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ADDENDUM TO THE AVIFAUNAL ASSESSMENT

OF THE PROPOSED KARREEBOSCH WIND FARM

This addendum is to address the potential changes in the impacts on birds that might result from the developer seeking to change the specifications for the wind turbines at the Karreebosch Wind Farm. Where previously the hub height was 100 m and the rotor blade diameter 140 m the new proposal is to increase the height of the hub to 125 m and the rotor blade diameter to 160m. The increase in turbine specifications would also increase the generation capacity up to 5.5MW per turbine.

What will be the effect of these changes to the potential impact on the local avifauna?

The key difference from an avifaunal perspective is that the lower extent of the rotor blades will be raised from 30 m to 45 m above ground. This will greatly reduce the risk of collision impact on the majority of bird species that occur on the ridges where the turbines are to be located.

There are differences in the potential avian collision risk based on the bird species which occur and the purposes of their flights on or above the ridges where the turbines are to be located. These differences are addressed as follows:

Foraging birds:

The increased height of the rotor blades above ground will reduce any potential collision risk of those bird species that forage for food in or near the vegetation along the ridges. Birds seeking food from on or among the scrubby vegetation seldom fly at heights of more than 5 m above the ground and so are unaffected. Swallows and martins aerially forage for insects in flight over, or close to, the vegetation. Rock Kestrels hover to observe prey on the ground on the ground below but do so along the ridges from heights generally of less than 20m.

Display heights:

The few species of passerines which perform display flights above the ridges do so largely within20 m of the ground and so well below the proposed lowest rotor blades.

Passage across ridges:

Several species of birds have been observed in the region to occasionally fly across ridges to move between valleys or further across country. To do so they have no reason to fly high above the ridges. To avoid birds of prey they may do this more at night than by day. Again, they will be exposed to reduced collision risk if the lowest sweep of the rotor blades is higher off the ground than previously proposed.

Passage along the ridges:

The only species observed to sometimes fly for distances along the ridges in this region are Namaqua Sandgrouse which fly in small flocks at heights of 5-40 m above the ground. The increased height of the rotor blades from ground level will greatly reduce the potential collision risk for this species.

Key risk species:

The potential for collision risk is greatest for species that frequently fly above the ridges at heights which coincide with the turbine specifications. Based on the four seasons of observation these fall into two categories: 1) foraging swifts; and 2) large predator/scavengers that cruise at height to visually detect food items below – in this region principally Verreaux's Eagle and White-necked Raven – and which have display or related activities that cause them to fly at turbine heights.

To detect food when in flight and or from considerable heights above potential food, birds in both categories have exceptional eyesight and forage by day. In most situations this should enable them to detect and avoid the turbines and rotor blades. Care has already been taken to ensure no turbines are located in areas which, based on four seasons of observation, are considered of particular local use by these aerial foragers.

The ability of these aerial foragers to detect the turbine blades in time to avoid collision will be reduced when the cloud base is low. However, in such conditions these birds will either not fly or will fly below the cloud level and so with suitable visibility to avoid collision. Nor will they be displaying in cloudy conditions.

Paucity of birds:

It must be emphasised, based on three years of experience in the immediate vicinity of, as well as the four seasons of observations on, the Karreebosch site that both the diversity and populations of birds at and above the ridges where the turbines will be located is extremely low. This condition applied in both wetter and drier than average seasonal conditions. The small numbers specifically apply to Verreaux's Eagle of which no more than 2-4 individuals occur locally. The number of birds likely to be at risk, even with the former turbine specifications, is very small. The revised turbine specifications will further reduce collision risk.

Pros- and cons:

Overall the new turbine specifications will reduce the risk of birds colliding with the turbines. Nor is sound emanating from the turbines at the proposed new heights considered to have any impact on birds. Thus, there are no negative aspects to the revised specifications.

Are any measures required to mitigate any increased impacts?

No new mitigation measures are required.

Are any changes needed to the EMP?

From an avifaunal perspective the proposed changes will require no (zero) changes to either the rating or assessment of significance table in the original avifaunal report that was used to inform the approved EIA.

Comment on validity of the data:

As previously emphasised, based on recent three years of experience in the immediate vicinity of, as well as the four seasons of observations on, the Karreebosch site it can be confirmed that both the diversity and populations of birds at and above the ridges where the turbines will be located is extremely low. There have been no material changes on site that would change the diversity and or population of the birds previously recorded in the area. Therefore, the data collected previously remains valid and sufficient to inform this amendment of turbine specifications.

Conclusion:

In my opinion the changed specifications will reduce the, already very small, risk of avian collision mortality. From an avifaunal perspective the change is entirely positive, welcomed, and approved.

Dr A.J. Williams

29 June 2018

References:

Williams, A. J., 2014: Avifaunal Pre-construction Monitoring Report – Karreebosch Wind Energy Facility, Northern Cape Province, African Insights.

AVIFAUNAL PRE-CONSTRUCTION MONITORING REPORT

KARREEBOSCH WIND ENERGY FACILITY,

NORTHERN CAPE PROVINCE

Fig. 1 View west across the upper Tankwa River valley and Ekkraal farmstead to the Central Ridge where turbines will be installed. Note the rounded contours, low scrub vegetation, stony ground, and restriction of richer habitats -dam, fields, and trees -to the narrow valley floor

Report compiled by Dr A.J. Williams

African Insights

October 2014

CONTENTS

1 EXECUTIVE SUMMARY

This report concerns the development of the Karreebosch (Roggeveld Phase 2) Wind Energy Facility (hereafter WEF) for Karreebosch Wind Farm (Pty) Ltd (as subsidiary of G7 Renewable Energies (Pty) Ltd). All the turbines of the Karreebosch WEF will lie within the Northern Cape Province, to the west of the Matjiesfontein-Sutherland (R364) Road, and some 60-70 km south of Sutherland.

The Karreebosch WEF proposal includes: up to 71 wind turbines with crane pads; one or two on-site substations; ground level cabling linking turbine strings; 33 kV power-lines linking these strings to the substation(s); 132 kV power-lines from the substation(s) to the Komsberg 400 kV booster station on the Eskom line; and attendant footprint areas. Access for turbine installation and servicing will, where possible, be via existing farm roads and tracks upgraded and broadened to 6 m width. New upper slope and ridge-top roads will be 12 m wide.

A programme of bird monitoring was conducted across an 18 month period, and for a total of > 430 hours in 2013-2014. This followed BirdLife South Africa's guidelines, where terrain & logistics permitted. Field techniques employed were: observations from 15 vantage points (three of them controls); walked linear transects in ridge areas adjacent to vantage points (including controls); drive transects in the valleys; inspection of focal sites; and incidental observations made by observers while traversing the study area. A total of 20 days were spent in the area across six visits which encompassed five seasons of which three were very dry and three were wet. Spring observations, when the greatest avian diversity is expected and display flights are most pronounced, were made in both wet (2013) and dry (2014) conditions.

Four types of impacts associated with this development will negatively affect birds in the area: collision mortalities with 1) turbines; and 2) powerlines; 3) bird displacement (including habitat loss and disturbance); and 4) electrocution. Impacts 1 and 3 affect birds on the turbine ridges, impacts 2, 3 and 4 affect birds in the valleys. A total of 115 bird species was recorded in the Karreebosch area of which only 47 species were seen on, or flying over, the ridges where turbines will be installed.

The local, ridge top, avifauna is depauperate in both diversity and numbers. Food resources and suitable nesting habitat on the ridges are both extremely limited and the, often persistent, winds severely restrict bird flight activities. During many hours of observation no birds were seen at all. Birds in most, 35, of the species seen on the ridges rarely flew at blade arcs heights. Only members of 13 of the 47 ridge top species flew at turbine blade heights and are considered at potential risk of mortality through collision. All but one of these 13 species, the Namaqua Sandgrouse, occurred in very small numbers and at low frequency. Only three species of established (red-listed) conservation concern were recorded on the ridges. Given the paucity of birds along the ridges the development footprint will not adversely affect either avian biodiversity or populations. Three project specific mitigations related to the siting of turbines are recommended. These are avoidance of 1) saddles; and 2) ridge rims; as well as 3) the Verreaux's Eagle nests.

The risk of bird collisions with cross-valley powerlines is the issue of most concern with the Karreebosch proposal. Many more birds, including more red-listed species - occur in the valleys than are found on the turbine ridges. The area of greatest concern is the Wilgebos Valley as bird diversity, and populations of most bird species, is greater in this valley than elsewhere in the Karreebosch area. Several red-listed bird species of established medium to high powerline collision risk are known, or likely, to traverse this valley. Means of mitigating powerline collisions, especially through reduction in the number of lines across the Wilgebos Valley, and the use of bird diverters on the lines, are indicated.

The area of habitat loss is less in the valleys and, despite potential negative biotic impacts on the avifauna, is considered of little impact. Electrocution risk can be prevented through use of approved types of installations.

An independent survey of raptors in the region was conducted in September 2014 by a team led by Dr R. Simmons. The findings of this team pertinent to the Karreebosch area are provided in an appendix to this report.

Fig. 2. View west across the upper Wilgebos Valley to the Western Ridge. Note: excellent visibility; the prevailing, resource poor, scrub vegetation; and the rounded nature of the ridges with only small cliffs.

2 DECLARATION OF CONSULTANT'S INDEPENDENCE AND QUALIFICATIONS

Dr. Anthony (Tony) Williams is an independent consultant. He has no business, financial, personal or other interest in the activity, application or appeal in respect of which he was appointed other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of this specialist performing such work.

Dr. Williams has been a professional ornithologist for 46 years, including: 1) 9 years as a researcher at the FitzPatrick Institute of African Ornithology; 2) 25 years as specialist ornithologist in the conservation departments of South West Africa (1982-1988) and the Cape (latterly Western Cape) Province (including five years secondment at the (then) Avian Demography Unit); and 3) 12 years as a consultant and independent researcher. He has worked on five other WEF projects, three in lowland areas and two in the Karoo margins - the Roggeveld (Phase 1) WEF and the Hidden Valley WEF in similar terrain some 10 km to the east.

The findings, results, observations, conclusions and recommendations given in this report are based on the author's best scientific and professional knowledge, as well as available information.

3 INTRODUCTION

Karreebosch Wind Farm (Pty) Ltd (a wholly owned subsidiary of G7 Renewable Energies (Pty) Ltd) propose to develop the Karreebosch wind energy facility (hereafter WEF) with turbines along four adjacent ridges in the Roggeveld region of the South Africa's Northern Cape Province (Map 1). The four ridges are not officially named on the 1:50,000 government survey maps. For convenience in this report the ridges are, from east to west, termed Eastern, Central, Spitzkop and Western. There will be up to 71 turbines with hub heights of 100 m and blade rotor diameter of up to 140m so that the blade arcs may extend from 30 to 170 metres above ground.

A typical wind farm is expected to impact birds through: disturbance, habitat destruction, and, in particular, mortality of birds through collision with turbines as well as associated power lines (Marques *et al*. 2014).

3.1: TERMS OF REFERENCE

The company African Insights, was appointed to:

- Determine bird occurrence within the impact area of the proposed Karreebosch WEF prior to the construction phase.
- Record the occurrence and behaviour (flight heights, directions etc) of bird species along the ridges along which turbines are proposed.
- Pay special attention to species red-listed by BirdLife South Africa as of particular conservation concern.
- Assess the significance, and acceptability, of the likely impacts of the proposed development on the local avifauna.
- Suggest reasonable, and feasible, measures to mitigate any negative impacts.
- Nocturnal observations were not included in the terms.

The initial focus of the study was to assess the risk to birds of the installation of wind turbines along the ridges. Through the first year of the study no information on the potential routing of powerlines was available to African Insights. When available, this information showed a number of potential powerlines. These were either 33 kV lines that link turbine strings to a substation or larger 132 kV power-lines to link the substation (s) to the ESKOM grid via the Komsberg booster station and a new 400 kV substation southeast of the Karreebosch area. To transfer power from the turbines strings aligned along the north-south ridges to the external Komsberg booster station requires a number of power lines routed west to east and so across the valleys between the ridges. A number of alternative potential routings were indicated.

Since, globally, there is well established risk to birds of collision with power lines it was pertinent to: a) appraise the potential risk relative to birds and especially priority species of the cross-valley lines; and b) to suggest means by which this risk could be mitigated. The valley drive transects and inspection of dams provided sufficient information to appraise the potential effects on birds of the several alternative powerline routings, and to suggest mitigations.

3.2 STUDY APPROACH

The occurrence of birds was assessed during six periods totaling 430 hours of observations in the impact area. These periods, and the conditions represented, were:

In 2013

1) 2-4 March hot dry late summer;

2) 9-11 May cool dry late autumn before any winter rain;

3) 27-29 July winter conditions following heavy rain in June;

4) 23-25 September spring with local warming following further rain;

5) 18-20 November early summer before conditions became too hot and dry.

and in 2014

6) 21-25 September a dry spring following poor winter rains

Local residents told us that, following a series of drier years, the rains in 2013 were heavier than usual. Thus observations in the area spanned the normal seasonal succession of weather conditions as well as particularly dry and wet conditions.

Monitoring in all five periods during 2013 was conducted by the same three observers. These were: 1: Dr AJ Williams – professional ornithologist, with prior experience at 5 WEFs; and two qualified bird guides 2: Mr. Brian Van Der Walt, a professional birding guide with experience of bird monitoring at 6 WEFs; and 3: Mr. V. Ward, doctoral student and part-time birding guide. In September 2014 only Dr Williams and Mr. Ward were involved. Additional observations of raptor occurrence were made By Dr R. Simmons in late September-early October (Appendix 9).

Fig. 3. Typical terrain of the upper slopes and ridges. Note the low scrub vegetation, lack of resources attractive to birds, and the carpet of loose stones that make walking difficult.

3.3: BROAD REGIONAL ECOLOGY

The area is characterized by ridges and valleys with altitudes ranging between 730 and 1400 m. Annual rainfall is about 170 mm, most of it falling in winter. Soils on the ridges and upper slopes are shallow, or non-existent, and are generally overlain by loose stones. There are numerous rock outcrops including some small cliffs. Soils, and so vegetation, are thicker in the valleys.

3.3.1 Vegetation:

Except for lines of riparian thorn trees along stream courses, the natural vegetation of the entire area is Karoo scrub- or shrub-land, scrub here considered simply as woody bushes that grow to less than knee height and shrubs as taller bushes generally reaching waist height. In most areas, especially along the ridges, scrub bushes are spaced out with intervening areas covered in loose stones or rocks (Fig 2). Following rain, flowering plants (forbs) grow on patches of bare earth between the bushes and stones. Native ungulates and, especially, sheep crop the forbs. The near absence of forb growth in September 2014 indicated limited rainfall in the preceding winter months.

The vegetation on the ridges where it is proposed to erect turbines is predominantly scrub. Such bushes lack height and woody structure suitable for birds to build nests in. Given the strong winds and the paucity of food resources along the ridges, most birds apparently opt for breeding on the mid to lower hill slopes or, especially, in the valley bottoms where the generally taller vegetation gives improved protection for nesting, shelter for foraging, as well as access to water and richer food resources.

Most human activity, and all housing, is confined to valley bottoms where on small fields bushes have been cleared for crop growing (largely irrigated onions grown for seed), dams have been constructed, and alien trees planted.

3.3.2 Mammals:

Twenty species of mammals, including five species of antelopes, were detected during field observations. These ranged in size from Elephant Shrew to Grey Rhebuck and Aardvark. Either live or as carrion these mammals provide potential food for predatory and scavenger bird species. Several mammals were seen that are potential predators of birds, or their eggs or young. These were two mongooses – Small Grey and Yellow – Chacma Baboon, Bat-eared Fox, and Black-backed Jackal. It is highly likely that Caracal also occurs but none of these, largely nocturnal, predators were seen. These, in addition to avian predators must constrain the numbers of birds, and restrict their selection of breeding sites, in this region.

3.3.3 Food resources for birds:

Due to the limited availability of forbs and the near absence of grasses along the ridges, the seed resource for large invertebrates and granivorous birds is limited. Along the ridges invertebrates were the most available animal food resource for birds and, due to the rocky nature of the ground and the limited seasonal availability of soft forbs (relative to the woody bushes), they were not abundant. The only reptiles detected were 2-3 species of lizards, infrequently seen, and tortoises. Apart from an Elephant Shrew rodents were only seen in the valleys and even there were not numerous. Potential food resources for large raptors were scarce. No Dassies were recorded in the Karreebosch area, except close to Snydersberg. This was probably due to the scarcity of suitable boulder outcrops. Scrub Hares were only seen in the valleys and were only numerous in the early summer of 2013 after the good winter rains. Numbers of antelope are very small. By far the most available potential food for large raptors is sheep carrion. As when lambing, and for access to supplemental food, sheep are mostly in the valleys there is little to attract large raptors to forage along the ridges.

3.3.4 Wetlands

There were three substantial dams in the three valleys of the Karreebosch area and a further four within 10 km. Waterbirds were assessed at all 7 dams. The dam at Ekkraal was close to the farm dwellings (Fig.1) and, probably as a result of consequent disturbance, supported few waterbirds. The two dams in the Wilgebos Valley (Fig. 4) supported 24 species of waterbirds including at the Rietfontein dam, in September 2014, 24 Maccoa Ducks (Near-threatened). Observations were also conducted at three dams in the lower Tankwa River valley after the stream from the three valleys merged to the northwest of the Karreebosch area. Most species of waterbirds prefer relatively shallow water and or the waters' edge. Following winter rains the farms dams fill and the increase in depth leads to displacement of those species that prefer shallows for foraging. Progressive dry-down through the summer leads to shallower conditions and there is movement of waterbirds back to these dams. Most waterbird movements in the area follow stream-lines and valleys. However, some waterbirds do cross the ridges, including the highest in this region.

Fig. 4. View west across the Wilgebos Valley to the Western Ridge. 33 kV lines should be avoided in this section of the valley between the dams Rietfontein (left) and Klipbanksfontein (just visible over the dark ridge at extreme right)

4 METHODOLOGIES

Initially the Karreebosch project was considered as a second phase of the Roggeveld WEF. Accordingly the Karreebosch area was monitored during the same field periods as that for the Roggeveld and vantage points were selected to provide interlocking scans between Phase 1 and 2 ridges. As the overall project was for phased development the DEA has required differential EIA treatment of these phase applications. This decision was made subsequent to the 2013 monitoring.

Only well into 2014, long after completion of the initial monitoring along the Eastern and Central Ridges, was it appreciated that the Karreebosch WEF would only be viable if turbines were installed along the Western and Spitzkop Ridges. In view of time constraints for the forthcoming round of DEA appraisals of proposed WEFs a single monitoring iteration of the Western Ridge was conducted in September 2014 to determine whether an extrapolation of the findings of this spring season, as the most important season of the year, onto the 12 months monitoring undertaken for the majority of the Karreebosch site is scientifically justifiable and defensible. Further monitoring, with an emphasis on raptors, was conducted by Dr R. Simmons along the Western Ridge in October 2014 (Appendix 12. 9). Fortunately observations had been made in the key Wilgebos Valley, between the Spitzkop and Western Ridges, during four of the five monitoring sessions in 2013.

The 2014 observations were conducted in September-October - the local spring. This had been shown during monitoring in 2013 to be the best season for avifaunal monitoring in the area. It is the best time for detection of breeding activity of resident raptors – in this area specifically Verreaux’s Eagles. Spring season monitoring, after the region’s winter rains, captures the potential spring influx of non-resident birds into the area. The winter rains also increase waterbird diversity and numbers on the recharged farm dams.

Although Western Ridge was only monitored in the spring of 2014, and the Spitzkop Ridge was only covered by the adjacent vantage points, the geology, terrain, and vegetation is in all essentials the same as along the Central and Eastern Ridges. The birdlife in the less monitored areas is unlikely to differ in any radical way from that of the Ridges monitored thoroughly in 2013. Nor are there any features apparent either from the OS 1:50,000 maps or observation from adjacent ridges that indicate any features – wetlands, cliffs etc. in the less observed area that might harbour species other than those recorded across the entire Roggeveld-Karreebosch area. In fact although vantage points were manned for longer on the Western Ridge than on the ridges monitored in 2013 fewer bird species were seen and numbers were also smaller than on the better monitored 2013 ridges. It is thus considered reasonable from a professional ornithological standpoint that the avifaunal coverage has been adequate for the EIA evaluation of the proposed development.

4.1 METHODS USED

4.1.1 Vantage Points:

This appraisal is based on observations from 15 vantage points, including controls: 9 on the Karreebosch ridges where turbines are to be located; and, in 2013, six vantage points used in Roggeveld WEF (Phase 1) monitored during the same weeks of monitoring as in the Karreebosch area and which scanned into the latter area. Visibility was generally excellent and large, collision-prone, birds could be observed and identified over distances of at least 3-5 km. This enabled watchers at vantage points to register movements of large birds on adjacent ridges. Thus watches from vantage points on the Central and Western ridges covered the intermediate Spitzkop Ridge. The overall time spent in vantage watches across the Karreebosch area was 326 hours.

Vision from one ridge to the next was good. There was some potential bias in that, given the flattish ridge tops, observers were usually based on the up-draught side of the ridge where most of the larger birds were anticipated. However, observations during calmer periods gave no indication that this bias would have resulted in fewer birds being recorded at ridge heights.

Views were obstructed in two situations. Firstly, because of the flattish ridge summits, observations were concentrated along the summits, so birds could often not be seen if they flew along the slopes of the vantage point ridge. However, they would then be outside the collision risk zone, and so of lower concern. The second situation was when intervening higher topographic features prevented observation of where some birds actually crossed the ridges.

Table 1: Grid co-ordinates and altitudes of Vantage Points used in this survey

(coordinates in degrees and fractional minutes)

Vantage Points		Altitude
VP 1	$32^0$55.5 S $20^0$26 E	1439
VP 2	$32^0$35 $20^0$30.5	1270
VP 3	$32^0$52.5 $20^0$32.3	1253
VP 4	$32^0$50.2 $20^0$30.2	1244
VP 5	$32^0$49.1 $20^0$32.8	1021
VP 6	$32^0$49 $20^0$30,8	1070
VP 7	32^0 53.4 20^0 25.6	1211
VP 8	32^0 52.5 20^0 6.4	1157
VP 9	$32^0$51.3 20^0 6.4	1128
VP 10	$32^0$50.2 20^0 26.8	940
VP 11	32^0 48 20^0 27.2	1016
VP 12	32^0 48.3 20^0 27.2	861
VP 13	$32^0$56 $20^0$01	1433
VP 14	$32^0$56.2 $20^0$19.9	1432
VP 15	$32^0$56 $20^0$25	1326

4.1.2 *Walked transects*

Two types of walked transects were conducted. 1) Where personnel had to walk from valley access tracks up to ridge summits observations were made whilst moving to and from these points - an ascending transect in the morning and a descending one in the late afternoon. 2) Other transects radiated from the vantage points and were either along ridge tops or were circuits around the summits of peaks. All transects were walked at least twice, during each visit. Transects are indicated on Fig. 5. An overall total of 23 walked transect routes were used 8 of them slope routes and 15 ridge-top routes. Ridge and peak transects generally provided unobstructed views across adjacent valleys and were considered as effectively mobile vantage points. The overall time spent on walked transects was 56 hours

4.1.3 Drive transects

The Wilgebos Valley was driven in both directions between Leustert and Klipbanksfontein in March and May 2013, and in both Septembers, but not in July 2013 due to the effect of heavy rains on the tracks. The Tankwa Valley was driven in March, May, July, September and November 2013. In September 2014 the Kareekloof Valley, west of the Western Ridge was driven between Kranskraal and Oude Huis 8 times and between Oude Huis and Kareekloof 4 times. The overall time spent on drive transects was 48 hours.

4.1.4 Focal points:

Observations were made at two types of focal points: 1) nest sites of priority species and 2) dams which were the only waterbodies in the Karreebosch area.

4.1.5 Nest sites

Small cliffs, deemed as potentially suitable for raptor nesting, were selectively scanned from vantage points. Activities indicative of breeding were only observed at one locality, here called Beacon Hill, where, in July, inspection located two Verreaux's Eagle nests close together on the west facing cliff.

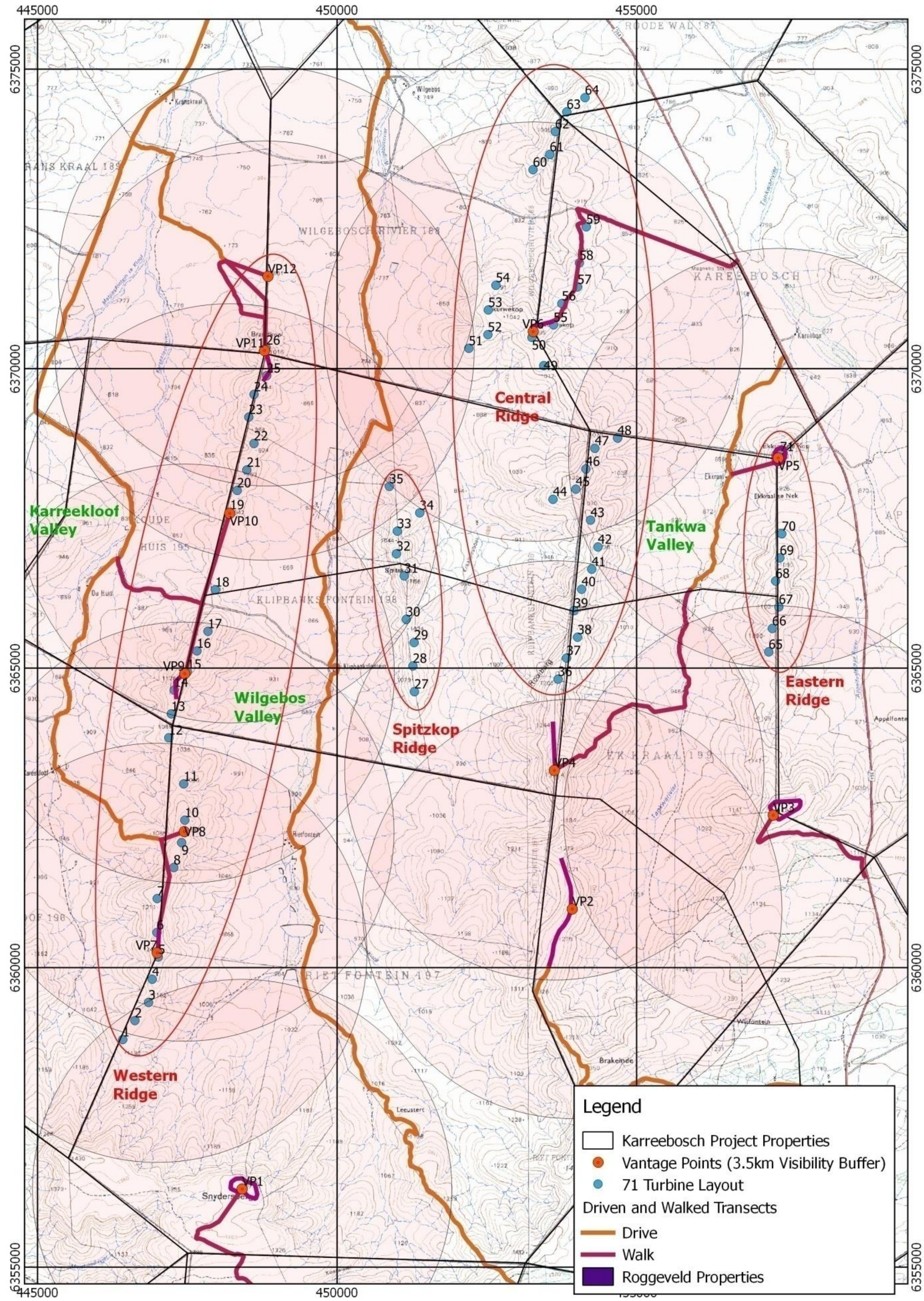
4.1.6 *Farm dams*

Observations were made at the four flooded dams in the Karreebosch area valleys. These were the Ekkraal, Rietfontein, Klipbanksfontein, and Kranskraal dams. The northern dam indicated near the Klipbanksfontein farmstead on the 1:50,000 map was dry in both 2013 and 2014. Additional observations were made at the large Tuinplaas, and two Seekoeigat dams, on or adjacent to the Tankwa River. These three dams are situated 8-10 km to the northwest of the immediate Karreebosch area.

4.1.7 *Incidental observations*

Records of priority species, and other noteworthy observations, were recorded incidentally during travel, other than transects, in the vicinity of the Karreebosch area. Opportunistic recording of bird species in the valleys and adjoining areas during driving or walking to or from the ridge-tops permitted comparison of bird diversity in these areas with that on the ridge-tops.

Fig. 5. Vantage point scan zones and transects used in bird monitoring across the six visits.



4.2 METHODOLOGICAL LIMITATIONS

The best practice guidelines are ideal for areas where conditions permit their full application. Marques *et al*. (2014) acknowledge that in remote areas logistic issues (and they should have also named terrain limitations), may constrain implementation of human surveillance related to WEFs. A number of constraints limited the application of the guidelines in the Karreebosch area.

4.2.1 *Logistic constraints*

In 2013 staff working on a new regional Eskom power line had booked all accommodation in and immediately around the survey area. The nearest available accommodation was in Laingsburg. This required almost an hour driving each way to reach the start of the access tracks within the Karreebosch survey areas. Once past farmsteads tracks towards the ridges were rough and poorly or un-maintained – often they had dongas and steep stone ridgelets - and, even with 4 X 4 vehicles, could only safely be driven slowly and in daylight. As evidence of the conditions, during the surveys two tyres were written off and an undercarriage damaged. Only the Central ridge has some vehicle access to the summits. The other three ridges - Eastern, Spitzkop and Western - have no vehicle access. For most vantage points observers were driven to the nearest vehicle accessible point. Then, with all their requirements for a day of potentially variable weather, they had to hike up the ridge slopes to the summit.

Departure from Laingsburg was before daybreak. The drive time to the study area was an hour. The farm track drives, that for safety had to be in daylight, took: 30-45 minutes to the near the first VP access point; a further 10-15 minutes to the next VP access point; and 10-15 minutes to the final access point. In most cases each observer then had to hike up to his vantage point. As a result vantage point observations could only begin about 1-2 hours after dawn. Departure from vantage points also had to be timed so that the farm tracks could be driven in daylight. In September 2014 local accommodation was available within 60 km. This enabled longer periods to be spent in the field.

Accordingly, in 2013, all vantage points were manned only through the day of ascent. Repetition of 3 hour scans across several days was deemed unjustifiable in view of the access difficulties, the extreme paucity of birds in the area, and physical exhaustion of the observers. In September 2014 all vantage points were manned for a total of nine hours. Again the paucity of birds did not justify longer observation. The conditions in the Roggeveld/Karreebosch area are unlike those in most windfarms, including all 11 WEFs in the experience of the observer team, in which there is generally reasonable road access close to vantage points.

4.2.2 *Psychological constraints*

Experience in the USA has shown that observer alertness at vantage points diminishes progressively after an hour (stated in an oral presentation by an invited American expert at the 2011 Brandfontein (R27) WEF workshop). This is especially the case when, as in the Roggeveld/Karreebosch region, there is very little bird activity to record. Accordingly, to sustain alertness, vantage points were monitored for the first hour upon arrival at the summit, then a transect was walked before a further hour of vantage monitoring, and so on through the day. As transects were walked along the ridges they acted as mobile vantage points.

4.2.3 *Vantage point constraints*

Due to the rounded nature of the ridges and the broadness of the summits it was generally not possible to simultaneously watch both sides of a ridge or peak. The breadth of the ridges made it difficult to select vantage points with more than a 180^0 vista. Preference was given to watching the windward side of the ridge where birds using updraughts were most likely to occur. Further the steep upper slopes to the ridges made it often impossible to watch over the immediate slopes whilst also watching for birds crossing the ridge summit which were given priority. This situation was overcome to a degree by monitors scanning the slopes of adjacent vantage points as there was normally good visual overlap between vantage points.

The flight heights of the few large birds seen from vantage points might have been less accurately recorded at distances greater than 2 km. However, there was no indication that the few individuals seen at this range acted in any way that was markedly different from those seen within the 2 km range.

4.2.4 *Walk transects*

Transects have two functions: to record species diversity and density; and, using statistical methods, to enable changes in numbers between pre- and post-construction periods as a means of assessing displacement. Only the first function is applicable on the ridge tops where turbines are to be sited in the Karreebosch project. Given the relatively narrow ridges, transects could only be walked along the ridge alignment. For installation and maintenance of turbine strings new 12 m wide roads will be constructed along these same ridges. These roads will effectively transform the ridge habitats and totally obliterate the walked summit transect routes. Even so, the number of birds recorded during transect walks was too small for meaningful statistical analysis to determine density.

5 BIRD OBSERVATIONS

A total of 115 bird species were recorded in, or immediately adjacent, to the Karreebosch area during the six visits. A further two species were recorded by Dr Simmons team in September 2014. These are all listed, arranged by groups of ecological similarity, in Appendices 1-7. The occurrence of birds along the ridge-tops and in the adjacent valleys is given in Table 2. During some 120 hours of observations on the ridges the total number of species recorded was 48 whereas in the valleys between the ridges the number of species recorded was 88 in a considerably shorter period of time. Though not quantified, it was clear that birds occurred in considerably greater numbers in the valleys than on the ridges where in many hours no birds of any species were recorded or often only 1-3 individual passerines.

Observations are here divided into two sections: 1) birds recorded along the ridge-tops; and 2) those below the ridge-tops i.e. on the ridge slopes below turbine positions and, especially, in the valley bottoms. This treatment is used because the diversity and number of birds, differs between the two sections, as do the potential impacts of the WEF. Along the ridges the diversity and number of birds is low and the impacts of the WEF on birds are the risk of collision with the wind turbines and displacement as a result of habitat loss and disturbance. Below the ridges the diversity and number of birds, especially conservation priority species, is greater and the impacts are collision with power lines, biotic impacts, and electrocution.

Table 2. Occurrence of bird groups - along the ridges by month and overall in adjacent valleys

Bird group	March ridges	May ridges	July ridges	September ridges	November ridges	Valleys
Birds of prey & carrion	4	4	6	9	6	14
Other non-passerines	1	1	3	3	5	9
Aerial insectivores	3	1	1	3	3	7
Ground invertivores	4	3	8	8	8	19
Bush foraging invertivores	3	4	7	8	10	21
Seed-eaters	2	2	5	5	5	10
Waterbirds	0	0	1	3	1	33
Totals	**17**	**15**	**31**	**36**	**38**	**113**

5.1 Ridge-top observations

The key purpose of the ridge watches was to establish which species, and in what numbers, birds flew at heights that would put them at potential risk of collision with turbine rotor blades i.e. according to the specifications provided, at heights of 30-170 m above the ground at the top of the ridges.

In many of the ridge-top vantage hours, and on several ridge transect walks, no birds at all were recorded. This was usually either when there was strong wind or in the hotter part of the day. Except for some early morning periods, generally fewer than 20 individual birds from all species were seen in any hour. Even the 20 sighted birds would probably often include repeated sightings of some of the same individuals as they moved about foraging.

In practice the 47 bird species that were seen along or over the ridges fell into two categories according to whether they were ever recorded flying at turbine blade arc heights (Table 3).

5,2 Ridge species whose members seldom, if ever, fly at turbine blade heights.

Of the 47 species seen along the ridges 35 were seldom or never seen to fly at turbine blade heights. Most of these were passerines associated with the local scrubland habitats. When flushed, or foraging, these birds seldom flew more than 3 m above the scrubby bushes. On more purposeful cross-ridge flights they still flew at less than 10 m. Except for a few display flights, none of these 35 species were considered at risk of collision with turbine blades.

Most birds breed during the regional spring season. In many ground-breeding bird species males perform display flights prior to mating. The heights to which they fly during such flights have not been well documented. Four species of passerine birds on the ridges were observed in display flights in the September 2013 observations. These were Mountain Wheatear and three species of larks – Cape Clapper, Large-billed, and Karoo Long-billed. Most flights were below 30 m, although some reached 40 m above the ridge and would be in the lower blade arc of a turbine. The flights were all performed within the first 2-3 hours of daylight. The number of individuals involved in displays was low. Displays were only observed when winds were light i.e. at times when turbine blades would be still, or slow moving, and so more easily seen and avoided. There was a marked contrast between the September 2013 and 2014 observations. There were numerous flight displays in wet 2013 but very few in dry 2014. Displays were usually performed over the rim of the ridges i.e. off the top of the ridges and over the upper-most slopes which is where nesting is more likely to occur. Thus these display flights were generally away from the centre of the ridges were it is recommended (see mitigations below) that the turbines be situated.

5.3 Species that sometimes fly at blade heights

Twelve of the ridge occurring species either occasionally, or often, flew at heights which would potentially bring them into turbine blade arcs (Table 3). Even in these species most of the observed flights along the ridges were below turbine blade heights, i.e. less than 30m off the ground. In stronger wind conditions fewer of these birds were seen in flight over the ridges and most that did so flew lower than during light winds. Thus in strong winds, when turbine blades rotate faster and may appear to blur, the number of individual birds at risk of flying into rotor blades will be lower.

During each season the total number of individuals in each of these at-risk species seen on the ridges across the observed sectors of the Karreebosch area was either very small, <10 or, where >10, it is highly probable that there were repeat observations of the same individuals e.g. White-necked Raven and Verreaux's Eagle. An exception was the Namaqua Sandgrouse in which several parties of 4-20 birds were seen.

Table 3: Bird species recorded along the ridges and their flight relative to turbine blade height

Birds of particular conservation concern are shown in bold

Species	Flight relative to turbine blade arc		Species	Flight relative to turbine blade arc	
	Below	Within		Below	Within
Ludwig's Bustard	X		Yellow Canary	X	
Verreaux's Eagle		X	Cape Bunting	X	
Rock Kestrel		X	Black-headed Canary	X	
White-necked Raven		X	White-throated Canary	X	
Pied Crow		X	Lark-like Bunting	X	
Black Harrier	X		Grey-backed Cisticola	X	
Booted Eagle	X		Bokmakierie	X	
Martial Eagle		X	Southern Banded Sunbird	X	
Jackal Buzzard	X		Layard's Tit-babbler	X	
Steppe Buzzard			Karoo Eremomela	X	
Peregrine Falcon		X	Spotted Prinia	X	
Sacred Ibis		X	Rufous-eared Warbler	X	
African Spoonbill		X	Malachite Sunbird	X	
Alpine Swift		X	Cape Penduline Tit	X	
White-rumped Swift		X	Cape Bulbul	X	
Little Swift		X	Fairy Flycatcher	X	
Namaqua Sandgrouse		X	Yellow-bellied Eremomela	X	
Grey-winged Francolin	X		Large-billed Lark	X	
Speckled Pigeon	X		Mountain Wheatear	X	
Crowned Plover	X		Long-billed Pipit	X	
Karoo Shelduck	X		Familiar Chat	X	
Pale-winged Starling	X		Karoo Long-billed Lark	X	
Rock Martin	X		Sickle-winged Chat	X	
Karoo Chat	X		Cape Clapper Lark	X	
Karoo Lark	X		Karoo Scrub Robin	X	
TOTAL	Flights within blade arc heights			12 species	
	Flights seldom or never in blade arc heights			35 species	
	All species recorded along/over ridges			47	

Only three species were observed in flight at ridge heights during strong winds. These were Verreaux's Eagle, White-necked Raven, and a large (probably Peregrine) falcon. Individuals in all three species engaged in "kiting" – hanging apparently motionless in the wind for seconds to minutes and then swooping into another kiting position. To do this the birds required updraughts. These updraughts occur over the upper valley slopes so kiting birds were located over these slopes and away from the centre of the ridge where the turbines are proposed.

Some unanticipated species, none of them red-listed, occurred on, or flew over, the high ridges. In September 2014 a flock of 12 African Spoonbills flew up the Karreekloof Valley adjacent to the Western Ridge. They used apparent thermals to circle upwards, and moved south-eastwards at a height that would have taken them over 1300 m ridges. Actual ridge crossing could not be observed as their flight was obscured by a topographic feature. Single Sacred Ibises and pairs of Karoo Shelducks were each seen twice crossing ridges. Both species used topographic saddles. During daylight these birds would have seen, and likely avoided, the turbines. The ibis and spoonbills are altricial waterbirds which roost at night and nocturnal crossing of ridges is extremely unlikely. In both September observation periods flocks of Namaqua Sandgrouse flew along or near the ridge-lines. The ibis and sandgrouse all flew at heights that would have brought them into the lower arc of turbine blades.

None of the aerial foraging swifts, swallows and martins were numerous. Although individuals in several species flew at blade risk heights they did so mainly in light winds conditions. Most foraged on the upper hillside slopes rather than over the ridges. The species concerned are all widespread, common, and not considered of especial conservation concern.

5.4 Priority species

Of the priority species along the ridge-tops species only the Verreaux's Eagles were sighted in every monitoring season. The flight paths for this eagle are presented on one map (Map 12) with seasonal flight paths colour-coded. Due to their extremely low occurrence flight path observations of other raptors have been amalgamated and presented in 5 maps, one for each month of observations.

The species considered to be at the greatest risk from collision with the proposed turbines is the **Namaqua Sandgrouse.** The reasons are: 1) the number of individuals seen along the ridges was greater than that of any other species; 2) they flew at heights that would bring them within rotor blade arcs; 3) they flew in small tight flocks of 4-20 individuals so more would be killed at a time; 4) they fly at speeds of 60 km/h and so would have less time to react to an obstruction; and 5) flew more along, than across, the ridges and so would thus approach turbine blades from the side. As rotor blades are more conspicuous when seen head on than from the side, this would result in their having a lowered likelihood of perceiving the turbine blades. These sandgrouse are known to die from collision with telegraph wires so must be considered a potentially high collision risk on the Karreebosch ridges. However, the species is considered of Least Concern in the latest IUCN and BirdLife South Africa appraisals. It is likely that numbers seen in 2013 were larger than usual in response to the flush of seed-producing plants following the unusually heavy rains. In September 2014 only one party of 8 was recorded.

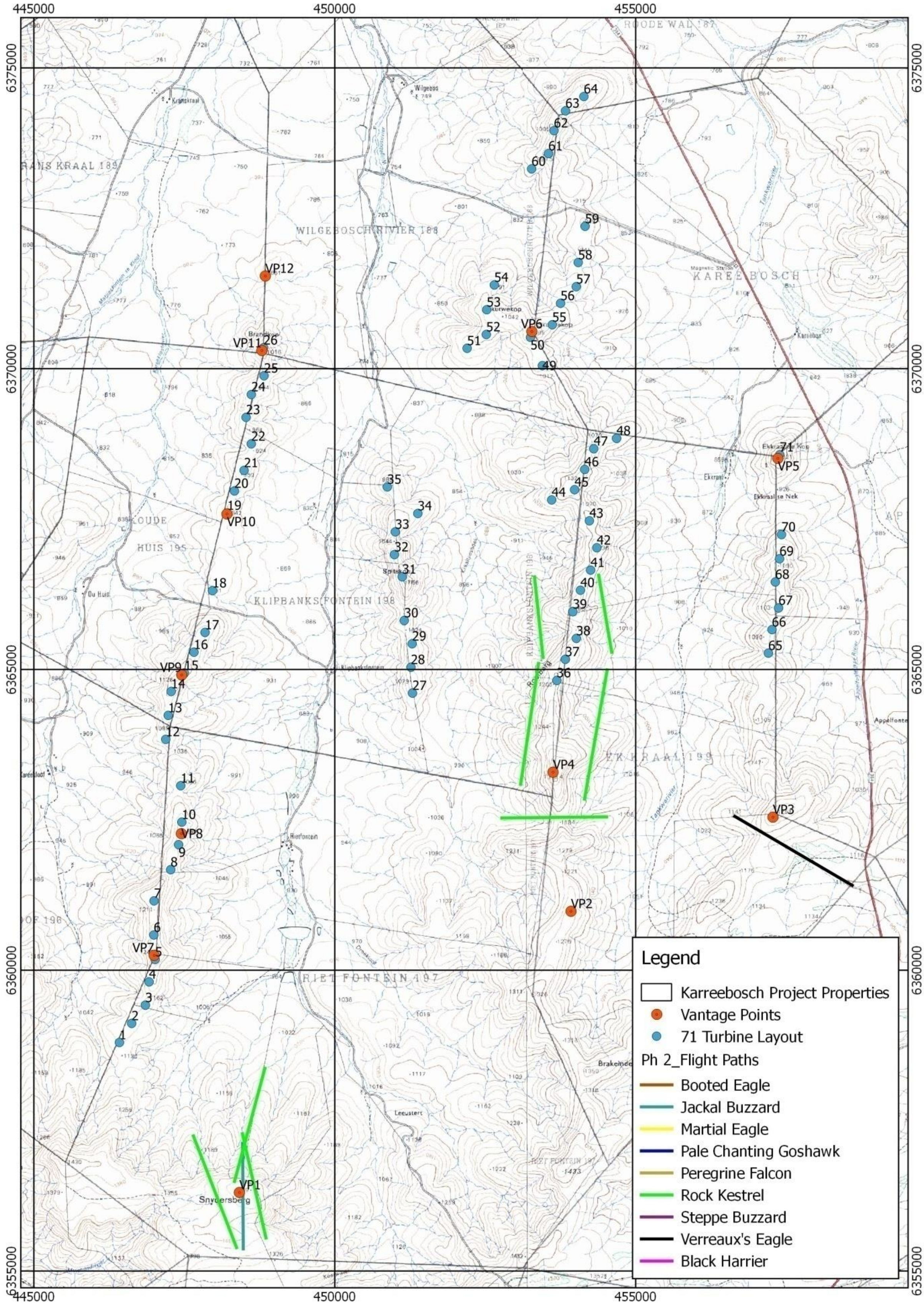


Fig. 6. Flight paths of raptors observed in March 2013

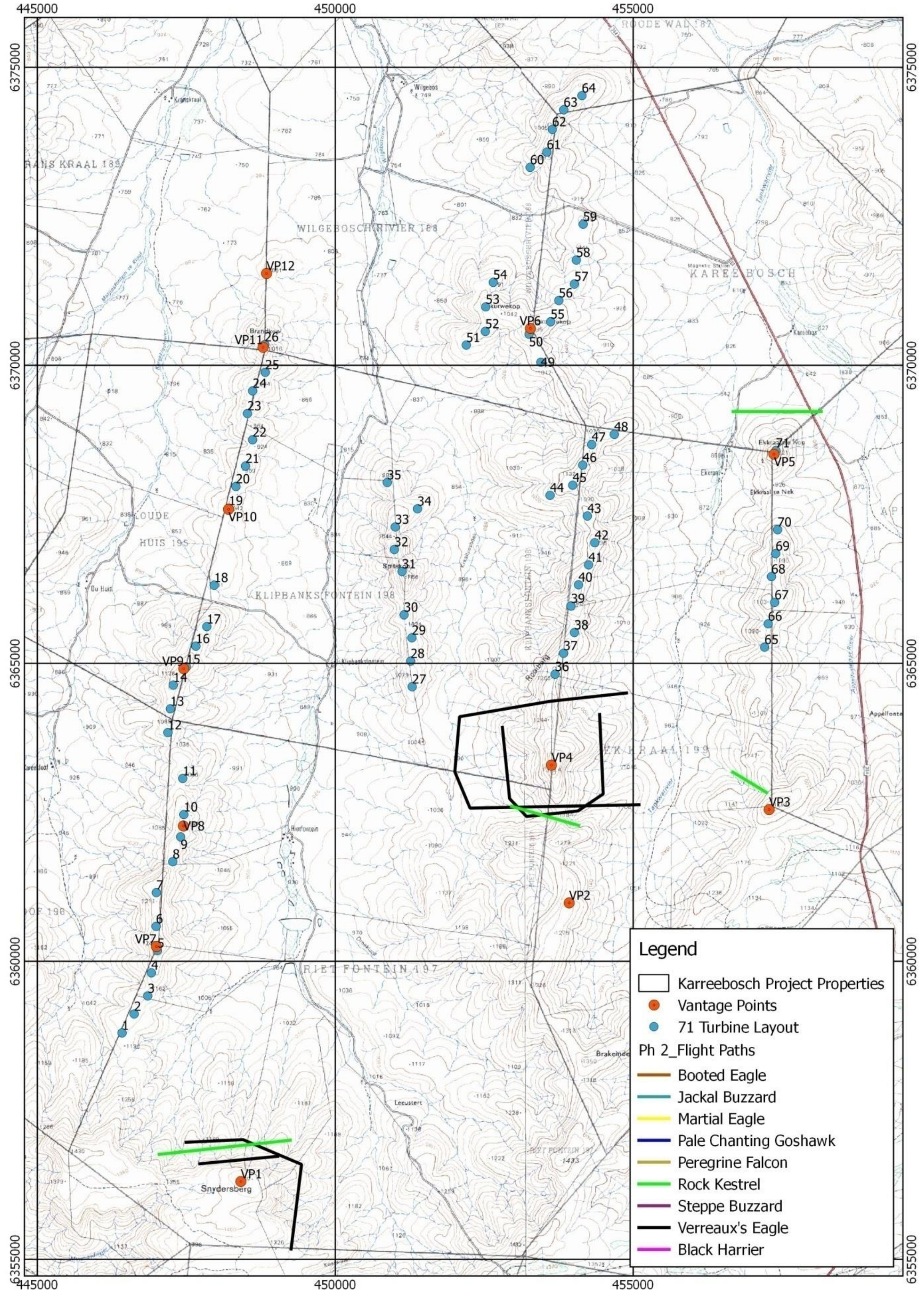


Fig. 7. Flight paths of raptors observed in May 2013

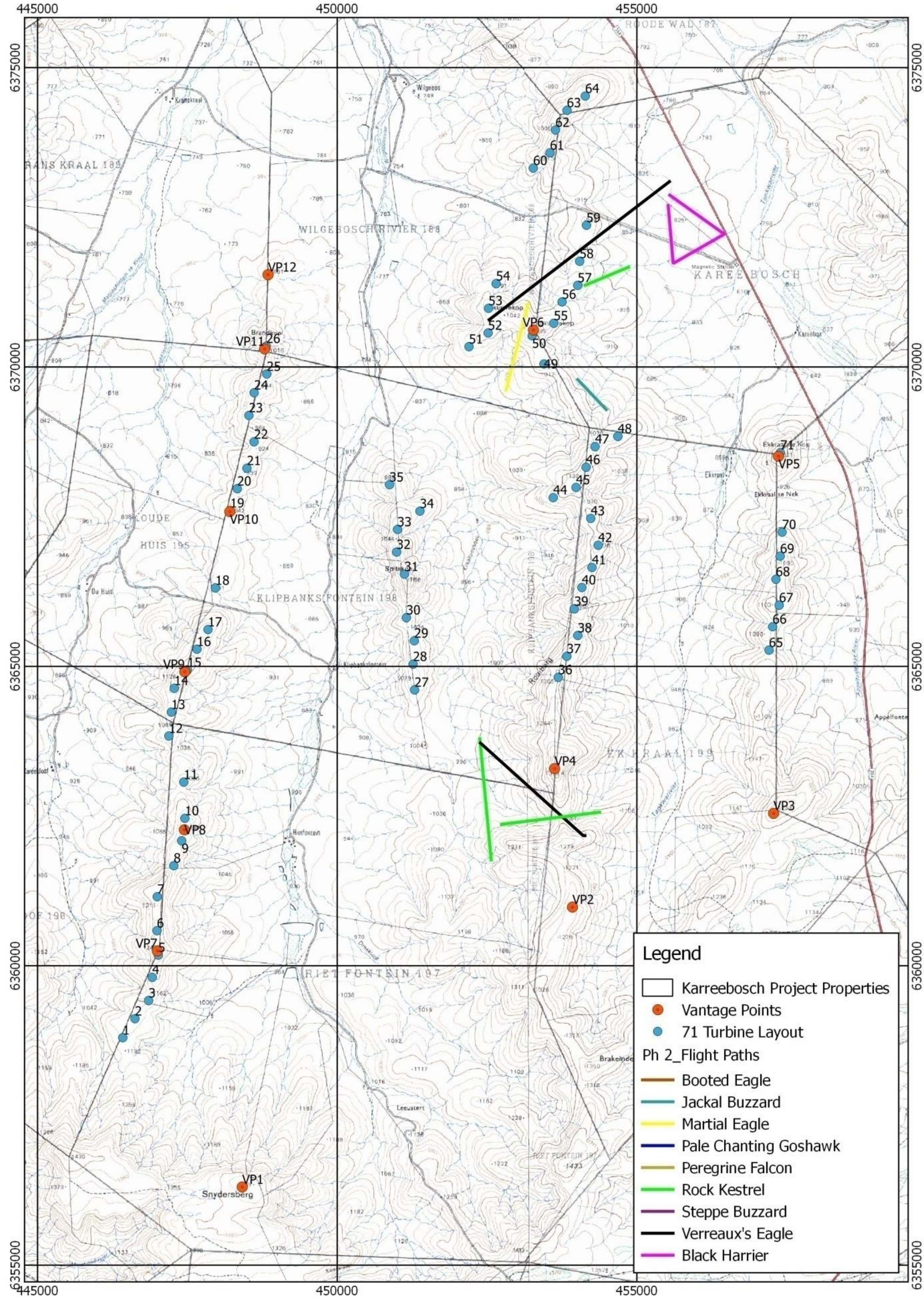


Fig. 8. Flight paths of raptors observed in July 2013

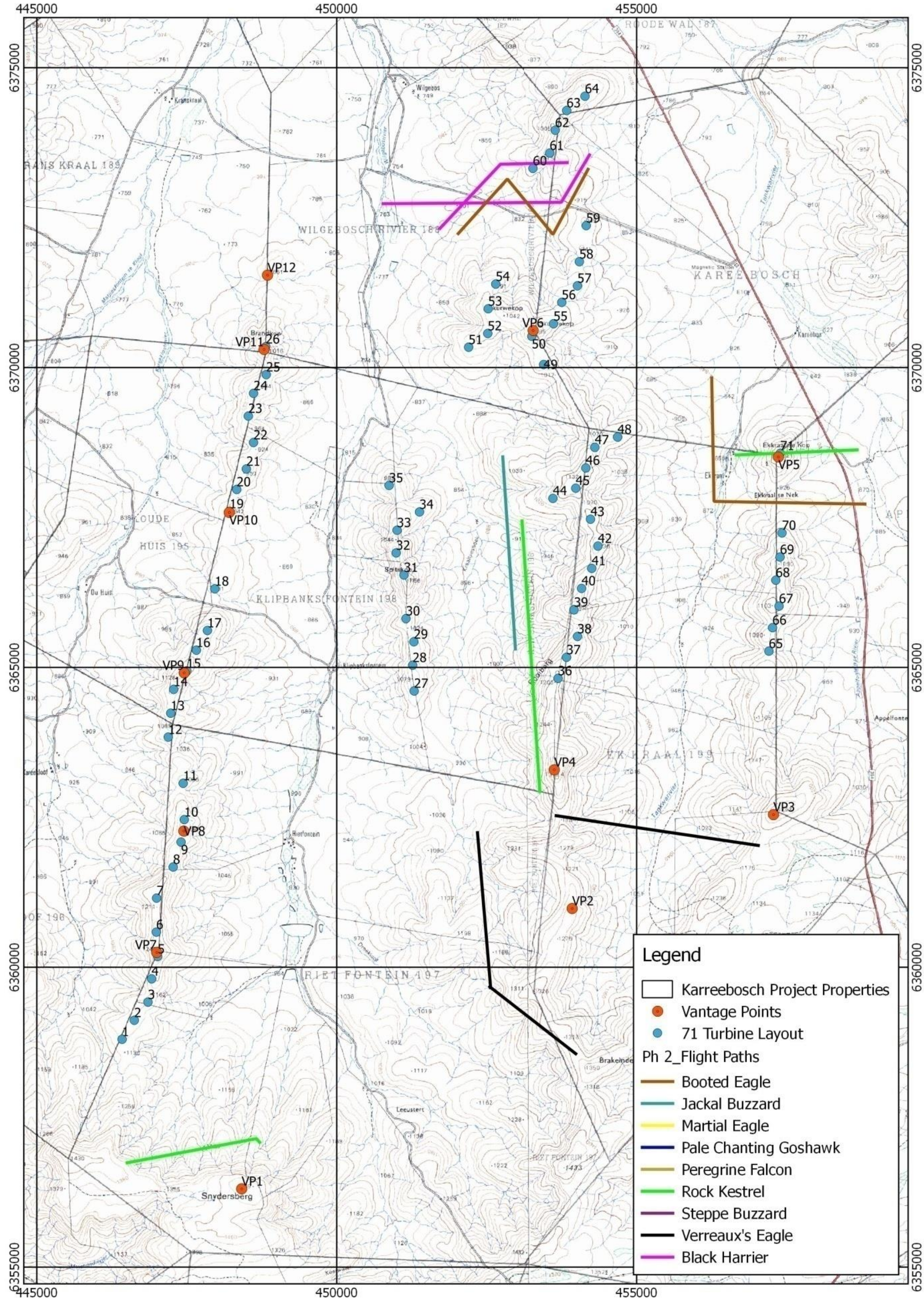


Fig. 9. Flight paths of raptors observed in September 2013

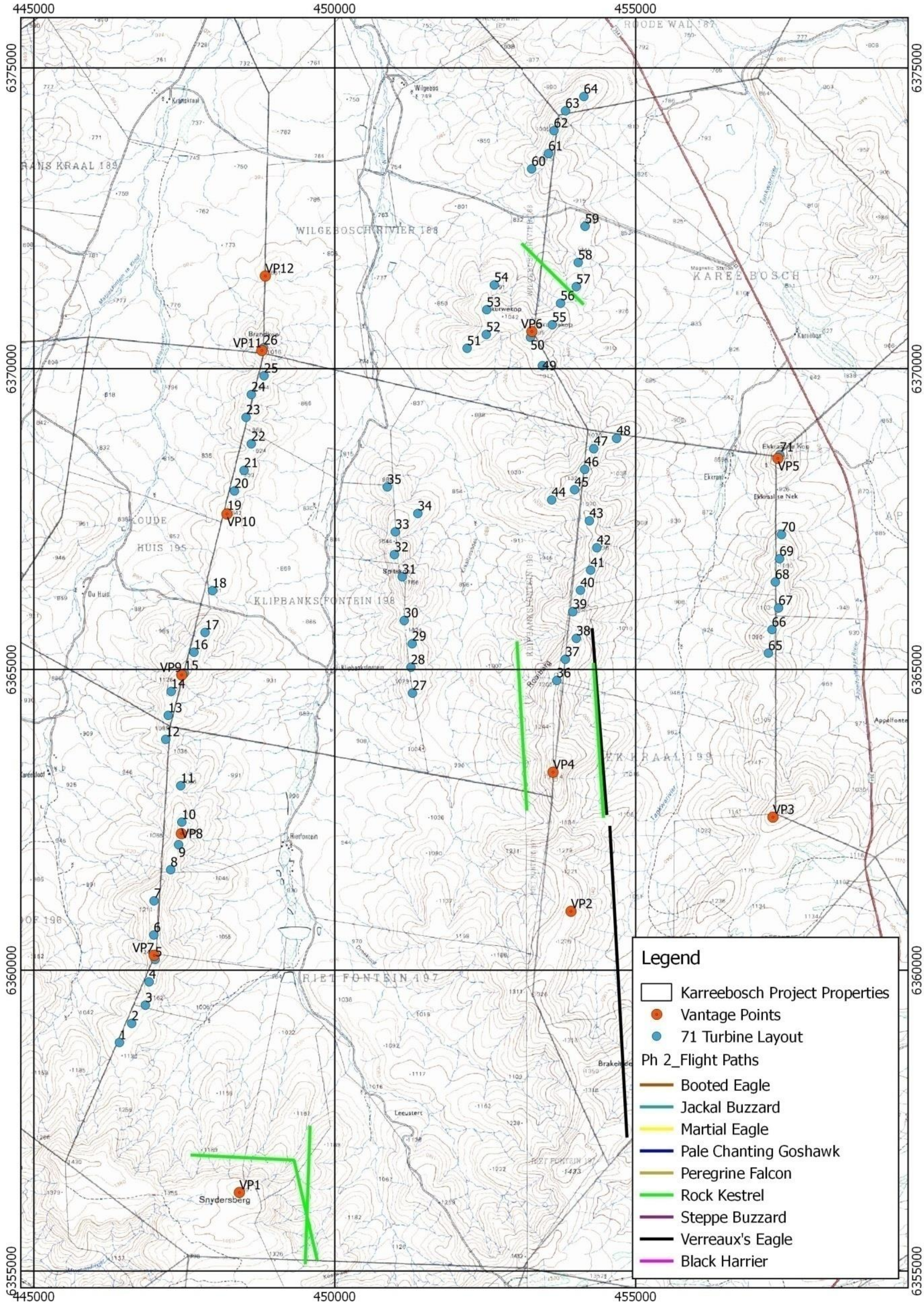


Fig. 10. Flight paths of raptors observed in November 2013

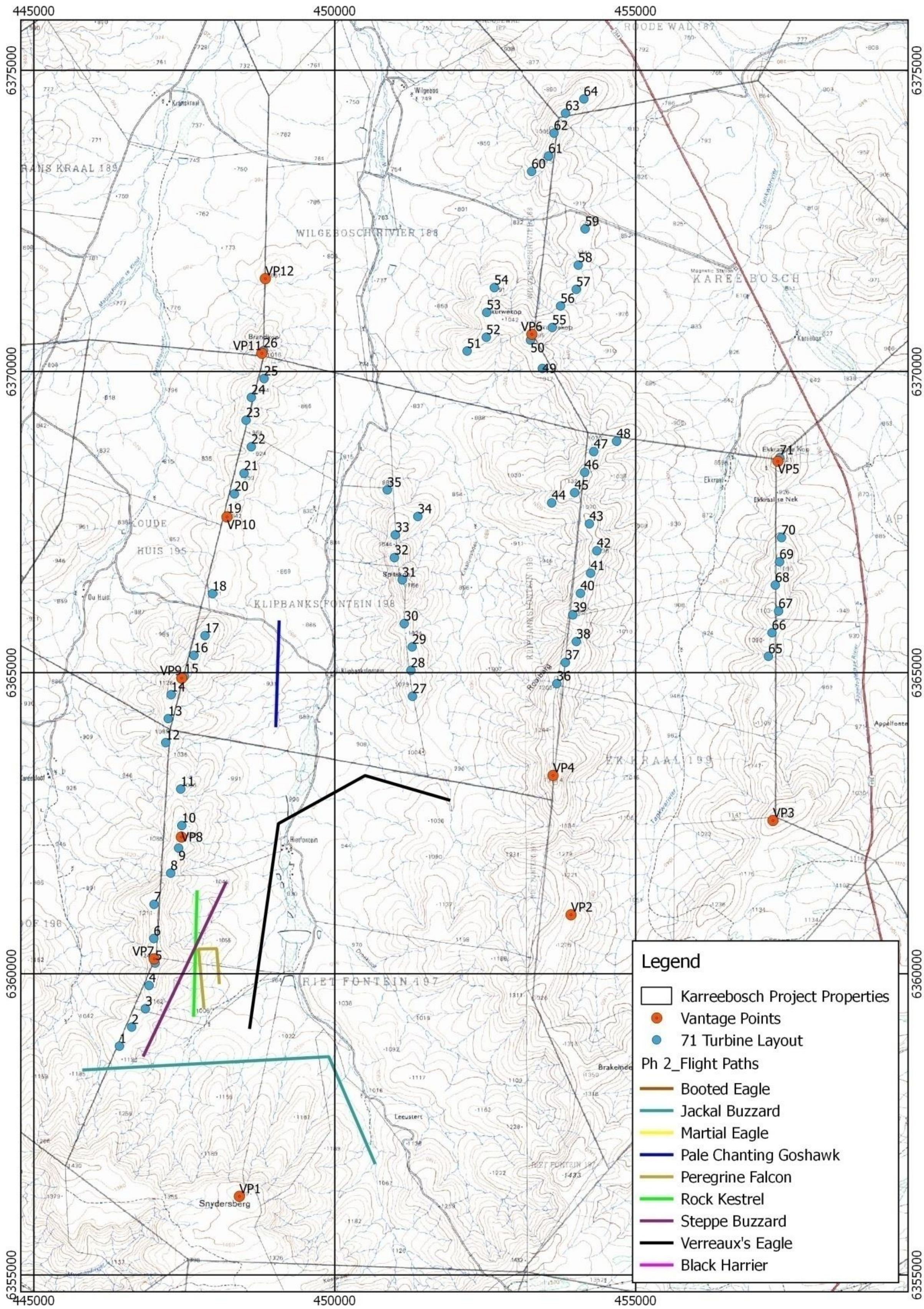


Fig. 11. Flight paths of raptors observed in September 2014

5.4.1 *Martial Eagles*

Seen only three times in the Karreebosch 2 area. In July 2013 a single individual vied with a Verreaux's Eagle for dominance of a lamb carcass on the slopes of the Central Ridge north-west of the Ekkraal farmstead. An adult that flew southwards high over the Wilgebos Valley well away from the ridges. A topographic obstruction prevented tracking of this individual but it probably crossed a high saddle near Snydersberg into the next valley which was outside the Karreebosch area. In September 2014 an immature Martial Eagle was seen on two consecutive days using thermals close to the Western Ridge (Appendix 9).

5.4.2 *Black Harriers*

Twice seen (possibly the same individual) quartering, < 5m off the ground, along the Central Ridge. The only other individual seen near the ridges was on the upper slope of the Central Ridge on the Wilgebos Valley side.

5.4.3 *Jackal Buzzard*

A single bird was recorded in July 2013 at a potential collision height.

5.4.4 *Rock Kestrel*

Most observations were of individuals using updraughts to hover over the upper slopes i.e. off the ridge-tops. Kestrels seen over the ridges were generally below turbine blade arc levels as they flew low to seek prey or crossed the ridge from one valley to another. Only when they flew up to harass eagles did these kestrels enter potential collision risk heights.

5.4.5 *White-necked Raven*

This species was often seen flying at turbine blade heights. Ravens are highly intelligent birds adept at coping with strong and variable winds in mountainous areas. It is considered highly unlikely that they will experience significant mortality through collision with turbine blades. Many of the observations were probably repeat sightings of the same individuals and the overall number of individual ravens seen in the Karreebosch area is probably less than 10. Larger numbers may occasionally gather at large carrion as 25 were observed at a sheep carcass in the Hidden Valley WEF area some 10 km east of the Karreebosch WEF.

In November 2013 the number of ravens seen was considerably lower than in previous monitoring iterations. Ravens are winter breeders. In other, better studied, raven species, newly fledged juveniles birds feed on large invertebrates found whilst walking. If this applies to White-necked Ravens then in spring those that have bred successfully must move to lowland areas where, for the juvenile ravens to cope, walking is easier and suitable prey are more abundant. Since collisions are more likely among juvenile than adult birds the evident removal of recently fledged ravens from the ridges will reduce overall collision mortality risk.

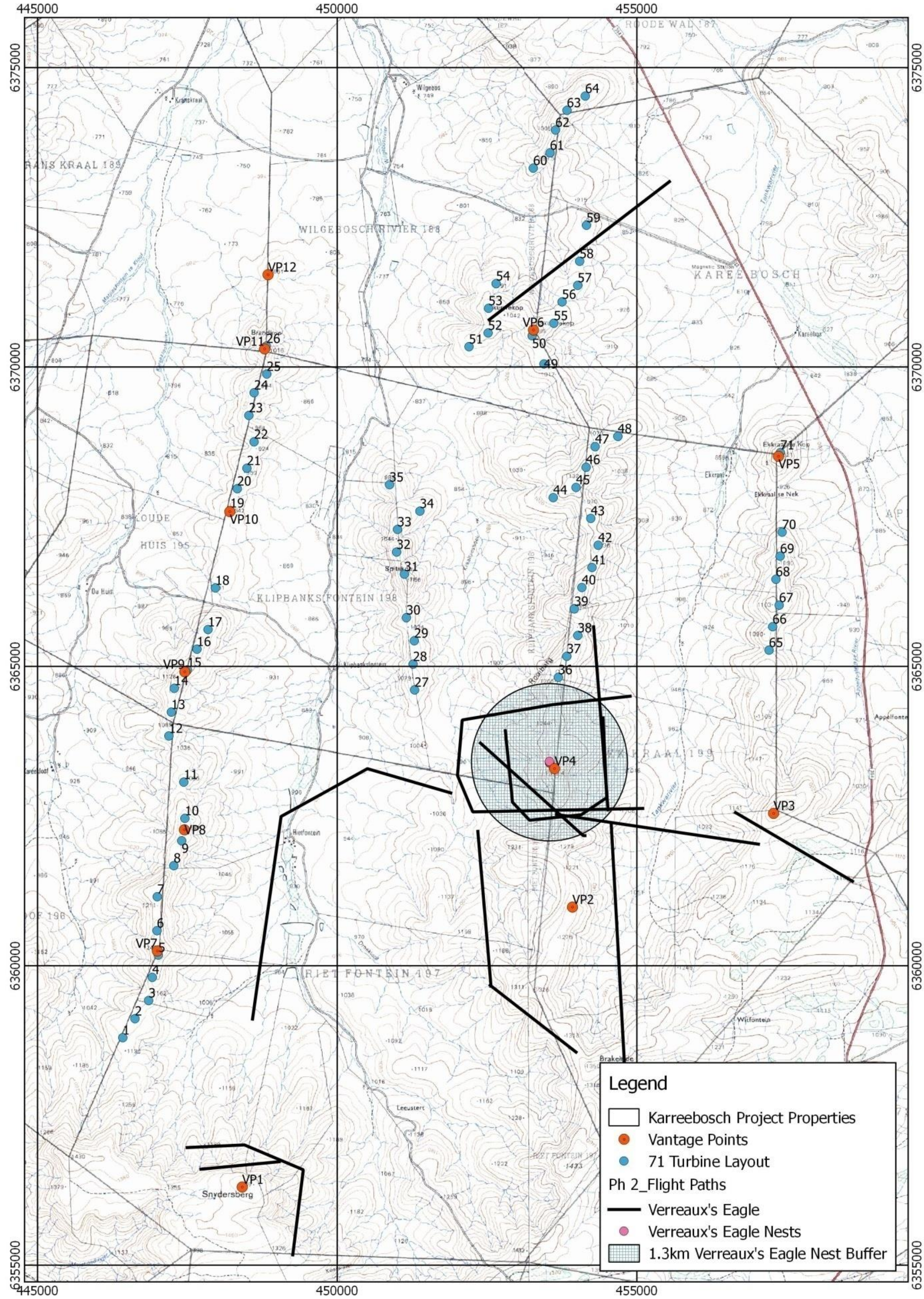


Fig.12. Flight paths of Verreaux's Eagles observed during the entire monitoring periods

5.4. 6 *Verreaux's Eagle*

The most frequently observed raptor seen along the ridges was Verreaux's Eagle. Observations for this species are presented on a single map with flight tracks colour-coded by season (Fig 12). Many of the observations were of a pair, probably that connected with the nests on Beacon Hill (see below). Most of the other sightings were probably repeated views of individuals from this pair. The total number of individual Verreaux's Eagles seen over the Karreebosch area was probably less than 5.

Verreaux's Eagle though rated as Vulnerable in South Africa is considered as of Least Concern on a global basis by Birdlife International (www.birdlife.org/datazone/speciesfactsheet 3539). This eagle is for two reasons considered a keystone species relative to the proposed Karreebosch WEF. These reasons are: 1) that flights by these eagles led to other species – Rock Kestrel and White-necked Raven - flying up into blade-arc heights to harass the eagles; and 2) a pair bred at the southern end of the proposed turbine layout.

In July 2013 two Verreaux's Eagle nests were found close together on the north-west facing cliff of Beacon Hill on the northern end of the turbine string on Central Ridge. The nests were large, so evidently added to over a number of years, but held no fresh green material, nor was there any whitewash from recent droppings. A pair of eagles flew nearby with twigs in their claws. Their continued presence near the nests, and the carriage of potential nest material, indicates that the nests are still being maintained and the overall site must be considered active. No evidence of breeding was seen when the nests were examined from above the cliff in July, September and November 2013. In the Karoo previous studies have shown that 35% of Verreaux's Eagles do not breed annually (Davies 1994). In low resource areas, like that monitored, pairs may only breed following a year of abundant prey production. Given the considerable winter rainfall in 2013 it was anticipated that there might be a prey recovery sufficient to stimulate breeding in 2014. However, in September 2014, despite repeated observations of the nesting cliff area over 5 days from the Western Ridge, and the survey by Dr Simmons (Appendix 9) no eagle activity was recorded at or in the immediate vicinity of the cliff with the nests.

5.5 Night active birds

The BirdLife guidelines concern diurnal monitoring. This provides little or no information about the potential risk of birds that might collide with turbines at night. There are two fundamental types of night activity by birds: a) foraging and other localized activities by locally resident species – owls, nightjars and thick-knees; and b) transient, cross-country, movements.

There is unlikely to be any substantial nocturnal use of the ridge-top areas by locally active nocturnal bird species as the food resources are too poor to sustain them and the frequent strong winds will deter them. Owls are the most likely to occur but most will remain in the valley bottoms, or forage along the lower slopes, where prey is more abundant. Furthermore, even if they do fly over the ridges, owls are unlikely to fly at turbine blade heights. The two species known or likely to occur in the region forage in low light conditions when detection of prey, either visually or through hearing, requires them to remain close to the ground.

5.6 Nocturnal transients:

Birds which are transient across turbine lines are considered at greater risk of collision mortality than birds resident in the immediate vicinity of turbines and the risk to transients is increased when their movement is at night. Long distance migrants often fly by night but most do so at heights that will keep them well above turbines even those on ridges. Nor is there any particular attraction which would lead them to descend towards this part of the Karoo.

The birds of potentially greatest concern are regionally resident birds that disperse at night. This particularly applies to waterbirds of which a surprising number and diversity (32 species see Appendix 7) were recorded on dams in the region of Karreebosch. Most waterbirds move between wetlands at night in order to avoid predatory eagles. There is the possibility that, in moving between dams, they would fly across ridges. It is likely that they fly high at night to be able to survey for wetland areas reflecting moonlight. They would thus potentially fly at blade heights. However, in this area the dams lie in relatively deep valleys. It is more likely that, when dispersing, these birds initially fly downstream and so would not cross ridges with their turbine arrays. Their reconnaissance excursions are also likely to be during clear nights and especially during full moon when waterbodies reflect the light and so are more readily detected by birds in flight. These conditions will also illuminate turbines. Overall, at this stage of our understanding, the risk of nocturnal collisions is considered to be low and within acceptable levels.

5.7 Displacement

The development of various footprint areas along the ridges – particularly the creation of 12 m wide roads and the turbine crane pads – will cause a considerable loss of habitat on the ridges. The turbines, and any noise that they generate, may well deter birds, especially larger sized species, from approaching the ridges. However, given the extreme paucity of bird diversity and numbers on the ridges, displacement is not considered to have more than a marginal impact on ridge-top bird numbers.

In all seven field periods (including Dr Simmon's 2014 visit – Appendix 9) the number and diversity of birds seen along the ridges was very small, remarkably so relative to experience in the considerable number (>20) of WEF locations previously worked on by Mr. Van der Walt and Drs Simmons & Williams. This situation applied across all field periods and the number of birds observed along the Western Ridge by the two teams was lower than seen on other areas in the combined Karreebosch/ Roggeveld areas during 2013. The small basic cadre of bird species along the ridges was similar across all iterations.

Differences in birds recorded along or near the ridges in the seven observation periods reflected: 1) seasonality; 2) weather conditions; and 3) the vagaries of bird occurrence. Most birds were regional residents. A few species were seasonal migrants that were absent from the region during the local winter – Booted Eagle, Steppe Buzzard, and most aerial insectivores. Fewer birds were seen, and bird diversity was lower on the ridges, in the four hot and dry visits (March and May 2013, as well as September and October 2014) than in the three visits when conditions were wetter (July, September and November 2013). In the wetter period there was indication of some resident species moving from the valleys onto the lower ridges (notably the northern section of Central

Ridge), and of some species e.g. Lark-like Bunting, Black-headed Canary, moving into the area from outside the region. Even display flights seemed related to the wetness along the upper slopes as though they were performed by a number of species in the wet September of 2013 few display flights were seen in the dry September of 2014. Moreover, there was no marked difference in bird diversity across the ridges. Though the frequency of observation along the Western Ridge was less than on the Eastern and Central Ridges there is no reason to think more observations would arrive at a dissimilar situation. In effect it is reasonable to consider the situation across the four ridges to be the same – one of a paucity of both bird numbers and species and a potential risk to only a very few individuals in red-listed species.

5.8 Valley birds

Of the 115 bird species recorded in the Karreebosch area 78 species were seen only in the valleys. Almost all the species seen along the ridges were also seen in the valleys. Of the red-listed species observed six - Maccoa Duck, Black Stork, Greater Flamingo, Blue Crane, Ludwig's Bustard, Karoo Korhaan, - would only be expected in the valley bottoms. The red-listed species that sometimes were recorded along the ridges – Verreaux's Eagle, Martial Eagle, and Black Harrier - also occur in the valleys though mainly over the slopes of the ridges.

The local topography is one of high north south ridges with intervening valleys. To avoid having to fly high over the ridges most birds will fly within the valleys which in the Karreebosch area are relatively narrow. As a consequence, other than local foraging, most bird flights are likely to be along the valleys. This will place these birds at risk of collision with cross-valley power-lines installed to service the WEF. Several groups of birds known from the area, including all the red-listed species, are considered at risk. Their occurrence in the Karreebosch valleys is now considered.

5.8.1 *Bustards*

Bustards are prone to collisions (Janss & Ferrer 2000). Two species, both red-listed, were observed in the region. These were the Ludwig's Bustard and Karoo Korhaan, rated respectively as Endangered and Near Threatened**.** Neither species was seen in the specific Karreebosch area but probably both sometimes occur.

Karoo Korhaans: In this region we only saw, or heard, Karoo Korhaans in valley bottom fields of the immediately adjacent Roggeveld WEF area. As there are few valley fields and, at any one time, even fewer fields with suitable plant cover, the potential number and distribution of Karoo Korhaans in the Karreebosch area is likely to be very small. If they do occur it is most likely that they will do so in the Wilgebos valley as this valley has most of the fields in the Karreebosch area.

Ludwig's Bustard: The three regional observations of the larger Ludwig's Bustard were of single individuals in flight: one flushed from an area of low shrubland in the Hidden Valley WEF area >10 km east of the Karreebosch area; another flying over a low ridge in the Roggeveld WEF area; and one seen in the upper Tankwa Valley within the Karreebosch area. Given the stony conditions and the paucity of large invertebrate prey it is probable that this species is only an occasional, generally non-breeding, visitor to the Karreebosch/ Roggeveld region.

In the Karreebosch area both bustard species will preferentially occur in the valleys. There they will be at potential collision risk with the proposed cross-valley power lines.

Though these bustards will preferentially fly over lower ground it is inevitable that they sometimes fly over the ridges. They are likely to avoid flying over the higher ridges and so if they do fly over ridges will be more at collision risk with turbines on lower ridges or near ridge saddles.

5.8.2 Waterbirds

Four species of red-listed waterbirds were observed. An immature Black Stork, rated Vulnerable, was seen by Dr Simmon's team in the Wilgebos Valley in September 2014. The other three species are all rated as Near Threatened. A flock of 24 Maccoa Duck were on the Rietfontein Dam in September 2014 and, in the same month, at least 5 others were on the Kranskraal Dam close to the Western Ridge. Also in September 2014 25 Greater Flamingoes were at the larger of the two Seekoeigat dams in the lower Tankwa Valley 10 km northwest of the Karreebosch area. A single Blue Crane was seen at a farm dam in the Roggeveld WEF area <1 km south of the Wilgebos Valley. With the marked exception of the Maccoa Duck, the there is little suitable habitat to attract these species in the valleys of the Karreebosch area. Most individuals seen must be considered as irregular, short-term, visitors or as vagrants. Probably most individuals are dispersing young birds. The greatest risk to any red-listed waterbird species in the Karreebosch area is that of collision with power-lines across the Wilgebos Valley by Maccoa Ducks as they move between dams in the valley and the larger dams in the lower Tankwa valley. The risk is considered great as: 1) these ducks are nocturnal dispersers; 2) in local movements probably fly at < 100 m; 3) fly in flocks; and 4) are stocky birds of low in-flight agility i.e. with little ability to adjust flight when a power-line is perceived.

To appreciate the potential impacts of the Karreebosch WEF on waterbirds, and the seasonally changing importance of local dams to waterbirds, it is necessary to understand some basic factors that affect the movement of waterbirds between regional dams in the area.

Focal observations of waterbirds were made at seven dams, 4 within the Karreebosch WEF impact area and 3 in the Tankwa Valley 8-10 km downstream. There is likely to be considerable movement of waterbirds between these dams especially in relation to seasonal rainfall. Many waterbird species prefer shallow waters that permit ready access to the wetland benthos. When small dams fill as a result of winter rains they become too deep for many of these shallow-water foragers and they move to other wetlands. In this region these are the larger dams on the Tankwa River which flood back across adjacent flatland as seen in September-November 2013. Through the long dry summers wetlands dry down and birds move back to the smaller dams. Waterfowl are characterised by having an annual moult in which they simultaneously lose all of their flight feathers. For safety in this period when they are flightless or flight impaired for 3-6 weeks they move to large deeper water bodies where they can avoid predators.

30 of the 32 species of waterbirds were recorded at the two dams in the Wilgebos Valley. There was noticeable difference between waterbird numbers in September 2013 and the same month in 2014. In 2013 after the unusually heavy rains and with consequently deeper water levels the Wilgebos dams supported notably fewer species, and numbers, of waterbirds, than at the same dams in 2014.

In the Tankwa Valley, 8-10 km outside the immediate Karreebosch area, 25 Greater Flamingoes (Near-threatened) were seen at the larger of the two Seekoeigat dams in September 2014. In the Tuinplaas dam a small tree-covered islet supported nests of Black-headed Heron, Cattle Egret and Reed Cormorants. An immature African Fish-Eagle was seen near these dams in November 2013 and September 2014. This may have been the same bird that Dr Simmon's team saw hunting waterfowl at the Klipbanksfontein dam.

5.8.3 Raptors

All the birds of prey recorded in the Karreebosch area, including the three red-listed species - Verreaux's Eagle, Martial Eagle and Black Harrier - occur in the valleys as prey is more available below the ridges. Some species were only seen in the valleys - Jackal Buzzard, Steppe Buzzard, Booted Eagle and Pale Chanting Goshawk. Most of these birds foraged along the scrubby slopes. Only the goshawk was primarily associated with riparian areas. These birds of prey are at a greater risk of colliding with power lines in the valleys, where the birds are more often foraging and so focused more on the ground, than they are from ridge-top turbines as on ridges they are less ground focused and have a better chance of seeing the obstruction.

5.8.4 Displacement and electrocution

The only footprint features envisaged in the valleys will be: 1) a widening of existing access track to a width of 6 m; 2) a straightening of some access roads to eliminate tight bends; 3) creation of some new roads up valley sides to provide access to the ridges; and 4) installation of power line support structures.

The total area of valley habitat loss will be small. Most of the area, especially the new roads to the ridges and access to install power lines, will be across low resourced scrubland. Relatively few birds will be affected by these footprints. Of greater impact will be increased destruction of the limited riparian vegetation where roads have to be improved across stream beds to facilitate heavy vehicle access. This riparian habitat supports a range of birds not generally present elsewhere in the Karreebosch area. However, none of the species likely to be affected are considered of particular conservation importance.

Electrocution is only a risk along valley power lines.

A number of species were represented by only single observations across the seven visits e.g. Black Sparrowhawk, Blue Crane, African Black Duck, and Black Stork. These are presumed to reflect the passage of birds through the region. It is likely that most of these individuals, especially where they occurred out of their species' normal habitat, were young birds dispersing from their particular breeding range. Observers commented on the frequency with which such "vagrant species" were recorded. This reflects a greater than anticipated movement of birds across this Karoo region. However, these do not represent a migration or even a predictable movement of individuals. The occurrence of these vagrants is too variable, and the numbers are too low, to have any reasonable importance in the siting of turbines along the ridges.

5.8.5 Overall statement

Based on the observations made across the five seasons: 1) the risk to birds of death through collision with turbines is considered low for all species except the Namaqua

Sandgrouse; 2) the risk of collision mortalities with cross-valley power lines is considered considerably greater and will affect a wider range of red-listed species than the risk of any collisions with turbines; 3) displacement of birds, through habitat loss and disturbance, is considered small.

6 POTENTIAL IMPACTS ON BIRDS OF THE PROPOSED DEVELOPMENT

The proposed Karreebosch development will potentially have four kinds of negative impacts upon birds, and no perceived positive impacts. In descending order of predicted importance these impacts are: 1) mortality through collision with the new powerlines necessary to link the turbine strings, via 33 kV line, to a substation, and from the substation(s) via 132 kV lines to the Eskom grid via the Komsberg booster station; 2) mortality through collision with wind turbines; 3) displacement from habitat; and 4) electrocution.

6.1 Collision risk

There are a number of generalities which affect bird collision risk with electrical infrastructures whether powerlines or turbines. Review of these generalities provides a context for appreciation of the differences in collision risk between that at powerlines and that at turbines in the Karreebosch area. These differences affect the manner in which collision mortality can be mitigated.

Most birds can fly and generally do so within 100 m of the ground. Electrical infrastructures – wind turbines and power lines with their support structures – intrude on this air space. This intrusion leads to collisions which are, both globally, and in southern Africa, the most direct and widespread impact of electrical infrastructure on birds (Bevanger 1998, van Rooyen & Ledger 1999, van Rooyen 2004, Rubolini *et al.* 2005, Drewitt & Langston 2006).

There are a number of generic factors which influence the risk of birds colliding with infrastructure. These include: whether flight is in daylight or at night; the agility and maneuverability of birds in flight; their age and experience; the sex of the birds; the degree to which birds fly by day or night; whether they fly in flocks; and especially the frequency with which their flights take them near infrastructure.

6.1.1 *Viewing ability*

The ability of most birds to detect obstructions in their flight path is considerably greater in daylight than in the dark. Birds in flight can obviously detect large structures, such as turbines or power line support structures, more easily than they can detect small features such as relatively thin power lines especially when these are seen against a dark background.

6.1.2 *Aerial maneuverability*

Birds differ in their ability to maneuver whilst in flight. This is an important attribute when there is a need to avoid colliding with structures, especially when these are only noted when the bird is already close upon them. Aerial maneuverability depends on the overall size of the bird, its wing span and wing-loading such that larger birds with wider wingspans are less maneuverable than smaller lighter individuals (Brown 1993, Janss 2000).

6.1.*3 Experience*

Young birds take time to fully develop their flight abilities (Nelson & Nelson 1976, APLIC 1994), more often fly in flocks, and form a high proportion of migrant populations

(Bevanger 1998). As a result young birds more frequently than adults fall victim of collisions (Rubolini *et al*. 2001).

6.1.4 *Sexual differences*

Differences may occur in the level of collision risk to male and female birds during the breeding season. Males may be more distracted than females during courtship (Brown 1993). In some birds, including ravens and some raptors, the female undertakes most incubation and brooding of chicks. During these periods the male feeds both the female and the brood and so undertakes most of the foraging which increases his risk of collision (Steinen *et al*. 2008).

6.1.5 *Ecological risks*

Particular ecological groupings of birds differ in the way their lifestyles expose them to the risk of collision. At the species level there are also differences in the degree to which such mortality is acceptable from a conservation perspective. In descending order of risk in the Roggeveld these groups, and the conservation priority species within them, are:

Large Ground Foragers: These are medium to large sized birds which feed whilst walking - cranes, bustards and korhaans, francolins, and the Secretarybird. Globally bustards and cranes are established high collision risk birds (Alonso *et al*. 1994, Janss 2000, Janss & Ferrer 2000, Dorfman *et al*. 2001, Garrido & Fernandez-Cruz 2003, Sundar & Choudhury 2005). In the Karreebosch area this group includes 7 species. Five of these are considered of high collision risk concern. These are: in the valleys Secretary-bird and three red-listed species - Ludwig's Bustard, Karoo Korhaan and Blue Crane; and, along the ridges, the Namaqua Sandgrouse. In semi-arid areas many ground foragers wander widely across suitable terrain in relation to rainfall and in the Karreebosch are there may be greater numbers in springs that follow heavier winter rains. Ludwig's Bustards are believed to migrate by night (Ledger *et al*. 1993) and this renders them especially vulnerable to collision mortality.

Waterfowl: These birds - ducks, geese, grebes, and coots– are largely associated with open water. Waterfowl regularly move by night and often fly in flocks both factors which increase collision risk. Geese and some ducks commute between day-use wetlands and nocturnal foraging areas. Most waterfowl must conduct repeated regional flights to assess the status and availability of alternative wetlands – especially important in the Karoo given the major regional wet and dry season differences in wetland availability. All waterfowl annually undergo a flightless moult. For their period of flightlessness most must move from smaller wetlands where they breed and forage to larger deep permanent wetlands where they can reliably feed without having to fly and are able evade terrestrial predators.

Waterfowl are the birds most impacted by collisions where power lines pass near wetlands (Scott *et al*. 1972, Anderson 1978, Faanes 1987, Bevanger 1998). At least 9 species, including the red-listed Maccoa Duck, are considered of medium risk of collision mortality in the Karreebosch area (Table 4).

Waders: Large wading birds **-** herons, flamingos, ibises etc – have long wing-spans, are generally large, and often fly in flocks, features that render them highly susceptible to collision with utilities. They are known internationally to have a high collision risk (Longridge 1986, Dorfman *et al*. 2001, Garrido & Fernandez-Cruz 2003, Rubolini *et al*. 2005). Most roost communally at night except when they migrate or undertake long distance dispersal. The 6 species considered at potential collision risk in the Karreebosch area (Table 4) include the red-listed Greater Flamingo.

Diurnal avian carnivore/scavengers: These are the birds of prey as well as the crows and ravens. Raptors are the birds that have been of most published concern in relation to electricity infrastructures. The risk of raptors colliding with power lines is considered small as all diurnal avian carnivores have good vision and so are less prone to collisions (Bevanger 1994, 1998). However, this is the group of birds that has most often been implicated with collision mortality at wind turbines. Of the 11 raptorial species recorded in the Karreebosch area 3 are red-listed, and two of these species plus the un-red-listed Secretarybird are considered of high collision mortality risk (Table 4).

Diurnal Aerial insectivores: Swifts**,** swallows and martins occur widely, but in small numbers, across the Karreebosch area. Visual foragers, they are not at high risk of collision. Some do collide with power lines but this is considered due to the frequency with which aerial foragers may cross lines (Bevanger 1998).

Scrub and shrub birds: The natural vegetation across most of the Karreebosch area is scrub on the ridges and upper slopes and shrubs towards the valley bottoms. This vegetation is dominated by birds whose food sources are found on plants (insects, berries, buds), on the soil below (insects, seeds, small vertebrates), or are hawked in the air just above the vegetation (insects). To move within scrubland these birds are generally small, possess good vision and have high flight agility to maneuver in and around the vegetation. These birds find their food visually and roost in cover at night. The shrubs offer dense vegetation where the birds, and their nests, are not readily accessible to large predators (mammals and avian carnivores). The climate in the Karreebosch area does not enforce migration so most birds, including all regional scrub-/shrub-land endemics, are resident. There is no incentive for these birds to fly much above the vegetation except for those that perform aerial displays. Thus most birds in natural shrubland habitat generally fly well below the height of telephone lines. Consequently they are scarcely at risk of collision with power- lines or turbine blades, especially as they seldom fly at night and, because they are resident, will be familiar with the location of support structures. Shrubland birds rarely occur in groups larger than family parties or small flocks. From this we can conclude that the majority of the birds that occur in the Karreebosch shrublands are at low risk from collision with electricity infrastructures whether power lines or turbines.

Tree-associated birds: In the Karreebosch trees only occur in the valley bottoms. In natural conditions these are mainly thorn trees beside stream beds. A few alien trees have been planted near farmstead to provide shade and, formerly, a source of wood. Together these trees provide habitat for a range of birds. Some species are wholly dependent on the trees. Some birds from the lower, less resourced, Karoo shrublands may move seasonally into areas of riparian trees. They breed in the shrublands during late winter to early summer when insects and seeds resources are most available and move into the tree areas in the summer as this provides access to water, aquatic insects, seeds and shade. Many shrubland birds also forage and breed in trees along watercourses. Aquatic insects, hatched from stream pools are mostly available in or near riparian trees and mainly in the summer months. Passerines that are particularly dependent on these insects tend to be seasonal migrants that move to more humid areas elsewhere in Africa during the local winter. The planting of regionally alien trees around farmsteads in the Karreebosch has enabled several bird species, which would formerly not have occurred, to colonise the region. These birds are at the edge of their species' range and have small and unimportant district populations. In all cases there is little motivation for these birds to fly above tree level and their risk of collision mortality is low.

6.2 Collisions with power lines

In the Karreebosch area the risk of collision with power lines is considered to be greater than that due to wind turbines. This is because a number of cross-valley power lines are proposed. The number and position of these is dependent upon which of the several proposed power line route options is taken. There are several reasons why risk is considered greater for these cross-valley power lines than for the wind turbines.

1) The number and diversity of birds is considerably greater in the valleys than along the ridges
2) The ridge and valley topography constrains most bird movement to the valleys
3) The larger birds of greatest risk of collision with power lines - raptors, bustards, and especially waterbirds - will all generally move along the valleys and so cannot avoid traversing cross-valley power lines.
4) Most of the precocial waterbirds (see Appendix 7), which often fly in groups, are nocturnal dispersers and in this terrain will usually follow river courses between dams. They are considered the group most at risk as a bird's ability to detect power lines is greatly reduced at night.
5) More red-listed species are at greater collision risk in the valleys than along the ridges. These are the two bustards, the Maccoa Duck and, if and when they occur, the Greater Flamingo and Blue Crane. In addition most of the birds of prey, including the red-listed Black Harrier, Martial Eagle and Verreaux's Eagle forage more in the valleys and over slopes than along the adjacent ridges.

It is therefore critically important that the risk of collision with cross-valley power lines is minimized (see mitigations below).

6.3 Collision prone priority species

The Karreebosch Area as a specific entity has not previously been documented in terms of bird conservation. Consequently no prior district-specific list of priority bird species has been available. Three information sources were used to prioritize Karreebosch bird species in terms of their sensitivity to the impacts of electricity infrastructure (Table 4).

The first source was BirdLife South Africa's latest (2014) red-list of species in South Africa, Lesotho and Swaziland that are considered threatened with extinction at the national level. The second source was Eskom's collision database. Seven of the top twenty birds in this list occur in the Karreebosch/Roggeveld. The third source was Shaw's (1995) evaluation of the conservation status of bird species in the Western Cape Province, with some modification according to subsequent changes to, or understanding of, population status.

None of these sources is ideal. The BirdLife red list evaluations reflect the national, not regional/provincial conservation situation. The Eskom collision database is derived largely from studies along power lines along far greater dryland distances than wetland distances so that the collision risk of wetland birds is under-represented. Shaw's evaluation rated a range of criteria – biodiversity value, distribution, estimated population, the species demography in terms of clutch size and longevity etc, and the range of threats faced by bird populations in the Western Cape Province. Given that the Karreebosch/Roggeveld area spans the border between the Western and Northern Cape Provinces, and in the absence of any similar document on bird status in the Northern Cape, the use of Shaw's evaluation is considered reasonable for this Karreebosch assessment.

The resultant list (Table 4) features 33 species. Of these 7 species are considered of high collision risk, 7 of low risk and the remainder of medium risk. The risk level is based on the Eskom list and on consideration of general flight heights, and whether the birds are flock or nocturnal fliers. Only 8 of the 30 species are considered of particular risk of collision with turbines whereas 25 species are considered at risk of collision with power-lines. A further two species, that regularly use power lines, are not considered to be at risk of collision.

6.4 Collisions with turbines

In the Karreebosch area the risk of bird collision with wind turbines is considered lower than the risk of powerline collisions.

The factors that affect bird collision with turbines are: 1) the degree to which birds fly at heights equivalent to the turbine rotor blades – planned to be 30-170 m above ground level; 2) their ability to maneuver in flight – which is lower for larger and heavier bird species, and for most birds in headwinds; 3) the degree to which birds may be pre-occupied - i.e. through chasing prey or in courtship displays – and so pay less attention to moving rotor blades; 4) familiarity with the location of turbines; 5) the frequency with which they place themselves at risk of collision; and 6) the angle of approach, since rotor blades are more conspicuous seen head on than from the side. Daylight fliers may have an increased risk of collision in periods of fog or mist when visibility is severely reduced. In the Karreebosch/Roggeveld area low clouds often cover the ridges in fog. It is unclear to what extent birds fly over the ridges in such conditions.

6.5 Collision evaluation

Collision mortality is the main potential negative impact on birds of the proposed Karreebosch WEF. The collision risk due to the proposed cross-valley power lines is considered to be greater than the risk of collision with wind turbines.

The Wilgebos Valley is the most important area for birds in the Karreebosch area. There are four reasons why this valley is important.

1) It has two substantial dams. These dams support regionally important numbers of waterbirds. Included among these are: the Near Threatened Maccoa Duck; populations of Karoo Shelduck and Cape Shoveler - two southern African endemic species each with small global populations of < 30,000 individuals (A.J. Williams et al. unpublished reports); and Black-necked Grebe and Cape Teal each from subspecies endemic to southern African and with global populations of <20,000 individuals (A.J. Williams et al. unpublished reports).

2) This valley has the main extent of riparian vegetation in the Karreebosch area. The Wilgebos stream is a critical water source for birds and supports the largest stands of riparian thorn trees to which many local bird species are restricted.

3) The valley has a greater area modified for agriculture especially croplands which are the habitat most likely to be used by the two red-listed bustard species.

4) The richer food resources on the lower slopes and in the valley bottom attract a greater diversity of foraging birds of prey than other parts of the Karreebosch area.

Table 4. A collision risk evaluation of the larger bird species in the Karreebosch area (see notes below)

Species	RDL status	ESKOM	WC P	Karreebosch status	Risk	Type
Red-listed species						
Ludwig's Bustard	END	10	17	Occasional in small numbers	highest	P
Black Harrier	END	6		Small local breeding population	low	PT
Martial Eagle	END	5	19	Breed near, but not in, the Karreebosch area)	high	PT
Verreaux's Eagle	VUL	2		A pair breeds within Karreebosch area	high	PT
Black Stork	VUL	7		A single young bird observed	High	P
Greater Flamingo	NT		16	Occur on large regional dam- Nocturnal flights	high	P
Karoo Korhaan	NT		10	Occur in valley bottoms	medium	P
Blue Crane	NT	11	12	Occasional occurrence at dams	Highest	P
Maccoa Duck	NT		9	Seen on 2 Karreebosch dams	medium	P
Other birds of prey						
Secretarybird	NT	12	16	Occasional in small numbers	high	P
Peregrine Falcon	NT		10	Occasional in small numbers	medium	T
Jackal Buzzard	-		9	Occasional in small numbers	medium	P
Cape Eagle Owl	-		15	Might occur near ridges	low	T
Pale Chanting Goshawk	-		12	Common adjacent to riparian habitat	low	
Booted Eagle				Seasonal visitor in small numbers	low	P
Steppe Buzzard				Occasional in small numbers	low	P
Rock Kestrel				Common resident	medium	T
Black Sparrowhawk				A single bird reported	low	
White-necked Raven				Common resident, usually near ridges	low	T
Pied Crow				Common resident, usually in valleys	low	
Waterfowl				All nocturnal dispersers and most are flock fliers		
Karoo Shelduck	-		9	Common	medium	P
Egyptian Goose	-			Common	medium	P
Yellow-billed Duck	-		6	Common.	medium	P
Cape Shoveler			7	Common	medium	P
Cape Teal			5	Small numbers	medium	P
Great Crested Grebe			8	Common	medium	P
Black-necked Grebe			7	Common	medium	P
Little Grebe				Common	medium	P
Waders				All are night roosters		
African Sacred Ibis	-		6	Common. Large size. flock flier	medium	P
Grey Heron	-		7	Common	medium	P
Cattle Egret	-		4	Terrestrial forager. Flock flier	medium	P
Black-headed Heron	-		6	Terrestrial forager. Usually solitary	low	P
Other species						
Namaqua Sandgrouse				Common on ridges & slopes, Flock flier	medium	PT

Notes for Table 4. RDL = BirdLife South Africa's 2014 red-list of threatened bird species; END=- Endangered; VUL= Vulnerable; NT= Near-threatened; ESK: species in Eskom's collision database. Numbers are by ranking within the top 20 species in the ESKOM database. WCP: Prioritisation rating of species for conservation in the entire Western Cape Province (Shaw 1995) in which the higher the score the greater the negative impacts and the greater the conservation concern.. Numbers are given only for those species rated higher than 5. P = power lines T = wind turbines

Because of the topographical constraints most bird movements are along the north-south line of the valley. The greatest threat to the widest range of priority species, and of bird diversity, comes from proposed cross-valley power lines, both 33 kV and 132 kV, which will obstruct long-valley bird movements. The risk of collision is greatest at night and so to nocturnally dispersing waterbirds moving between the two dams in the valley and to or from the several larger dams on the downstream sector of the Tankwa Valley. The risk of birds of prey colliding with cross-valley power lines is also greater than their risk of collision with turbines. This is because: 1) more individual raptors, and a higher diversity of raptor species, occur in the valleys; 2) food resources are richer in valleys than they are along the resource poor turbine ridges so raptors will spend a greater proportion of their time foraging for prey and, when so occupied, are less likely to perceive power lines.

Thus the primary mitigation need for the entire Karreebosch area is to minimize the number of cross-valley power lines, and especially in the Wilgebos Valley.

Further, since more species and more movements occur in the lower or downstream parts of the valleys (i.e. farthest from the source) necessary power lines should, where feasible, be located as far upstream as possible. Specifically in the Wilgebos Valley power line crossings should be away from the two dams and ideally upstream of the Rietfontein dam.

6.6 Habitat loss

Development of the project footprint - turbine pads, access roads, power lines or cables, and substations – will inevitably cause destruction of habitat and the loss of potential foraging and nesting habitat for birds in the affected areas. The impact is not only due to the loss of the immediate footprint area. Disturbance during installation and maintenance, noise generated, and physical obstruction of the environment can all lead to birds avoiding habitat in a wider area around the footprint. Electric magnetic forces may also have undesirable effects on birds. Birds displaced by this loss of habitat must find alternative suitable habitat, which may be less favourable. The displaced birds must compete for resources with the established population of birds of the same, or other, species potentially to the detriment of both displaced and established birds. Birds affected fall into two broad groups - those with small and large foraging areas.

The immediate, and most evident impact, is greatest on birds with small, usually highly localized, foraging areas. The result of habitat destruction is likely a reduction in the local population of most such birds. The degree to which such birds are impacted depends upon the area of habitat destruction and the degree to which that area has been used by the birds.

In the Karreebosch area habitat loss for birds with small foraging ranges is considered of less importance on the low resourced slopes and ridges and of greater impact in the valley bottoms where habitats are richer and more varied and support a greater diversity and number of bird species

For birds with more extensive foraging areas, and usually of larger size, the loss of use of the precise footprint area is less important than for small birds. However, these birds are more affected by disturbances (perceived as a potential mortality risk) during installation and maintenance. Large physical structures on the footprint – turbines, power lines and their supports may also be deter larger birds from using adjacent habitat (Larsen & Madsen 2000, Exo et al. 2003).

Some area-sensitive passerines have reduced populations and substantially lower densities within 80 m of wind turbines (Leddy *et al.* 1999) and roosting and feeding of some species is reduced within 800 m of turbines (Exo *et al*. 2003). Generally larger birds are more readily disturbed in areas where human populations are low as the birds do not become habituated to human disturbance.

In the Karreebosch area habitat destruction will occur in two basic environments: 1) for turbine installation and associated footprint on the scrubby slopes and ridges; and 2) for access roads and installation of cross-valley powerlines in the richer habitats of the valley bottoms. Habitat destruction on the slopes and particularly along the ridges is not considered to have a serious impact on birds as a high proportion of the ground is bare and or rock covered and is poorly resourced for birds. Nor is population displacement a major issue for most resident bird species since the population of birds using the ridges and slopes is very small and all their needs can be reasonably fulfilled on lower ground where most already forage and breed. Habitat destruction in the valley bottoms will be limited to widening, by about 2 m, of existing roads and clearance of small areas for the installation of trans-valley powerlines. In neither case is this considered likely to have a significant effect on local bird populations.

6.7 Disturbance

Construction period disturbance, and subsequent operational maintenance, along the ridges and powerlines is unlikely to have substantial negative effects on resident bird populations since the species will temporarily avoid the area largely by moving into the ample adjacent areas of similar habitat. In 2013 a new Eskom 400 kV powerline was being constructed within 1-5 km of the southern part of the Karreebosch project. Observations from a control site overlooking the powerline construction area showed that, despite considerable vehicle and human activity, birds of prey still traversed the area, indeed were seen as commonly there as during observations in more distant undisturbed areas within the Karreebosch area.

6.7.1 Noise:Blades from some wind turbines emit low frequency AM-sounds that can be heard by a human for up to 2 km (Ahlen 2003). Noise generated by wind turbines may also deter birds in groups of both large and small foraging areas from using habitats adjacent to turbine strings Weiserbs & Jacob 2001, Rheindt 2003).

6.7.2 Electro-magnetic field effects

Electro-magnetic fields (EMF) have been shown to affect birds in three ways. Birds subject to EMF: 1) are more active and increase activity during courtship, probably due changes in corticosterone (Fernie *et al*. 2000a); 2) have increased fertility, egg size, embryonic development and fledging success; but 3) have reduced hatching success, apparently because EMF-affected parents lay eggs with thinner shells which are more likely to crack or break (Fernie *et al*. 2000b). The degree to which the wind turbines or the associated powerlines to be used in the Karreebosch development produce bird-affecting EMFs is unknown.

6.8 BIOTIC IMPACT ON THE ENVIRONMENT

6.8.1 Risk of alien ant introduction

Alien invasive ants are often transported with construction materials (Feare 1999), thrive in disturbed soils, and in shrubland prefer mesic conditions (Holway *et al*. 2002) such as the micro-environment created by condensation moisture from structures. Invasive ant species have a deleterious impact on surrounding plant and animal communities including predation of bird nestlings as well as upon eggs of reptiles and changes in plant seed longevity (Pedersen *et al*. 1996, Smith *et al*. 2004).

6.8.2 Subsidy of scavengers and predators

The carcasses of birds and bats killed through collision with turbines and power lines, or by electrocution, form a food resource for a variety of scavenging animals including birds, mammals, reptiles, and a wide range of invertebrates (such as ants, necrophilous beetles, and carrion flies). Where such mortalities are few there may be no impact. However, where there are regular mortalities associated with power structures, scavenger species may learn to patrol along turbine strings or power lines (McNeil et al. 1985). As many scavengers are also predators this may increase the local level of predation upon birds, and especially their eggs and chicks.

Raptors and corvids (crows and ravens) all readily eat the flesh of vertebrate animals whether killed by these avian carnivores or scavenged. Avian carnivores gain two important benefits from power lines support structures: safe roosting and breeding sites; and elevated surveillance perches. Support structures are difficult for mammalian and reptilian predators of birds to climb. The risk from avian predators is also low because there is little cover to hide their approach. The resultant safety from predation is a major reason why raptors and corvids choose to perch, roost and in some species nest, on utility structures.

The other major reason why these birds use utility structures is because they provide elevated perches for surveillance of potential food items in the adjacent area. The taller the structure the wider the area which the birds can survey (Malan 2002). In areas of low vegetation where there are few elevated perches, such as much of the Karoo scrublands, raptors and corvids must locate prey during foraging flights. Such flights consume energy and, because the bird's attention must be substantially occupied by flying, give a less accurate means of watching prey activities. By watching for prey whilst perched on an elevated utility structure the predator uses minimal energy and can better concentrate on watching for prey. Use of structures by predatory birds is likely to increase depredation of prey species within the area they can survey. Since the vegetation where birds are predated is unaltered, there will be under-used resources that the depredated animals would have consumed. Such availability of resources will attract "replacement" animals from adjacent areas. These are then also likely to be killed by predators. Thus the area around the utility perch can become a local population sink for prey bird species.

Crows and ravens, among the commonest birds using utility structures, though seldom predators of adult birds are avid predators of bird eggs and nestlings. The crows detect active nests by watching activities of breeding birds. Utility structures provide the corvids with vantage points from which to detect nests. By then eating the nest contents crows reduce the productivity of the local bird population. Studies in America have shown that the construction of a new power line increases the number and density of raptors and crows in the area traversed (Stahlecker 1978). Utility structures are generally superior to natural breeding and roosting sites because they provide greater safety of nests from predators and enable all-round surveillance (Stahlecker 1978). Increased numbers of raptors and corvids can be especially expected where utility lines are erected across areas where elevated surveillance perches and safe nest sites are scarce.

7 MITIGATION MEASURES

7.1 Reduction of power line collision risk

Bird mortality through collision with new powerlines is the most significant potential impact of the proposed Karreebosch WEF. This risk can be substantially mitigated by minimizing the number of cross-valley powerlines, especially in the Wilgebos Valley, and the placing of bird diverters on those powerlines that are installed

7.2 Power line routing options

Kareebosch WEF has indicated 2 pairs of alternatives routings for their 132 kV lines (Fig. 13).

7.2.1 Alternative 1

Alternative 1 is based on single substation located on the southern end of the Spitzkop Ridge. Alternatives 1a and 1b concern routing of 132 kV lines from this substation to deliver power to the Eskom grid at the Komsberg grid connection.

7.2.2 Alternative 2

Alternative 2 is based on having two substations, one on the Western Ridge and another on the northern section of the Central Ridge. Alternatives 2a and 2b concern routing of 132 kV lines from these substations to deliver power to the Eskom grid at the Komsberg station. Alternative 2a involves a 132 kV line running northeast from the Western Ridge substation across the Wilgebos Valley close to the Klipbanksfontein Dam to the Central Ridge substation, thence southeast across the lower Tankwa Valley as well as the northern end of the Eastern Ridge, before turning south beside the R354 road and finally to the Eskom grid at the Komsberg station. In alternative 2b a 132 kV line is routed southeast from the Western Ridge substation across the Wilgebos Valley between the Klipbanksfontein and Rietfontein Dams and then along the same route as alternative 1b to the Komsberg grid connection.

In addition to these effectively four alternatives for 132 kV powerlines there will be lower voltage 33 KV power lines that link turbine strings to the substations. Currently six of these proposed powerlines will be cross-valley lines: 3 traversing the Wilgebos Valley, two crossing the Tankwa Valley, and one linking the Central Ridge to the proposed substation on the Spitzkop Ridge.

The most important mitigation measure for the Karreebosch project is the reduction of any power lines crossing the Wilgebos Valley. At least one overhead power line across the Wilgebos Valley is inevitable whichever alternative substation arrangement is selected. However, it is feasible to eliminate the three initially proposed lower and less conspicuous (and so more likely to cause bird collision mortalities) cross-valley power lines. If it is feasible, the two 33 kV lines from the Spitzkop Ridge turbine strings should be routed eastwards to the Central Ridge. If Alternative 2a is chosen then there is no need for the initially proposed 33 kV line across the Wilgebos Valley between the Western Ridge and the Alternative 1 substation on the southern end of the Spitzkop Ridge. The overall result, if these amendments are made, would be a single 132 kV line, and no 33 kV line, across the Wilgebos Valley. With adequate line markers, that are visible at night (see below), this solution which will reduce the bird collision mortality risk from powerlines across the Wilgebos Valley to an acceptable level.

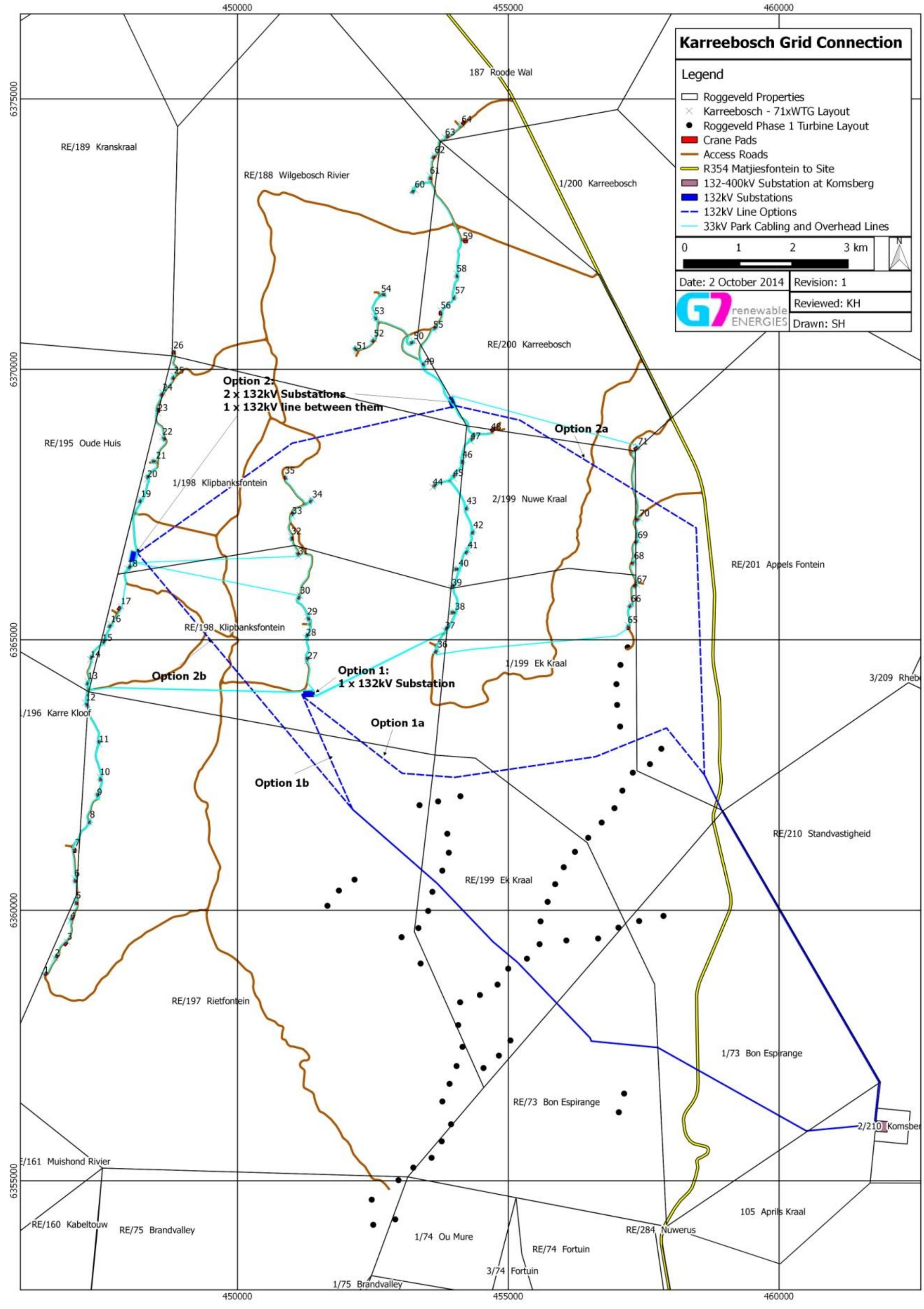


Fig. 13. Alternative locations for sub-stations and powerlines

Cross-valley 33 kV power lines across the upper Tankwa Valley and between the Spitzkop and Central Ridges pose a substantially lower risk as, relative to the Wilgebos valley, these areas support no or smaller dams and fields and little riparian vegetation. Nevertheless, to make them more visible to birds of prey, the 33 kV lines across these areas will require markers that are visible in daylight.

Alternative 1 is not supported from an avifaunal perspective as it requires more lines across the Wilgebos Valley. The 1a routing crosses the Central Ridge in the deep saddle within < 1km of the Verreaux's Eagle breeding locality. This route is undesirable as it implies considerable risk to the pair of eagles which are still resident even though they did not breed at their local nest sites in either of the two years of monitoring. Route 1b takes the line down the Bonne Esperance Valley.

Alternative 2a is the preferred option from an avifaunal perspective and will be more so if it is feasible to locate the substation on the Western Ridge farther to the north than currently planned. With a more northerly location the 132 kV line link to the Central Ridge substation will have a more direct, and so shorter, crossing of the Wilgebos Valley than the currently planned diagonal.

7.2.3 Marking power lines with bird diverters
Day-visible bird diverters should be installed on all cross-valley power lines to make the lines, and especially the earth-wires, more conspicuous. Where lines cross waterbird flight paths in the Wilgebos Valley and or between the Wilgebos Valley and the large dams on the Tankwa River there must be night visible diverters (see Appendix 8 for a suitable type of diverter).

7.2.4 Mitigation of turbine collisions
The risk of birds being killed through collision with turbines can be mitigated in two ways: 1) through making the turbines more conspicuous; and 2) siting turbines away from areas much used by birds.

Conspicuousness To reduce the risk of bird collision with turbine blades should be made more conspicuous. This is especially necessary to reduce collisions in low light situations and when turning blades create motion smear.

Turbine siting In the Karreebosch area there are three means of reducing potential bird collision with turbines: 1) not siting any turbines closer than 1.3 km from the established Verreaux's Eagle breeding cliff on Beacon Hill; 2) as already planned, siting of turbines on the flatter middle part of the ridges will minimize the risk of collisions by birds using wind updraughts on the upper slopes; and 3) not siting turbines closer than 50 m from the lowest point of upper valley saddles as with increasing ridge height birds increase their selection of the lowest points that provide exits from the upper reaches of the valleys.

Fig. 13 shows all raptor flight lines recorded during the six visits plotted against the proposed siting for turbine. There are two focal areas one around Snydersberg where no turbines are planned and the other around vantage point 4. This vantage point was close to Beacon Hill and the Verreaux's Eagle's nest location. The flight paths all fell within the 1.3 km turbine exclusion zone around this nest site. The other cases of flight paths passing near proposed turbines were of single flights not indicative of regular flight routes. The flights of the Black Harrier near turbine 60 were of birds quartering and so below collision risk height. Otherwise there were no regularly used bird flight paths observed near proposed turbines and so there is no obvious problem with the siting of the turbines as proposed

7.3 Displacement

Minimize the destruction of riparian habitat in the valley bottoms when upgrading existing tracks to allow heavy vehicle access.

7.4 Reduction of biotic impacts

Invasive ants: Fill used should only be local material

Surveillance perches: Powerline support structures should be designed to minimize positions which scavenger/predator birds can perch upon to monitor prey.

Electrocution

The risk of electrocution can be mitigated by the use of bird-safe structures, the physical exclusion of birds from high risk area of live infrastructure, and comprehensive insulation of such areas.

8 CUMULATIVE IMPACTS

The proposed Karreebosch WEF is immediately adjacent to two currently proposed windfarms – Roggeveld and Hidden Valley – and it is known that proposals are being developed for other windfarms immediately to the west of the Karreebosch area.

Each of the three afore-mentioned WEFs have been the subject of avifaunal studies that included observations across the areas from many points over at least 12 month periods that encompassed all seasons. Despite these relatively intense surveys only a single breeding site of any large raptor has been found. This is the Verreaux's Eagle nest on the boundary of the Karreebosch and Roggeveld WEFS a site where, though still occupied, there was no active breeding in either 2013 or 2014. Nor, across the three WEFs have red-listed bird species been recorded in other than extremely small numbers and then generally of infrequent occurrence.

Food resources for birds across these three WEF areas, as well as across the adjacent areas likely to be developed, are limited. Accordingly the diversity, and number, of large, high collision risk, bird species are low. They are known to be lower than in the mountains some 70 km south of Karreebosch. These mountains differ geologically from the Karreebosch-Roggeveld area. There are more cliffs which provide suitable nest sites for raptors and higher rainfall provides support for a greater abundance of suitable prey. The situation in the vicinity of Karreebosch is also of far lower bird diversity and numbers, including those of red-listed species, than in lowland areas.

Given the low numbers and diversity of birds in the region of these proposed WEFS the cumulative impact on birds in this broken terrain on the periphery of the karoo is likely to be lower than most areas across southern Africa. This includes any WEFS proposed for the much flatter karoo plateau area some 60 km to the north of the Karreebosch WEF.

The single Verreaux's Eagle breeding locality in the region lies along the Central Ridge that will house turbines for both the Roggeveld and Karreebosch WEFs. A no-go area of

1.3 km (as already accepted by BirdLife for the Roggeveld WEF) is designated along the Central Ridge on either side of the breeding locality. There will also be turbines on the two adjacent ridges so in a sense the eagles at this locality will be "surrounded". However, due to the established paucity of prey for eagles along the summit ridges, most eagle activity will be within the valleys and so below the turbine ridges. This is particularly the case when the eagles are foraging and so might be distracted. Observations in both the Roggeveld and Karreebosch avian assessments showed that these eagles generally occurred at turbine blade heights during strong winds but that they used updraughts from the valley sides and so flew primarily above the lip of the ridge summits and not where the turbines will be established. BirdLife (in litt.) accepts that so far we have no appreciation of how Verreaux's Eagles will react to turbines. Apparently in North America Golden Eagles have shown signs of adequately avoiding turbines. provide suitable nest sites for raptors The eagles mortalities in North America ccurred mainly where long strings of turbines were aligned across a migration route. This is not the situation in the Karreebosch-Roggeveld area. Whether this will be the case with Verreaux's Eagles is still unknown.

Two eagles still frequented the Karreebosch breeding locality in 2013-2014. However, despite several observations directly into the two old nests in 2013 and observation of the nesting cliff from several vantage points across 6 days in 2014 there was no indication of active breeding in either 2013 or 2014. This is surprising as rainfall in the area had been excellent in 2013 and observations indicated an associated rebound in the numbers of potential prey. That there was no breeding indicates that this is a marginal locality for these eagles. As such it cannot be considered a critical locality for the species. It is better for wind farms to be established in this area, accepting the potentially risk the loss of this breeding pair, than for windfarms being established in other areas where there are more successful breeding pairs of this eagle.

Overall the cumulative effects on the regional avifauna is considered of very low significance. Reasons for this appraisal are the:

1) Paucity of both bird numbers and diversity on the ridges where turbine are to be established - as further confirmed by Dr Simmons observations (Appendix 9);

2) Extremely few bird species recorded flying at heights that would bring them into risk of collision with turbine blades;

3) Few priority species that do occur at blade heights along the ridges are adapted to montane conditions. These conditions require fine flight control to avoid collision with sold features (cliffs etc.) even in strong winds with often unpredictable shifts in wind strength and direction; and that

4) Due to the lack of food resources along the ridge summits these birds forage mainly in the valleys. When they do fly over the ridges they are not distracted by foraging needs and so can be anticipated to be more alert to their surroundings and more likely to avoid large structures including the blur of moving blades.

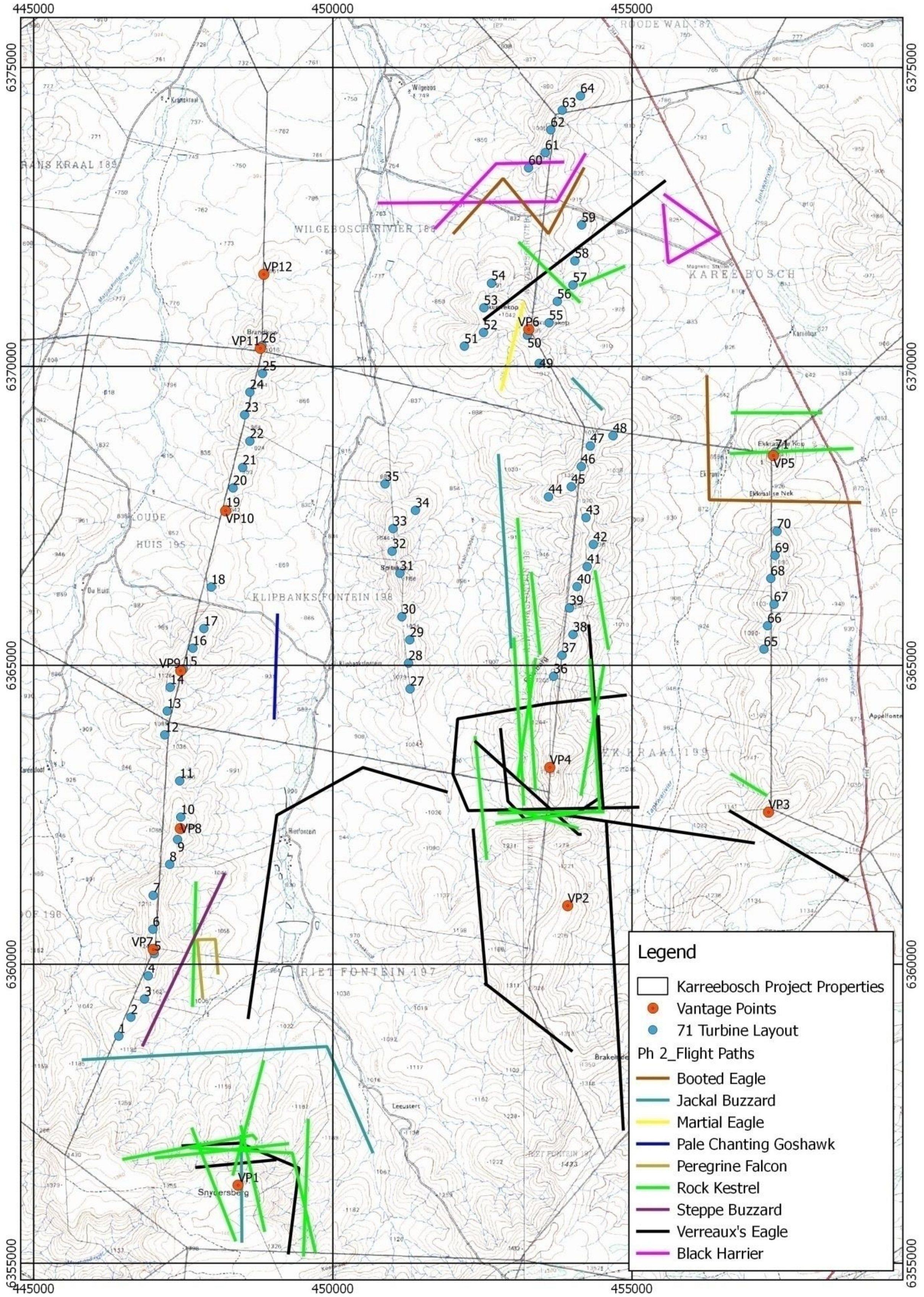


Fig. 14. Amalgamation of all flight paths recorded during the six visitations

9. IMPACT ASSESSMENTS

9.1 CONSTRUCTION & MAINTENANCE IMPACTS

9.1.1 *Habitat Loss*

Nature: Construction activities will result in a negative direct impact on the WEF site avifauna
Impact Magnitude: Low
Extent: Local (ridge-wide)
Duration: Medium term – the ecology is unlikely to recover within the 20 year operational phase
Intensity: Minimal loss of habitat for any bird species. Magnitude low.
Likelihood: There is a high likelihood that areas of habitat will be lost

IMPACT SIGNIFICANCE (PRE-MITIGATION) – LOW

Degree of confidence: High

9.1.2 DISTURBANCE

Nature: Construction activities might result in a negative direct impact on the WEF site avifauna
Impact Magnitude: Low
Extent: Local
Duration: Short-term
Intensity: No threatened species will be particularly impacted. The magnitude will be low
Likelihood: There is a medium likelihood that birds will be disturbed
IMPACT SIGNIFICANCE (PRE-MITIGATION) – LOW TO MEDIUM
Degree of confidence: High

9.2 OPERATIONAL IMPACTS

9.2.1 Disturbance and Displacement

Nature: Negative direct impact on birds
Impact Magnitude: Low
Extent: Local
Duration: Long-term but in short-term bursts
Intensity: The magnitude is low
Likelihood: There is a low likelihood that any key species will be disturbed or displaced
IMPACT SIGNIFICANCE (PRE-MITIGATION) – LOW

9.2.2 MORTALITY THROUGH COLLISION WITH POWER LINES

Nature: Operations may result in negative direct impact on birds
Impact Magnitude: Low –medium,
Extent: Local
Duration: Long-term i.e. throughout the operational life of the WEF
Intensity: Low.

Likelihood: It is likely that some individuals in key species will be killed

IMPACT SIGNIFICANCE (PRE-MITIGATION) – LOW- MEDIUM

Degree of confidence: Medium-High (due to uncertainty about nocturnal bird activities)

9.2.3 MORTALITY THROUGH COLLISION WITH TURBINES

Nature: Operations may result in negative direct impact on birds

Impact Magnitude: Low –medium,

Extent: Local

Duration: Long-term i.e. throughout the operational life of the WEF

Intensity: Low.

Likelihood: There is low likelihood that key species will be killed

IMPACT SIGNIFICANCE (PRE-MITIGATION) – LOW

Degree of confidence: Medium (due to uncertainty about nocturnal bird activities)

9.2.4 Pre- and post- mitigation significance: Roggeveld WEF - Birds

Phase	**Pre-mitigation significance**	**Residual Impact Significance**
Construction		
Habitat Loss	Low	Low
Disturbance	Low	Low
Operation		
Displacement	Low	Low
Mortality	Medium	Low

10

CONCLUSIONS

The impacts of the proposed Karreebosch WEF will have a negligible effect on the majority of bird species that occur on the concerned properties. The turbines will be established on ridge tops and far from sensitive habitats. The only features of serious concern are potential mortality through collisions with powerlines and, to a far lesser extent, rotor blades. The means of mitigating the impacts on birds of the proposed wind farm development are simple but limited.

Based on the:

1) bird-depauperate habitat;
2) low overall number of birds
3) small number of species that, at least by day, fly over the ridges at potential collision height

There is minimum probable impact on the local avifauna whether in terms of habitat loss, disturbance, or collision risk from the turbines. This site is likely to cause substantially less impact on birds than a WEF of equivalent size in almost any lowland situation. Provided the identified mitigations are undertaken, there is no overwhelming reason from an avifaunal perspective to object to this proposed Karreebosch WEF development and its authorization is recommended.

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12 APPENDICES

12.1 BIRDS OF PREY AND SCAVENGERS

Species	Ridges					Valleys
	March	May	July	Sept	Nov	
Verreaux's Eagle	X	X	X	X	X	X
Rock Kestrel	X	X	X	X	X	X
White-necked Raven	X	X	X	X	X	X
Pied Crow			X	X	X	X
Black Harrier				X	X	X
Booted Eagle				X		X
Martial Eagle			X	X		X
Jackal Buzzard			X	X		X
Peregrine Falcon				X	X	
Steppe Buzzard						X
Pale Chanting Goshawk						X
Secretarybird						X
Black-shouldered Kite						X
African Fish Eagle						X
Black Sparrowhawk				X		X
15	**3**	**3**	**6**	**10**	**6**	**14**

12.2 OTHER NON-PASSERINES

Species	Ridges					Valleys
	March	May	July	Sept	Nov	
Namaqua Sandgrouse		X	X	X	X	X
Karoo Korhaan						X
Cape Spurfowl						X
Red-eyed Dove						X
Cape Turtle Dove						X
Laughing Dove						X
Namaqua Dove						X
White-backed Mousebird						X
Pied Barbet						X
9	**0**	**1**	**1**	**1**	**1**	**9**

12.3 AERIAL INSECTIVORES

Species	Ridges					Valleys
	March	May	July	Sept	Nov	
Rock Martin	X	X	X	X	X	X
Alpine Swift	X			X	X	
White-rumped Swift				X	X	X
Little Swift	X					X
Greater Striped Swallow						X
Cliff Swallow						X
Barn Swallow						X
Brown-throated Martin						X
8	**3**	**1**	**1**	**3**	**3**	**7**

12.4 GROUND FORAGING INVERTIVOROUS PASSERINES

Species	Ridges					Valleys
	March	May	July	Sept	Nov	
Large-billed Lark	X	X	X	X	X	X
Mountain Wheatear	X	X	X	X	X	X
Karoo Long-billed Lark		X	X	X	X	X
Sickle-winged Chat	X		X	X	X	X
Cape Clapper Lark			X	X	X	
Karoo Scrub Robin			X	X	X	X
Familiar Chat			X	X		X
Karoo Chat			X		X	X
Karoo Lark			X			X
Long-billed Pipit	?			X		X
Pale-winged Starling					X	X
Karoo Thrush						X
Red-capped lark						X
Ant-eating Chat						X
Capped Wheatear						X
Cape Robin						X
African Pipit						X
Cape Wagtail						X
Pied Starling						X
Common Starling						X
Wattled Starling						X
20	**4**	**3**	**9**	**8**	**8**	**19**

12.5 BUSH FORAGING INVERTIVOROUS PASSERINES

Species	Ridges					Valleys
	March	May	July	Sept	Nov	
Grey-backed Cisticola	X	X	X	X	X	X
Bokmakierie		X	X	X	X	X
Southern Banded Sunbird		X	X	X	X	X
Layard's Tit-babbler			X	X	X	X
Karoo Eremomela	X		X		X	X
Spotted Prinia		X		X	X	X
Rufous-eared Warbler	X		X	X		X
Malachite Sunbird	X			X	X	X
Cape Penduline Tit				X	X	X
Cape Bulbul					X	X
Fairy Flycatcher			X			X
Yellow-bellied Eremomela	X					
Dusky Sunbird					X	X
Pririt Batis						X
Grey Tit						X
Cape Batis						X
Chestnut-vented Tit-babbler						X
Namaqua Warbler						X
Fiscal Shrike						X
Bar-throated Apalis						X
Long-billed Crombec						X
Cape White-eye						X
22	**5**	**4**	**7**	**8**	**10**	**21**

12.6 PASSERINE SEEDEATERS

Species	**Ridges**					**Valley s**
	March	May	July	Sept	Nov	
Yellow Canary	X	X	X	X	X	X
Cape Bunting	X	X	X	X	X	X
Black-headed Canary			X	X	X	X
White-throated Canary			X	X	X	X
Lark-like Bunting			X	X	X	X
House Sparrow						X
Cape Sparrow						X
Cape Weaver						X
Southern Masked Weaver						X
Common Waxbill						X
10	**2**	**2**	**5**	**5**	**5**	**10**

12.7 Waterbirds observed within 10 km of the Karreebosch project

Precocial			Altricial		
Species	**Ridges**	**Valleys**	**Species**	**Ridges**	**Valleys**
Great Crested Grebe		X	White-breasted Cormorant		X
Black-necked Grebe		X	Reed Cormorant		X
Little Grebe		X	Grey Heron		X
Greater Flamingo		X	Black-headed Heron		X
Egyptian Goose		X	Cattle Egret		X
Karoo Shelduck	x	X	Hamerkop*		X
Cape Teal		X	Sacred Ibis	X	X
Red-billed Teal		X	Hadeda Ibis		X
Cape Shoveler		X	Spoonbill	X	X
Yellow-billed Duck		x	Black Stork		X
African Black Duck		x	Precocial shorebirds		
Spurwinged Goose		X	Kittlitz's Plover		X
African Pochard*		X	Three-banded Plover		X
Maccoa Duck		X	Crowned Plover	X	X
Moorhen		X	Blacksmith Plover	X	X
Red-knobbed Coot		X	Greenshank		X
Blue Crane*		X	Black-winged Stilt		X
Overall 32 species of which 5 seen on or crossing ridges					

12.8 Description of a suitable bird diverter for use on overhead power lines across the Wilgebos Valley

The most effective diverter for the proposed installations is the Firefly FF, manufactured in the USA by P & R technologies Inc [www.pr-tech.com]. Considerable bird-pertinent research went into the development of this diverter which combines motion, reflectivity, and glowing light. During daylight the Firefly FF has a visible element that spins in winds exceeding 3 mph. It has a "diamond bar" whose material causes sunlight to be refracted during daylight. This refracted light in combination with wind induced motion, causes a sparkle effect and is reported to haze birds within a 25 foot radius. The Firefly FF has a light panel that glows for up to 10 hours after dusk and a moonshine system that emits UV and is designed to use the light wavelengths which are most visible by birds – 360 nm and 560 nm. It has a snap-fast mounting clamp that prevents slippage on lines of up to 70mm diameter. The clamp is suitable for wires of 03-2.75 inches diameter and voltages to over 115kV. The snap-fast clamp is weather resistant and is easy and safe to install or to remove even from live wires. Firefly has a video of installation and removal on the web.

12.9 Dr R. Simmons' report on the occurrence of raptors in the Karreebosch area in September 2014.