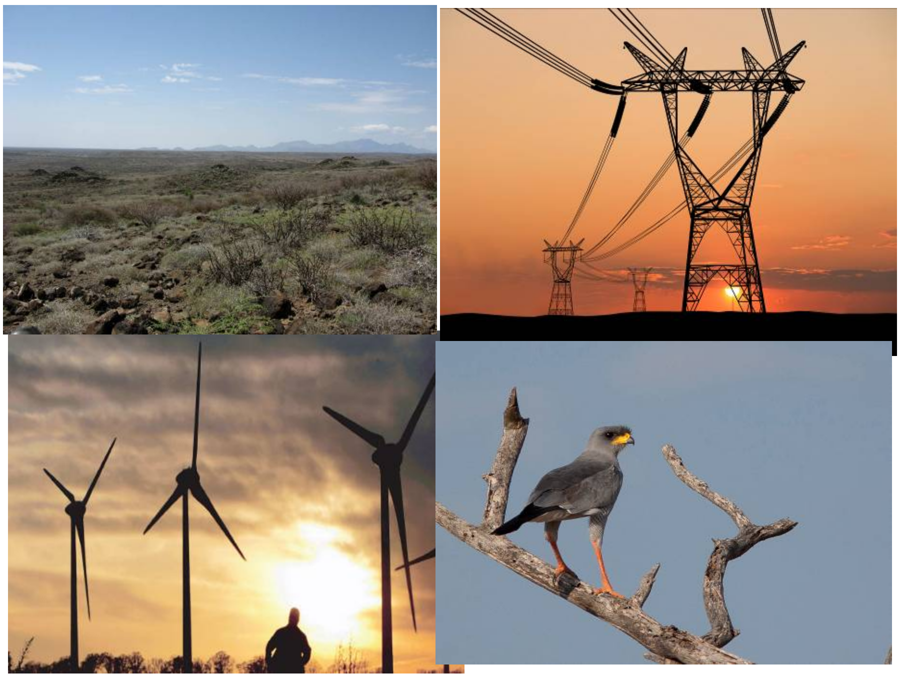
Lake Turkana Wind Power Project - Kenya

Ornithological and Bat Surveys – Final Survey Report

Technical Report
December 2011



Revision Schedule

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Table of Contents

1 Executive Summary

1.1.1 The proposed Lake Turkana Wind Power Project (LTWP) is situated in the Marsabit district of northwest Kenya. Comprising a total of 365 turbines, the wind farm will be positioned within an overall project site of 40,000 acres (162km^2), with the turbines located at a distance of around 7km to the east of Lake Turkana.

1.1.2 An Environmental and Social Impact Assessment (ESIA) for the Project has been undertaken, and formally approved by NEMA in July 2009. It was recommended in the report that a one-year programme of ornithological surveys be carried out to validate the conclusions of the ESIA prepared for the Project. URS Scott Wilson was commissioned to design and manage the ornithological surveys.

1.1.3 The ornithological survey method was based on best practice methods and was prepared following a reconnaissance survey and discussions with the Royal Society for the Protection of Birds (RSPB) and the National Museums of Kenya (NMK).

1.1.4 The surveys commenced in October 2010 using a team of ornithologists from the NMK. The surveys were conducted over a twelve month period, to capture the spring and autumn bird migration periods.

1.1.5 The data collected over a year of surveys indicates that a low resident population of target bird species is present on site and that during the autumn migration period there is a significant increase in birds of prey passing through the site.

1.1.6 Based on the turbine layout, observed flight routes undertaken by migrating birds of prey and avoidance rates it is unlikely that there will be a significant impact to migrating birds through collision with the turbines. A small collision risk remains during the autumn migration, to a few species of birds of prey and to some resident species such as eagles, kestrel and vultures. No risk to water birds associated with Lake Turkana has been identified.

1.1.7 The scheme involves connection of all turbines to a grid of overhead power lines which will be approximately 7.5m above ground level. These could present a certain degree of risk especially for the large, less manoeuvrable species such as birds of prey and bustard species.. Flight heights recorded during the surveys suggest that bustard species would be at an elevated risk from collision with the grid connector system, whereas migrating raptors (which tended to fly at a much higher altitude) are at a much lower risk. To reduce the risk of collision with the grid system within the site, it is recommended that bird deflectors are fitted to the power lines.

1.1.8 Whilst not a specific requirement for approval of the ESIA for the wind farm, following an independent review of the ESIA, it was recommended that further investigation be carried out to determine potential impacts to any bats using the project site. This involved a week of surveys undertaken in March 2011 using bat specialists from URS Scott Wilson and the NMK.

1.1.9 Bats use the site, with increased activity close to vegetation around the lagas. Activity was low on the ridges where the turbines are to be located. A risk remains that bats recorded on the ridges may be at risk of collision or decompression barotraumas.

1.1.10 A programme of monitoring as per best practice guidelines for wind farms has been recommended to validate the conclusions made during this assessment and to quickly identify any impacts to birds and bats from the operational wind farm.

2 Introduction

2.1 Background

2.1.1 The proposed Lake Turkana Wind Power Project (LTWP) is situated in the Marsabit district of northwest Kenya (see Figure 1). The wind farm will be positioned within an overall project site of 40,000 acres (162km^2), with the turbines located at a distance of around 8km to the east of Lake Turkana itself.

2.1.2 The project aims to provide 300MW of wind energy for the national grid, via a series of 365 wind turbines. In addition to the turbines associated infrastructure will include turbine connection cables, improved access roads and workers village.

2.1.3 An Environmental and Social Impact Assessment (ESIA) for the wind farm development has been undertaken by others, formally approved and an EIA license issued. It was recommended that a one-year programme of ornithological surveys be carried out to validate the conclusions of the ESIA prepared for the Project.

2.1.4 LTWP commissioned URS Scott Wilson to carry out a review (the 'Review[1]') of the Project and the relevant project submissions, against the environmental and social requirements of the World Bank/ International Finance Corporation (IFC) Performance Standards. URS Scott Wilson was also commissioned to design and manage the ornithological surveys.

2.1.5 The ornithological survey method was based on best practice methods and was prepared following a reconnaissance survey and discussions with the Royal Society for the Protection of Birds (RSPB) and the National Museums of Kenya (NMK).

2.1.6 The surveys commenced in October 2010 using a team of ornithologists from the NMK. The surveys were conducted on a monthly basis over a twelve month period, including additional survey effort in the two migration periods of Autumn and Spring, which coincide with the months of October/November 2010 and March/April 2011.

2.1.7 An initial Progress Report was issued in December 2010, presenting a summary of the initial results arising from the first two months of survey, October and November 2010. An interim report was issued in May 2011 presenting the results from the first seven months of survey.

2.1.8 This report presents the results of the pre-construction surveys from October 2010 to September 2011) including both the autumn and spring migration periods and an additional raptor flight line survey at one Vantage Point (VP8). It includes the results of the analysis of potential for bird strike from the wind turbines and an estimate of the density of target species on the site.

2.1.9 The purpose of this report is to present the findings of the pre-construction surveys, including recommendations and conclusions, which might affect the project process. This includes operational monitoring recommendations.

2.1.10 Whilst not a specific requirement for approval of the EIA for the wind farm, it was recommended in the Review that investigation of any bats using the site be carried out to determine potential

[1] Scott Wilson (May 2011) Lake Turkana Wind Power Project, Kenya, IFC Performance Standards on Social & Environmental Sustainability: Project Review

impacts to bats from the project. The survey involved a week of surveys undertaken in March 2011 using bat specialists from URS Scott Wilson and the NMK.

Site Description

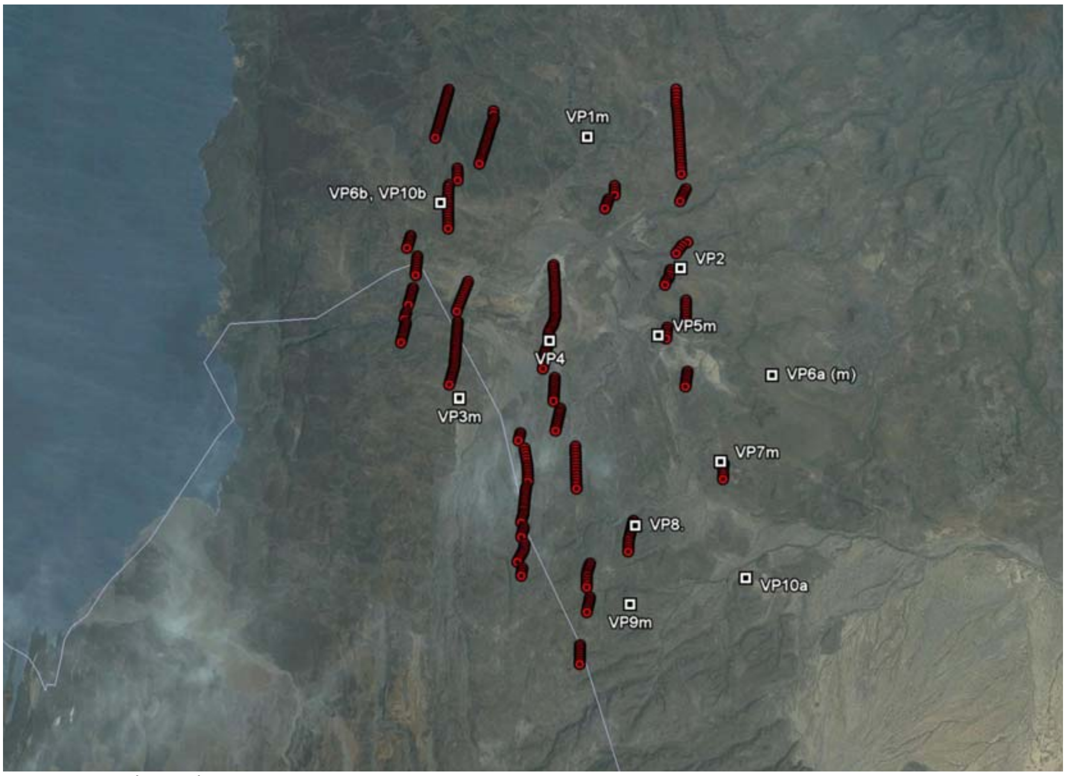
2.1.11 The wind farm site is approximately 162km[2] in size and comprises 'masai xeric[2]' grassland and scrubland with areas of bare alluvial deposits. There are very few trees across the site and no permanent water bodies. There are a number of bare ridges across the site, where the turbines will be positioned. The site is difficult to traverse due to the rocky terrain, however tracks have been cleared to facilitate construction of eight data masts which are situated on representative ridges located across the area to be occupied by the turbines.

2.1.12 Some acacias are found growing along occasional low lying "lagas[3]" which pass through the site. The lagas may be periodically flooded for a few days/weeks (possibly happening only between twice a year and one-in-ten years). Flooding happened during the surveys in August 2011. The southern end of the site generally has a greater frequency of acacia-commiphora scrub, although this is sparse compared to habitats further south. Further north the habitats are dominated by a rocky desert habitat with very sparse vegetation. The main habitation is Sirima encampment located in the middle of the site. It comprises thatched grass huts, a dry reservoir and a brick school building; in April it was observed that there were less than 50 people from the nomadic Turkana tribe present. There are a few other disused huts around the site, which may be used from time to time.

2.1.13 To the west of the site boundary is the shoreline of Lake Turkana, which is dominated by bare lava rocks. From the southern site boundary the habitats gradually change to scrub and tall acacia woodland as the main settlement of South Horr is approached at c.24km to the south of the site. South Horr is located within a canyon between Mount Nyiru and Mount Ol Donyo Mara. To the east of the site the land rises up to Mount Kulal (2335m) where the village of Gatab is located. This is a cooler habitat with moist broadleaf forests and steep sided valleys.

[2] Includes a mix of desert, savanna woodland, wetland, and bushland.
[3] An intermittent stream or water course which dries up in the dry season.

Figure 1 – Wind Turbine and Vantage Point Locations



Source: Google Earth

15km (approx.)

Note: Due to an amended turbine layout VP6a and VP10a were replaced by VP6b and VP10b from February 2011

3 Ornithological Surveys

3.1 Methods

3.1.1 The survey methods involved vantage point (VP) watches and transect surveys. The methods were developed from a reconnaissance survey undertaken in 2010[4], best practice methods[5] and consultation with the RSPB and NMK. Experienced ornithologists from NMK were used for the majority of the surveys, with quality checking and some additional site work by a URS Scott Wilson ornithologist. The methods are described below.

3.1.2 To assess the likelihood of collision with wind turbines VP watches were carried out overlooking the proposed site to assess the level of usage of the site by overflying birds. The data was then analysed to estimate the probability of collision for potentially susceptible species and in turn the potential impact on such species was assessed.

3.1.3 To estimate the population size of all of the species believed to have the potential to be excluded from the proposed wind farm it was necessary to estimate the population sizes of the bird species, primarily bustards that were found within the area of the proposed wind farm. To do this a bird recording transect was used (transect survey). This allowed for the baseline population of potentially affected species to be established so that potential impacts can be established.

3.1.4 Limitations of the bird surveys include:

- Disturbance: It was not possible to survey at or close to Sirima village, because the presence of 'outsiders' attracts the attention of large numbers of local children.
- Security: Surveys were undertaken either at the guarded mast sites or from a vehicle.
- Climate: e.g. orientation to the sun, dehydration risk, wind.
- Access and terrain: Surveys were undertaken by 4x4 vehicle from tracks.

3.1.5 The methodology used for the VP watches and transects surveys are as follows:

Vantage point watches

3.1.6 Recording focussed on larger, less manoeuvrable species which are known to be at potential risk of collision with wind turbines (target species), these are as follows:

- All large water birds (plover sized and above), e.g. flamingos, pelicans, storks and cranes;
- Birds of prey, including owls and raptors such as vultures, eagles, buzzards; and
- Bustards.

3.1.7 The International Union for Conservation of Nature (IUCN) Red List status of target species recorded on site are listed in Appendix 4.

[4] Scott Wilson (2010) Lake Turkana Wind Power Project: Methodology for Ornithological Survey.
[5] SNH (2005) Bird survey methods for use in assessing the impacts of onshore wind farms on bird communities

3.1.8 The VP watches entailed recording bird flights over a set area of the proposed wind farm at a representative number of locations which consisted of 10 VPs (see Figure 2). The orientation of each VP covered a 180° field of view. Initially six of these VPs were located at meteorological mast sites (indicated with the suffix 'm') and four adjacent to a track. These ten locations were chosen as a sample to give good spatial coverage across the site, approximately 50% of the area (based on an average 2km field of view), to cover regular bird-flight lines and potential migratory movement. The locations included views of ridgelines and valleys, and the full range of habitats on the site (i.e. from desert to scrub). From February 2011 VP6a(m) and VP10a were moved to new locations to account for minor layout changes, becoming VP6b and VP10b (see Figure 2 for locations). The total survey area remained the same.

3.1.9 Bird flight heights were recorded within three flight height bands which correspond to the current turbine specifications (i.e. Vestas V52 turbines with a 44m hub height). These height bands were as follows:

- Band A below rotor sweep height (<18m a.g.l[6])
- Band B within rotor sweep height (18 to 70m a.g.l)
- Band C above rotor sweep height (>70m a.g.l)

3.1.10 Further detail on the location of the VPs and method is shown in Appendix 1. To ensure accurate identification binoculars and a tripod-mounted telescope with a suitable magnification (25-40x) were used during all VP watches. The number of seconds for each bird flight was entered onto standard recording proforma (see Appendix 1).

3.1.11 Each VP was visited twice per month for one year (from October 2010 to September 2011) with each watch lasting 3 hours, resulting in a total of 72 hours of observations at each VP. In addition during the autumn and spring migration, additional survey effort was undertaken to ensure this important bird migration time was not missed. Therefore in October/November 2010 and March/April 2011 each VP was visited a total of four times per month (4 x 3 hours). The timing of the surveys at each VP was varied to include all daylight hours and a proportion of early morning and dusk visits, which are included to capture periods of bird activity in which birds may be moving to or from roosting and feeding areas.

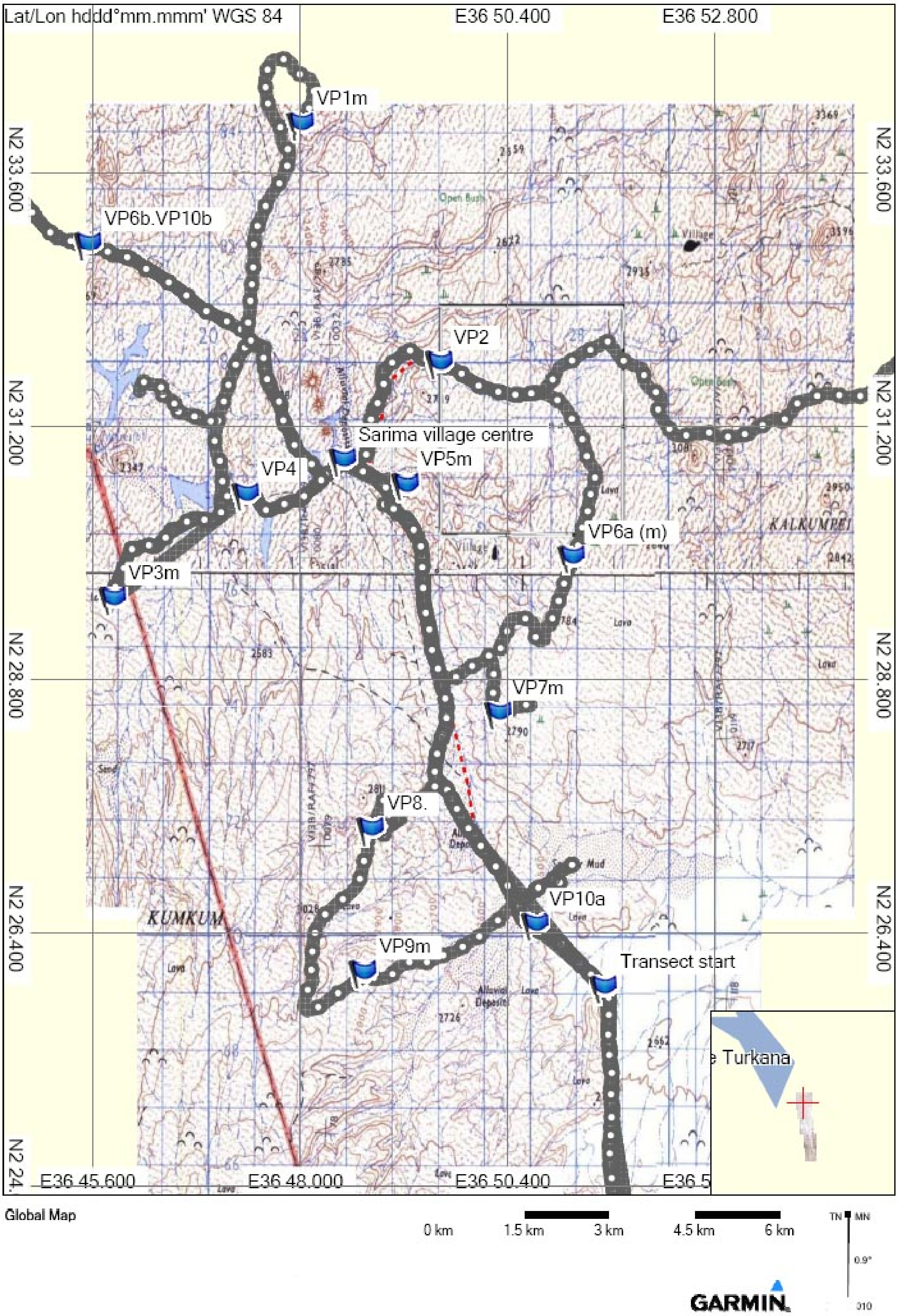
3.1.12 During the October 2010 surveys a high concentration of migrating raptors were recorded around VP8. Therefore during November 2010 an additional raptor flight line survey was undertaken to gather more data on the movements of raptors around VP8.

3.1.13 Data collected has been input to the Collision Risk Model[7] (CRM) which was used to estimate the likely number of collisions for each species per year. A full description of the model is given in Appendix 2. The data used in the model included flight heights and time spent within the rotor sweep height, bird flight direction and details on individual birds (e.g. bird length and flight characteristics). This resulted in calculations of mean annual number of bird movements through the wind farm at rotor sweep height and thus, ultimately, predicted collision risk for each target species.

[6] a.g.l above ground level

[7] Band, W., Madders, M., & Whitfield, D.P. 2007. Developing field and analytical methods to assess avian collision risk at wind farms. In: de Lucas, M., Janss, G.F.E. & Ferrer, M. (eds.) Birds and Wind Farms: Risk Assessment and Mitigation, pp. 259- 275. Quercus, Madrid

Figure 2 – Vantage point locations and access tracks



Bird recording transects

3.1.14 A number of different methods for the transect survey were investigated during the reconnaissance survey. The following method was undertaken based on the low number of birds recorded, lack of suitable habitat in most areas and the limitations stated in section 3.1.4 (e.g. practicalities of surveying the site due to access and climate, etc).

3.1.15 Access tracks through the site and up to the meteorological masts provide a good sample of the habitats across the site (e.g. desert to scattered scrub). Transects along access tracks were surveyed by vehicle. This started from c.500 metres south of the site boundary on the main track and continued within the site boundary en route to the first VP watch location on each day (see Figure 2). Stops were made when target bird species (same as for VPs) were encountered both flying and on the ground, and details were recorded on the standard pro-forma (see Appendix 1). The primary reason for the transect survey was to quantify the population of the bustard species. Additional species such as birds of prey were included in the data collection exercise. However due to the low occurrence of some species it has not been possible to calculate any meaningful population densities for these species. We have therefore not calculated any species densities for any species occurring on less than three occasions.

3.2 Results

Vantage point observations October 2010 to September 2011

3.2.1 Target species flights recorded at each VP from October 2010 to September 2011 are shown in Appendix 1, with target species flights recorded during observations from all ten VPs shown in Table 1.

3.2.2 Very few water-birds or bustards were recorded from any of the VP watches during the period (960 hrs in total). Records were one Heuglin's bustard recorded in January, four white storks and an unidentified stork recorded in February, one Heuglin's bustard, three unidentified bustards, three yellow-billed storks and two unidentified waders in May. The only other occurrences of a bird which was not a bird of prey, but is a target species, were three Somali coursers recorded during February and six in May.

3.2.3 October was the month with the most bird activity on the site. The total number of raptor flights recorded in October during the 120 hrs of observations across all the VPs was 272 flights, or just over two flights per hour. The most common species involved was steppe buzzard with 198 flights, followed by lesser-spotted eagle with 15 flights and greater kestrel with 10 flights. The remainder consisted of 13 further species making less than 10 flights during all of the October watches (see Table 1).

3.2.4 The number of bird flights in November was noticeably lower than was recorded in October with 92 raptor flights recorded during the 120 hrs of VP watches (Table 1). Species abundance recorded in November was slightly different to that recorded in October, with steppe eagle being the most common species with 24 flights, followed by steppe buzzard with only 21 flights, followed by lesser kestrel and Eurasian hobby with 11 and 10 flights respectively.

3.2.5 The lower numbers of observed raptor flights in November compared to October appears to indicate that the raptor migration season may have begun to slow down during November (Table 1). Overall this trend was largely due to the fact that steppe buzzard flights dropped from 198 flights in October to 21 flights in November.

3.2.6 From December onwards the number of bird flights decreased from what was recorded in October and November, with the most frequently recorded species African white-backed vulture and common kestrel having just four flights each.

3.2.7 The low numbers of bird flights in December continued to the end of the survey period in September. It is particularly noteworthy that during the spring migration period of March and April, even when taking into account double the survey effort at this time, the frequency of bird flights did not generally change significantly over what was recorded during the preceding months of December, January and February. The exception was a slightly higher occurrence of returning migratory raptors noted in March; namely 19 lesser kestrel and 10 steppe buzzard recorded.

3.2.8 Vantage Point 8 which is situated close to the top of a ridge that runs roughly north to south through the site produced a higher number of flights of migrating birds of prey during October and November. During the 24 hours of VP watches conducted in October and November from VP8 a total of 67 steppe buzzards, 12 lesser-spotted eagles, 11 steppe eagles were recorded. All other species were recorded in numbers of less than five individuals during October to November from VP8. VP's 2, 3 and 4 also produced moderate numbers of raptor flights although not quite in the numbers recorded at VP 8. No concentration of migrating raptors was noted at VP 8 during the spring migration period (March to April).

3.2.9 In response to the concentration of raptor flights at VP8 recorded in October additional study was carried out to look at raptor movements from this VP during November. This study has indicated that southward migrating raptors (in October and November) most probably use this ridge and high ground to the west of VP8 as a part of their migration route towards the mountains which lie between Lake Turkana and South Horr. This study confirmed that the number of low altitude flights (turbine height and below) peak during early morning and then again later on in the day when their flight is much lower than during the middle part of the day. It was noted that many of the raptors migrating past VP8 tended to fly just below the top of the ridge. During the middle part of the day migrating raptors were generally flying at a great height at least 1km above ground level and therefore well above turbine height and as a consequence they were mostly undetectable.

Table 1 – The number of target species flights, recorded during observations from all ten vantage points during the one year monitoring period October 2010 to September 2011 inclusive

Species	**Month**											
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**
Number of hours of watches per month at each vantage point	***12***	***12***	***6***	***6***	***6***	***12***	***12***	***6***	***6***	***6***	***6***	***6***
Black-shouldered kite	-	-	-	1	-	1	1	-	-	-	-	-
African swallow-tailed kite	-	-	1	-	-	1	-	-	-	6	2	-
Osprey	1	-	-	-	-	-	-	-		-	-	-
Gabar gosshawk	-	-	-	-	-	-	1	-	1	-	-	-
Eastern pale chanting gosshawk	-	-	1	2	-	-	-	-	-	-	-	-
Steppe buzzard	198	21	1	2	-	10	2	-	-	-	-	-
Long-legged buzzard	-	-	-	-	-	1	-	-	-	-	-	-
Tawny eagle	7	1	2	3	1	8	2	2	4	2	-	-
Steppe eagle	6	24	-	2	2	3	1	-	-	-	-	-
Lesser-spotted eagle	15	4	-	-	-	-	-	-	-	-	-	-
Greater-spotted eagle	4	-	-	-	-	-	-	-	-	-	-	-
Martial eagle	2	2	-	-	-	-	-	-	-	-	-	1
Verreaux's eagle	-	-	-	-	-	-	3	1	1	-	-	1
Walbherg's eagle	-	-	-	-	-	-	-	-	1	-	-	-
Bateleur	4	-	-	-	1	2	1	-	-	-	1	1
Black-chested snake eagle	-	2	-	1	-	-	1	-	2	-	1	-
Egyptian Vulture	5	8	-	-	1	-	1	1	-	1	-	-
African white-backed vulture	-	-	4	1	5	1	-	-	1	-	3	-
Lappet-faced vulture	-	-	2	-	-	-	-	-	-	-	-	-
Rüppell's griffon vulture	2	-	-	-	-	-	-	-	-	-	-	4
Pallid harrier	4	1	-	-	-	3	-	-	-	-	1	-
Saker falcon	4	-	1	-	-	-	-	-	-	-	-	-
Lanner falcon	-	3	-	-	-	-	-	-	-	-	-	-
Peregrine falcon	-	-	-	-	-	-	1	-	-	-	-	-
Barbary falcon	-	-	1	-	-	-	-	-	-	-	-	-
Greater kestrel	10	-	-	-	-	1	-	-	-	2	1	-
Eurasian hobby	-	11	-	-	-	2	-	-	-	-	-	-
Fox kestrel	-	-	-	-	3	-	8	1	-	2	1	-
Common kestrel	2	5	4	3	5	-	12	-	-	1	1	-
Lesser kestrel	7	10	1	-	2	19	-	-	-	-	-	-
Black-shouldered kite	1	-	-	-	-	-	-	-	-	-	-	-
Unidentified raptor	-	-	-	-	2	-	-	3	-	-	2	-
Unidentified kestrel	-	-	-	-	-	1	-	5	-	-	2	-
White stork	-	-	-	-	1	-	-	-	-	-	-	-
Yellow-billed stork	-	-	-	-	-	-		3	-	-	-	-
Unidentified stork	-	-	-	-	1	-	-	-	-	-	-	-
Heuglin's bustard	-	-	-	1	-	-	-	1	-	-	-	-
Unidentified bustard	-	-	-	-	-	-		3	-	-	-	-
Somali courser	-	-	-	-	3	-	-	6	-	-	-	-
Unidentified waders	-	-	-	-	-	-		2	-	-	-	-
Monthly totals	**272**	**92**	**18**	**16**	**27**	**53**	**34**	**28**	**10**	**14**	**15**	**7**

Predicted Collision Risk

3.2.10 For the majority of species the predicted collision risk over the 20 years of operation of the wind farm is relatively low (Table 2). Species for which predictions could be more significant are the long-lived resident and wintering species with low population recruitment, for example eagles and vultures. Primarily these are tawny eagle with 9 collisions predicted over the 20 year life of the wind farm, with Verreaux's eagle with 7.8 collisions predicted, Egyptian vulture with 5 collisions predicted and steppe eagle 4.2 collisions predicted. In addition lesser kestrel (not an eagle or vulture species) has a relatively high predicted collision risk with 17 birds over the life of the wind farm. Species with lower predicted collision risk are species such as black-chested snake-eagle and lesser spotted eagle.

Table 2 - Predictions of bird collision risk within the study area derived from observations from all vantage points over the 12 month survey period.

Species	Number of collisions per year without bird avoidance	Number of collisions per year with 98% bird avoidance*	Prediction of possible collisions over life of the wind farm (20 yrs)
Black-shouldered kite	1.09	0.02	0.4
African swallow-tailed kite	17.27	0.35	7
Osprey	0.06	<0.01	<0.2
Gabar goshawk	1.13	0.02	0.4
Eastern pale chanting goshawk	1.12	0.02	0.4
Steppe buzzard	30.1	0.60	12
Booted eagle	1.16	0.02	0.4
Tawny eagle	22.54	0.45	9
Steppe eagle	10.4	0.21	4.2

Species	Number of collisions per year without bird avoidance	Number of collisions per year with 98% bird avoidance*	Prediction of possible collisions over life of the wind farm (20 yrs)
Lesser-spotted eagle	6.29	0.13	2.6
Martial eagle	0.21	<0.01	<0.2
Verreaux's eagle	19.6	0.39	7.8
Bateleur	2.52	0.05	1
Black-chested snake-eagle	5.63	0.11	2.2
Egyptian Vulture	12.51	0.25	5
African white-backed vulture	7.77	0.16	3.2
Lappet-faced vulture	3.56	0.07	1.4
White-headed vulture	3.13	0.06	1.2
Pallid harrier	1.36	0.03	0.6
Lanner falcon	1.35	0.03	0.6
Saker falcon	0.02	<0.01	<0.2
Peregrine falcon	0.05	<0.01	<0.2
*Greater kestrel	5.1	0.26	5.2

Species	Number of collisions per year without bird avoidance	Number of collisions per year with 98% bird avoidance*	Prediction of possible collisions over life of the wind farm (20 yrs)
Eurasian hobby	1.26	0.03	0.6
*Fox kestrel	8.46	0.42	8.4
*Common kestrel	11.18	0.56	11.2
*Lesser kestrel	17.04	0.85	17
Yellow-billed stork	6.5	0.13	2.6
Somali courser	2.04	0.04	0.8

*An avoidance rate of 98% has been used for all species except kestrel where an avoidance rate of 95% has been used. (Based on Scottish Natural Heritage guidelines)

Transect survey observations October 2010 to September 2011

3.2.11 A total of 93 survey transects counts were conducted during the survey period. The average transect length was 12.8km giving a total length of 1190km of transect survey.

3.2.12 The primary reason for carrying out the transect survey was to assess the sites bustard population. Five species of bustard were recorded during the surveys; both white-bellied and black-bellied bustards appear to be relatively scarce and were only recorded on a handful of occasions on or near the site. In contrast buff crested, Kori bustard and Heuglin's bustard were seen regularly in and around the site. Density estimates are also relatively high i.e. Heuglin's bustard 0.4 birds per km^2 (65 for the site), Kori bustard 0.21 per km^2 (36 for the site) and buff-crested bustard 0.315 per km^2 (51 for the site).

3.2.13 Many species were recorded only once or twice on up to three occasions, for example; Verreaux's eagle, lappet-faced vulture, Somali ostrich and white stork (see Table 3). For this reason it has not been possible to calculate an accurate density for such birds on the site and these have been omitted. For the species that we have not calculated a density value, these species were rare or scarce on site (possibly just one or two birds present) during the one-year period of our surveys.

3.2.14 Birds of prey were also recorded during the transect surveys, species such as steppe buzzard (12 for the site), steppe eagle (1 for the site) and lesser spotted eagle (1 for the site) appear to be predominately passage migrants recorded mainly in October with only occasional wintering birds being present (Steppe buzzard and eagle). Density results for migrant species are relevant when they are present on site during the migratory periods only, as they are not present all year round.

3.2.15 The raptor species more likely to be resident which were occasionally recorded from the transect surveys were martial eagle (1 for the site) and Egyptian vulture (6 for the site). Gabar goshawk was recorded more frequently with an estimate of 10 individuals for the site.

3.2.16 Caution should be attached to the estimate of 6 Egyptian vulture for the site which is without doubt an over estimate. Our observations indicate only two individuals were present on site. The over estimate derived from transect data is believed to be due to the fact the two individuals were regularly recorded on site and were normally present close to and associated with Sirima encampment by the road along which the transect was conducted. This meant that this species was regularly seen during the transect surveys due to their regular proximity to the road which in turn has led to a density over estimate for the species.

3.2.17 Besides birds of prey and bustards other target species such as storks or herons were extremely scarce (Table 3), therefore it can be concluded that the wetland bird species associated with Lake Turkana rarely if ever use or over-fly the site.

Table 3 – Total number of bird registrations for all target species recorded during transect counts conducted during the period October 2010 to September 2011

Species	**Number of birds recorded per month**												
	Oct 2010	Nov 2010	Dec 2010	Jan 2011	Feb 2011	Mar 2011	April 2011	May 2011	Jun 2011	Jul 2011	Aug 2011	Sep 2011	Density of birds per km2 and for the **whole site (in bold)***
Kori bustard	-	-	-	1	-	-	-	1	-	-	-	2	0.22 (**36**)
Heuglin's bustard	1	1	-	-	5	-	-	3	8	-	11	1	0.40 (**65**)
White-bellied bustard	-	-	-	-	-	-	-	-	3	-	-	-	0.02 (**4**)
Black-bellied bustard	-	-	-	-	-	-	-	-	2	-	-	-	+
Buff-crested bustard	5	-	-	1	-	-	-	-	8	-	-	-	0.32 (**51**)
Abdim's stork	-	1	-	-	-	-	-	-	-	-	-	-	+
White stork	-	-	-	-	1	-	-	-	-	-	-	-	+
Somali ostrich	-	-	-	-	-	-	-	1	-	-	-	-	+
Somali courser	-	-	-	-	2	-	-	-	-	-	-	-	+
Crowned plover	-	-	-	-	-	-	-	5	-	-	-	-	0.02 (**4**)
Unidentified sandgrouse	-	-	-	-	12	-	-	-	-	-	-	-	+
Eastern chanting Goshawk	2	-	1	1	1	1	-	1	-	1	-	1	0.03 (**5**)
Verreaux's eagle	-	-	-	-	-	-	-	-	-	-	-	1	+
African hawk-eagle	2	-	-	-	-	-	-	-	-	-	-	-	+
Long-legged buzzard	1	-	-	-	-	-	-	-	-	-	-	-	+
Steppe (common) buzzard	81	2	1	-	-	-	-	-	-	-	-	-	0.07 (**12**)
Pallid harrier	3	-	-	-	-	-	-	-	-	-	-	-	0.01 (**1**)
Eurasian sparrowhawk	2	-	-	-	-	-	-	-	-	-	-	-	+
Steppe eagle	4	1	-	1	-	-	1	-	-	-	-	-	<0.01 (**1**)
Lesser kestrel	3	-	-	1	-	-	-	-	-	-	-	-	<0.01 (**1**)
Lesser spotted eagle	5	-	1	-	-	-	-	-	-	-	-	-	<0.01 (**1**)
Greater kestrel	3	-	-	-	-	-	3	1	-	-	-	-	0.01 (**2**)
Martial eagle	1	-	-	-	-	-	-	1	-	1	-	-	<0.01 (**1**)
Tawny eagle	1	-	-	-	-	-	-	-	2	-	-	-	<0.01 (1)
Lappet-faced vulture	2	-	-	-	-	-	-	-	-	-	-	-	+
Egyptian vulture	1	6	1	-	-	-	-	-	-	1	-	-	0.03 (**6**)
Gabar goshawk	1	-	-	-	3	1	1	-	-	-	-	-	0.06 (**10**)

Species	**Number of birds recorded per month**											
Black-shouldered kite	-	1	-	-	-	-	-	-	-	-	-	-	+
Eurasian hobby	-	1	-	-	-	-	-	-	-	-	-	-	+
White-backed vulture	-	1	-	-	-	-	-	-	-	-	-	-	+
European honey buzzard	-	-	1	-	-	-	-	-	-	-	-	-	+
Common kestrel	-	-	-	2	-	-	-	-	-	2	-	-	0.01 (**2**)
Black-chested snake-eagle	-	-	-	-	1	-	-	-	-	-	-	-	+
Fox kestrel	-	-	-	-	-	-	5	-	-	-	-	-	0.01 (**2**)
Whalberg's eagle	-	-	-	-	-	-	-	1	-	-	-	-	+
Unidentified raptor sp.	-	-	-	-	-	-	-	2	-	-	-	-	+

+Due to low frequency of occurrence or unidentified species no density calculation has been possible.

*Density estimate for the whole site round up to the nearest 1 bird.

3.3 Discussion

3.3.1 The survey data presented and discussed in this report represent twelve months of data (October 2010 to September 2011 inclusive). This period includes both the autumn and spring migration period for migrating raptors and other target species.

3.3.2 There are two main potential impacts on avifauna brought about by wind farms, these are i), the risk of collision, potentially from the large and less manoeuvrable species colliding with the wind turbines and ii) general bird avoidance of wind turbines meaning birds are excluded from otherwise suitable habitat within the vicinity of the wind farm. Direct habitat loss from wind farm infrastructure may also be an impact on breeding habitat. These impacts are discussed further below in relation to the survey findings.

3.3.3 Although we have collected and analysed one years worth of bird flight data, it is widely known that modelling of such data using the CRM model gives at best an approximate guide to what might be expected to happen. There are also no comparable schemes on this scale in this location to compare the studies to. A recent paper by Ferrer et al. (2011) found a weak relationship between collision risk assessment studies and recorded mortality in a study pool of 53 windfarms[8]. They concluded that studies often made their assessments at a scale of the whole wind farm rather than a smaller scale, taking into account where birds might fly in relation to features such as ridges. At present CRM is the main method available for assessing the potential impacts of wind farms on flying birds and for this reason this is the method we have used for our assessment. We have taken into account the localised nature of some bird movements through the study of the species migrating along the ridge overlooked by VP 8.

3.3.4 From the data collected it is possible to make inferences regarding the occurrence of target species observed on the site, which have the potential for collision risk. Firstly, of the species recorded, there were very few records of water birds during a transect survey and VP watches (see Tables 1 and 2). Following consultation the potential impact upon water birds at Lake Turkana was the primary concern arising from the project and the main basis for recommending the surveys. The low number of records of water-bird species seems likely to be due to the fact that there is little or no water on site and that Lake Turkana lies a considerable distance from the Site (c.8km). Furthermore, the site does not lie directly between Lake Turkana and any other of the Rift Valley lakes and as a consequence does not lie on any regular water bird flyway.

3.3.5 The main bird issue identified is the collision risk of raptors. Raptors can be categorised into three groups,

- Western Palaearctic migrants (migrating October/November and in March/April e.g. steppe buzzard, steppe eagle)
- Resident species (present all year round e.g. martial eagle, vultures.)
- Wintering species (October to April, possibly small numbers of species such as steppe eagle which may remain on site throughout the winter months).

3.3.6 The first two months of survey (October and November 2010) coincided with the autumn migration of Western Palaearctic birds from Europe to Africa. As a consequence it was predicted that the first two months of survey would be likely to record higher numbers of birds than the rest of the year except for March and April, when migration is reversed with birds migrating from Africa to Europe and Asia for the summer months. This was shown clearly by the data which

[8] Ferrer, M., de Lucas, M., Janss, G. F.E., Casado, E., Munoz, A. R., Bechard, M.J. & Calabuig, C.P. *Weak Relationship between risk assessment studies and recorded mortality in wind farms.* Journal of Applied Ecology 2011

recorded much higher numbers of birds during the October period than the mid-winter non-migration period (see Table 1). However, it should be noted that this was restricted to birds of prey and virtually no water birds were recorded on site during this period or during the remainder of the year.

3.3.7 Unexpectedly, during the spring migration period of March and April 2011 bird numbers remained relatively low with no large increase in numbers of birds of prey or other migrating target species. A possible explanation is that migrating birds of prey take a different migration route across the general area in spring compared to their autumn migration. This could be caused by the prevailing wind conditions on the site which are invariably from a south-easterly direction. This could have the effect of deflecting birds towards or away from the site depending on the season. It should be noted that the pattern of migratory movement may vary on an annual basis.

Notes on western Palaearctic migrants

3.3.8 Data collected during both the autumn and spring migration periods suggests that bird numbers were lower than might have been expected for a location within or close to a main migration route thought to be taken by Western Palaearctic migrants.

3.3.9 Western Palaearctic migrant species were recorded in higher numbers than resident species, for example the most numerous species was steppe buzzard with 219 flights recorded from the autumn migration period with 12 birds during the spring migration period, of this approximately 50% of flights recorded at a height where collision would be possible. However when taking into account avoidance rates (at 98% and 95% for kestrels) and the fact most flights were below the ridgelines where the turbines will be sited. We believe that the actual numbers collisions will be significantly less than the collision risk modelling predicts, this is because the CRM model makes predictions irrespective of the fact that birds may not actually migrate along the tops of ridgelines and fly just below this level as observed during our study. Other factors at this site that suggest that collisions are likely to be less than predicted by the CRM include the fact that most raptor flights are undertaken during the day and the visibility is usually good at the site, as opposed to sites where fog and bad weather may cause additional risk of collision. Despite the above some risk of collision remains to certain target species.

Resident Species

3.3.10 Of the larger raptor species (not including kestrel and sparrowhawk sp.) only Martial eagle, Egyptian vulture, dark-chested snake eagle and tawny eagle appear to be resident breeding species. Based on a combination of general observations, transect and vantage point data one pair of each of the above three species appear to be present on site. As resident bird of prey species appear to be present in small numbers this resulted in only a small number of flights being recorded during the VP watches. Whilst predicted collisions of these species are low, up to one bird per year, with a few individuals (e.g. one pair of Martial eagle and Egyptian vulture), due to the low recruitment rate of these long lived species (up to 25 years) any collision would be significant locally. Other species such as African white backed vulture is observed occasionally, with these birds most likely to be originating from small colony of 20 nests observed near South Horr approximately 25km to the south of the site. Verreaux's eagle was observed on a number of occasions and these are thought to be birds wandering from their core territories from mountains flanking the South Horr Valley or Mount Kulal. Over the twenty five year life of the wind farm the CRM predicts 10 collisions for this species. Similar to Martial eagle and Egyptian vulture, any collision for these species could be locally significant.

3.3.11 Only five bustard flights were recorded from all of the VP watches over the survey period of one year and all of these flights were below turbine blade height. This is despite Kori, Heuglin's and buff-crested bustards being seen fairly frequently during the transect surveys. Therefore on the basis of the data, the potential for collision risk from turbines appears to be negligible for the bustard species.

3.3.12 There is likely to be some displacement of birds from the footprint of the wind farm infrastructure itself. However, due to the generally low numbers of target species recorded on site, the location of the turbines on the ridges and the presence of large areas of alternative suitable habitat the impacts from exclusion is likely to be low. Species with relatively high densities such as bustards were generally not observed on the tops of ridges where the turbines are to be located, although we did observe Heuglin's bustard on ridge tops on several occasions. Therefore some displacement could be a possibility for this species.

3.3.13 Nightjars were seen at night along the main access road often close to lagas. Whilst vehicles travelling at night are a potential threat to nightjars, and other nocturnal species, it is understood that all construction vehicle movement will be restricted to daylight hours.

3.3.14 Nightjars could also be potentially vulnerable to collision with turbines although this species is less likely to forage along the ridges as it was mostly observed along the road and in lagas.

3.3.15 Vultures (which are also a migrant species) were recorded in low numbers and were seen on occasions around settlements, e.g. Sirima village. Precautions may be needed to ensure that the presence of the proposed wind farm workers settlement does not attract large numbers of vultures to the site where they could be at increased risk of collision with turbines.

Wintering Species

3.3.16 Numbers of birds were relatively low compared to the Autumn migration period with only small numbers of Western Palaearctic migrants being recorded during the winter period. For example only three steppe buzzard flights and four steppe eagle flights were seen from all VP watches during December, January and February.

Notes on the higher concentration of birds of prey occurring during the autumn migration at VP8

3.3.17 During autumn migration there was a distinct concentration of raptors moving along the ridge which is overlooked by VP8. Low level movements (turbine height and below) of raptors along the above mentioned ridge normally occur early and late in the day. During the middle part of the day, the raptors that were recorded were usually at great height and barely detectable.

3.3.18 Based on the studies to date, it is believed that some raptors migrating south in autumn use the ridge and high ground to the west of VP8 as a part of their migration route towards the mountains which lie between Lake Turkana and South Horr. Observations in this area suggest that most raptors fly along the edge of the ridges and would therefore avoid the proposed turbines.

Notes on overhead power cables

3.3.19 As part of the scheme there will be an overhead network of 33kV power lines linking collections of turbines to the onsite sub-station. These pose two potential dangers to birds: direct collision with the cables (birds of prey and bustards) and electrocution (birds of prey only)[9]. Providing that the insulators are of the suspended type[10] and that they are long enough to prevent perching birds of prey from electrocuting themselves this can be ruled out as an impact.[11] Similar to the wind turbines overhead cables can pose a collision risk to birds. The risks to bustards and birds of prey have been well documented in other countries and are, in particular, the two groups at potential risk. The risk of this can be reduced by attaching bird deflectors to all or particularly hazardous stretches of power cable (see below).

3.4 Conclusions and Recommendations

3.4.1 The data collected indicates that a low resident population of target bird species is present on site and that during the autumn migration period there is a significant increase in birds of prey passing through the site.

3.4.2 The site is approximately 8km from Lake Turkana and water birds are extremely rare on the site. For example only one osprey, one Abdim's stork and one occurrence of three yellow-billed storks are the only water bird records of note. For this reason we believe the scheme presents an extremely negligible risk to water birds associated with Lake Turkana.

3.4.3 Based on the location of the proposed turbines and the observed flight routes undertaken by migrating birds of prey: and taking into account avoidance rates, it is unlikely that there will be a significant impact to migrating birds through collision with the turbines. However a small risk remains for a number of the rarer long-lived species with low population recruitment such as tawny and steppe eagle. The CRM predicts for these species only one collision every 2 to 4 years (Table 2). Some species such as steppe buzzard do have higher predicted collision rates although these species tend to be much more common and are therefore unlikely to have their populations impacted by the scheme.

3.4.4 Resident birds of prey at risk include eagles and vultures. As with migrating species the collision risk is small, up to one bird per year of each species; however this may not be insignificant, particularly to species such as Verreaux's eagle with only a few long-lived individuals resident on or close to the site.

3.4.5 There is a possible risk from collision with overhead power lines, although the flight heights of migrating birds of prey and the low density of most target species on site reduces the likelihood of this. The exception to this are bustard species which have a higher density than other target species on site and were recorded flying much closer to the ground than other species.

3.4.6 We recommend that bird deflectors (also known as flight diverters) are fitted to power cables to prevent collisions by large less manoeuvrable species birds such as bustards and birds of prey. These have been shown to reduce bird collisions.[12]

3.4.7 There are other associated risks such as a potential increase in traffic collisions that have been mitigated for by limiting the speed of vehicles on site and avoiding use of construction vehicles at night.

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[9] Raab, R., Spakovszky, P., Julius, E., Schutz, C. & Schulze, C.H. (2010) Effects of power lines on flight behaviour of the West-Pannonian Great Bustard *Otis tarda* population. Birdlife International.
[10] The currnet plan is that the insulators are of the suspended type
[11] Ferrer,M., de la Riva, M., Castrovie, J. (1991) Electrocution of Raptors on Power Lines in southwestern Spain. Journal of Field Ornithology, Vol.62, No.2 (Spring 1991), pp.181-190.
[12] Frost, D. (2008) The use of 'flight diverters' reduces mute swan Cygnus olor collision with power lines at Abberton Reservoir, Essex, England. Conservation Evidence (2008) 5, 83-91.

3.4.8 To avoid attracting vultures any waste food produced by the wind farm workers village should be stored in secure containers or composters on site prior to removal.

3.4.9 A programme of monitoring is recommended to validate the conclusions made during this assessment and to quickly identify any impacts to birds from the operational wind farm. In particular this should include monitoring migrating and resident raptors and bustards. A draft monitoring plan for the operational stage of the wind farm is provided in section 6.

4 Bat Surveys

4.1 Introduction

4.1.1 Based on the reconnaissance survey of the site undertaken in July 2010 the site appeared to have low potential for bats. However, it was recommended in the Review that bats should be considered, via a one-off survey, in order to close out the possibility of a significant threat to bats from the wind turbines. The aim of this study was to appraise the use of the project site by bats as no background data was available and determine any potential impacts to bats from the proposed wind turbines.

4.2 Methods

4.2.1 A range of techniques were used to determine the use of the site and surroundings by bats.

4.2.2 The method is based on using a variety of techniques to record both fruit bats (Megachiroptera) and insect bats (Microchiroptera). It should be noted that this is a baseline appraisal for bats and does not constitute a comprehensive study of bats using the site. The survey comprised a week of surveys on and around the site from the 12th to 18th March 2011. Methods involved daylight roost surveys, bat activity surveys, mist and hand netting, transect surveys using hand-held bat detectors, and use of static bat detectors.

4.2.3 The daylight roost surveys comprised searching disused shelters, mature trees, suitable rocky outcrops and caves within and up to 10km from site. This included off-site habitats at Mount Kulal, Mount Nyiru, and the eastern shore of Lake Turkana.

4.2.4 Bat activity surveys were undertaken in five different sample points (SP) on the site (see Figure 3), that encompassed the full range of habitats present including wooded areas, lagas, scrub habitat, grassland habitat, and exposed rocky ridges. Bats from these SP may forage over the whole wind farm site and across the surrounding landscape.

4.2.5 The mist netting was undertaken under guidance of the NMK bat ecologist to ensure minimal distress or harm to the bats. Mist nets were located in suitable habitats to catch and identify flying bats. Bats were identified in the hand where possible, and/or photographed for future identification.

4.2.6 Transects were walked at the SP (where the terrain allowed for this) at a steady speed using hand held heterodyne/frequency division bat detectors (Bat box duets) connected to a recording device (Edirol R-09). The surveys commenced up to 0.5 hours before sunset and were completed within 3 hours after sunset. This aimed to sample the peak of dusk and post dusk bat activity. Environmental parameters and bat activity were recorded on standard proforma.

4.2.7 The static bat detectors (Anabat SD1 and SD2) were used during the surveys and left overnight at SPs to provide additional data.

4.2.8 Within each habitat type a Bat Activity Index (BAI) was calculated as follows:

Bat Activity Index = Number of passes / time[13]

[13] Time calculated as from sunset to sunrise.

4.2.9 The objectives were to find not only an estimate of the population size and the species present, but also to identify those parts of the site that are most important for bats.

4.2.10 The bat recordings made during the survey were analysed in Batsound and Analook. Where data existed on echolocation calls of Kenyan species of bats the calls were assigned to genus, species or unknown.

Figure 3 – Bat Sample Point (SP) Locations

4.3 Results

Daylight roost surveys

4.3.1 On the site there are estimated to be approximately 50 mature trees, particularly along the lagas with potential for roosting bats. The only suitable building on site at Sirima village did not contain any signs of bats. There are some rocky outcrops with suitable roosting habitat; however no actual bat roosts were observed within the footprint of the wind farm site.

4.3.2 Off site, towards the summit of Mount Kulal (c. 15km from site) are numerous caves in mostly inaccessible locations and mature woodland with potential for bats. On Mount Nyiru (c.20km from site) a *Hipposideros* sp (a leaf nosed bat) roost was found in a rocky outcrop by a waterfall. There were also feeding signs of *Epomophorus* sp (an epauletted fruit bat) in the wooded areas. There were no signs of roosts along the 3km surveyed section of the eastern shore of Lake Turkana.

Bat Activity Surveys on site

4.3.3 Five SP were surveyed (see Figure 3) comprising sparsely wooded lagas (SP1,2,3 and 5), an exposed ridge at a mast site (SP4) and open semi-desert/scrub (also at SP5). The results are shown in Appendix 5.

4.3.4 At least 15 different bat species were recorded during the activity surveys on site with six identified to species; *Lavia frons* (yellow-winged bat), *Pipistrellus nanulus* (tiny pipistrelle), *Chaerophon bivittata* (a wrinkle lipped bat), *Scotoecus hirundo* (an evening bat), *Hipposideros commersoni* (Commerson’s leaf nosed bat), *Scotophilus nigrita* (Schreber's yellow bat); seven to Genus *Chaerophon* sp., two *Rhinolophus* species (horseshoe bats), *Neuromicia* sp., *Tadarida* sp. (a guano bat), two *Nycteris* species (slit-faced bats); and at least two unknown bats.

4.3.5 Bats recorded at, or soon after the expected emergence times, indicate the presence of roosts on site. For example at SP5, five *Pipistrellus nanulus* were caught in nets within 1 minute of each other at 19:15.

4.3.6 BAIs were calculated (see 4.2.8), based on transect and Anabat data for each habitat type sampled during the survey. This gave a comparison between the usage of different habitats (and wind conditions) on the site by bats.

4.3.7 Surveys undertaken in the lagas, ranging from still to windy conditions had a mean BAI of 0.13, with surveys during an absence of wind with a BAI of 0.21, and in windy conditions a BAI of 0.06. An exposed windy ridge had a BAI of 0.03. An open desert with scattered scrub had a BAI of 0.03 (no wind).

Other mammal records

4.3.8 Populations of large mammals in the area are understood to be low. The endangered Grévy's zebra were seen on three occasions at close range a few kilometres south east of the site well away from any habitation. Numbers ranged from between two and 11 animals. Two Grévy's zebra were filmed using night vision cameras 2km to the south of the site crossing the road along a laga. Gerenuk were recorded between South Horr and the site and occasionally on the site. Günther's and Kirk’s dik-dik were also seen occasionally along the roadside, mainly to the south of the site.

4.3.9 A female cheetah with two well grown cubs were recorded crossing the access track at one of the less rocky areas towards the south of the site on 1st August 2010. Footprints were also seen in the same area on 15th March 2011. Other species recorded occasionally, all south of the site included common jackal, black-backed jackal, striped hyena, spotted hyena, greater kudu, grey striped bush squirrel, Somali galago and cape hare.

4.4 Discussion

4.4.1 Bats were found using all of the habitats on site, with at least 15 species recorded during the surveys. The highest level of bat activity was recorded in and around the sparsely wooded lagas when there was little or no wind. The presence of bats recorded soon after expected emergence times indicate bat roosts on site, most likely in mature trees or rocky outcrops close to the lagas.

4.4.2 The presence of bats flying in windy condition over the exposed sparsely vegetated ridges, albeit in lower numbers, was largely unexpected, indicating that there is an availability of food in these habitats and that certain bat species can tolerate the exposed, windy conditions experienced on site.

4.4.3 Consideration will need to be given to the potential impact to bats flying across the ridges interacting with the rotating turbine blades. The risk of death or injury as a result of collision or decompression barotrauma arising from the operation of the wind turbines is a function of the characteristics and behaviour of the individual bat species involved. The risk of an impact occurring is also a function of the position (proximity) of the turbine in relation to features used by bats.

4.4.4 Although bat activity is low on the ridges where the turbines are located, some of the bat species recorded here are likely to be at moderate to high risk of collision or decompression barotrauma[14]. Monitoring of the behaviour of bats and any collisions is therefore recommended particularly in these areas on site.

4.4.5 Collision risk by vehicles and potential displacement of other mammals is a possibility, albeit low.

4.5 Conclusions and Recommendations

4.5.1 With regards to bat roosts, it is understood that trees will not be lost as part of the proposed wind farm. If any mature trees are required to be de-limbed, e.g. for cabling or road widening at laga crossings, the following method should be followed.

4.5.2 Prior to any tree felling work, the contractor should undertake a visual inspection of the tree to check for bats. As far as possible, fissures and cavities should be inspected e.g. with the use of a small hand-torch. Special attention should be given to splits that are held open by the weight of a branch, and which will close once the branch is removed.

4.5.3 If more complex cavities are present within the trees, the section should be carefully lowered to the ground and left with the entrance upward facing for at least 2 nights before limbing or removal. Unless the section is to remain intact onsite, after 2 nights the cavity should be cut into sections and inspected to ensure that bats are absent.

[14] Natural England (2009) Bats and onshore wind turbines: Interim guidance, first edition. Natural England Technical Information Note TIN051

4.5.4 Trees with active maternity roosts should not be removed until the juvenile bats can safely fly (usually 8 weeks after being born). For health and safety reasons, it is important to ensure that bats are not handled under any circumstances without the use of gloves.

4.5.5 Due to the potential for bats interacting with the turbines a programme of monitoring is recommended to determine any changes to bat activity as a result of the operational wind farm.

4.5.6 The speed of vehicles on site will be limited and as such the collision risk to other mammals is likely to be low. Displacement of mammal remains a possibility particularly during construction.

5 Overall Conclusions

5.1.1 The data collected over a year of surveys including capturing both Autumn and Spring migrations, indicates that a low resident population of target bird species is present on site and that during the autumn migration period there is a significant increase in birds of prey passing through the site.

5.1.2 Based on the turbine layout, observed flight routes undertaken by migrating birds of prey and avoidance rates it is unlikely that there will be a significant impact to migrating birds through collision with the turbines. A small collision risk remains during the autumn migration, to a few species of birds of prey and to some resident species such as eagles, kestrel and vultures. No risk to water birds associated with Lake Turkana has been identified.

5.1.3 The scheme involves connection of all turbines to a grid of overhead power lines which will be approximately 7.5m above ground level. These could present a certain degree of risk especially for the large less manoeuvrable species such as birds of prey and bustard species which are known to be especially at risk[15]. Flight heights recorded during the surveys suggests that resident bustard species, classified by IUCN Red List as of 'Least Concern', would be more at risk whereas migrating raptors which tended to fly at a much higher level are at a much lower risk. The risk to birds is likely to be significantly reduced by fitting bird deflectors to the power lines.

5.1.4 Bats use the site, with increased activity close to vegetation around the lagas. Activity is low on the ridges where the turbines are to be located. A risk remains that bats recorded on the ridges may be at risk of collision or decompression barotraumas.

5.1.5 A programme of monitoring as per best practise guidelines[16] for wind farms is recommended to validate the conclusions made during this assessment and to quickly identify any impacts to birds and bats from the operational wind farm.

[15] Guyone, F, .Janss, E and Ferrer, M. (2000) Collision Risk Exposure, common crane and great bustard collision with power lines: collision risk and risk exposure. JSTOR: Wildlife Society Bulletin, Vol.28, No. 3 (Autumn, 2000), pp. 675-680
[16] Natural England (2010) Technical Information Note TIN069: Assessing the effects of onshore wind farms on birds. Scottish Natural Heritage, (2009) Guidance on Methods for Monitoring Bird Populations at Onshore Wind Farms.
Onshore Wind Farms

6 Recommendations

6.1.1 It is recommended that bird deflectors are fitted to all power lines within the site. These vary in design but normally hang or are threaded onto the wires making them much more visible allowing birds to take avoiding action early enough to prevent collision. An example is shown in Appendix 6.

6.1.2 As per best practice guidelines for wind farms[12] it is recommended that the operational wind farm is monitored to identify bird movement patterns, flight characteristics and actual collisions. This is usually undertaken in years 1, 2, 3, 5, 10 and 15 of operation. At the end of year 3 there would be a review to determine whether to continue the monitoring.

6.1.3 The monitoring should include similar surveys to those being undertaken during the pre-construction monitoring. These would comprise vantage point and transect surveys to identify any displacement of birds from the wind farm, changes in flight lines and collision or avoidance of collision with turbines or power cables. In addition, corpse monitoring would be undertaken particularly at times of the year when more birds are present (e.g. Autumn migration) to assess true collision rates.

6.1.4 It is anticipated that the full scope of the operational monitoring surveys will be agreed with LTWP and consultation with the RSPB/Birdlife International. A draft plan is presented below for Year 1 of operation.

6.1.5 The vantage points would be surveyed as per the current methods, with a reduced surveyor effort, during four periods per year. This would involve 1 day (6 hours) per vantage point per month during the autumn migration (October and November), 1 day per vantage point during the winter (January), 1 day per vantage point per month during the spring migration (March and April) and 1 day per vantage point during the summer (June). Transect surveys should also be undertaken during this period as per current methods. In total this would be 60 man days of bird surveys providing 360 hours of data for analysis.

6.1.6 Bat surveys, comprising one week activity surveys per year should be undertaken during years 1, 2, 3, 5, 10 and 15 to assess any changes in the bat activity on the site. The surveys should follow the methods used during this study with particular focus on areas around the turbines. At the end of year 3 there would be a review to determine whether to continue the monitoring.

6.1.7 Corpse monitoring for birds and bats should be undertaken around a sample of the turbines, during a two week period around both autumn and spring migration and two other one week periods in winter and summer. Local staff will be trained by a consultant with large-scale wind farm monitoring experience to undertake this to the agreed methods. This training would assess scavenger rates and surveyor efficiency. Calculations of actual collisions would then be undertaken and reported on annually.

6.1.8 Outside of this time period nominated people based on the site would undertake regular checks around the turbines to look for any dead/injured birds or bats. These will be reported on standard forms and sent to an experienced consultant for analysis.

6.1.9 Where any mitigation is required this would then be discussed and agreed with LTWP.

Appendices

Appendix 1 - Vantage Point Locations, Method and Recording Forms

VP1m Grid ref. N2 34.041 E36 48.011

VP Orientation: 180° centre line is NORTH EAST

VP2 Grid ref. N2 31.783 E36 49.602

VP Orientation: 180° centre line is NORTH

VP3m Grid ref. N2 29.546 E36 45.840

VP Orientation: 180° centre line is NORTH EAST out of the gate at mast site (Photo n/a)

VP4 Grid ref. N2 30.532 E36 47.375

VP Orientation: 180° centre line is NORTH WEST

VP5m Grid ref. N2 30.623 E36 49.223

VP Orientation: 180° centre line is SOUTH WEST just outside entrance of Mast Site

VP6a (m) (Oct 2010 to Jan 2011) Grid ref. N2 29.938 E36 51.159

VP Orientation: 180° centre line is NORTH

VP6b (from Feb 2011) Grid ref. N2 32.906 E36 45.560

VP Orientation: 180° centre line is NORTH

VP7 Grid ref. N2 28.459 E36 50.283

VP Orientation: 180° centre line is EAST

VP8 Grid ref. N2 27.359 E36 48.833

VP Orientation: 180° centre line is NORTH

VP9m Grid ref. N2 26.003 E36 48.744

VP Orientation: 180° centre line is WEST

VP10a (Oct 2010 to Jan 2011) Grid ref. N2 26.456 E36 50.711

VP Orientation: 180° centre line is NORTH

VP10b (from Feb 2011) Grid ref. N2 32.906 E36 45.560

VP Orientation: 180° centre line is SOUTH

Methods for Vantage Point (VP) watches

This is taken from the generic guidance for onshore wind farms by Scottish Natural Heritage (SNH). Full details can be found at http://www.snh.gov.uk/planning-and-development/renewable-energy/onshore-wind/

Watches are undertaken between dawn and dusk by a single observer under conditions of good ground visibility (>3km).

Each watch should last a maximum of three hours but can be suspended and then resumed to take account of changes in visibility (e.g. fluctuations in the cloud base). Experience from field trials suggest that the accuracy of most observers declines after three hours, and some may prefer to conduct shorter watches. A gap of at least one hour between watches is advisable.

During each watch the area in view is scanned until a target species is detected at which point it is followed until it ceases flying or is lost from view. The time the target bird was detected and the flight duration are recorded. The route followed is plotted in the field onto the field maps. The bird's flight height is estimated at the point of detection and then at 15 second intervals thereafter, using, for example, a count-down timer with an audible alarm. A 15 second interval is recommended as a practical compromise that aims to minimise dependency within data while maximising the sample of observations. Flight heights will be classified to height bands reflecting rotor swept area as appropriate (see main text). Training and checking of observer accuracy in relation to height estimation should be made and accounted for where this is possible. Use of a clinometer and range finder provides one means of determining flight heights accurately. Observations of target species take priority over completion of activity summaries.

At the end of each watch, the locations and activity indicative of breeding by target species should be recorded on the map.

Data should be recorded on the form and maps. Forms must be completed for each VP watch, regardless of whether target species were recorded or not. Use different forms for different watches (i.e. do not combine data from different watches onto one form or map). Forms used should encapsulate the observations listed below and, of course, record start and finish times, observer name, weather records and VP location (cross referenced to the map).

Forms:

- For each watch number each flying bout consecutively. Cross reference this number to the flight path recorded on the relevant map.
- Record the time the bird is first detected to the nearest minute e.g. 15:45.
- Record duration of flying bout to the nearest second.
- For each flying bout: starting at 0 (zero – point of first detection), number each 15 second interval consecutively, and tick appropriate flying height for each 15 second interval.
- Rule off under each flying bout to highlight end of recording.

Map(s):

- Mark the location of the VP used.
- Mark flight paths of target species and indicate direction of flight. Use different colours and symbols for each species. Provide key on back of form.
- Number each flying bout and cross reference with Form.
- Use additional map(s) if data records are cluttering initial map.

Vantage Point Recording Form (*Total seconds for each band to be completed by Surveyor)

VP recording sheet		**Project**	**LTWP**			
VP number:		Name:		start/end time /	wind speed/direction	precipitation
Date:				temp C *max* *min*	cloud cover %	Visibility

flight no.	time	species	number	total secs.	Height(15 sec intervals)																												*Total secs for each band
				A. <18m																													
				B. 18 to 70m																													
				C. >70m																													
				A. <18m																													
				B. 18 to 70m																													
				C. >70m																													
				A. <18m																													
				B. 18 to 70m																													
				C. >70m																													
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				C. >70m																													
				A. <18m																													
				B. 18 to 70m																													
				C. >70m																													
				A. <18m																													
				B. 18 to 70m																													
				C. >70m																													

Transect Recording Form

LTWP transect recording form

Start Point	**Start of site**	**End Point, VP number**	**VP**
DATE	/ /	Temp C	
Observer		Cloud %	
start /end time	/	Wind mph	

Map ref.	**Species**	**No. of birds**	**Waypoint**	**Distance from Waypoint**	**Bearing from Waypoint**	**GPS Co-ordinates**

Appendix 2 – Scottish Natural Heritage Collision Risk Model

WINDFARMS AND BIRDS: Calculating a theoretical collision risk assuming no avoiding action

Windfarms may impact on ornithological interests in a number of ways. There may be:

- loss of habitat, due to the construction of turbine bases and tracks
- displacement of birds as a result of disturbance
- potential mortality through collision.

SNH Guidance note describes a methodology for assessing in full the impact of windfarms on ornithological interests, taking account of each of these effects. The methodology includes a two-stage process for the assessment of collision risk.

More detailed prescriptions for use in the second stage of that collision risk assessment are set out here. It sets out how to estimate a 'no-avoidance risk', ie the rate of collision assuming that birds fly as if the wind turbine structures and rotors were not there and take no avoiding action whatsoever. It is assumed that if a bird is hit it is killed, whether immediately or through injury.

Avoidance

In practice, most birds do take avoiding action: they may detect either an entire wind farm array, or an entire wind turbine, and alter their flight lines such as to avoid the structures; or they may at close quarters see an oncoming blade and take emergency avoiding action. The result of a no-avoidance calculation must therefore be moderated by an 'avoidance factor' which represents the (often high) proportion of birds which are likely to take effective avoiding action. However the data available on avoidance factors is limited, and often relates to topographic and climatic conditions which differ from most Scottish windfarms, and to species not common in Scotland. The difficulties of collecting such data are also considerable. It can rarely be assumed that all collisions have been detected, because of scavenging losses, injured birds escaping from the search area, or because of rough ground or tall vegetation. A precautionary approach is recommended when basing an avoidance factor on available data. Greater significance can be attached when data from a number of comparable sites yield similar conclusions.

The remainder of this note assumes no avoiding action.

No-avoidance collision risk

The aim, normally, is to estimate the number of bird collisions over a period of time such as a year. The calculation proceeds in two stages:

Number of birds colliding per annum =
number flying through rotor (Stage 1) x
probability of bird flying through rotor being hit (Stage 2)

Stage 1: Number of bird flying through rotors

There are two standard approaches which may be appropriate depending on the species and flight behaviour. Usually the detailed method of calculation set out below will have to be modified in some way to make best use of the available data. If the flight data available is detailed, the approach below may be refined by considering separately different sectors of the wind farm area, or different seasons of the year when the flight behaviour may differ, or different scenarios such as when site-faithful birds are breeding. However, in most circumstances the following can guide the general approach.

1. Regular flights through a windfarm

The first approach is where a bird population makes regular flights through the windfarm, possibly in a reasonably defined direction. This applies for example to over-wintering geese making their twice-daily flights from roost to feeding areas, within habitually-used flight corridors; or to divers making regular feeding trips from hill lochan nest sites to the coast.

1. Identify a 'risk window' ie a window of width equal to the width of the windfarm across the general flight direction of the birds, and of height equal to the maximum height of the highest turbine (see Fig 1). The cross-sectional area W = width x height.

2. Estimate the number of birds n flying through this risk window per annum, ie flock size x frequency of flight. Make allowance in the flock size for occasions on which birds which may fly higher than this risk window and for the fact that the risk window may only straddle a proportion of the overall flight corridor used by the birds.

3. Calculate the area A presented by the wind farm rotors. Assume the rotors are aligned in the plane of the risk window as, to a first approximation, any reduction in cross-sectional area because the rotors are at an oblique angle is offset by the increased risk to birds which have to make a longer transit through the rotors. Where rotors overlap when viewed in cross-section, allow for the full cross-sectional area of separate rotors as the risk to birds is doubled if passing through two successive rotors:

   $A = N \times \pi R^2$ where N is the number of rotors and R is the rotor radius

4. Express the total rotor area as a proportion A / W of the risk window.

5. Number of birds passing through rotors = number of birds through risk window x proportion occupied by rotors = n x (A / W)

Birds using the windfarm airspace

The second approach (se Fig 2) is most appropriate for birds such as raptors which occupy a recognised territory, and where observations have led to some understanding of the likely distribution of flights within this territory.

1. Identify a 'flight risk volume' V_w which is the area of the windfarm multiplied by the height of the turbines.

2. Calculate the combined volume swept out by the windfarm rotors

   $V_r = N \times \pi R^2 \times (d + l)$ where N is the number of wind turbines, d is the depth of the rotor back to front, and l is the length of the bird.

3. Estimate the bird occupancy n within the flight risk volume. This is the number of birds present multiplied by the time spent flying in the flight risk volume, within the period (usually one year) for which the collision estimate is being made.

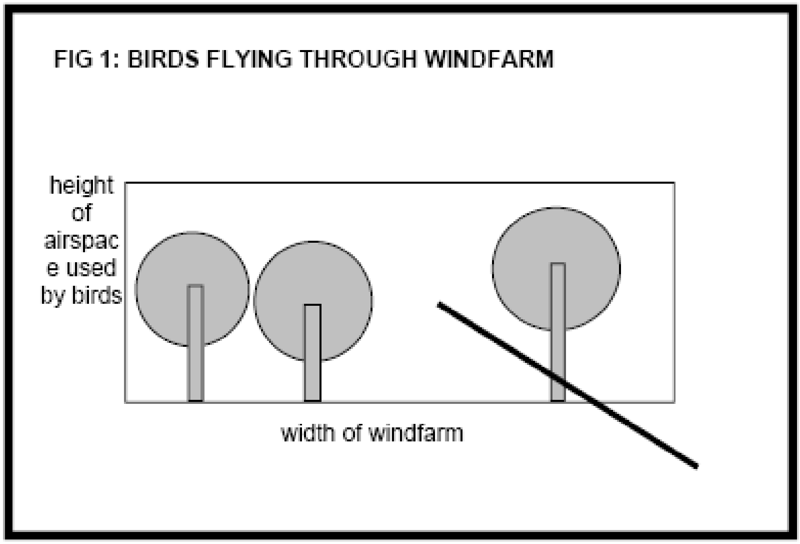


FIG 1: BIRDS FLYING THROUGH WINDFARM
height of airspac e used by birds
width of windfarm

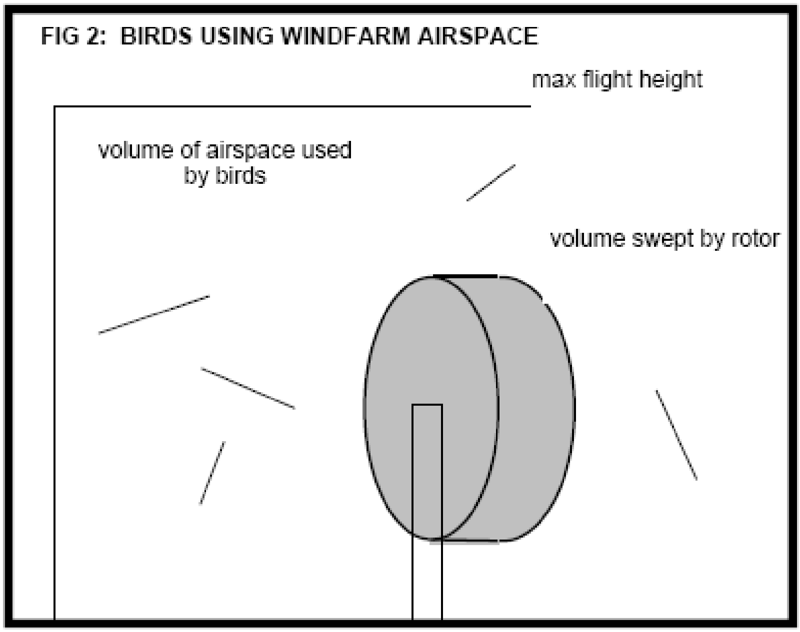


FIG 2: BIRDS USING WINDFARM AIRSPACE
max flight height
volume of airspace used by birds
volume swept by rotor

For good results the data available should be based on actual observations within the area of the windfarm alone (provided the observation is done without disturbance), and the best results will be based on observational data about flight heights, such as will enable informed estimate of the proportion of flights at a level which may collide with the windfarm rotors. However, in the absence of such data, an estimate can be made knowing only the number of birds, and proportion of time flying, within the bird's territory, and using some knowledge of flight behaviour to gauge the proportion of flights at a height to be at risk.

4. The bird occupancy of the volume swept by the rotors is then

   $n \times (V_r / V_w)$ bird-secs.

5. Calculate the time taken for a bird to make a transit through the rotor and completely clear the rotors:
   $t = (d + l) / v$ where v m/sec is the speed of the bird through the rotor

6. To calculate the number of bird transits through the rotors, divide the total occupancy of the volume swept by the rotors in bird-secs by the transit time t:

   Number of birds passing through rotors = $n \times (V_r / V_w) / t$

Note in this calculation that the factor (d + l) actually cancels itself out, so only assumed values need be used - it is used above to help visualise the calculation.

Both approaches yield the number of bird transits (per annum) through the rotors of the windfarm.

Stage 2: Probability of bird being hit when flying through the rotor

This stage computes the probability of a bird being hit when making a transit through a rotor. The probability depends on the size of the bird (both length and wingspan), the breadth and pitch of the turbine blades, the rotation speed of the turbine, and of course the flight speed of the bird.

To faciltate calculation, many simplifications have to be made. The bird is assumed to be of simple cruciform shape, with the wings at the halfway point between nose and tail. The turbine blade is assumed to have a width and a pitch angle (relative to the plane of the turbine), but to have no thickness.

It is best to visualise this as in Fig 3, looking vertically down on the flying bird in a frame which is moving with the bird. In this moving frame, each rotor blade is both moving from right to left (say) and also progressing towards the bird. Each blade cuts a swathe through the air which depends both on the breadth of the blade and its pitch angle. Successive blades cut parallel swathes, but progressively closer to the bird. The angle of approach of the blade α, in this frame, depends on both bird speed and blade speed. At the rotor extremity, where blade speed is usually high compared to bird speed, the approach angle α is low, ie the blades approach the bird from the side. Close to the rotor hub, where the blade speed is low and the bird is therefore flying towards a slow-moving object, the approach angle α is high.

The probability of bird collision, for given bird and blade dimensions and speeds, is the probability, were the bird placed anywhere at random on the line of flight, of it overlapping with a blade swathe (since the bird, in this frame, is stationary). It may therefore be calculated from simple geometric considerations. Where the angle of approach is shallow, it is the length of the bird, compared to the separation distance of successive swathes, which is the controlling factor. Where the angle of approach is high, it is the wingspan of the bird compared to the physical distance between blades, which is the controlling factor.

The calculation derives a probability $p(r, \varphi)$ of collision for a bird at a radius r from the hub, and at a position along a radial line which is an angle φ from the vertical. It is then necessary to integrate this probability over the entire rotor disc, assuming that the bird transit may be anywhere at random within the area of the rotor disc:

Total probability

$$= (1/\pi R^2) \iint p(r, \varphi)\, r\, dr\, d\varphi$$

$$= 2 \int p(r)\, (r/R)\, d(r/R) \qquad \ldots\ldots \quad \mathbf{(1)}$$

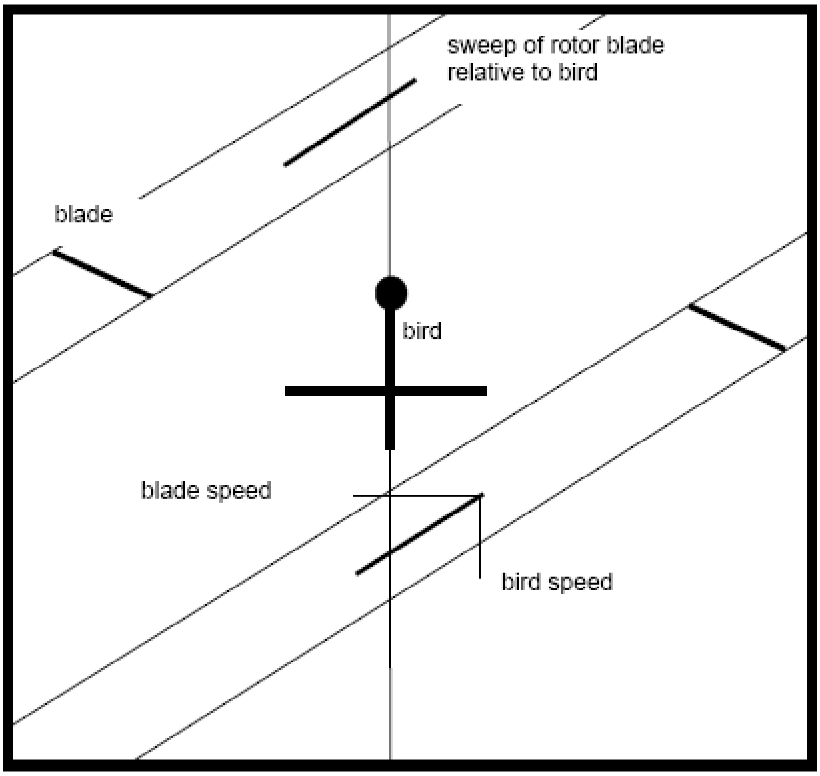
where $p(r)$ now allows for the integration over φ.

Probability p of collision for a bird at a radius r from hub

$$p(r) = (b\Omega/2\pi v)\left[\, K\, |\pm c \sin\gamma + \alpha c \cos\gamma| + \begin{cases} l & \text{for } \alpha < \beta \\ w\alpha F & \text{for } \alpha > \beta \end{cases} \right] \qquad \ldots\ldots \quad \mathbf{(2)}$$

where b = number of blades in rotor
Ω = angular velocity of rotor (radians/sec)
c = chord width of blade
γ = pitch angle of blade
R = outer rotor radius

FIG 3: COLLISION RISK FLYING THROUGH ROTOR



l = length of bird
w = wingspan of bird
β = aspect ratio of bird ie l / w
v = velocity of bird through rotor

r = radius of point of passage of bird
α = v/rΩ

F = 1 for a bird with flapping wings (no dependence on φ)
= (2/π) for a gliding bird

K = 0 for one-dimensional model (rotor with no zero chord width)
= 1 for three-dimensional model (rotor with real chord width)

The chord width of the blade c and the blade pitch γ, ie the angle of the blade relative to the rotor plane, vary from rotor hub to rotor tip. The chord width is typically greatest close to the hub and the blade tapers towards the tip. The pitch is shallowest close to the tip where the blade speed is highest. The apparent width of the blade, looked at from the front, is c cosγ, and the depth of blade from back to front is c sinγ.

The factor F is included to cover the two extreme cases where the bird has flapping wings (p(r, φ) has no dependence on φ) or is gliding (p(r, φ) is φ dependent, ie at maximum above and below hub, at minimum when wings are parallel with rotor blade). F=1 for flapping bird, F = 2/π for a gliding bird.

The sign of the c sinγ term depends on whether the flight is upwind (+) or downwind (-).

The factor K is included to give a simple option of checking the effect of real blade width in the result: K=0 models a one-dimensional blade with no chord width.

As α, c and γ all vary between hub and rotor tip, a numerical integration is easiest when evaluating equation (1).

For ease of use these calculations are laid out on spreadsheet (Fig 4). The spreadsheet calculates p(r) at intervals of 0.05 R from the rotor centre (ie evaluating equation (2)), and then undertakes a numerical integration from r=0 to r=R (ie evaluating equation (1). The spreadsheet is set out as follows:

1 The input parameters are in the first two columns. Bird aspect ration β is calculated.

2 Collision probabilities are then calculated for radii at intervals of 0.05 R from the hub to the tip. Each radius is represented by a row in the table, with the value of the radius r/R in the first column..

3 The second column of the table is the chord width at radius r as a proportion of the maximum chord width. The taper profile here is that of a modern Aerpac turbine blade. The taper will differ for different turbine blades.

4 Factor α is calculated.

5. The 'collide length' is the entire factor within square brackets within equation (2) above, using the upwind case.

6. p(collision) is p at radius r, as calculated by equation (2). It is however limited to a maximum value of 1.

7. 'contribution from radius r' is the integrand of equation (1) (including the factor 2) prior to integration.

8. The total risk is then the summation of these contributions.

9. The calculation is then repeated for the downwind case.

10 The spreadsheet then shows a simple average of upwind and downwind values. (Note that in a real case it may be important to add in the effect of wind to the bird's

ground speed, and flight patterns may not be such that upwind and downwind flights are equally frequent.)

The result is an average collision risk for a bird passing through a rotor.

Appendix 3 - Target species flights recorded at each vantage point from October 2010 to September 2011

Table 1 – Target species flights recorded during the 12 hrs of observations at each vantage point during October 2010

Species	Location										total
	VP1	VP2	VP3	VP4	VP5	VP6	VP7	VP8	VP9	VP10	
Osprey	1	-	-	-	-	-	-	-	-	-	1
Steppe buzzard	3	22	31	24	5	6	3	66	7	31	198
Tawny eagle	-	-	-	-	1	2	1	-	2	1	7
Steppe eagle	-	-	-	-	-	1	-	2	-	3	6
Lesser-spotted eagle	1	-	-	2	-	1	1	9	-	1	15
Greater-spotted eagle	-	-	-	-	-	-	-	1	-	3	4
Martial eagle	-	-	-	-	-	-	-	-	2	-	2
Bateleur	-	1	-	-	-	-	-	2	-	1	4
Egyptian Vulture	-	-	-	2	3	-	-	-	-	-	5
Rüppell's griffon vulture	-	-	-	-	-	-	-	2	-	-	2
Pallid harrier	-	1	-	-	1	1	1	-	-	-	4
Saker falcon	-	-	-	-	-	-	2	2	-	-	4
Greater kestrel	-	1	1	-	-	-	-	2	5	1	10
Common kestrel	-	-	1	-	-	-	-	-	-	1	2
Lesser kestrel	-	-	-	-	-	-	-	1	-	6	7
Black-shouldered kite	-	-	-	-	-	-	-	-	1	-	1

Table 2 – Target species flights recorded during the 12 hrs of observations at each vantage point during November 2010

Species	Location										Total
	VP1	VP2	VP3	VP4	VP5	VP6	VP7	VP8	VP9	VP10	
Steppe buzzard	1	1	4	5	-	3	-	1	6	-	21
Tawny eagle	-	-	-	-	-	-	-	1	-	-	1
Steppe eagle	1	-	1	3	-	3	3	9	4	-	24
Lesser-spotted eagle	-	-	-	1	-	-	-	3	-	-	4
Martial eagle	1	-	-	-	-	-	-	1	-	-	2
Black-chested snake eagle	1	-	-	-	-	-	1	-	-	-	2
Egyptian Vulture	-	-	-	-	1	-	-	-	2	5	8
Pallid harrier	-	-	-	-	-	-	1	-	-	-	1
Lanner falcon	-	-	-	-	-	1	-	2	-	-	3
Eurasian hobby	-	1	-	1	-	7	-	2	-	-	11
Common kestrel	-	-	-	2	1	-	-	2	-	-	5
Lesser kestrel	-	-	-	-	-	7	-		3	-	10

Table 3 – Target species flights recorded during the 6 hrs of observations at each vantage point during December 2011

Species	Location										Total
	VP1	VP2	VP3	VP4	VP5	VP6	VP7	VP8	VP9	VP10	
African swallow-tailed kite	-	-	-	-	-	-	-	-	-	1	1
Steppe buzzard	-	1	-	-	-	-	-	-	-	-	1
Tawny eagle	-	-	1	-	-	-	-	-	1	-	2
African white-backed vulture	-	-	-	-	-	-	-	-	4	-	4
Lappet-faced vulture	-	-	-	-	-	-	-	-	2	-	2
Saker falcon	-	1	-	-	-	-	-	-	-	-	1
Barbary falcon	-	1	-	-	-	-	-	-	-	-	1
Common kestrel	-	-	-	-	-	-	-	1	1	2	4
Lesser kestrel	-	-	-	-	-	-	-	-	-	1	1
Eastern pale chanting gosshawk	-	-	-	-	-	-	-	-	-	1	1

Table 4 – Target species flights recorded during the 6 hrs of observations at each vantage point during January 2011

Species	Location										Total
	VP1	VP2	VP3	VP4	VP5	VP6b	VP7	VP8	VP9	VP10b	
Black-shouldered kite	-	-	-	-	1	-	-	-	-	-	1
Steppe buzzard	-	-	-	-	-	-	-	2	-	-	2
Tawny eagle	1	-	-	-	1	-	-	-	1	-	3
Steppe eagle	-	-	-	-	-	-	-	-	2	-	2
Black-chested snake eagle	-	-	1	-	-	-	-	-	-	-	1
African white-backed vulture	-	-	-	-	-	-	1	-	-	-	1
Common kestrel	-	2	1	-	-	-	-	-	-	-	3
Eastern pale chanting gosshawk	-	-	-	-	-	1	1	-	-	-	2
Heuglin's bustard	-	-	-	-	-	-	1	-	-	-	1

Table 5 – Target species flights recorded during the 6 hrs of observations at each vantage point during February 2011

Species	Location										Total
	VP1	VP2	VP3	VP4	VP5	VP6b	VP7	VP8	VP9	VP10b	
Tawny eagle	-	-	-	-	-	-	1	-	-	-	1
Steppe eagle	1	-	-	1	-	-	-	-	-	-	2
Bateleur							1				
African white-backed vulture	3	-	-	-	-	-	2	-	-	-	5
Egyptian Vulture	-	-	-	-	-	-	-	1	-	-	1
Common kestrel	-	-	-	-	5	-	-	-	-	-	5
Lesser kestrel	-	-	-	-	-	-	2	-	-	-	2
Fox kestrel	-	-	-	-	-	1	-	-	-	2	3
Unidentified raptor	-	-	-	-	1	-	1	-	-	-	2
Unidentified stork	-	-	-	-	-	-	1	-	-	-	1
Somali courser	-	-	-	-	-	-	-	3	-	-	3
White stork	4	-	-	-	-	-	-	-	-	-	4

Table 6 – Target species flights recorded during the 12 hrs of observations at each vantage point during March 2011

Species	Location										Total
	VP1	VP2	VP3	VP4	VP5	VP6b	VP7	VP8	VP9	VP10b	
African swallow-tailed kite	-	1	-	-	-	-	-	-	-	-	1
Black-shouldered kite	-	-	-	-	-	-	-	-	-	1	1
Steppe buzzard	-	-	2	-	2	1	1	1	-	3	10
Tawny eagle	2	-	-	-	1	-	1	-	1	3	8
Long legged buzzard	-	-	-	-	-	-	-	1	-	-	1
Steppe eagle	-	-	-	-	-	-	3	-	-	-	3
Bateleur	2	-	-	-	-	-	-	-	-	-	2
African white-backed vulture	-	-	-	-	-	-	-	-	1	-	1
Pallid harrier	-	1	1	-	-	-	1	-	-	-	3
Eurasian hobby	-	-	1	-	-	-	1	-	-	-	2
Greater kestrel	-	-	-	-	-	-	-	-	-	1	1
Lesser kestrel	-	5	9	-	2	1	-	-	-	2	19
Unidentified kestrel	-	-	-	-	1	-	-	-	-	-	1

Table 7 – Target species flights recorded during the 12 hrs of observations at each vantage point during April 2011

Species	Location										Total
	VP1	VP2	VP3	VP4	VP5	VP6	VP7	VP8	VP9	VP10	
Black-shouldered kite	-	-	-	-	-	-	-	-	1	-	1
Steppe buzzard	-	-	-	1	-	-	1	-	-	-	2
Tawny eagle	-	-	-	-	-	-	-	2	-	-	2
Steppe eagle	-	-	-	-	-	1	-	-	-	-	1
Black-chested snake eagle	-	-	-	-	-	1	-	-	-	-	1
Bateleur	-	-	-	-	-	-	-	-	1	-	1
Verreaux's eagle	-	-	-	-	-	3	-	-	-	-	3
Egyptian Vulture	-	-	-	-	-	-	-	-	1	-	1
Peregrine falcon	-	-	-	-	-	-	1	-	-	-	1
Common kestrel	-	-	1	6	-	3	-	2	-	-	12
Fox kestrel	-	1	-	-	-	-	-	5	2	-	8
Gabar gosshawk	-	-	-	-	-	1	-	-	-	-	1

Table 8 – Target species flights recorded during the 12 hrs of observations at each vantage point during May 2011

Species	Location										total
	VP1	VP2	VP3	VP4	VP5	VP6	VP7	VP8	VP9	VP10	
Tawny eagle	1	-	-	-	1	-	-	-	-	-	1
Verreaux's eagle	-	2	-	-	-	-	-	-	-	-	2
Egyptian Vulture	1	-	-	-	-	-	-	-	-	-	1
Fox kestrel	-	-	-	-	-	1	-	-	-	-	1
Unidentified kestrel	-	-	-	-	-	5	-	-	-	-	5
Unidentified raptor	-	-	-	-	-	3	-	-	-	-	3
Unidentified bustard	-	-	-	-	-	3	-	-	-	-	3
Heuglin's bustard	-	-	-	-	-	1	-	-	-	-	1

Species	Location										total
	VP1	VP2	VP3	VP4	VP5	VP6	VP7	VP8	VP9	VP10	
Yellow-billed stork	-	-	3	-	-	-	-	-	-	-	3
Somali courser	4	2	-	-	-	-	-	-	-	-	6
Unidentified waders	-	-	2	-	-	-	-	-	-	-	2

Table 9 – Target species flights recorded during the 12 hrs of observations at each vantage point during June 2011

Species	Location										total
	VP1	VP2	VP3	VP4	VP5	VP6	VP7	VP8	VP9	VP10	
Gabar gosshawk	-	-	1	-	-	-	-	-	-	-	1
Tawny eagle	-	-	2	-	-	-	2	-	-	-	4
Verreaux's eagle	-	-	-	-	-	-	-	1	-	-	1
Whalberg's eagle	-	-	1	-	-	-	-	-	-	-	
Black-chested snake-eagle	-	-	2	-	-	-	-	-	-	-	2
African white-backed Vulture	1	-	-	-	-	-	-	-	-	-	1

Table 10 – Target species flights recorded during the 12 hrs of observations at each vantage point during July 2011

Species	Location										total
	VP1	VP2	VP3	VP4	VP5	VP6	VP7	VP8	VP9	VP10	
African swallow-tailed Kite	-	-	-	-	-	-	-	6	-	-	6
Tawny eagle	-	-	-	-	-	-	-	1	1	-	2
Egyptian Vulture	-	-	-	-	1	-	-	-	-	-	1
Greater kestrel	-	-	-	-	-	-	-	-	2	-	2
Fox kestrel	-	-	-	-	-	-	-	-	-	2	2
Common kestrel	-	-	-	-	-	-	-	1	-	-	1

Table 11 – Target species flights recorded during the 12 hrs of observations at each vantage point during August 2011

Species	Location										total
	VP1	VP2	VP3	VP4	VP5	VP6	VP7	VP8	VP9	VP10	
African swallow-tailed Kite	-	-	-	-	-	-	-	-	2	-	2
Black-chested snake-eagle	-	-	-	-	-	-	-	-	1	-	1
Bateleur	-	-	-	-	-	-	-	1	-	-	1
African white-backed vulture	-	-	-	-	-	-	-	3	-	-	3
Pallid harrier	-	-	-	-	-	-	-	1	-	-	1
Greater kestrel	-	-	-	-	-	-	-	1	-	-	1
Common kestrel	-	-	-	-	-	-	-	-	1	-	1
Fox kestrel	-	-	-	-	-	1	-	-	-	-	1
Unidentified kestrel	-	-	-	-	-	-	-	2	-	-	2
Unidentified raptor	-	-	-	-	-	-	-	2	-	-	2

Table 12 – Target species flights recorded during the 12 hrs of observations at each vantage point during September 2011

Species	Location										total
	VP1	VP2	VP3	VP4	VP5	VP6	VP7	VP8	VP9	VP10	
Verreaux's eagle	-	-	-	-	1	-	-	-	-	-	1
Martial eagle	-	-	-	-	-	-	-	-	1	-	1
Bateleur	-	-	-	-	-	-	-	-	1	-	1
Rüppell's griffon vulture	-	-	-	-	-	-	-	-	4	-	4

Appendix 4 – IUCN Red List status of target species recorded on site

IUCN Red List status of 'endangered'

Egyptian vulture is an endangered species which a population which is at risk of becoming extinct because it is either few in numbers, or threatened by changing environmental or predation parameters. **Grévy's zebra** is also listed as endangered.

IUCN Red List status of 'vulnerable'

White-headed vulture, **lappet faced vulture,** and **saker falcon** are listed. Vulnerable species are likely to become endangered unless the circumstances threatening its survival and reproduction improve. Vulnerability is mainly caused by habitat loss or destruction. **Cheetah** is also listed as 'vulnerable'.

IUCN Red List status of 'near threatened'

Populations of **African white-backed vulture, Rüppell's vulture** have declined and the IUCN predicts that populations of the species will continue to decline. **Bateleur**, **martial eagle** and **pallid harrier** are also listed as 'near threatened'. Of the mammals **gerenuk** listed as 'near threatened'.

All the other target species recorded including the bustards are of 'least concern'.

Appendix 5 – Bat Survey Results March 2011

Sample Point 1

SP1 – A wooded laga close to main access track	Date: 12/3/11	Sunset time: 18:45
Weather conditions: 30 to 25 C , 0% cloud, gusty wind up to 15 mph		

Transect at SP1

Time Start	**Time End**	**Species**	**Notes**
18:30			Survey start
19:10	19:10	Unknown bat	
19:18	19:20	*Pipistrellus nanulus*	Five passes
19:50	19:50	Large bat	Visual passing
20:00	20:00	Unknown bat	Foraging call
	21:00		Survey end

Two mist nets at SP1 - No bats caught

Anabat at SP1

8 calls recorded between 19:21 to 19:57

1. Six are of *Pipistrellus nanulus* (tiny pipistrelle) calling at c. 48khz
2. Two are indeterminable

Sample Point 2

SP2 – A wooded laga 1.5km to west of main access track	Date: 13/3/11	Sunset time: 18:45
Weather conditions: 30 to 25 C , 0% cloud, gusty wind up to 15 mph		

Transect at SP2

Time Start	**Time End**	**Species**	**Notes**
18:30			Survey start
18:50	18:51	*Pipistrellus* sp.	Two passes in laga
19:00	20:30	*Pipistrellus nanulus, Pipistrellus sp.* and unknown bat	Ten passes in laga, one outside laga
	21:00		Survey end

Three mist nets at SP2 - No bats caught.

Anabat at SP2
There are 5 recorded calls
1. Four are of *Pipistrellus nanulus* calling at c. 48 khz
2. One indeterminable

Sample Point 3

SP3 – A wooded laga just south of Sirima village	Date: 15/3/11	Sunset time: 18:44
Weather conditions: 30 to 25 C , 0% cloud, sheltered, light wind up to 5 mph		

Transect at SP3

Time Start	**Time End**	**Species**	**Notes**
18:30			Survey start
18:45	20:30	20 passes of *Pipistrellus nanulus/Pipistrellus sp.* One unknown bat.	Passing and feeding in laga
	21:00		Survey end

Three mist nets at SP3 – one *Pipistrellus nanulus,* one *Lavia frons* (yellow-winged bat) and one *Nycteris* sp. (a slit-faced bat) caught in nets.

Anabat at SP3 used during the survey only on 15th March

No. of recordings	**Description of call**	**Bat identified**
14	48khz	*Pipistrellus nanulus*
2	Calling between 30-35khz with very shallow long duration FM	?
2	Calling at about 38khz with long CF end	*Pipistrellus* sp

Anabat at SP3 left overnight on 16th March

154 calls between 19:04 and 07:15

No. of recordings	**Description of call**	**Bat identified**
4	Indeterminable calls/pulses	?
1	strange call, opposite hockey stick shape	?
11	*Lavia frons* CF between 30 & 25khz	*Lavia frons*
57	*Pipistrellus nanulus* at c. 46-57khz	*Pipistrellus nanulus*
1	*Pipistrellus* like pulses (hockey stick at 37-46khz	*Neuromicia* sp.
42	unidentified shallow between 30-35 khz	?
8	unidentified shallow FM just at or just above 35 khz	*Nycteris* sp 2(a slit-faced bat)
7	unidentified CF between 16-20 khz	*Tadarida* (a guano bat)
4	unidentified FM nearly CF just below 25 khz	*Chaerophon* (a wrinkle-lipped bat)
8	unidentified CF with tiny FM head at 70khz	*Hipposideros commersoni* (Commerson's leaf nosed bat)
6	unidentified arch-shaped shallow FM at 40khz	*Scotophilus nigrita* (Schreber's yellow bat)
2	unidentified tiny FM tail-long CF-tiny FM head at 45	*Rhinolophus* sp. (a horseshoe bat)
3	Steep sharp gradient FM at nearly 50 khz	*Nycteris* sp 1 (a slit-faced bat)

Sample Point 4

SP4 – On a windy exposed ridge with limited vegetation at a mast site	Date: 16/3/11	Sunset time: 18:44
Weather conditions: 25 to 20 C , 0% cloud, exposed, windy up to 20 mph		

Anabat left overnight at SP4 on 16th March

There are 19 calls recorded between 19:45 and 01:28

No. of recordings	Description of call	Bat identified
1	Call at about 48khz	*Pipistrellus nanulus*
1	Very broad band call 16-37FM bat	?
2	Shallow (narrow band) between 31-39khz	?
13	Calling at 25khz with low duty narrow band	*Chaerophon* sp (a wrinkle-lipped bat)
2	Narrow band call between 14-15khz	?

Sample Point 5

SP5 – A shelter wooded laga and open scrub/ desert located 1km west of the main access track	Date: 17/3/11	Sunset time: 18:44
Weather conditions: 30 to 25 C , 0% cloud, sheltered, no wind		

Transect at SP5

Time Start	Time End	Species	Notes
18:30			Survey start
18:45	20:30	*20 passes Pipistrellus sp*. 10 passes unknown bats	Passing and feeding in and around the laga.
	21:00		Survey end

Three mist nets at SP5 one in the laga and two in open scrub areas– five *Pipistrellus nanulus* caught at 19:15, one *Pipistrellus nanulus* caught at 20:50 all in the laga.

Two Anabats (one in the laga, one in the open area) at SP5 overnight on 17th March.

Laga – 143 calls from 18:56 to 06:27

No. of recordings	Description of call	Bat identified
28	Call at about 47khz	*Pipistrellus nanulus*
2	Calling at about 80khz high duty CF frequency with brief FM end	*Rhinolophus* sp 1(a horse shoe bat)
2	Calling at 69khz	*Rhinolophus* sp 2
46	A shallow, narrow band FM tending towards CF call at c. 33khz	*Chaerophon* sp (a wrinkle-lipped bat)
10	Calling with hockey stick type of steep FM pulse ending shallow at nearly 40khz	*Scotoecus hirundo* (an evening bat)
15	Bat call at about 18khz	*Mollosid* sp (free-tailed bat)
41	Unidentified bats, peaking at 26khz and 37khz at least 2 two species	Unidentified

Open area – 19 calls from 19:12 to 07:05

No. of recordings	Description of call	Bat identified
1	Just below 30khz	*Lavia frons*
9	Call at about 47khz	*Pipistrellus nanulus*
4	Sp1-calling at 30khz with shallow FM	?
4	Sp2-calling at just above 25khz with shallow FM	*Chaerophon bivittata* (a wrinkle lipped bat)
1	Sp2-calling at just below 35khz with shallow FM	?

Other bat observations

Daytime walkover surveys were undertaken at surrounding sites including a small section of the shore at Lake Turkana, Mount Kulal and Mount Nyiru.

No roosting potential was found adjacent to the lake as it was devoid of trees, structures and crevices, although there is excellent foraging potential over the lake itself. Caves were inspected for bat roosts on the way to Mount Kulal. No roost were confirmed, but there were many inaccessible caves and crevices suitable for bats.

On the east side of Mount Nyiru a *Hipposideros* sp. (a leaf-nosed bat) roost was found in a cave above a waterfall. Signs of *Epomophorus* sp. (epilauted fruit bats) were found in the form of feeding remains (figs sucked dry).

Appendix 6 – An example of bird deflectors used on overhead power cables

This type of deflector is fitted at 5m intervals of the earth wire of the overhead power line network. The aim is to increase the visibility of the earth wire. The design of the diverter used is shown in the photo below. The dimensions of the deflectors were 320mm for the gripping section and 175mm for the outside diameter of the coil (catalogue no.BFD5249065: Preformed Line Products (GB) Ltd). This design and spacing was chosen as tests in the Netherlands indicated that when installed at 5m intervals the collision rate decreased by 80% (Koops 1982[17]). Note that the specification for the diverter will be specific to the conditions encountered e.g. lines and pylon specifications, weather conditions and species involves.

Source

Frost, D. (2008) The use of 'flight diverters' reduces mute swan Cygnus olor collision with power lines at Abberton Reservoir, Essex, England. Conservation Evidence (2008) 5, 83-91.

[17] Koops F. B. J. & de Jong J. (1982) Vermindering van draadslachtoffers door markering van hoogspanningsleiden in de omgeving van Heerenveen. Het Vogeljaar, 30, 308-316.