conditions are more clement.
Meadow Pipit	Amber listed	Widely but thinly distributed around the survey area throughout the winter months, with fewest recorded during the February survey. Birds in song in March.
Wren		Widely distributed across the survey area in low numbers throughout the winter; recorded from woodland and open areas, particularly adjacent to small burns.
Robin		Single birds recorded in November and December in the plantation at the western edge of the survey area, with song noted in December.
Stonechat		One to two birds recorded in November, January and February, mostly within the northern half of the survey area, with a single record in the south-western area.
Fieldfare	Red listed, Schedule 1	A flock of five birds in the plantation at the western edge of the survey area in November.

Species	Conservation Status	Details
Redwing	Red listed, Schedule 1	A flock of five birds in the plantation at the western edge of the survey area in November.
Coal Tit		Single birds in the plantation at the western edge of the survey area in November and December.
Magpie		A single bird in the plantation at the western edge of the survey area in November.
Rook		A group of five in the plantation at the western edge of the survey area and one in flight over the site, all in November.
Carrion Crow		Between two and 14 birds recorded within the survey area throughout the winter period, with peak numbers in March.
Raven		Occasionally recorded over and within the survey area in November and between January and March, with a peak count of four over the site in January.
Chaffinch		Small numbers occasionally recorded during the winter, with a maximum of ten birds in November, and two in song from deciduous woodland at the north-western edge of the survey area in March.
Reed Bunting	Amber listed, UKBAP, LBAP	One or two birds present in the north-western sector of the survey area in January and February.

Flight Activity Survey

Target Species

64. Fifteen target species (excluding unidentified grey goose) were recorded during vantage point watches between September 2008 and August 2009. Flights are detailed for each species in **Tables 12 to 27** below. The flight "ID" is a unique code allowing cross-reference to the labelled flight-lines in the Figures. Risk height or 'potential collision height' (PCH) was defined by height recording band 2 during the flight activity surveys, as the height interval 20-125m above ground level. Grey-shaded rows indicate wildfowl flights that were either entirely above or below risk height, or that were beyond 200m from the final turbine layout; or flights of all other species that were entirely above or below risk height (within or beyond 200m from the final layout). Unshaded rows indicate wildfowl flights that were entirely or partly at risk height and within 200m of the final turbine layout; or flights of any other species that were entirely or partly at risk height.

Pink-footed Goose

65. Two flights of 18 and 44 birds, recorded in November 2008 and January 2009 respectively, both partly at risk height, but over 1.7km north of the final layout (**Figure 10.7**).

Table 12: Details of observed flights of pink-footed geese.

ID	Date	Time	VP	Number of birds	Duration of flight (s)			Within 200m of turbines
					below	at PCH	above	
PG1144	11/11/2008	09.43	1	18	0	37.5	37.5	N
PG1153	06/01/2009	12.23	1	44	0	70	126	N

66. There were incidental observations outside timed flight activity surveys of two skeins of pink-footed geese comprising 400 and 95 birds respectively flying over to the north of the survey area in January.

Greenland White-fronted Goose

67. A single flight of five birds on 28th October 2008 flew across the final layout at risk height (**Figure 10.7**).

Table 13: Details of observed flights of Greenland white-fronted geese.

ID	Date	Time	VP	Number of birds	Duration of flight (s)			Within 200m of turbines
					below	at PCH	above	
WG1139	28/10/2008	11.05	2	5	0	240	0	Y

Greylag Goose

68. A total of eight flights recorded of between four and 26 birds, the majority of which were at risk height. Three of these flights were within 200m of the final layout, whilst the remainder were to the east, west and north (**Figure 10.7**).

Table 14: Details of observed flights of greylag geese.

ID	Date	Time	VP	Number of birds	Duration of flight (s)			Within 200m of turbines
					below	at PCH	above	
GJ1130	28/01/2008	11:04	1	6	0	120	0	Y
GJ1133	28/10/2008	10:11	2	6	0	56.5	183.5	N
GJ1134	28/10/2008	10:15	2	6	0	0	45	N
GJ1138	28/10/2008	11:04	2	6	0	240	0	Y
GJ1148	18/11/2008	09:50	2	9	0	0	90	N
GJ1158	24/02/2009	09:09	2	26	0	88	132	Y
GJ1162	10/03/2009	06:49	3	4	0	211.8	28.2	N
GJ1163	10/03/2009	06:53	3	4	0	30.8	169.2	N

69. Flights GJ1130 and GJ1138 are considered to be the same birds recorded from two different vantage points.

Unidentified Grey Goose

70. Three flights of between three and 20 birds, all at risk height, but over 1.7km north of the final layout (**Figure 10.7**). These may have been greylag geese, pink-footed geese or Greenland white-fronted geese.

Table 15: Details of observed flights of unidentified grey geese.

ID	Date	Time	VP	Number of birds	Duration of flight (s)			Within 200m of turbines
					below	at PCH	above	
UO1142	04/11/2008	14:23	2	16	0	51.4	0	N
UO1143	04/11/2008	15:53	2	3	0	0	90	N
UO1145	04/11/2008	13:01	1	20	0	120	0	N

Mallard

71. A single flight of a single bird at risk height over the final layout on 20th May 2009 (**Figure 10.7**).

Table 16: Details of observed flights of mallard.

ID	Date	Time	VP	Number of birds	Duration of flight (s)			Within 200m of turbines
					below	at PCH	above	
MA1746	20/05/2009	12.13	1	1	0	90	0	Y

Red Kite

72. A total of four flights involving between two and three individuals, all recorded on 28th October 2008. One of the flights was at risk height throughout; the other three were above risk height. Two flights were within 200m of the final layout and the other two flights were to the south-east of the final layout (**Figure 10.8**).

Table 17: Details of observed flights of red kite.

ID	Date	Time	VP	Number of birds	Duration of flight (s)			Within 200m of turbines
					below	at PCH	above	
KT1128	28/10/2008	10.35	1	2	0	215	115	N
KT1129	28/10/2008	10.40	1	3	0	0	210	N
KT1136	28/10/2008	10.40	2	3	0	0	240	Y
KT1137	28/10/2008	10.44	2	2	0	0	221	Y

Hen Harrier

73. A total of 16 flights recorded of which four were at least partly within 200m of the final layout. All the flights were of single, hunting individuals, with the vast majority below risk height. Two flights were at risk height for at least a part of the flight, including one flight over the final layout. The majority of flight activity was to the north-west, north and north-east of the turbine envelope and were observed during the non-breeding season. Only two flights of hen harrier were recorded during the breeding season (April to August for hen harrier) (**Figure 10.9**).

Table 18: Details of observed flights of hen harrier.

ID	Date	Time	VP	Number of birds	Duration of flight (s)			Within 200m of turbines
					below	at PCH	above	
HH1121	26/09/2008	17.52	1	1	64.3	25.7	0	Y
HH1122	30/09/2008	13.02	1	1	71	0	0	N
HH1124	14/10/2008	13.37	2	1	16	0	0	N
HH1126	24/10/2008	15.27	1	1	59	0	0	Y
HH1132	28/10/2008	11.49	1	1	30	0	0	N
HH1135	28/10/2008	10.35	2	1	212	0	0	N
HH1146	11/11/2008	10:13	2	1	4	0	0	N
HH1147	11/11/2008	10:54	2	1	97	0	0	N
HH1148	25/11/2008	11.40	1	1	9	0	0	N
HH1154	20/01/2009	12.24	2	1	107	0	0	Y
HH1165	10/03/2009	07.39	3	1	7	0	0	N
HH1166	13/03/2009	15.13	3	1	3	0	0	N
HH1168	24/03/2009	08.38	3	1	375	0	0	N
HH1682	10/03/2009	08.08	1	1	80	0	0	Y
HH1718	20/05/2009	10.02	2	1	135	0	0	N
HH1734	01/07/2009	13.27	2	1	0	195	405	N

Osprey

74. Three flights within the survey area, all of single birds in April (1 flight) and May 2009 (2 flights), likely to be birds on passage. The two flights in May were both above risk height, with one flight over the final layout. The April flight was at risk height over the final layout (**Figure 10.8**). A fourth flight was seen several kilometres to the east of the site in July, probably hunting at the local reservoirs in that area.

Table 19: Details of observed flights of osprey.

ID	Date	Time	VP	Number of birds	Duration of flight (s)			Within 200m of turbines
					below	at PCH	above	
OP1733	20/05/2009	11.56	3	1	0	0	15	Y
OP1744	20/05/2009	11.43	1	1	0	0	195	N
OP1685	15/04/2009	11.48	2	1	0	105	30	Y

Merlin

75. Three observations, all involving single individuals; a single female bird on 15th October 2008 flew from the eastern part of the final layout at risk height before dropping low out of view; a single flight in June 2009, partly at risk height, but well north of the final layout at Auchincarroch Hill; and a low flight in August over the area just north of the final layout (**Figure 10.8**).

Table 20: Details of observed flights of merlin.

ID	Date	Time	VP	Number of birds	Duration of flight (s)			Within 200m of turbines
					below	at PCH	above	
ML1125	15/10/2008	09.58	2	1	12	49	0	Y
ML1710	03/06/2009	04.25	3	1	54.7	27.3	0	N
ML1749	27/08/2009	09.39	2	1	60	0	0	Y

Peregrine

76. A total of 11 flights, all of single birds, of which eight were at least partly at risk height. Of the 11 flights in total, five were at least partly within the final layout, with the remainder to the north, east and west of the final layout. Three of the flights that were partly at risk height were over the final layout (**Figure 10.10**).

Table 21: Details of observed flights of peregrine.

ID	Date	Time	VP	Number of birds	Duration of flight (s)			Within 200m of turbines
					below	at PCH	above	
PE1140	29/10/2008	09.04	1	1	33.75	11.25	0	Y
PE1141	29/10/2008	10.21	2	1	12.2	24.4	24.4	N
PE1152	06/01/2009	11.45	1	1	22.5	22.5	0	Y
PE1155	20/01/2009	12.41	1	1	26.5	26.5	0	N
PE1159	24/02/2009	08.23	2	1	0	13	13	N
PE1167	24/03/2009	06.21	3	1	0	0	225	N
PE1169	24/03/2009	06.15	1	1	0	45	0	N
PE1727	03/06/2009	07.51	1	1	0	45	0	Y
PE1679	01/04/2009	11.14	1	1	45	0	0	Y
PE1688	15/04/2009	09.21	1	1	45	0	0	Y
PE1742	22/07/2009	12.41	3	1	75	0	0	N

Black Grouse

77. Only two flights recorded of a male within 200m of the final layout and a male and female together just beyond 200m from the turbines; both were observed to the south-west of the final layout. Both flights were below risk height (**Figure 10.6**).

Table 22: Details of observed flights of black grouse.

ID	Date	Time	VP	Number of birds	Duration of flight (s)			Within 200m of turbines
					below	at PCH	above	
BK1127	24/10/2008	15:38	1	2	10	0	0	Y
BK1695	29/04/2009	06:34	1	1	15	0	0	N

Golden Plover

78. Three flights of between two and 14 birds on 15th April 2009, all within 200m of the east side of the final layout and all likely to relate to the same pre-breeding flock of birds present onsite for a short duration (**Figure 10.11**).

Table 23: Details of observed flights of golden plover.

ID	Date	Time	VP	Number of birds	Duration of flight (s)			Within 200m of turbines
					below	at PCH	above	
GP1689	15/04/2009	09.46	1	2	15	30	0	Y
GP1683	15/04/2009	09.35	2	14	60	0	0	Y
GP1684	15/04/2009	09.54	2	14	15	0	0	Y

Lapwing

79. Three brief flights all relating to a single bird over 500m to the north-east of the final layout. All of the flights were below risk height, and all observations were made on 20th May 2009 (**Figure 10.11**).

Table 24: Details of observed flights of lapwing.

ID	Date	Time	VP	Number of birds	Duration of flight (s)			Within 200m of turbines
					below	at PCH	above	
L1715	20/05/2009	09.43	2	1	15	0	0	N
L1716	20/05/2009	09.45	2	1	10	0	0	N
L1717	20/05/2009	09.51	2	1	10	0	0	N

Snipe

80. A total of ten flights of between one and two individuals, recorded in February (4 flights), April (3 flights), May (1 flight) and June 2009 (2 flights). All the flights were very brief and almost all below risk height. There were two centres of activity, which may relate to breeding territory locations to the north-east and to the south-east of the final layout (**Figure 10.11**).

Table 25: Details of observed flights of snipe.

ID	Date	Time	VP	Number of birds	Duration of flight (s)			Within 200m of turbines
					below	at PCH	above	
SN1156	24/02/2009	06.29	1	1	10	0	0	N
SN2257	24/02/2009	06.34	1	1	10	0	0	N
SN1160	24/02/2009	08:24	2	2	16	0	0	N
SN1161	24/02/2009	09.03	2	1	4	0	0	N
SN1729	03/06/2009	08.02	1	1	30	0	0	N
SN1714	20/05/2009	09.34	2	1	9	0	0	N

ID	Date	Time	VP	Number of birds	Duration of flight (s)			Within 200m of turbines
					below	at PCH	above	
SN1691	29/04/2009	04.36	1	1	15	0	0	N
SN1692	29/04/2009	04.38	1	1	15	0	0	N
SN1693	29/04/2009	04.43	1	1	30	0	0	N
SN1732	03/06/2009	05:27	1	1	15	30	0	Y

Curlew

81. A total of 42 recorded flights between March and June, mostly of single birds, with the majority within the south and south-eastern part of the survey area (**Figure 10.12**). Twenty-seven flights were at least partly at risk height. All flights are likely to relate to locally breeding birds.

Table 26: Details of observed flights of curlew.

ID	Date	Time	VP	Number of birds	Duration of flight (s)			Within 200m of turbines
					below	at PCH	above	
CU1164	10/03/2009	07:24	3	1	52.7	26.3	0	N
CU1170	31/03/2009	08:53	3	1	10	0	0	N
CU1661	03/04/2009	09.09	1	1	20	0	0	Y
CU1662	03/04/2009	09.12	1	1	61.1	48.9	0	Y
CU1663	03/04/2009	09.30	1	1	0	40	0	Y
CU1664	03/04/2009	10.35	1	1	45	15	0	Y
CU1665	03/04/2009	11.30	1	1	135	45	0	Y
CU1666	03/04/2009	11.29	1	1	10	0	0	Y
CU1667	03/04/2009	11.40	1	2	13.3	66.7	0	Y
CU1668	03/04/2009	12.12	1	2	0	50	0	Y
CU1670	03/04/2009	08.54	2	1	30	0	0	Y
CU1671	03/04/2009	11.01	3	1	0	31	0	N
CU1672	01/04/2009	08.30	1	1	30	15	0	Y
CU1673	01/04/2009	08.36	1	1	0	45	15	N
CU1674	01/04/2009	08.36	1	1	0	165	15	Y
CU1675	01/04/2009	09.10	1	1	30	30	0	Y
CU1676	01/04/2009	09.43	1	1	60	0	0	Y
CU1677	01/04/2009	10.48	1	1	30	90	0	Y
CU1678	01/04/2009	10.53	1	1	45	15	0	Y
CU1680	01/04/2009	12:40	1	1	30	30	0	Y
CU1681	15/04/2009	09.57	3	1	60	15	0	N
CU1686	15/04/2009	08.37	1	1	60	15	0	Y
CU1687	15/04/2009	09.06	1	1	30	15	0	Y
CU1694	29/04/2009	06.03	1	1	29.5	132.5	0	Y
CU1696	29/04/2009	07.48	1	1	14.3	128.7	0	Y
CU1708	29/04/2009	05.13	2	1	15	0	0	N

ID	Date	Time	VP	Number of birds	Duration of flight (s)			Within 200m of turbines
					below	at PCH	above	
CU1709	29/04/2009	05.13	2	1	15	0	0	N
CU1711	03/06/2009	04.32	3	1	0	90	0	N
CU1712	03/06/2009	05.10	3	1	14.4	100.6	0	N
CU1713	03/06/2009	06.37	3	1	0	14	0	N
CU1719	03/06/2009	04.03	2	1	10	10	0	N
CU1720	03/06/2009	04.35	2	1	15	0	0	N
CU1721	03/06/2009	04.41	2	1	15	0	0	N
CU1722	03/06/2009	06.23	1	1	0	60	0	Y
CU1723	03/06/2009	07.18	1	2	45	0	0	Y
CU1724	03/06/2009	07.25	1	1	30	0	0	N
CU1725	03/06/2009	07.36	1	1	30	0	0	Y
CU1726	03/06/2009	07.43	1	1	15	30	0	Y
CU1728	03/06/2009	07.54	1	1	30	0	0	N
CU1731	03/06/2009	04.04	1	1	15	45	0	Y
CU1743	20/05/2009	09.21	1	1	45	0	0	Y
CU1745	20/05/2009	11.48	1	1	45	0	0	Y

Redshank

82. Two birds flying around alarm-calling in October 2008 over 500m north-east of the final layout (**Figure 10.11**).

Table 27: Details of observed flights of redshank.

ID	Date	Time	VP	Number of birds	Duration of flight (s)			Within 200m of turbines
					below	at PCH	above	
RK1123	14/10/2008	12.58	2	2	59.2	73.8	0	N

Secondary Species

83. Eight secondary species were recorded. These included buzzard, sparrowhawk, kestrel, great black-backed gull, herring gull, lesser black-backed gull, black-headed gull and raven.

84. Raptor and raven activity was infrequent, with activity recorded in approximately 5-10% of 5-minute recording periods. Their activity was frequently outside the turbine envelope of the final layout and most often below potential collision height. Activity within the turbine layout footprint at potential collision height was very infrequent, with activity recorded in less than 1% of 5-minute recording periods.

85. Gulls were frequently recorded, with numbers increasing through the late summer period into the autumn and winter. The activity recorded mostly related to observations from VP3 of gulls at the landfill site 2km north-west of the site. There were no discrete flight lines of gulls across the final layout. Movements on site tended to consist of small groups of birds which drifted across the site, often below collision risk height.

COLLISION RISK MODELLING

86. Flight activity by the majority of target species at potential collision height (PCH) was sufficiently infrequent that collision risk modelling is not required. For the following target species, collision risk, based on the flight activity data collected over a period of 12 months, is considered to be negligible:

- Pink-footed goose – no flights at PCH within 200m of final layout;
- Greenland white-fronted goose – one flight of five birds at PCH over the final layout;
- Unidentified grey goose – no flights at PCH within 200m of final layout;
- Mallard – no flights at PCH within 200m of final layout;
- Red kite – one flight at PCH which was beyond 200m of final layout;
- Hen harrier – two flights of single birds at PCH;
- Osprey – one flight of a single bird at PCH, which was within 200m of final layout;
- Merlin – two brief flights of single birds at PCH;
- Black grouse – no flights at PCH;
- Golden Plover – one short flight of two birds at PCH, which was within 200m of final layout;
- Lapwing – no flights at PCH;
- Snipe – one flight of a single bird at PCH, which was within 200m of final layout; and
- Redshank – one flight at PCH, which was beyond 200m from final layout.

87. Flight activity by three species at PCH within 200m of the final layout was sufficiently frequent to warrant collision risk modelling:

- Greylag goose – three flights at PCH within 200m of final layout, although two of the records are considered to represent the same flight of six birds observed from two different VPs.

- Peregrine – all five flights recorded during the non-breeding season were at PCH and two out of six flights were at PCH in the breeding season. March to August was defined as the breeding season for peregrine, which tend to start breeding display early in the year, and September to February was defined as the non-breeding season.

- Curlew – 27 flights at PCH, some involving two birds, but mostly singles. The breeding season was defined by their recorded presence at the site between March and June. Curlew was not recorded outside that period.

88. For these three species, the risk of birds colliding with the turbine rotors has been assessed using a model developed by W. Band (Band et al. 2007)[v], which estimates the number of bird collisions with the turbine rotors during a specified time period. Collision risk was calculated in two stages:

- Estimating the number of birds passing through the area or volume swept by the rotors; and

- Estimating the probability that a bird will be struck by a rotor blade when passing through the area or volume swept by the rotors.

89. The modelling method for raptors and other species with irregular flight activity requires the calculation of the amount of time that birds were observed flying per unit of area surveyed. This level of flight activity is then applied to the windfarm area in subsequent calculations of the collision risk. This model is applicable to peregrine (split between breeding – March to August – and non-breeding – September to February – seasons) and curlew (breeding season only – March to June).

90. The modelling method for geese and other species with regular or predictable flight activity through the site, for example when commuting between roosting and feeding areas, or during migratory movements, requires the calculation of the number of transits across a 'risk window'. From this, the number of birds likely to fly through the rotor swept area is then calculated in order to estimate the collision risk. This model is applicable to greylag goose (winter only – October to March).

91. These two methods and the results of the modelling for each species are described below:

Irregular or unpredictable flight activity collision risk method (peregrine and curlew)

92. The combined visible area surveyed from the vantage points (A_{VP}) was calculated by producing a predicted 'viewshed' from the VPs using terrain data within a Geographical Information System (GIS) (**Figure 10.3**). The viewshed was calculated as the area (in hectares) visible 20m above ground level (the lowest part of the risk height band used during the surveys) from 1m height at the vantage points and was restricted to a 180° arc of observation in front of the observer and to a maximum distance of 2km from each vantage point.

93. The total time that birds were observed flying at risk height was calculated for the relevant season[1]. This was done by summing the observed duration of flight activity in height band 2 from each VP.

94. The proportion of the total survey time (for the relevant season) that birds were observed flying at risk height was calculated (t), by dividing the total observed duration of flight activity at risk height by the total observation duration[2]. Therefore, flight activity at risk height per hectare of visible area (F) was t/A_{VP}. This approach, using summed total duration of flight activity within the combined viewshed area, was used due to the considerable amount of overlap between the viewsheds of the vantage points and because most of the flight activity surveys were carried out simultaneously from the VPs. It is considered that this provides a better estimate of flight activity rates per unit of area surveyed than by calculating the flight activity rate from each VP and then using the average rate, which would be more applicable to a situation with little or no overlap between the visible areas from each VP, or where VP watches are not carried out simultaneously.

95. A flight risk area (A_{RISK}) was defined as all land within 200m of the turbine envelope (an envelope around the outermost turbines of the final layout) and the area was calculated in a GIS.

96. The proportion of time that birds would spend at PCH in the flight risk area (t_{RISK}) was calculated by multiplying the flight activity per visible hectare (F) by the flight risk area (A_{RISK}).

97. The windfarm will comprise two different turbine models: seven turbines with hub height 69m and rotor radius of 41m and three turbines with 79m hub and 41m rotor radius. The surveys were carried out assuming a height risk band of 20-125m, which more than covers the span of the operational rotor height for either turbine model. No correction factor was applied in this model for the discrepancy between the 82m rotor span and the 105m risk height band used in the surveys, as it is considered that this would allow for any error in recording heights of birds flying within the survey area.

98. Bird occupancy (n) of the flight risk area throughout the year or season was calculated by multiplying t_{RISK} by the number of hours that birds are potentially active during the season. For peregrine, this was assumed to be an average of 9 hours per day during the non-breeding season and 15 hours per day during the breeding season. For curlew, this assumed to be an average of 15 hours per day between March and June.

99. The flight risk volume (v_{RISK}) was calculated by multiplying the flight risk area by the diameter of the rotors. The volume of air swept by the rotors of all proposed

[1] Peregrine collision risk was modelled for the breeding season defined as March to August and the non-breeding season defined as September to February; Curlew collision risk was modelled for the breeding season defined as March to June, based on their observed presence within the survey area.

[2] The total observation duration is that for the whole windfarm, not the sum of the duration from each VP – e.g. if 52 hours of watches were carried out in the season from each of three VPs, the observation duration used in the model was 52 hours, not 156 hours. Note that hours of observation were subtracted from the total observation duration for that season if the visibility during the survey was recorded as 'poor' (<1km).

turbines in the wind farm (v_{ROTOR}) was calculated by multiplying the number of turbines by the volume of air swept by one rotor ($\pi R^2 \times (d + l)$), where R is the rotor radius, d is the maximum depth of the blade and l is the length of the bird). Bird dimensions have been taken as the mean value of the upper and lower range given in *The Birds of the Western Palearctic*[vi,vii].

100. Bird occupancy of the volume swept by all rotors each year or season (b) was calculated by multiplying the bird occupancy of the flight risk area (n) by the proportion of the flight risk volume swept by the rotors (v_{ROTOR}/v_{RISK}).

101. By allowing for a typical speed of a bird (v) flying in the volume of air swept by the rotors, the number of transits ($N_{TRANSIT}$) that may be made by birds through the rotors each year was calculated by dividing the occupancy of the rotor swept volume (b) by the time taken to transit through the rotor swept volume ((d+l)/v). The flight speed for peregrine was taken as 12.1m/s, which is the mean air-speed of radar tracked birds reported by Bruderer and Boldt (2001)[viii] and of radio-tagged birds reported by Cochran and Applegate (1986)[ix]. Flight speed for curlew was taken as 13.2m/s (Bruderer and Boldt 2001).

102. The probability of a bird that flies through the volume swept by the rotors being hit by a rotor blade (p) depends on a number of parameters: the dimensions of the bird and type of flight (speed, and flapping or gliding), and the size and rotation speed of the rotors. For this assessment, birds were assumed to use flapping flight. These parameters were input into a bespoke Excel spreadsheet (available from the SNH website) that calculates the average collision risk for a bird flying through the rotor swept volume, expressed as a percentage.

103. From the above results, the number of birds colliding with the rotors during each season was calculated, assuming that birds take no avoiding action, by multiplying the number of transits ($N_{TRANSIT}$) by the probability of being struck by the rotor (p). Note that the assumption has been made that turbines are operational for a maximum of 85% of the time, therefore the collision risk has been reduced by 15%, as birds are unlikely to be at risk of collision with the stationary turbine structure.

104. The above calculations make an estimate of collision risk, assuming that birds take no action to avoid being struck by the operating rotor blades. In reality, a very high proportion of birds are likely to take avoiding action. SNH have provided guidance[x] on the appropriate avoidance rates to use for each species. An avoidance rate of 98% is applicable for both peregrine and curlew.

Irregular or unpredictable flight activity collision risk results (peregrine and curlew)

105. The following constants are applicable in the model for both species (**Table 28**).

Table 28: Constant parameters used in the predictable collision risk model

Parameter	Value	Units
Combined viewshed area (A_{VP})	756.2	ha
Turbine hub height	69/79	m
Turbine rotor diameter	82	m
Depth of rotor (d)	2	m
Maximum chord width	3.2	m
Number of turbines	10	
Pitch of rotors	15	°
Rotation period (at rated output)	3.50	s
Operational percentage	85	%
Flight risk area (A_{RISK})	145	ha
Flight risk volume (v_{RISK})	118900000	m3

Peregrine

106. The choice of flight activity data to input into the model can vary between assessments. Sometimes, it is applicable to clip the observed flight line data and only use the part of the observed flight line that occurred within the viewshed of the VP and within a certain distance of the turbine layout. This is particularly the case when the habitats at a site are heterogenous, resulting in differing levels of flight activity in different areas observed, due to habitat effects. The habitats within the survey area for Merkins Windfarm are fairly homogenous, comprising open moorland habitats. Analysis of the peregrine flight lines shows that almost all of the flight activity occurred within the viewsheds shown in **Figure 10.3**. There are some portions of individual flight lines that extended beyond the theoretical viewshed because birds can be recorded beyond the arbitrary limit of 2km that is used in the design of the surveys. As the extent of this occurrence was very limited in this case, all peregrine flight activity data recorded at potential collision height (PCH) was input into the models. It is expected that this may balance out some flight activity within the viewsheds that is potentially missed before birds are seen for the first time when scanning the survey area.

107. **Tables 29 and 30** provide the calculations of theoretical estimated collision risk to peregrines during the non-breeding and breeding seasons respectively. **Table 31**

provides the output from the bespoke Excel spreadsheet (produced by W. Band, SNH) that estimates the probability of being struck by the rotors if a peregrine flies through the rotor swept volume.

Table 29: Calculation of the estimated collision risk to peregrines during the non-breeding season

Parameter	Value	Units
Bird length (l)	0.42	m
Bird wing-span	1.02	m
Bird speed (v)	12.1	m/s
Seconds activity at PCH from VP1	60.25	seconds
Seconds activity at PCH from VP2	37.4	seconds
[No observation from VP3 in non-breeding season]		
TOTAL observed activity	97.65	seconds
Observation time between September 2008 and February 2009	219600	seconds
Proportion of observation time at PCH (t)	4.45×10^{-4}	
Flight activity per visible hectare (F)	5.88×10^{-7}	ha-1
Proportion of time at PCH in flight risk area (t_{RISK})	8.53×10^{-5}	
Potentially active hours in non-breeding season	1629	hours
Occupancy of flight risk area in non-breeding season (n)	500	seconds
Combined rotor swept volume (v_{ROTOR})	127801	m3
Occupancy of rotor swept volume (b)	0.537	seconds
Number of transits through the rotors ($N_{TRANSIT}$)	2.687	
Probability of being struck (p)	8.22%	%
Collision risk (no avoidance)	0.19	birds per year
Collision risk (98% avoidance)	0.0038	birds per year
Collision risk (98% avoidance)	266	years per collision

Table 30: Calculation of the estimated collision risk to peregrines during the breeding season

Parameter	Value	Units
Bird length (l)	0.42	m
Bird wing-span	1.02	m
Bird speed (v)	12.1	m/s
Seconds activity at PCH from VP1	90	seconds
Seconds activity at PCH from VP2	0	seconds
Seconds activity at PCH from VP3	0	seconds
TOTAL observed activity	90	seconds
Observation time between March and August 2009	244800	seconds
Proportion of observation time at PCH (t)	3.68×10^{-4}	
Flight activity per visible hectare (F)	4.86×10^{-7}	ha-1
Proportion of time at PCH in flight risk area (t_{RISK})	7.05×10^{-5}	
Potentially active hours in breeding season	2760	hours
Occupancy of flight risk area in breeding season (n)	700	seconds
Combined rotor swept volume (v_{ROTOR})	127801	m3
Occupancy of rotor swept volume (b)	0.753	seconds
Number of transits through the rotors ($N_{TRANSIT}$)	3.764	
Probability of being struck (p)	8.22%	%
Collision risk (no avoidance)	0.26	birds per year
Collision risk (98% avoidance)	0.0053	birds per year
Collision risk (98% avoidance)	190	years per collision

108. The combined collision risk for the breeding and non-breeding seasons presents an overall annual collision risk of one bird approximately every 111 years.

Table 31: Probability of being struck by the rotors if a peregrine flies through the rotor swept volume

CALCULATION OF COLLISION RISK FOR PEREGRINE PASSING THROUGH ROTOR AREA

Input parameters entered in blue — W Band — 25/03/2011

K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**								
NoBlades	3					Upwind:			Downwind:		
MaxChord	3.2	m	r/R	c/C	α	collide		contribution from radius	collide		contribution
Pitch (degrees)	15		radius	chord	alpha	length	p(collision)	r	length	p(collision)	from radius r
BirdLength	0.42	m	0.025	0.575	6.58	18.87	1.00	0.00125	17.92	1.00	0.00125
Wingspan	1.02	m	0.075	0.575	2.19	6.61	0.47	0.00351	5.66	0.40	0.00300
F: Flapping (0) or gliding (+1)	0		0.125	0.702	1.32	4.77	0.34	0.00423	3.61	0.26	0.00320
			0.175	0.860	0.94	4.17	0.30	0.00517	2.74	0.19	0.00340
Bird speed	12.1	m/sec	0.225	0.994	0.73	3.81	0.27	0.00608	2.17	0.15	0.00345
RotorDiam	82	m	0.275	0.947	0.60	3.14	0.22	0.00612	1.57	0.11	0.00307
RotationPeriod	3.50	sec	0.325	0.899	0.51	2.67	0.19	0.00614	1.18	0.08	0.00271
			0.375	0.851	0.44	2.31	0.16	0.00612	0.90	0.06	0.00238
			0.425	0.804	0.39	2.05	0.14	0.00616	0.72	0.05	0.00215
			0.475	0.756	0.35	1.85	0.13	0.00624	0.60	0.04	0.00203
Bird aspect ratioo: β	0.41		0.525	0.708	0.31	1.69	0.12	0.00629	0.52	0.04	0.00193
			0.575	0.660	0.29	1.55	0.11	0.00632	0.46	0.03	0.00186
			0.625	0.613	0.26	1.43	0.10	0.00631	0.43	0.03	0.00190
			0.675	0.565	0.24	1.31	0.09	0.00628	0.46	0.03	0.00221
			0.725	0.517	0.23	1.21	0.09	0.00622	0.49	0.03	0.00250
			0.775	0.470	0.21	1.12	0.08	0.00613	0.50	0.04	0.00275
			0.825	0.422	0.20	1.03	0.07	0.00602	0.51	0.04	0.00298
			0.875	0.374	0.19	0.95	0.07	0.00587	0.51	0.04	0.00318
			0.925	0.327	0.18	0.87	0.06	0.00570	0.51	0.04	0.00335
			0.975	0.279	0.17	0.80	0.06	0.00550	0.51	0.04	0.00349
				Overall p(collision) =			**Upwind**	**11.2%**		**Downwind**	**5.3%**
								Average	**8.2%**		

Curlew

109. The same method as for peregrine was used to estimate the theoretical collision risk to curlews. **Table 32** provides the calculations of theoretical estimated collision risk to curlews during the breeding season. **Table 33** provides the output from the bespoke Excel spreadsheet (produced by W. Band, SNH) that estimates the probability of being struck by the rotors if a curlew flies through the rotor swept volume.

Table 32: Calculation of the estimated collision risk to curlews during the breeding season

Parameter	Value	Units
Bird length (l)	0.55	m
Bird wing-span	0.9	m
Bird speed (v)	13.2	m/s
Seconds activity at PCH from VP1	1198.5	seconds
Seconds activity at PCH from VP2	10	seconds
Seconds activity at PCH from VP3	276.9	seconds
TOTAL observed activity	1485.4	seconds
Observation time between March and June 2009	172800	seconds
Proportion of observation time at PCH (t)	8.596×10^{-3}	
Flight activity per visible hectare (F)	1.14×10^{-5}	ha-1
Proportion of time at PCH in flight risk area (t_{RISK})	1.65×10^{-3}	
Potentially active hours in breeding season	1830	hours
Occupancy of flight risk area in breeding season (n)	10859	seconds
Combined rotor swept volume (v_{ROTOR})	134666	m3
Occupancy of rotor swept volume (b)	12.299	seconds
Number of transits through the rotors ($N_{TRANSIT}$)	63.664	
Probability of being struck (p)	8.55%	%
Collision risk (no avoidance)	4.62	birds per year
Collision risk (98% avoidance)	0.0925	birds per year
Collision risk (98% avoidance)	11	years per collision

Table 33: Probability of being struck by the rotors if a curlew flies through the rotor swept volume

CALCULATION OF COLLISION RISK FOR CURLEW PASSING THROUGH ROTOR AREA

Input parameters entered in blue — W Band — 26/03/2011

K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**								
NoBlades	3						Upwind:			Downwind:	
MaxChord	3.2	m	r/R	c/C	α	collide		contribution from radius	collide		contribution
Pitch (degrees)	15		radius	chord	alpha	length	p(collision)	r	length	p(collision)	from radius r
BirdLength	0.55	m	0.025	0.575	7.17	19.68	1.00	0.00125	18.73	1.00	0.00125
Wingspan	0.9	m	0.075	0.575	2.39	6.88	0.45	0.00335	5.93	0.38	0.00289
F: Flapping (0) or gliding (+1)	0		0.125	0.702	1.43	4.98	0.32	0.00404	3.82	0.25	0.00310
			0.175	0.860	1.02	4.36	0.28	0.00495	2.93	0.19	0.00333
Bird speed	13.2	m/sec	0.225	0.994	0.80	3.99	0.26	0.00583	2.34	0.15	0.00342
RotorDiam	82	m	0.275	0.947	0.65	3.28	0.21	0.00586	1.71	0.11	0.00306
RotationPeriod	3.50	sec	0.325	0.899	0.55	2.83	0.18	0.00597	1.34	0.09	0.00283
			0.375	0.851	0.48	2.51	0.16	0.00612	1.10	0.07	0.00269
			0.425	0.804	0.42	2.26	0.15	0.00625	0.93	0.06	0.00257
			0.475	0.756	0.38	2.06	0.13	0.00635	0.81	0.05	0.00249
Bird aspect ratioo: β	0.61		0.525	0.708	0.34	1.88	0.12	0.00642	0.71	0.05	0.00242
			0.575	0.660	0.31	1.73	0.11	0.00647	0.64	0.04	0.00239
			0.625	0.613	0.29	1.60	0.10	0.00650	0.59	0.04	0.00238
			0.675	0.565	0.27	1.48	0.10	0.00650	0.55	0.04	0.00243
			0.725	0.517	0.25	1.37	0.09	0.00647	0.58	0.04	0.00274
			0.775	0.470	0.23	1.27	0.08	0.00642	0.60	0.04	0.00303
			0.825	0.422	0.22	1.18	0.08	0.00634	0.62	0.04	0.00330
			0.875	0.374	0.20	1.10	0.07	0.00623	0.62	0.04	0.00354
			0.925	0.327	0.19	1.02	0.07	0.00610	0.62	0.04	0.00375
			0.975	0.279	0.18	0.94	0.06	0.00595	0.62	0.04	0.00394
				Overall p(collision) =			**Upwind**	**11.3%**		**Downwind**	**5.8%**
								Average	**8.5%**		

Regular or predictable flight activity collision risk method (greylag goose)

110. This model uses flight activity data of greylag goose gathered during timed observation of bird movements during the non-breeding season, defined in this case as October to March – the period during which greylag geese were recorded in the survey area.

111. Greylag geese were observed flying across the survey area on a NNE-SSW axis. A 'risk window' was therefore defined through which geese approaching the windfarm were predicted to pass. The window measured 105m tall (the span of the risk height band between 20-125m used during the surveys) and 1270m wide (the maximum distance across the turbine envelope of the final layout (plus 200m buffer to allow for potential error in recording flight lines) on a perpendicular axis to the primary flight direction). The cross-sectional area (W) of the risk window was calculated (width × height).

112. The mean number of geese per hour of observation that flew through the risk window was determined – this is the sum of the number of birds observed passing through the risk window at risk height divided by the observation duration between the VPs during October to March. No reduction in observation duration is made for periods of poor visibility, as auditory records are considered appropriate for this species.

113. The number of greylag geese (n) assumed to fly through the risk window each year was calculated by multiplying the mean number of geese observed per hour by the number of hours that they are potentially active in the season. Geese were assumed to be active for an average of 10 hours per day and 25% of the night (i.e. 13.5 hours per 24 hours).

114. The area (A) presented by the windfarm rotors was calculated by multiplying the number of turbines by the area swept by one rotor. Note that it is assumed that the rotors are aligned in the plane of the risk window. In this model some allowance is made for overlap in the cross-sectional area of separate rotors, which is justified because although collision risk increases in proportion to the number of rotors that birds may pass through, few birds will fly through successive rotors. Therefore a 50% overlap is assumed and A is reduced by a factor of 0.5.

115. The proportion of the risk window occupied by the rotors is A/W. Therefore the number of greylag geese assumed to pass through the rotors each year ($N_{TRANSIT}$) is the number of birds estimated to cross the risk window each year multiplied by the proportion of the risk window occupied by the rotors (n × A/W).

116. The probability of a bird that flies through the area swept by the rotors being hit by a rotor blade (p) depends on a number of parameters: the dimensions of the bird and type of flight (speed, and flapping or gliding), and the size and rotation speed of the rotors. For this assessment, birds were assumed to use flapping flight. These parameters were input into a bespoke Excel spreadsheet (available from the SNH website) that calculates the average collision risk for a bird flying through the rotor swept volume, expressed as a percentage.

117. The flight speed for greylag goose was taken as 15m/s (approximately 35 miles per hour). Bird length and wing-span were taken as the mean value of the upper and lower range given in *The Birds of the Western Palearctic*[xi].

118. From the above results, the number of birds colliding with the rotors during each season was calculated, assuming that birds take no avoiding action, by multiplying the number of transits ($N_{TRANSIT}$) by the probability of being struck by the rotor (p). Note that the assumption has been made that turbines are operational for a maximum of 85% of the time, therefore the collision risk has been reduced by 15%, as birds are unlikely to be at risk of collision with the stationary turbine structure.

119. The above calculations make an estimate of collision risk, assuming that birds take no action to avoid being struck by the operating rotor blades. In reality, a very high proportion of birds are likely to take avoiding action. An avoidance rate of 99% is applicable for greylag goose.

Regular or predictable flight activity collision risk results (greylag goose)

120. The following constants are applicable in the model (**Table 34**).

Table 34: Constant parameters used in the predictable collision risk model

Parameter	Value	Units
Risk window height	105	m
Risk window width	1270	m
Cross-sectional area of risk window (W)	133350	m2
Turbine hub height	69/79	m
Turbine rotor diameter	82	*m*
Maximum chord width	3.2	m
Number of turbines	10	
Pitch of rotors	15	deg
Rotation period	3.50	s
Operational percentage	85	%
Cross sectional area presented by rotors (A)	52810	m2
Proportion of risk window occupied by rotors allowing for 50% overlap (A/W*0.5)	0.198	

Greylag goose

121. **Table 34** provides the calculations of theoretical estimated collision risk to greylag geese during the non-breeding season. **Table 35** provides the output from the bespoke Excel spreadsheet (produced by W. Band, SNH) that estimates the probability of being struck by the rotors if a greylag goose flies through the rotor swept area.

Table 34: Calculation of the estimated collision risk to greylag geese during the non-breeding season

Parameter	Value	Units
Bird length (l)	0.825	m
Bird wing-span	1.635	m
Bird speed (v)	15	m/s
Number of birds crossing the risk window (October 2008 to March 2009)[3]	32	birds
Total observation time between October 2008 and March 2009	80	hours
Rate of goose activity	0.4	birds per hour
Potentially active hours	2457	hours
Potential number of birds through the risk window each season (n)	983	birds
Potential number of birds through the rotor swept area each season ($N_{TRANSIT}$)	195	birds
Probability of being struck (p)	9.94	%
Collision risk (no avoidance)	16.45	birds per year
Collision risk (99% avoidance)	0.1645	birds per year
Collision risk (99% avoidance)	6	years per collision

[3] Although **Table 14** shows three flights of greylag goose crossing the risk window at risk height totalling 38 birds, the two records of six birds represented by flight ID GJ1130 and GJ1138 are considered to be the same birds recorded from different VPs.

Table 35: Probability of being struck by the rotors if a greylag goose flies through the rotor swept volume

CALCULATION OF COLLISION RISK FOR GREYLAG GOOSE PASSING THROUGH ROTOR AREA

Input parameters entered in blue — W Band — 26/03/2011

K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**								
NoBlades	3						Upwind:			Downwind:	
MaxChord	3.2	m	r/R	c/C	α	collide		contribution from radius	collide		contribution
Pitch (degrees)	15		radius	chord	alpha	length	p(collision)	r	length	p(collision)	from radius r
BirdLength	0.825	m	0.025	0.575	8.15	28.29	1.00	0.00125	27.34	1.00	0.00125
Wingspan	1.635	m	0.075	0.575	2.72	9.75	0.56	0.00418	8.80	0.50	0.00377
F: Flapping (0) or gliding (+1)	0		0.125	0.702	1.63	6.78	0.39	0.00484	5.62	0.32	0.00401
			0.175	0.860	1.16	5.71	0.33	0.00571	4.29	0.25	0.00429
Bird speed	15	m/sec	0.225	0.994	0.91	5.09	0.29	0.00654	3.44	0.20	0.00442
RotorDiam	82	m	0.275	0.947	0.74	4.16	0.24	0.00654	2.60	0.15	0.00408
RotationPeriod	3.50	sec	0.325	0.899	0.63	3.51	0.20	0.00652	2.02	0.12	0.00376
			0.375	0.851	0.54	3.02	0.17	0.00648	1.61	0.09	0.00346
			0.425	0.804	0.48	2.68	0.15	0.00651	1.35	0.08	0.00328
			0.475	0.756	0.43	2.45	0.14	0.00666	1.20	0.07	0.00326
Bird aspect ratioo: β	0.50		0.525	0.708	0.39	2.26	0.13	0.00678	1.09	0.06	0.00326
			0.575	0.660	0.35	2.10	0.12	0.00689	1.00	0.06	0.00329
			0.625	0.613	0.33	1.95	0.11	0.00696	0.94	0.05	0.00334
			0.675	0.565	0.30	1.82	0.10	0.00702	0.88	0.05	0.00341
			0.725	0.517	0.28	1.70	0.10	0.00706	0.85	0.05	0.00350
			0.775	0.470	0.26	1.60	0.09	0.00707	0.83	0.05	0.00369
			0.825	0.422	0.25	1.50	0.09	0.00706	0.85	0.05	0.00402
			0.875	0.374	0.23	1.40	0.08	0.00702	0.87	0.05	0.00433
			0.925	0.327	0.22	1.32	0.08	0.00697	0.87	0.05	0.00461
			0.975	0.279	0.21	1.24	0.07	0.00689	0.88	0.05	0.00488
				Overall p(collision) =			**Upwind**	**12.5%**		**Downwind**	**7.4%**
								Average	**9.9%**		

[i] Dunbartonshire Local Biodiversity Action Plan; the Dunbartonshire Biodiversity Partnership 2010 – 2013. Website address: http://www.wdcweb.info/EasySiteWeb/GatewayLink.aspx?alId=61259 accessed February 2011.

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MERKINS WINDFARM

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Sites Designated for Nature Conservation Considered in Ornithological Assessment

Merkins Windfarm

20km study area from outer turbines

Designated Sites

Ramsar Site

Special Protection Area (SPA)

Site of Special Scientific Interest (SSSI) within 5km of Site

Loch Lomond

Caldarvan Loch

Blairbeich Bog

Aucheneck

Dumbarton Muir

Auchenreoch Glen

Lang Craigs

Loch Humphrey Burn

Glenarbuck

Hawcraig - Glenarbuck

Inner Clyde

Renfrewshire Heights

Black Cart

5km

20km

0 5 10 Km

Map Scale: 1:160,000

Figure 10.1

arcus

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MERKINS WINDFARM

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Ornithology Survey

Proposed Scheme Layout

- Site Boundary
- Turbine Layout
- Access Tracks
- Crane Pad
- Control Building
- Construction Compound

Survey Areas

- Winter Walkover Survey Area (500m Buffer of Initial Layout)
- Breeding Bird Survey Area (500m Buffer of Interim Layout)
- Barn Owl Survey Area (1km Buffer of Interim Layout)
- Black Grouse Survey Area (1.5km Buffer of Interim Layout)
- Breeding Raptor Survey Area (2km Buffer of Interim Layout)

Note: survey areas were initially based on a 12-turbine layout ('Initial Layout'). The scope of the proposed development was revised in March 2009 to an interim, extended 20-turbine layout, which resulted in the need to increase the size of the survey areas north of the initial 12-turbine layout ('Interim Layout'). The final turbine layout was reduced in size again to a 10-turbine layout, but turbines are positioned further south than the initial 12-turbine layout ('Final Layout').

Map Scale: 1:25,000

Figure 10.2

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MERKINS WINDFARM

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Flight Activity Survey

Proposed Scheme Layout

- Site Boundary
- Turbine Layout
- Access Tracks
- Crane Pad
- Control Building
- Construction Compound

Survey Areas

- Vantage Point Locations
- Vantage Point 1 Viewshed
- Vantage Point 2 Viewshed
- Vantage Point 3 Viewshed
- Combined Viewshed (28m agl)

Note:
Combined viewshed (28m agl) equates to the visible area at a height which is the lowest sweep of any of the turbine models considered.

Map Scale: 1:15,000

Figure 10.3

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Breeding Activity - Waders

Proposed Scheme Layout

- Site Boundary
- Turbine Layout
- Access Tracks
- Crane Pad
- Control Building
- Construction Compound

- Breeding Bird Study Area

Curlew

- Territory
- Probable Territory
- Non Breeding Activity

Snipe

- Territory
- Probable Territory

Map Scale: 1:15,000

Figure 10.4

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Breeding Activity - Skylark

Proposed Scheme Layout

- Site Boundary
- Turbine Layout
- Access Tracks
- Crane Pad
- Control Building
- Construction Compound

- Breeding Bird Study Area

Skylark

- Territory
- Probable Territory
- Non Breeding Activity

Map Scale: 1:15,000

Figure 10.5

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Black Grouse Activity

Proposed Scheme Layout

- Site Boundary
- Turbine Layout
- Access Tracks
- Crane Pad
- Control Building
- Construction Compound

- Black Grouse Lek
- 500m Buffer of Black Grouse Lek
- Black Grouse Flight Activity

Note: Flight lines are labelled by a unique ID number allowing cross-reference to flight activity details presented in the tables in the Technical Report

Map Scale: 1:15,000

Figure 10.6

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LUCGL Fig10-06_4621-0134-r1_BlackGrouseResults 16/08/2011

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Flight Activity - Wildfowl

Proposed Scheme Layout

- Site Boundary
- Turbine Layout
- Access Tracks
- Crane Pad
- Control Building
- Construction Compound

Flight Activity (Relation to Blade Sweep)

- Greylag Goose (within)
- Greylag Goose (above)
- White Fronted Goose (within)
- Pink-footed Goose (within)
- Unidentified Goose (within)
- Unidentified Goose (above)
- Mallard (within)

Note: Flight lines are labelled by a unique ID number allowing cross-reference to flight activity details presented in the tables in the Technical Report

Map Scale: 1:20,000

Figure 10.7

LUC arcus

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MERKINS WINDFARM

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Flight Activity - Osprey, Red Kite, Merlin

Proposed Scheme Layout

- Site Boundary
- Turbine Layout
- Access Tracks
- Crane Pad
- Control Building
- Construction Compound

Flight Activity (Relation to Blade Sweep)

- Red Kite (within)
- Red Kite (above)
- Osprey (within)
- Osprey (above)
- Merlin (within)
- Merlin (below)

Note: Flight lines are labelled by a unique ID number allowing cross-reference to flight activity details presented in the tables in the Technical Report

Map Scale: 1:20,000

Figure 10.8

arcus

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MERKINS WINDFARM

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Flight Activity - Hen Harrier

Proposed Scheme Layout

- Site Boundary
- Turbine Layout
- Access Tracks
- Crane Pad
- Control Building
- Construction Compound

Non Breeding Season

Flight Activity (Relation to Blade Sweep)

- Hen Harrier (within)
- Hen Harrier (below)

Breeding Season

Flight Activity (Relation to Blade Sweep)

- Hen Harrier (within)
- Hen Harrier (below)

Note: Flight lines are labelled by a unique ID number allowing cross-reference to flight activity details presented in the tables in the Technical Report

Map Scale: 1:20,000

Figure 10.9

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MERKINS WINDFARM

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Flight Activity - Peregrine

Proposed Scheme Layout

- Site Boundary
- Turbine Layout
- Access Tracks
- Crane Pad
- Control Building
- Construction Compound

Flight Activity (Relation to Blade Sweep)

- Peregrine (within)
- Peregrine (above/below)

Note: Flight lines are labelled by a unique ID number allowing cross-reference to flight activity details presented in the tables in the Technical Report

Map Scale: 1:20,000

Figure 10.10

LUC arcus

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MERKINS WINDFARM

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Flight Activity - Golden Plover, Lapwing, Redshank and Snipe

Proposed Scheme Layout

- Site Boundary
- Turbine Layout
- Access Tracks
- Crane Pad
- Control Building
- Construction Compound

Flight Activity (Relation to Blade Sweep)

- Golden Plover (within)
- Golden Plover (below)
- Lapwing (below)
- Redshank (within)
- Snipe (within)
- Snipe (below)

Note: Flight lines are labelled by a unique ID number allowing cross-reference to flight activity details presented in the tables in the Technical Report

Map Scale: 1:20,000

Figure 10.11

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LUCGL Fig10-11_4621-0139-r1_FlightActivityGoldenPloverEtc 16/08/2011

MERKINS WINDFARM

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Flight Activity - Curlew

Proposed Scheme Layout

- Site Boundary
- Turbine Layout
- Access Tracks
- Crane Pad
- Control Building
- Construction Compound

Flight Activity (Relation to Blade Sweep)

- Curlew (within)
- Curlew (below)

Note: Flight lines are labelled by a unique ID number allowing cross-reference to flight activity details presented in the tables in the Technical Report

Map Scale: 1:20,000

Figure 10.12

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