AVIFAUNAL WALK-THROUGH REPORT

PROPOSED DE AAR 2 SOUTH WIND ENERGY FACILITY NEAR DE AAR IN THE NORTHERN CAPE PROVINCE

October 2022

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EXECUTIVE SUMMARY

INTRODUCTION

Chris van Rooyen Consulting was contracted by Holland & Associates Environmental Consultants to conduct a “walk-through” report of the proposed 156MW De Aar 2 South Wind Energy Facility (WEF) site on behalf of Mulilo Renewable Project Developments (Pty) Ltd (Mulilo) to identify any avifaunal sensitivities and associated mitigation measures to be considered for the final lay-out of the turbines and to advise the updated Environmental Management Plan (EMP). The holder of the EA, Mulilo De Aar 2 South (Pty) Ltd, is preparing an updated EMPr and final layout map for submission to the DFFE to meet the requirements of conditions 13 and 14 of the original Environmental Authorisation (EA).

The project was originally authorised in 2013 to construct a 258 MW facility consisting of 103 turbines. There have been various amendments to date, and currently the project is authorised to construct a maximum of 61 wind turbines. The proposed final turbine layout for the project consists of up to 28 turbine positions (of which a maximum of 26 will be constructed) with a total capacity of 156 MW. The original authorised layout of a maximum of 61 turbines has been reduced by 57.3% to a maximum of 26 turbines inter alia to reduce the potential avifaunal impact. This lay-out was assessed during the walk-through exercise, with a view to include any required mitigation measures in an updated Environmental Management Programme EMPr. The proposed site is situated in the Emthanjeni and Renosterberg Local Municipalities in the Northern Cape Province. The site is approximately 9 200 ha in extent and consists of nine portions of four farms.

RECOMMENDATIONS

The recommendations below are put forward for inclusion in the Final Environmental Management Programme (EMPr). These recommendations are based on the pre-construction monitoring conducted in 2013-2014 (Van Rooyen et al. 2014), the second year of pre-construction monitoring that was completed in July 2022, and the additional analysis of flight data undertaken to inform a curtailment programme. These recommendations replace all recommendations contained in previous avifaunal impact assessment reports and Environmental Management Programmes, which are now outdated.

1.1 Design phase

The following design changes were recommended to the applicant and implemented in the current layout to be included in the updated EMPr:

- It is noted that the project received environmental authorization before the Verreaux’s Eagle guidelines, or the Verreaux’s Eagle Risk Assessment (VERA) model came in to being. This assessment is, however, advised by these guidelines and the VERA model as they are the latest scientific advances in this area.
- It is understood that 26 of the current 28 turbine positions will be utilised, which means that a further two turbines can be removed.
- It is recommended that a 200m turbine exclusion zone around dams and water troughs is implemented as a pre-cautionary measure against Species of Conservation Concern (SCC) and other priority species collisions.
- A 750m turbine exclusion zone around the Jackal Buzzard nests must be implemented.
- A 100m turbine setback zone from the escarpment edge must be maintained.
- All internal 33kV medium voltage cables are to be buried if technically and practically possible.

- Those sections where the 33kV medium voltage cable cannot be trenched due to technical or environmental reasons, but needs to be run on overhead poles, the proposed pole designs must be approved by the avifaunal specialist, to ensure that the designs are raptor-friendly.
- Bird flight diverters are to be fitted to all internal 33kV overhead lines according to the applicable Eskom Engineering Instruction.
- All turbines must have one blade painted in signal red according to pattern no.4 depicted in Figure (i) below. It is acknowledged that blade painting as a mitigation strategy is still in an experimental phase in South Africa, but research indicates that it has a very good chance of reducing raptor mortality, based on research conducted in Norway (see Simmons *et al*. 2021 (Appendix 6) for an explanation of the science and research behind this mitigation method).

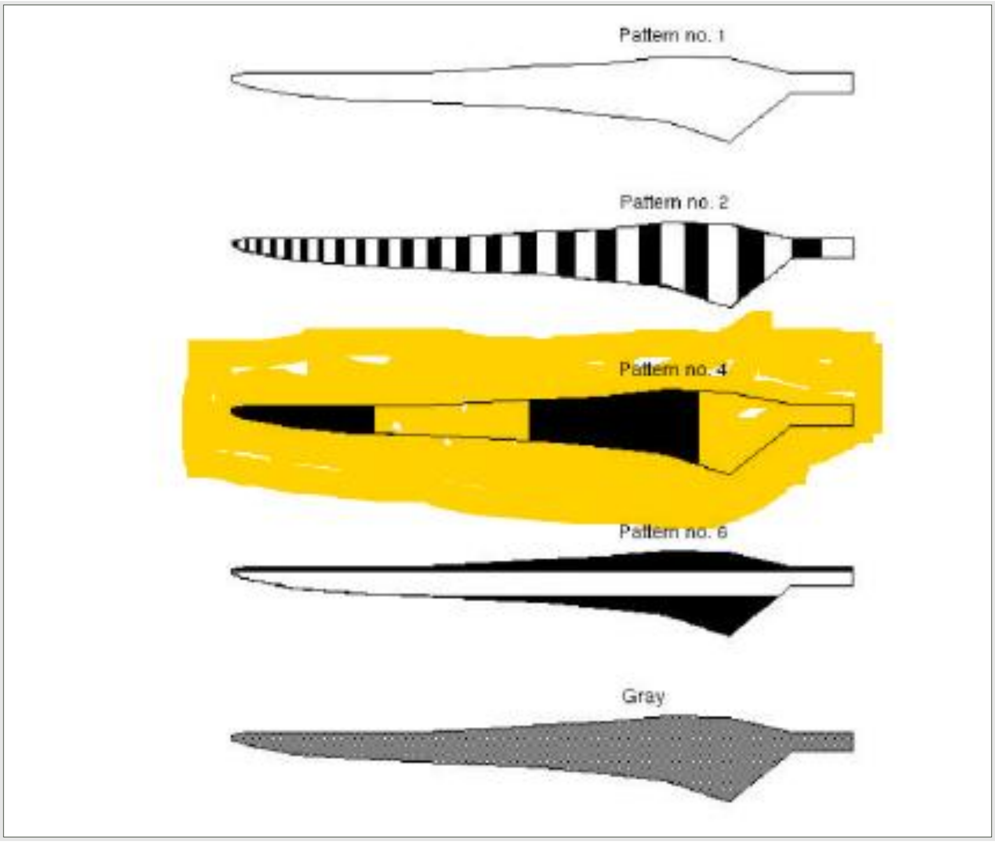

Figure (i): Pattern no.4 is the recommended pattern for blade painting at the WEF

1.2 Construction phase

- Construction activity should be restricted to the immediate footprint of the infrastructure, and in particular to the proposed road network. Access to the remainder of the site should be strictly controlled to prevent unnecessary disturbance of SCC.
- Removal of vegetation must be restricted to a minimum.
- Construction of new roads should only be considered if existing roads cannot be upgraded.

1.3 Operational phase

- A programme of observer-based Shutdown on Demand (SDoD) to reduce potential SCC turbine collisions must be implemented for the whole wind farm. Trigger species are the following: Verreaux's Eagle, Martial Eagle, Black Stork, Lanner Falcon, Tawny Eagle, Cape Vulture and White-backed Vulture. The details of the SDoD (number of observation points, training of observers and scheduled shifts) must be determined in consultation with the avifaunal specialist, who must be appointed shortly after financial close of the project, prior to construction commencing. The SDoD programme must be in place when the turbines start turning in the testing phase.

- In addition to the SDoD programme, a system of automated curtailment of the highest risk turbines, based on observed Verreaux's Eagle flight activity and proximity to nests, must be implemented for those times of day and climatic conditions and varied seasonally when flight activity is most likely to happen. A detailed analysis of the Verreaux's Eagle flight data from the proposed De Aar 2 South WEF, as well as all vantage point and tracking data available from the pre- and post- construction monitoring at the De Aar 1 WEF and the De Aar 2 North WEF was undertaken to identify the highest risk windows (based on several variables) for potential flight activity. In addition, the flight activity of 5 pairs of Verreaux's Eagles recorded during 156 hours of vantage point watches was analysed to determine seasonal patterns of flight activity. Based on this analysis, the following are recommended:
    - Turbines 2, 6, 14, 15, 16, 17, 18, 19 must be curtailed (see Figure (ii) for the location of the turbines).
    - Curtailment threshold for summer and autumn (1 November to 31 May): When conditions predict 80% or greater probability of flying.
    - Curtailment threshold for winter and spring (1 June to 31 October): When conditions predict 60% or greater probability of flying. The lower threshold may result in more curtailment and is recommended in winter and spring to reduce the likelihood of impact on dependent chicks/fledglings.

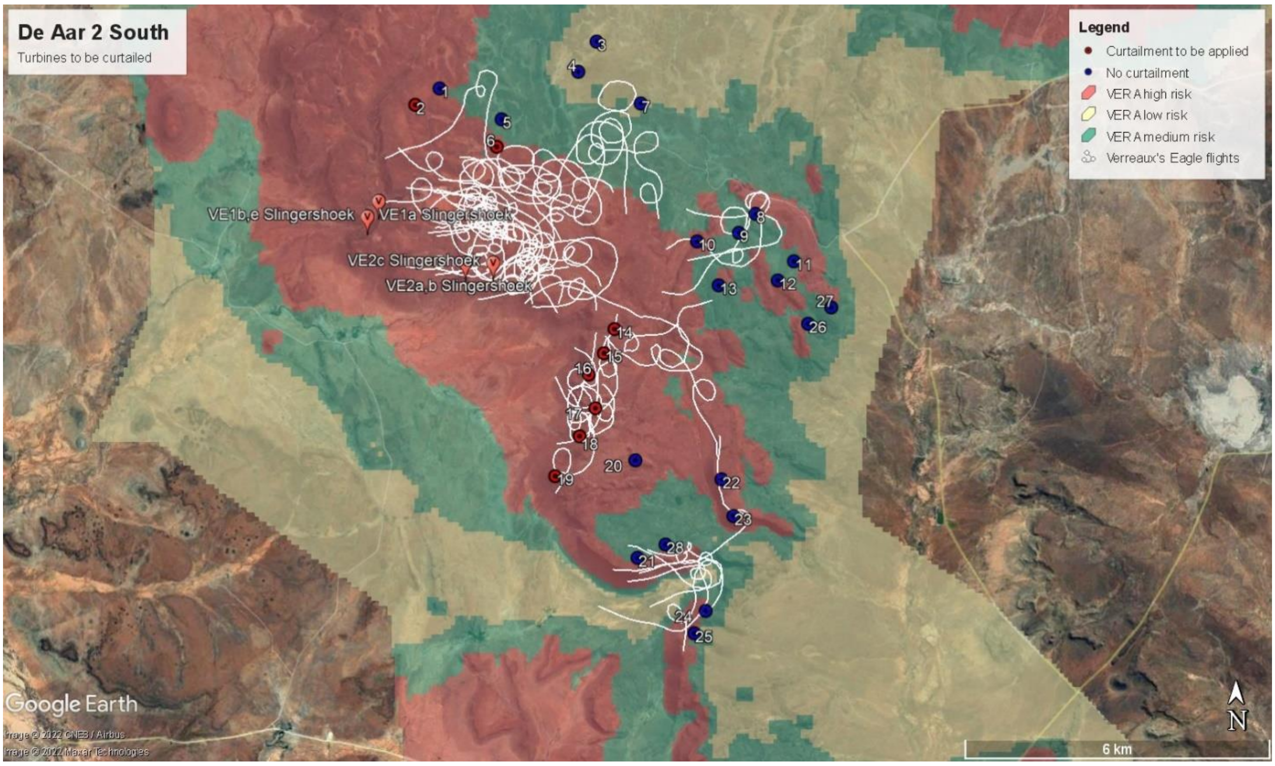

Figure (ii): Turbines to be curtailed during periods of high probability of Verreaux's Eagle flight activity. Turbines were identified based on proximity to nests. (Note: White lines indicate all VE flights recorded over 288 hours of vantage point watches, representing a passage rate of 0.19 birds/hour)

- Vehicle and pedestrian access to the site should be controlled and restricted to access roads to prevent unnecessary disturbance of SCC.
- Formal operational monitoring should be resumed once the turbines have been constructed, as per the most recent edition (2015) of the best practice guidelines (Jenkins *et al.* 2011). The exact time when post-construction monitoring should commence, will depend on the construction schedule, and will be

agreed upon with the site operator once these timelines and a commercial operational date have been finalised.

- As a minimum, operational monitoring should be undertaken for the first five years of operation, and then repeated every five years thereafter for the operational lifetime of the facility. The exact scope and nature of the post-construction monitoring will be determined on an ongoing basis by the results of the monitoring through a process of adaptive management.
- Depending on the results of the operational monitoring, a range of mitigation measures will have to be considered if the impact on mortality turns out to be significant, including expanding curtailment to additional problem turbines during high-risk periods.

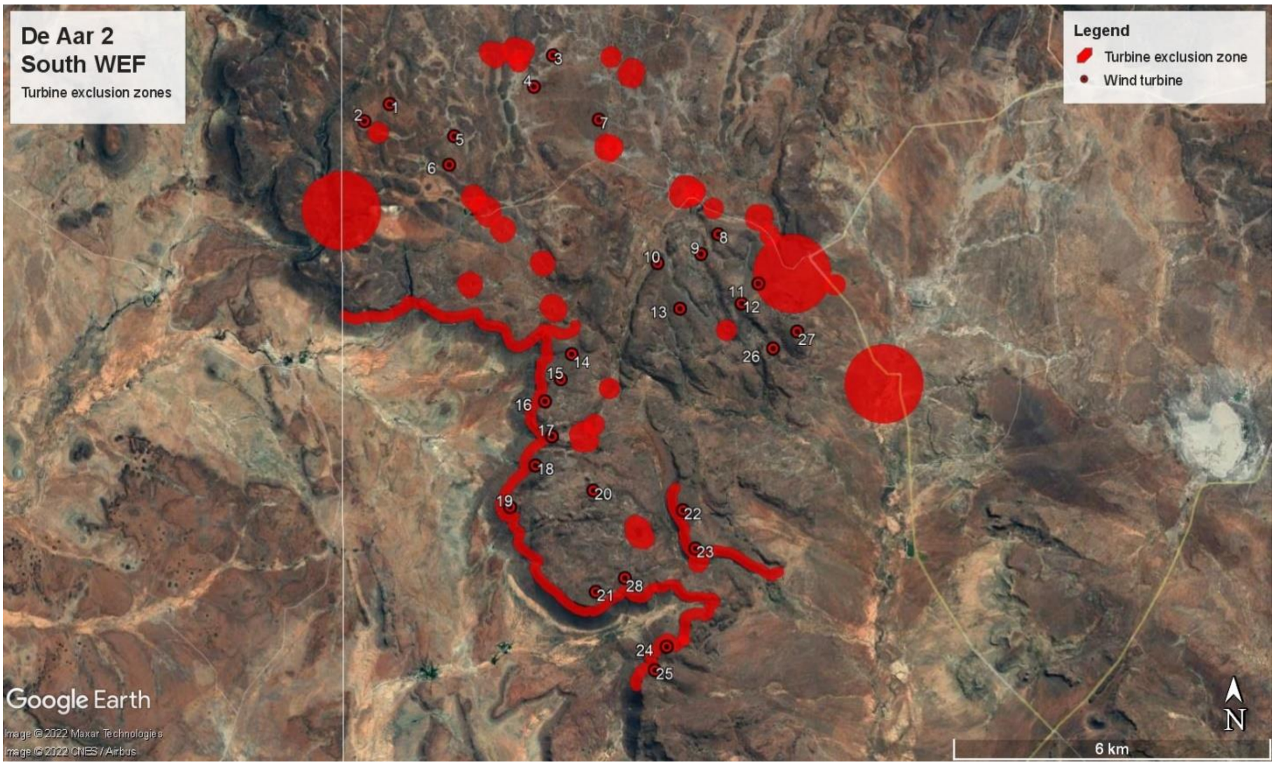

Figure (iii): The proposed turbine exclusion zones for Jackal Buzzard nests, boreholes, dams and escarpment edge. It has been confirmed by the specialist that all 28 positions are outside of these recommended exclusion zones

2 CONCLUSION AND IMPACT STATEMENT

The De Aar 2 South Wind Energy Facility was authorised in 2013 for a total of 103 turbines. Since then, various amendments have been applied for and granted, and the currently authorised layout comprises **61 turbines**. It is now proposed to **reduce this to a total of 26 turbines**, which translates to a reduction of 57.3% in the number of turbines and a reduction in the estimated collision risk for Verreaux's Eagle, the primary species of conservation concern at the proposed WEF.

Ideally no turbines should be located in the VERA high risk zone. The applicant has confirmed that it has implemented the most conservative lay-out possible to avoid the VERA high risk zones and maintain the viability of the project. It is noted that the project received environmental authorization before the Verreaux's Eagle guidelines, or the VERA model came in to being. In addition to the reduction of the total number of turbines, various additional mitigation measures are recommended to further reduce the risk of collision mortality for priority species, including Verreaux's Eagle. These are Shutdown on Demand for the entire WEF, automatic curtailment of selected turbines under certain high-risk conditions, the painting of one blade red on all turbines and turbine exclusion zones for high-risk areas (priority species nests, the escarpment edge, dams and drainage lines). Taking into account the reduced number of turbines and these additional mitigation measures, the risk of collision mortality will be significantly reduced.

It is recommended that the lay-out is approved, subject to the implementation of the mitigation measures as detailed in this report, to be included in the updated EMPr.

DETAILS OF THE CONTRIBUTING SPECIALISTS

Chris van Rooyen (Avifaunal Specialist)

Chris has decades of experience in the management of wildlife interactions with electricity infrastructure. He was head of the Eskom-Endangered Wildlife Trust (EWT) Strategic Partnership from 1996 to 2007, which has received international acclaim as a model of co-operative management between industry and natural resource conservation. He is an acknowledged global expert in this field and has worked in South Africa, Namibia, Botswana, Lesotho, New Zealand, Texas, New Mexico and Florida. Chris also has extensive project management experience and has received several management awards from Eskom for his work in the Eskom-EWT Strategic Partnership. He is the author of 15 academic papers (some with co-authors), co-author of two book chapters and several research reports. He has been involved as ornithological consultant in numerous power line and wind generation projects. Chris is also co-author of the Best Practice for Avian Monitoring and Impact Mitigation at Wind Development Sites in Southern Africa, which is the industry standard. Chris also works outside the electricity industry and had done a wide range of bird impact assessment studies associated with various residential and industrial developments.

Albert Froneman (Avifaunal Specialist)

Albert has a Master of Science degree in Conservation Biology from the University of Cape Town and started his career in the natural sciences as a Geographic Information Systems (GIS) specialist at Council for Scientific and Industrial Research (CSIR). In 1998, he joined the Endangered Wildlife Trust where he headed up the Airports Company South Africa – EWT Strategic Partnership, a position he held until he resigned in 2008 to work as a private ornithological consultant. Albert's specialist field is the management of wildlife, especially bird related hazards at airports. His expertise is recognized internationally; in 2005 he was elected as Vice Chairman of the International Bird Strike Committee. Since 2010, Albert has worked closely with Chris van Rooyen in developing a protocol for pre-construction monitoring at wind energy facilities, and he is currently jointly coordinating pre-construction monitoring programmes at several wind farm facilities. Albert also works outside the electricity industry and had done a wide range of bird impact assessment studies associated with various residential and industrial developments.

Dr Rob Simmons (Avifaunal Specialist)

Rob has a PhD in Zoology and worked in many parts of southern Africa: In Namibia as Wetlands Biologist, then Ornithologist, specialising on threatened raptors, waders, flamingos, endemics and Namibia's wetlands. In South Africa with the FitzPatrick Institute his research took him to Angola to complete work on Namibia-Angolan endemics. He researches the impact of domestic cats, harrier ecology and evolution of giraffe with his students. Collaborative biodiversity and genetic studies have been undertaken with Berkley, Cambridge, Durham, Edinburgh, Oxford, SANBI, Sheffield, Stanford and Uppsala Universities. He has authored/co-authored 110 papers and 70 popular articles, written two books (Harriers of the World - Oxford University Press - 2000 and Birds to watch in Namibian - 2015) and contributed to 9 others. He lives in Cape Town and has undertaken over 60 impact assessments (from diamond mines to solar farms) over 23 years with Birds & Bats Unlimited. He is on the advisory board of the wind-energy specialist group for Birdlife SA, is the Birdlife SA Black Harrier species champion and completed guidelines for Black Harriers-wind farms in 2020.

FALX artificial intelligence (Dr Brendan Williams, Matthew Erasmus, Morne Botha & Dr Juan Klopper)

FALX is a technology company and service provider to businesses focused on problem solving and the production of efficiencies; these gained through the successful implementation of data science and artificial intelligence technologies. FALX services span from data wrangling and analysis to the implementation of live software interventions in decision-making processes. Their team consists of leaders in their fields and academic personnel focused on the creation and implementation of new technologies. FALX has industry experience in the following fields: Renewable Energy, Research, Healthcare Technology, Property, Supply Chain Management and Logistics.

SPECIALIST DECLARATION

environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

DETAILS OF THE SPECIALIST, DECLARATION OF INTEREST AND UNDERTAKING UNDER OATH

	(For official use only)
File Reference Number:	
NEAS Reference Number:	DEA/EIA/
Date Received:	

Application for authorisation in terms of the National Environmental Management Act, Act No. 107 of 1998, as amended and the Environmental Impact Assessment (EIA) Regulations, 2014, as amended (the Regulations)

PROJECT TITLE

Avifaunal Impact Assessment: Proposed De Aar 2 South Wind Energy Facility Near De Aar in The Northern Cape Province

Kindly note the following:

1. This form must always be used for applications that must be subjected to Basic Assessment or Scoping & Environmental Impact Reporting where this Department is the Competent Authority.
2. This form is current as of 01 September 2018. It is the responsibility of the Applicant / Environmental Assessment Practitioner (EAP) to ascertain whether subsequent versions of the form have been published or produced by the Competent Authority. The latest available Departmental templates are available at https://www.environment.gov.za/documents/forms.
3. A copy of this form containing original signatures must be appended to all Draft and Final Reports submitted to the department for consideration.
4. All documentation delivered to the physical address contained in this form must be delivered during the official Departmental Officer Hours which is visible on the Departmental gate.
5. All EIA related documents (includes application forms, reports or any EIA related submissions) that are faxed; emailed; delivered to Security or placed in the Departmental Tender Box will not be accepted, only hardcopy submissions are accepted.

Departmental Details

Postal address:
Department of Environmental Affairs
Attention: Chief Director: Integrated Environmental Authorisations
Private Bag X447, Pretoria, 0001

Physical address:
Department of Environmental Affairs
Attention: Chief Director: Integrated Environmental Authorisations
Environment House, 473 Steve Biko Road, Arcadia

Queries must be directed to the Directorate: Coordination, Strategic Planning and Support at:
Email: EIAAdmin@environment.gov.za

1. **SPECIALIST INFORMATION**

Specialist Company Name:				
B-BBEE	Contribution level (indicate 1 to 8 or non-compliant)	Level 2	Percentage Procurement recognition	
Specialist name:	Chris van Rooyen			
Specialist Qualifications:	BA LLB			
Professional affiliation/registration:	I work under the supervision and in association with Albert Froneman (MSc Conservation Biology) (SACNASP Zoological Science Registration number 400177/09) as stipulated by the Natural Scientific Professions Act 27 of 2003			
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Postal address:	PO Box 2676, Fourways, 2122			
Postal code:	2055	Cell:	0824549570	
Telephone:	0824549570	Fax:		
E-mail:	Vanrooyen.chris@gmail.com			

2. **DECLARATION BY THE SPECIALIST**

I, Christiaan Stephanus van Rooyen, declare that –

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

Signature of the Specialist

Name of Company: Afrimage Photography t/a Chris van Rooyen Consulting

10 November 2022

Date

3. UNDERTAKING UNDER OATH/ AFFIRMATION

I, Christiaan Stephanus van Rooyen, swear under oath / affirm that all the information submitted or to be submitted for the purposes of this application is true and correct.

Signature of the Specialist

Afrimage Photography (Pty) Ltd t/a Chris van Rooyen Consulting

Name of Company

10 November 2022

Date

Sgt. Negqwarube 2114043-1

Signature of the Commissioner of Oaths

SOUTH AFRICAN POLICE SERVICE
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SOUTH AFRICAN POLICE SERVICE

2022-11-10

Date

3 INTRODUCTION

Chris van Rooyen Consulting was contracted by Holland & Associates Environmental Consultants to conduct a "walk-through" report of the proposed 156MW De Aar 2 South Wind Energy Facility (WEF) site on behalf of Mulilo Renewable Project Developments (Pty) Ltd (Mulilo) to identify any avifaunal sensitivities and associated mitigation measures to be considered for the final layout of the turbines and to advise the updated Environmental Management Plan (EMP). Mulilo De Aar 2 South (Pty) Ltd, is preparing the updated EMPr and Final Layout for submission to the DFFE to meet the requirements of conditions 13 and 14 of the original Environmental Authorisation (EA).

Mulilo applied for Environmental Authorisation from the Department of Environmental Affairs (DEA) in 2011 to establish a Wind Energy Facility (WEF) and associated infrastructure on the eastern plateau of De Aar (approximately 20 km to the east of the town). The EIA process for the proposed project was undertaken by Aurecon South Africa (Pty) Ltd in 2012 and Environmental Authorisation for the proposed project was granted by DEA on 1 March 2013. The EIA listed activities for which environmental authorisation has been granted includes Items 10, 11 and 18 of GN R.544, Item 1 of GN R. 545 and Item 14 of GN R.546 published in terms of NEMA EIA Regulations (2010). Furthermore, on 24 July 2014, a further environmental authorisation for the project was granted in respect of Items 13 and 16 of GN 546 by the Northern Cape Department of Environment and Nature Conservation (DENC) for activities that had not been applied for in the original EIA for the project.

The original EA for the project authorised 103 wind turbines with a potential capacity of 155 – 258MW and associated infrastructure. Eight amendments to the DEA (now DFFE) EA have been applied for by the Applicant, and granted by DFFE, in 2013, 2014, 2016, 2018, 2019, 2020 and 2021 respectively, including a change in the name of the holder of the EA, extensions of the EA validity period, amendments to Conditions of the EA, amendments to the project description and amendments to the turbine specifications.

The proposed final turbine layout for the project (initially referred to as the wind energy facility located on the southern portion of the plateau) consists of up to 28 turbine positions (upon which a maximum of 26 will turbines be constructed) with a total capacity of 156 MW. The original authorised layout was reduced by 57.3% from a maximum of 61 turbines to a maximum of 26 turbines, in order to cater for increased mitigation measures and reduce any significant avifaunal sensitivies. The power generated by the project will be transmitted to the national grid via a proposed on-site Eskom Switching Station. This Station will connect via a 132 kV overhead line to a new Main Transmission Substation, subject to a separate Basic Assessment process. The 28 turbine lay-out was assessed during the walk-through exercise, with a view to include any required mitigation measures in an updated EMPr. The proposed site is situated in the Emthanjeni and Renosterberg Local Municipalities in the Northern Cape Province. The site is approximately 9 200 ha in extent and consists of nine portions of four farms.

4 BACKGROUND

Since the original bird impact study and pre-construction monitoring for the proposed De Aar 2 South (DA2S) Wind Energy facility (WEF) were completed in 2012 (Harebottle 2012) and 2014 (Van Rooyen *et al.* 2014) respectively, the "Best practice guidelines for avian monitoring and impact mitigation at proposed wind energy development sites in southern Africa", (Jenkins *et al*. 2011) have been revised in 2015, and new guidelines have been produced specifically for Verreaux's Eagles (the VE guidelines) (Ralston-Paton 2017 updated in 2021). This was necessary after it became apparent through operational monitoring at several wind farms in South Africa, including the neighbouring De Aar 2 North Wind Farm, that the species is highly susceptible to wind turbine collisions.

As part of an amendment application to the DA2S WEF's Environmental Authorisation (EA) in June 2019, in view of new guidelines and the experience gained since the original studies were completed, it was recommended that the original mitigation measures for the DA2S WEF, as formulated in 2012 and 2014, needed to be revisited. The amendment was subsequently approved[1], subject to revisiting and updating the mitigation measures, which were described in the specialist input report to the amendment motivation.

The following approach was recommended to be followed prior to commencement of construction and finalisation of the Environmental Management Programme (EMPr) and final turbine layout: Additional bird monitoring to be implemented on the project site, to update the baseline data set and to align the monitoring with guideline requirements, including the following:

1. VP watches (12 hours per VP per survey, totaling an additional 72 hours per VP per year) to be conducted for a period of one year, to establish the flight activity of raptors at the site and immediate environment[2].
2. A thorough nest search (screening) and survey of known nest sites to be conducted to establish the status of breeding raptors at the site and within the vicinity of the site.
3. Should there be active Verreaux's Eagle nests, that the satellite tagging of at least one individual of each breeding pair be considered in order to establish the actual shape of the territories in order to further increase mitigation measures.
4. Once the tagging data becomes available, the shape of the proposed buffer zones will be determined, based on the actual flight data.

Following on from these recommendations, nest searches were conducted in October 2019 as per recommendation No 2 above. Of the three known potential territories previously recorded in the immediate vicinity of the proposed WEF, only one could be confirmed as occupied by a breeding pair of eagles in October 2019 (van Rooyen & Froneman 2019). Given the fact that two of the three territories were likely inactive in October 2019, it was concluded that recommendations 3 and 4 (i.e the option of catching the birds and tagging them with tracking devices) would not be practical or possible at that time. Instead, it was recommended by Chris van Rooyen Consulting that a Verreaux's Eagle Risk Assessment (VERA) modelling analysis be conducted (instead of tracking live birds) for DA2S WEF to identify areas of high risk in order to assist with and advise the final lay-out of turbines to minimise the risks to the eagles, should those territories be active, or become active again. This recommendation was also made, based on the inherent risk to the birds themselves of capturing and tagging, uncertainty about if/when birds could be caught, uncertainty in the longevity of the tracking devices, and the knowledge that the VERA model had been revised/improved to the point of imminent public release[3]. VERA was subsequently implemented for the DA2S WEF site, and a report was produced by Dr Megan Murgatroyd indicating the area where the highest risk of collisions was expected, based on the presence of the VE territories (both active and inactive) recorded in October 2019 (Appendix 5)[4].

Based on the outcome of the VERA modelling, the turbine lay-out was significantly adapted and reduced to 26 turbines to be constructed from 28 proposed positions (from the currently authorised maximum of 61

[1] Approved on 6 Sept 2019 (DEA Ref: 12/12/20/2463/1/AM6)

[2] This was recommended to update the baseline monitoring data for the site which is over 5 years old.

[3] The model has since been published as a peer reviewed paper: Murgatroyd, M., Bouten, W. & Amar, Arjun. 2020. A predictive model for improving placement of wind turbines to minimise collision risk potential for a large soaring raptor. Journal of Applied Ecology. 2020;00:1 – 12. DOI: 10.1111/1365-2664.13799. It has also been incorporated in the latest (2021) edition of the Verreaux's Eagle (VE) guidelines.

[4] According to the VERA model approximately 85% of potential air space use by breeding eagles is protected by the combination of High and Medium risk zones, and approximately 73% by the High-risk zone only (Murgatroyd et al. 2020). Wind development in High-risk zones is discouraged. Development in Medium-risk zones should be avoided where possible and only proceed with additional specialist input and mitigation measures.

turbines) in order to avoid as much of the identified high-risk area as possible (see Figure 1). This represents a 57.3% reduction in the latest number of authorised turbines (and a 74% reduction from the original 103 authorised turbines) and it is understood to be the most conservative lay-out possible without compromising the viability of the project.

In addition to VERA modelling, the applicant engaged Chris van Rooyen Consulting to implement the additional proposed monitoring (i.e. a second year of pre-construction monitoring) as per recommendation 1 in the 2019 amendment application, with a second objective of ascertaining/confirming the non-suitability/suitability of some turbine positions that remain in High risk and Medium risk zones as identified by VERA, and advising additional detailed mitigation measures. This is in line with the Verreaux's Eagle guidelines, which recommend additional monitoring (or a second year of assessment) to be done in instances where the applicant wishes to maximise use of site (i.e. build turbines in areas where high fight activity or risky behaviour is likely, but not confirmed). The second year of pre-construction monitoring was completed in July 2022, with a total of six surveys being completed, totaling 288 hours of vantage point watches. The results of the second year of monitoring (which included the site "walkthrough" work as well) are presented in this report.

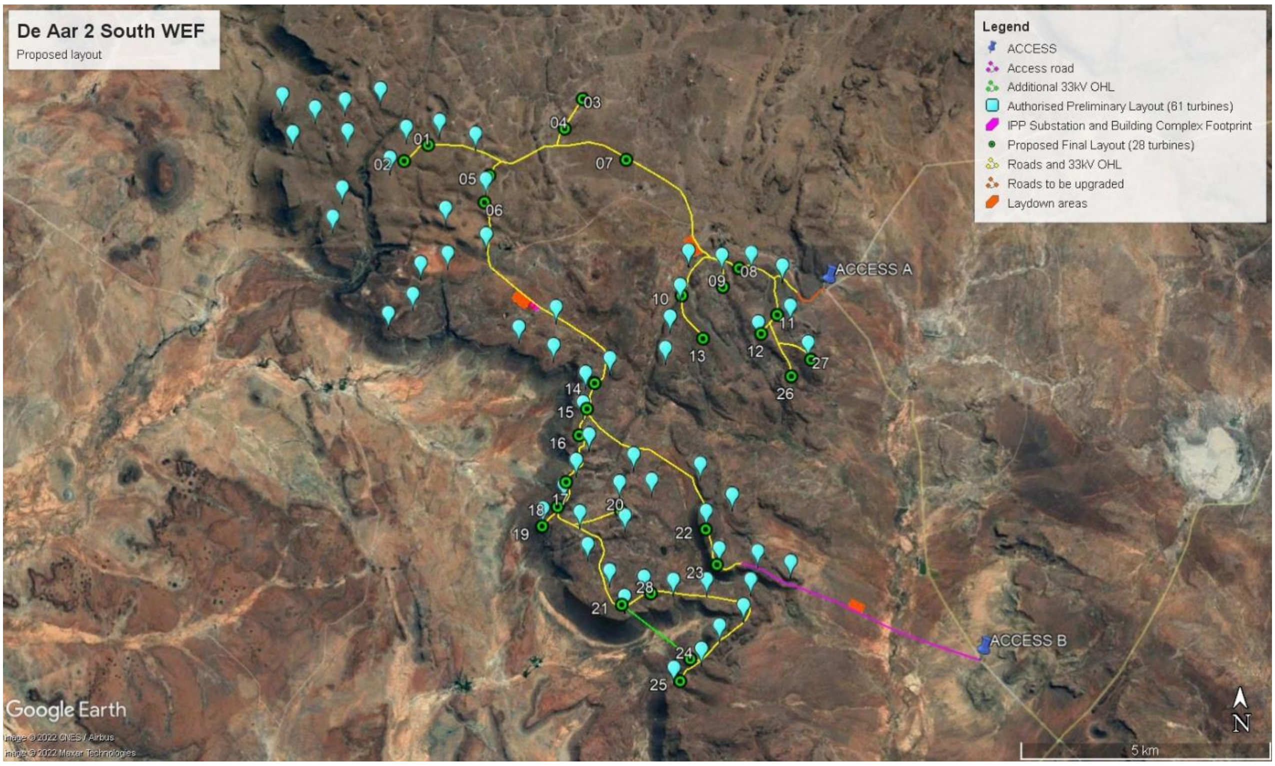

Figure 1: The proposed final lay-out that was assessed. The layout shows 28 turbine positions, of which up to 26 will be selected. The preliminary authorised layout (61 turbines) is also shown for comparison.

5 RECEIVING ENVIRONMENT

5.1 DFFE National Screening Tool

5.1.1 Avian Wind Theme

The project site is located outside of a Renewable Energy Development Zone, therefore the Wind Theme is not applicable.

5.1.2 Terrestrial Animal Species Theme

The project site and immediate environment is classified as a mixture of **Medium** and **High** sensitivity for avifauna. The High sensitivity is linked to Ludwig's Bustard *Neotis ludwigii* (Globally and Regionally Endangered), Lanner Falcon *Afrotis afra* (Globally and Regionally Vulnerable), Tawny Eagle *Aquila rapax* (Regionally Endangered) and Verreaux's Eagle *Aquila verreauxii* (Regionally Vulnerable). The medium sensitivity is linked to Ludwig's Bustard and Black Stork (*Ciconia nigra*).

The project site contains confirmed habitat for species of conservation concern (SCC), as defined in the Protocol for the specialist assessment and minimum report content requirements for environmental impacts on terrestrial animal species (Government Gazette No 43855, 30 October 2020), namely listed on the IUCN Red List of Threatened Species or South Africa's National Red List website as Critically Endangered, Endangered, Vulnerable, Near threatened or Data Deficient. The occurrence of SCC was confirmed during the original 12 months pre-construction monitoring in 2013 – 2014, subsequent nests searches in October 2019, and the second year of pre-construction monitoring that was completed in July 2022. SCC recorded included Verreaux's Eagle, Tawny Eagle, Black Stork, Lanner Falcon, Karoo Korhaan *Eupodotis vigorsii* (Regionally Near-threatened), Martial Eagle *Polemaetus bellicosus* (Globally and Regionally Endangered), and Ludwig's Bustard.

The classification of High sensitivity is assessed to be accurate, based on the presence of SCC recorded on the ground during the site surveys.

See Appendix 1 for the DFFE screening report.

5.2 Bird habitat

The project site falls within the Platberg-Karoo Conservancy Important Bird Area (IBA) SA037. This IBA contributes significantly to the conservation of large terrestrial birds and raptors. These include Blue Crane *Anthropoides paradiseus*, Ludwig's Bustard, Kori Bustard *Ardeotis kori*, Blue Korhaan *Eupodotis caerulescens*, Black Stork, Secretarybird *Sagittarius serpentarius*, Martial Eagle, Verreauxs' Eagle and Tawny Eagle (Marnewick *et al.* 2015).

The turbine site is located primarily in Besemkaree Koppies Shrubland, which consists of a mixture of dwarf, small-leaved shrubs and tall shrubs, with an abundance of grasses, especially after good rains, and forms part of the Grassland Biome ((Mucina & Rutherford 2006, SANBI 2018). From an avifaunal perspective, the habitat is classified as Grassy Karoo (Harrison *et al.* 1997). The site itself is located on a plateau. The plateau is one of a handful of high-lying areas in the region. Altitude on the plateau ranges from about 1400 – 1670m above sea level. The most important avifaunal habitat feature on the site is the extensive cliffs, rocky slopes and wooded kloofs which are found on the western edge of the plateau, which constitute suitable habitat for a range of cliff-nesting raptors, but especially for Verreaux's Eagle, Booted Eagle *Aquila pennatus* and Jackal Buzzard *Buteo rufofuscus*. Temperatures at De Aar range between a mean daily maximum of 31˚C in January (summer) and 15.1˚C in July (winter), and rainfall happens mostly between October and April and averages about 211mm per year, which makes for a fairly arid climate (meteoblue.com). The principal land-use at the site is live-stock farming.

See Appendix 2 for images of the habitat at the project site.

6 PRE-CONSTRUCTION MONITORING

6.1 Vantage point watches

A species list of the avifauna recorded during the original 12 months pre-construction monitoring in 2013 - 2014 is attached as Appendix 3

During a second year of pre-construction monitoring, a total of 288 hours of vantage point watches were implemented at the site consisting of six surveys at four vantage points in the period 2020 - 2022. This was specifically implemented to assess the reduced turbine lay-out, with vantage points positioned to give the best possible view of the proposed turbine positions. Surveys were conducted in the following periods:

- 11 - 15 October 2020
- 13 – 18 November 2020
- 07 – 11 December 2021
- 03 - 06 May 2021
- 18 – 22 May 2021
- 18 – 22 July 2022

A site-specific collisions risk rating for each priority species recorded during VP watches was calculated to give an indication of the likelihood of an individual of a specific species to collide with the turbines at this site. This was calculated taking into account the following factors:

- The duration of rotor altitude flights;
- The susceptibility to collisions, based on morphology (size) and behaviour (soaring, predatory, ranging behaviour, flocking behaviour, night flying, aerial display and habitat preference) using the ratings for priority species in the Avian Wind Farm Sensitivity Map of South Africa (Retief *et al.* 2012); and
- The number of planned turbines.

This was done in order to gain some understanding of which species are likely to be most at risk of collision. The formula used is as follows:

Duration of rotor altitude flights x collision susceptibility calculated as the sum of morphology and behaviour ratings x number of planned turbines ÷100.

Figure 2 shows the species-specific collision risk index for the second year of pre-construction monitoring calculated for priority species based on a potential lay-out of 61 and 26 turbines. As can be seen in Figure 2, the reduction of the number of turbines from 61 to 28 will bring about an estimated 57% reduction in the collision risk for Verreaux's Eagles.

Figure 3 shows the original site-specific risk rating for the original 103 authorised turbines, based on the 12-month pre-construction monitoring completed in 2014 (four surveys). The risk rating for Verreaux's Eagles have been reduced by an estimated 93% when comparing the original 103 turbine layout with the proposed 26 turbine layout. The huge difference in risk ratings between 2014 and 2022 can be ascribed to the reduced number of turbines but also to the reduced number of active Verreaux's Eagle and Booted Eagle nests at the De Aar 2 South site in 2020 to 2022 when compared to 2013 to 2014.

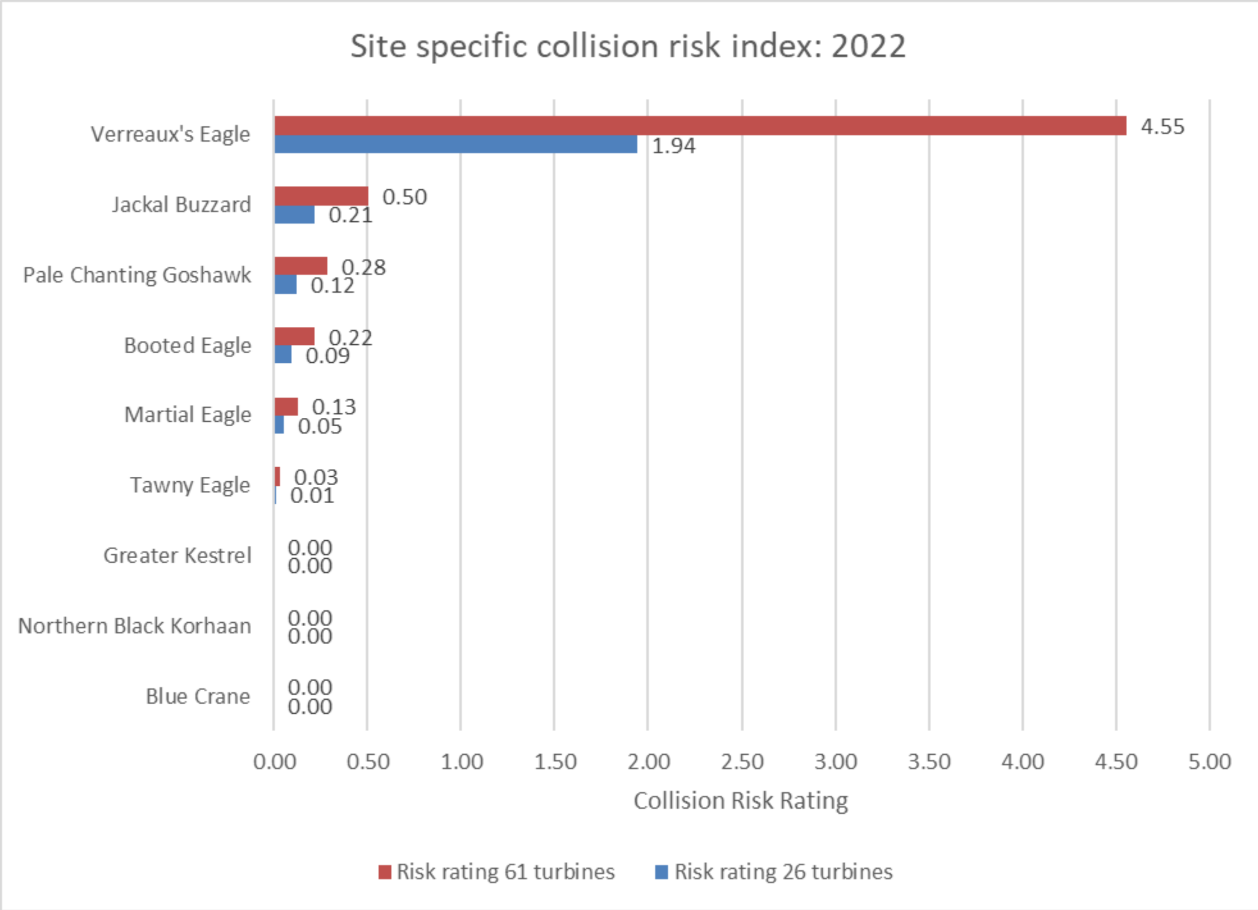

Figure 2: Site specific collision risk rating for priority species based on pre-construction monitoring 2020 – 2022 (288 hours of VP watches), showing the ratings for a 61 turbine lay-out vs a 26 turbine layout.

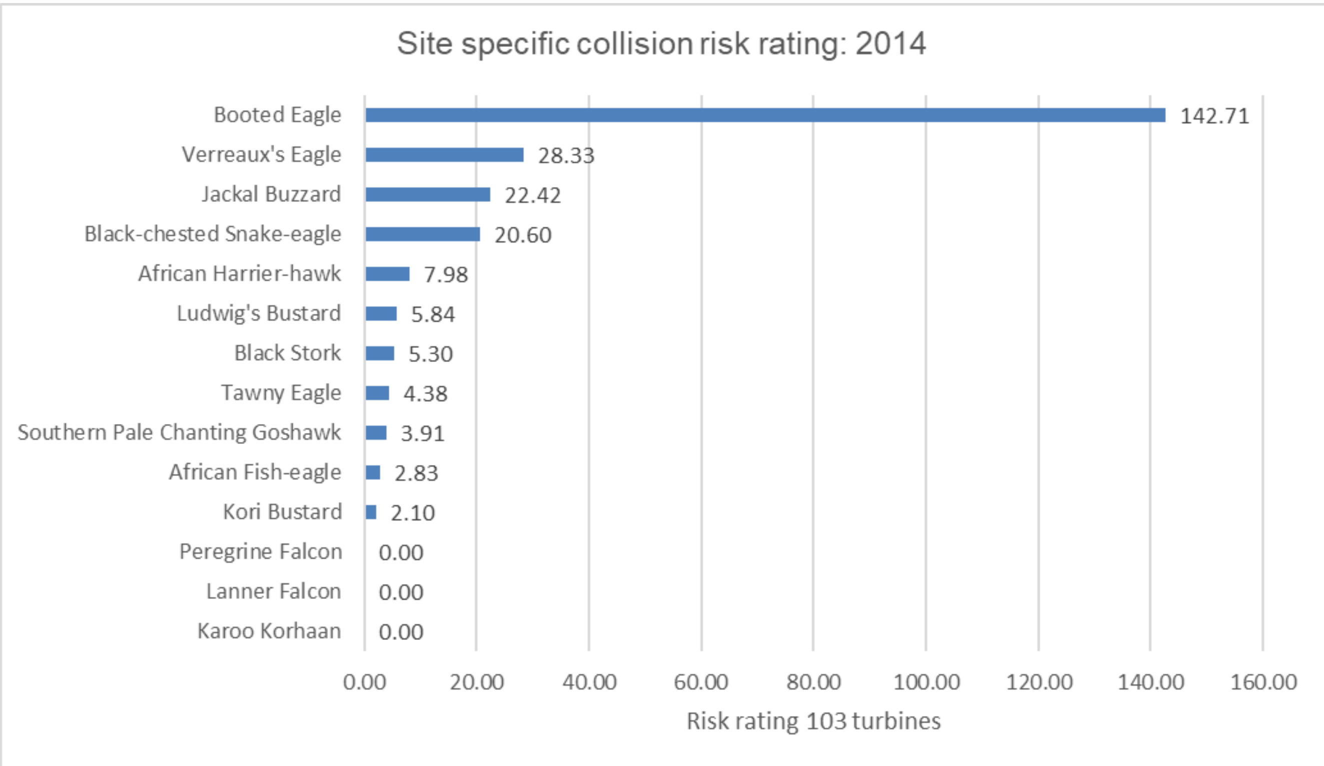

Figure 3: Site specific collision risk rating for priority species based on pre-construction monitoring 2013 – 2014 (240 hours of VP watches), showing the ratings for a 103 turbine layout.

6.2 Nests

The nests of SCC and other priority species that were recorded during the site surveys in 2020 – 2022 are indicated in Figure 3.

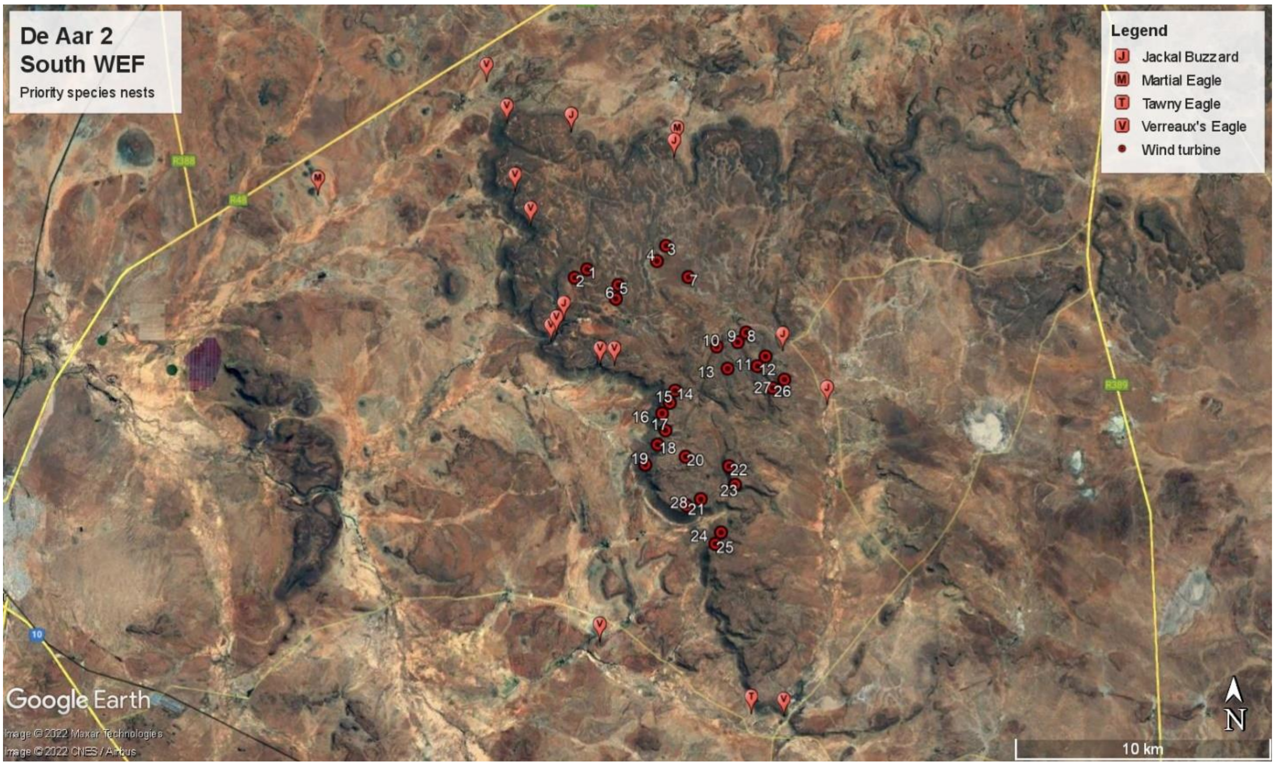

Figure 4: The location of priority species nests in the vicinity of the proposed De Aar 2 South WEF

6.2.1 Verreaux's Eagle

- A total of twelve Verreaux's Eagle nests (representing six potential eagle territories) have been recorded on the escarpment edge and on powerlines in the broader area. Some of the nests are alternative nests for the same pair of birds.
- The latest version of the BLSA Verreaux's Eagle (VE) guidelines (November 2021) recommend that all Verreaux's Eagle nests are buffered regardless of whether the nest is active at the time of the monitoring (i.e. containing an egg of nestling), because the nest is an indication of an occupied territory, or a vacant territory which could be occupied in future.
- The 2021 VE guidelines recommend that no turbines should be located in the High-risk zones as indicated by VERA. In addition, all turbines in Medium-risk zones should be relocated if possible. Should relocation not be feasible, these turbines should be subject to pro-active mitigation in the form of a proven mitigation method such as Shutdown on Demand (SDoD).
- The flight activity of Verreaux's Eagles recorded during the pre-construction monitoring in 2020 – 2022 was analysed in order to ground-truth the VERA model, and to advise on the updated turbine layout, which was reduced from 61 to 26 turbines. The results indicate a high level of correlation with the VERA sensitivity layers based on the distance and location of recorded flights within the respective VERA zones (see Figure 4 and Figure 5).

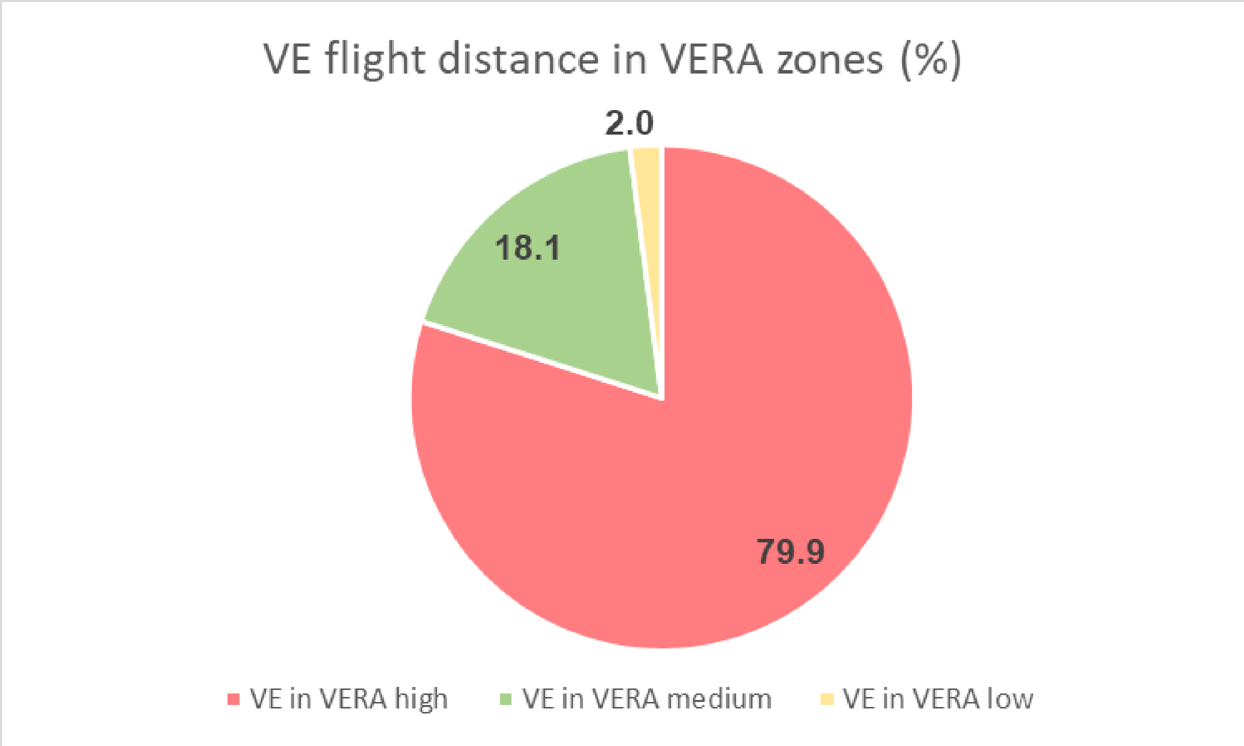

Figure 5: The percentage of flight activity (distance of flights) in the various VERA zones recorded during pre-construction monitoring in 2020 – 2022. A total of 319.9km of flights were recorded during 288 hours of VP watches.

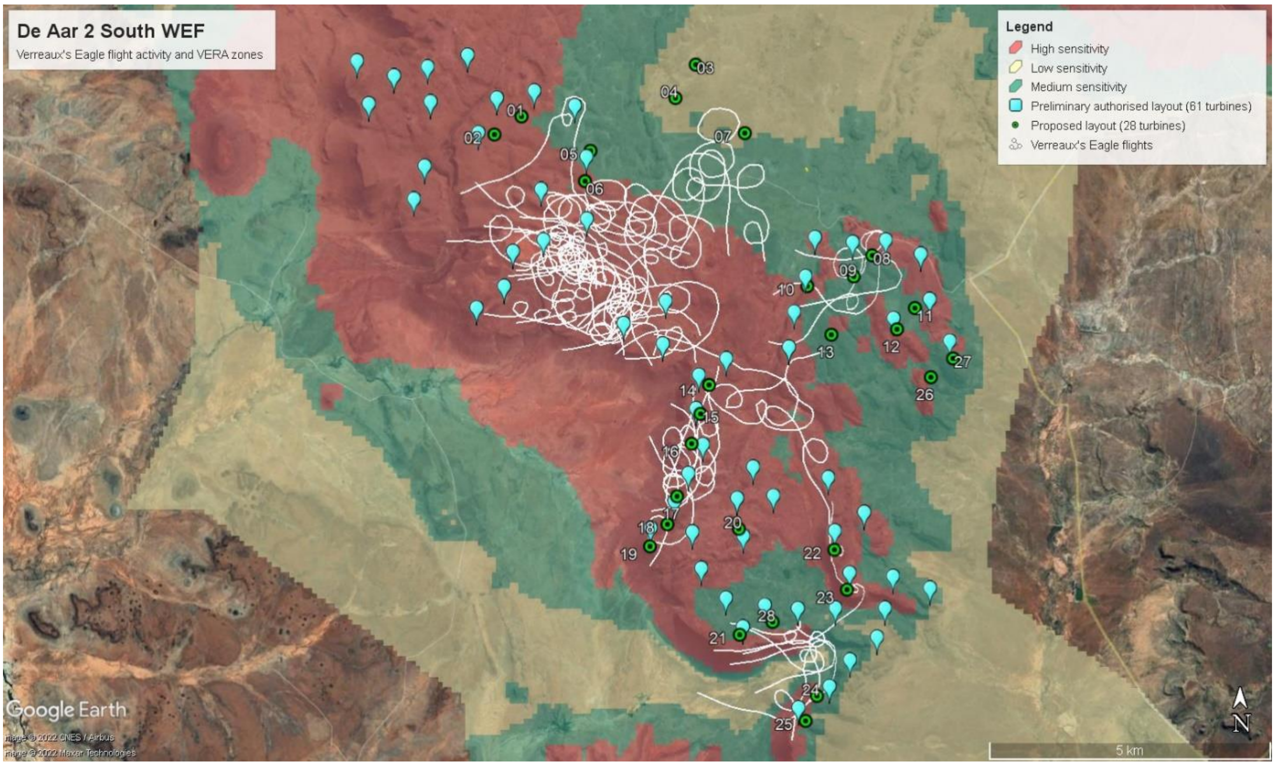

Figure 6: The Verreaux's Eagle flight activity recorded during the pre-construction monitoring in 2020 – 2022, during 288 hours of VP observations. Passage rate for Verreaux's Eagles was 0.19 birds/hour. The layout shows 28 turbine positions, of which up to 26 will be selected. The previously authorised 61 turbine layout is also shown for comparison.

- Figure 5 shows all the VE flight lines recorded in 288 hours of VP monitoring from 2020-2022, which translated to a passage rate of 0.19 birds per hour, or approximately 2.4 birds per day.[5]

[5] This is based on 13 hours of daylight averaged over all seasons

- Based on the outcome of the VERA modelling and the subsequent pre-construction monitoring, the turbine lay-out was significantly adapted and reduced to 26 proposed positions (from the currently authorised maximum of 61 turbine positions) in order to avoid as much of the identified high-risk area as possible. This represents a 57.3% reduction in the latest number of authorised turbines (and a 74% reduction from the original 103 authorised turbines) and is understood to be the most conservative lay-out possible without compromising the viability of the project. In order to reduce the risk of collision to Verreaux's Eagles a combination of several mitigation strategies is recommended (see Section 5).

6.2.2 Martial Eagle

- A new Martial Eagle nest was established on the Eskom transmission lines at the site of the De Aar 2 North WEF in 2022, with positive identification of the occupants of the nest only confirmed in July 2022. The nest is approximately 4 km away from the closest planned turbine position (see Figure 3).
- The current buffer zone recommended by BirdLife South Africa around Martial Eagle nests is 5km. There are currently only two planned turbines within 5km of the nest. The removal of these two turbines will in any event have a negligible impact on the overall risk to the pair of Martial Eagles, because there are already 47 existing turbines (of the De Aar 2 North WEF) within 5km of the nest.
- Given the context of the existing turbines, other mitigation measures e.g. SDoD must be implemented to adequately reduce the risk that these two turbines pose (see Section 5).

6.2.3 Jackal Buzzard

There are three known Jackal Buzzard nests in the immediate vicinity of the WEF, one of which could be a Booted Eagle nest (see Figure 3). An appropriate buffer zone is recommended around each of the nests (see Section 5).

6.3 Other sensitivities

Surface water (boreholes and dams) is crucially important for priority avifauna including all SCC in this dry climate. It is important to leave open space with no obstructions for birds to access and leave the surface water area unhindered by placing appropriate turbine exclusion zones around them. Ridges, and especially the escarpment edge, are also important landscape features for soaring species, including SCC such as Verreaux's Eagle, Black Stork, and Lanner Falcon, and other non-threatened raptors such as Booted Eagle and Jackal Buzzard. It is therefore required to place appropriate turbine exclusion zones around them as well (see Section 5).

7 ADDITIONAL ANALYSIS OF FLIGHT DATA

7.1 Aims

The additional data analysis focused on the definition of a relationship between the movement of Verreaux's Eagles and specific meteorological conditions at that time. Verreaux's Eagle flight data from the proposed De Aar 2 South WEF, as well as all vantage point data available from the pre- and post- construction monitoring at the De Aar 1 WEF and the De Aar 2 North WEF were used to identify the highest risk windows for potential flight activity, with a view to designing an automated curtailment programme for the highest risk turbines.

7.2 Data Collection

The analysis comprised of GPS tracking and vantage point data for tagged Verreaux's Eagles from De Aar 1, De Aar 2 North and De Aar 2 South locations dated from 2013-2022. Meteorological data utilised was sourced from adjacent met masts dating from 2012-2022.

7.3 Statistical Analysis

A statistical analysis to define the relationship between specific meteorological conditions and Verreaux's Eagle flight patterns at the aforementioned locations was undertaken. This initial analysis omitted any spatial or positioning data analysis, this data being used solely to classify the bird's movement at a specific time. Results from data analysed indicated time of day to be the key variable driving variation in flight patterns. Other variables such as barometric pressure, standard deviation in wind speed, wind direction and strength, temperature and relative humidity were shown to contribute to variation in flight patterns at certain times of the day.

7.4 Modelling

A data modelling exercise was undertaken to formulate the predicted likelihood of Verreaux's Eagle flight under specific meteorological conditions. This information would contribute to the proposed curtailment strategy. A data function was produced to accurately determine the conditions under which flight was most likely. The output of this function represented an indication of the extent of plant curtailment expected under specific meteorological conditions.

7.5 Methodology

Data modelling architecture included the use of deep neural network techniques. These networks were trained and tested against datasets containing GPS and vantage point data in combination with meteorological data. Meteorological data was provided as an input to predict the probability of flight as an output. The data models developed in this project produced a resulting accuracy of 86%.

7.6 Results

The resultant probability of Verreaux's Eagle flight, based upon predefined thresholds, is illustrated in the below table.

Table 1: Overall Summary of Expected Curtailment per Probability Threshold

	Probability >50%	Probability >60%	Probability >70%	Probability >80%	Probability >90%
Predicted Number of High-risk Collision Points	33000	15141	9161	4731	1423
Total Number of Points	430248	430248	430248	430248	430248
Predicted High-Risk Collision Rate [%]	7.67	3.52	2.13	1.10	0.33
Portion of Facility to be Curtailed (8/26) [%]	31	31	31	31	31
Total Loss for Curtailment [%]	**2.36%**	**1.08%**	**0.66%**	**0.34%**	**0.10%**

For more detail on the methodology to arrive at a curtailment strategy see Appendix 7.

In addition, the flight activity of 5 pairs of Verreaux's Eagles recorded during 156 hours of vantage point watches was analysed to determine seasonal patterns of flight activity (see Figure 7).

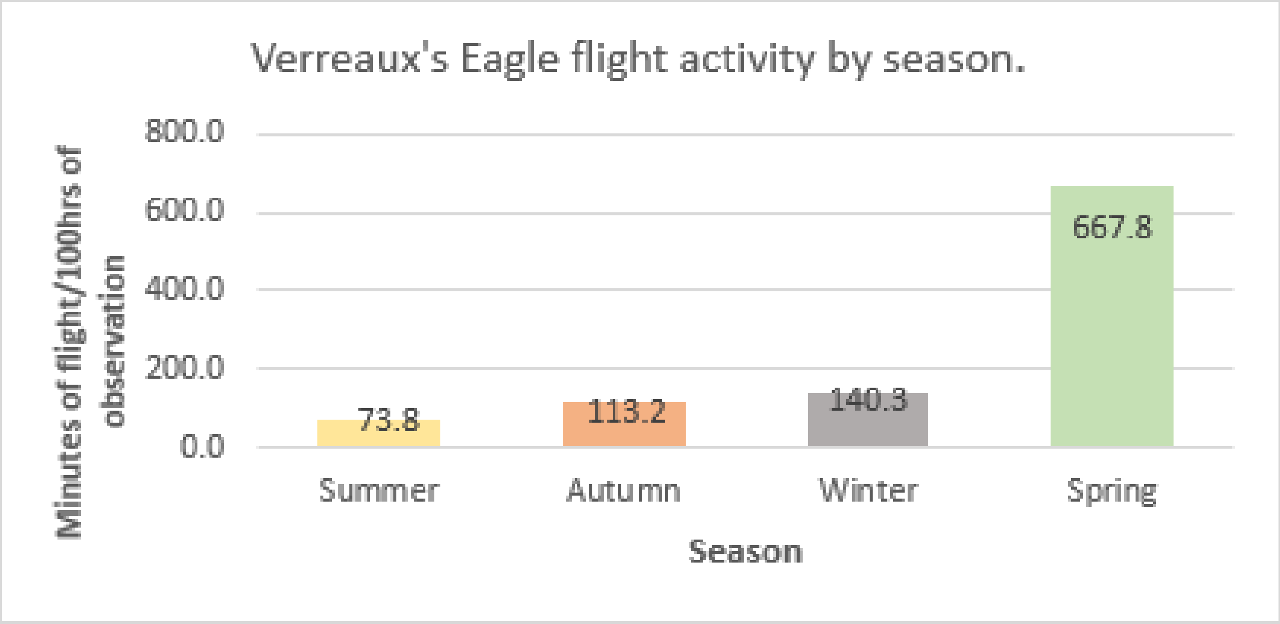

Figure 7: Seasonal changes in flight times per 100 hours of observation for Verreaux's Eagles at two locations in the Karoo mountains. Based on 156 hours of VP observation at 5 eagle nests and 12 651 seconds (~3.5 h) of recorded flights. (Source: R Simmons - Birds and Bats Unlimited).

8 RECOMMENDATIONS

The recommendations below are put forward for inclusion in the Final Environmental Management Programme (EMPr). These recommendations are based on the pre-construction monitoring conducted in 2013-2014 (Van Rooyen *et al*. 2014), the second year of pre-construction monitoring that was completed in July 2022, and the additional analysis of flight data undertaken to inform a curtailment programme. These recommendations replace all recommendations contained in previous avifaunal impact assessment reports and Environmental Management Programmes, which are now outdated.

8.1 Design phase

- Ideally no turbines should be located in the VERA high risk zone. It is noted that the project received environmental authorization before the Verreaux's Eagle guidelines, or the VERA model came in to being. The current turbine layout has been assessed as the most conservative layout possible in terms of avoiding VERA high risk zones and maintaining the viability of the project, in contrast to the previous layout which was authorized prior to the release of the VERA model and Verreaux's Eagle guidelines.
- It is understood that the 26 of the current 28 turbine positions will be utilised, which means that a further two turbines will be removed. This represents a significant 57.3% reduction ,with 35 turbines being removed from the authorized layout of 61**.**
- It is recommended that a 200m turbine exclusion zone around dams and water troughs as a pre-cautionary measure against SCC and other priority species collisions.
- A 750m turbine exclusion zone around the Jackal Buzzard nests must be implemented.
- A 100m turbine setback from the escarpment edge must be maintained.
- All internal 33kV medium voltage cables are to be buried if technically and practically possible.

- Those sections where the 33kV medium voltage cable cannot be trenched due to technical or environmental reasons, but needs run on overhead poles, the proposed pole designs must be approved by the avifaunal specialist, to ensure that the designs are raptor-friendly.
- Bird flight diverters are to be fitted to all internal 33kV overhead lines according to the applicable Eskom Engineering Instruction.
- All turbines must have one blade painted in signal red according to pattern no.4 depicted in Figure 6. It is acknowledged that blade painting as a mitigation strategy is still in an experimental phase in South Africa, but research indicates that it has a very good chance of reducing raptor mortality, based on research conducted in Norway (see Simmons *et al*. 2021 (Appendix 6) for an explanation of the science and research behind this mitigation method).

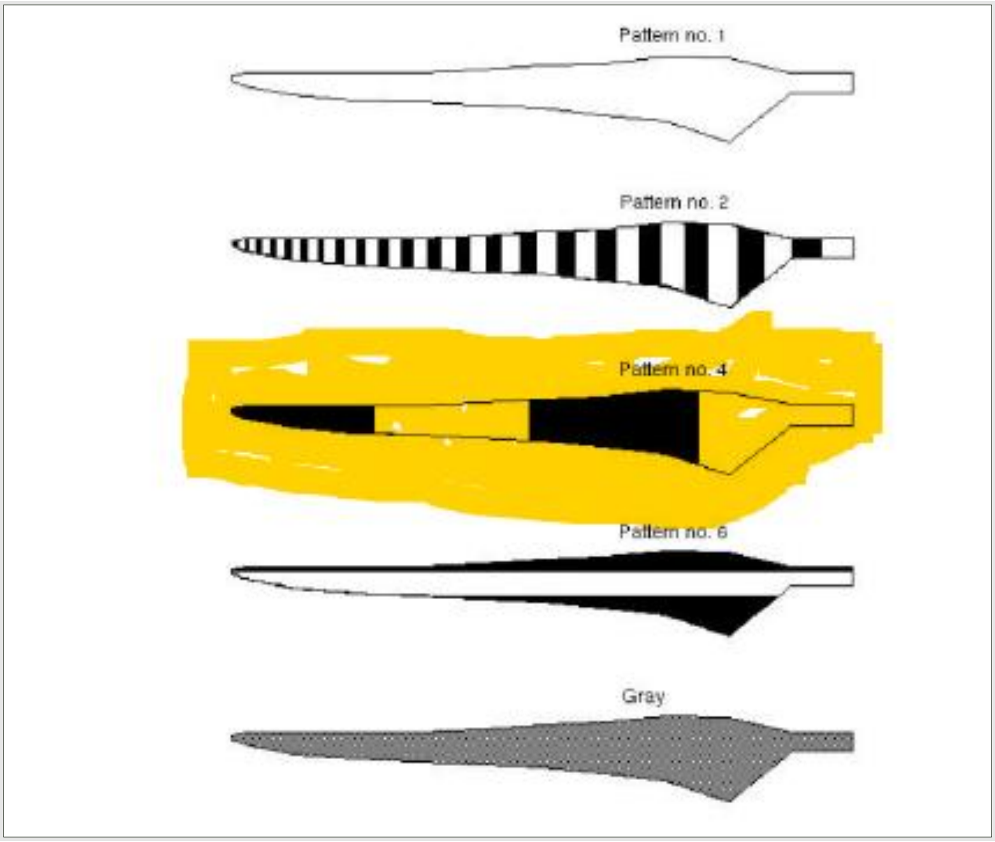

Figure 8: Pattern no.4 is the recommended pattern for blade painting at the WEF

8.2 Construction phase

- Construction activity should be restricted to the immediate footprint of the infrastructure, and in particular to the proposed road network. Access to the remainder of the site should be strictly controlled to prevent unnecessary disturbance of SCC.
- Removal of vegetation must be restricted to a minimum.
- Construction of new roads should only be considered if existing roads cannot be upgraded.
- Care should be taken not to create habitat for prey species that could draw priority raptors into the area and expose them to collision risk. Rock piles must be removed or covered and compacted with topsoil to prevent them from becoming habitat for Rock Hyrax (Dassie).

8.3 Operational phase

- A programme of observer-based Shutdown on Demand to reduce potential SCC turbine collisions must be implemented for the whole wind farm. Trigger species are the following: Verreaux's Eagle, Martial Eagle, Black Stork, Lanner Falcon, Tawny Eagle, Cape Vulture and White-backed Vulture. The details of the SdoD (number of observation points, training of observers and scheduled shifts) must be determined in consultation with the avifaunal specialist. The SdoD must be in place to commence on the first day of commercial operation.
- In addition to the SdoD, a system of automated curtailment of the highest risk turbines must be implemented for those times of day and varied seasonally when flight activity is most likely to happen. Based on the analysis of flight data as explained in Section 7, the following are recommended:
    - Turbines 2, 6, 14, 15, 16, 17, 18, 19 must be curtailed (see Figure 9 for the location of the turbines). Turbines were identified based on proximity to Verreaux's Eagle nests, and observed flight activity.
    - Curtailment threshold for summer and autumn (1 November to 31 May): 80% or higher probability of flying.
    - Curtailment threshold for winter and spring (1 June to 31 October): 60% or higher probability of flying. The lower threshold is to reduce the likelihood of impact on dependent chicks/fledglings.
- Vehicle and pedestrian access to the site should be controlled and restricted to access roads to prevent unnecessary disturbance of SCC.
- Formal operational monitoring should be resumed once the turbines have been constructed, as per the most recent edition (2015) of the best practice guidelines (Jenkins *et al.* 2011). The exact time when post-construction monitoring should commence, will depend on the construction schedule, and will be agreed upon with the site operator once these timelines and a commercial operational date have been finalised.
- As a minimum, operational monitoring should be undertaken for the first five years of operation, and then repeated again every five years thereafter for the operational lifetime of the facility. The exact scope and nature of the post-construction monitoring will be determined on an ongoing basis by the results of the monitoring through a process of adaptive management.
- Depending on the results of the monitoring, a range of mitigation measures will have to be considered if the impact on mortality turns out to be significant, including expanding curtailment to additional problem turbines during high-risk periods.

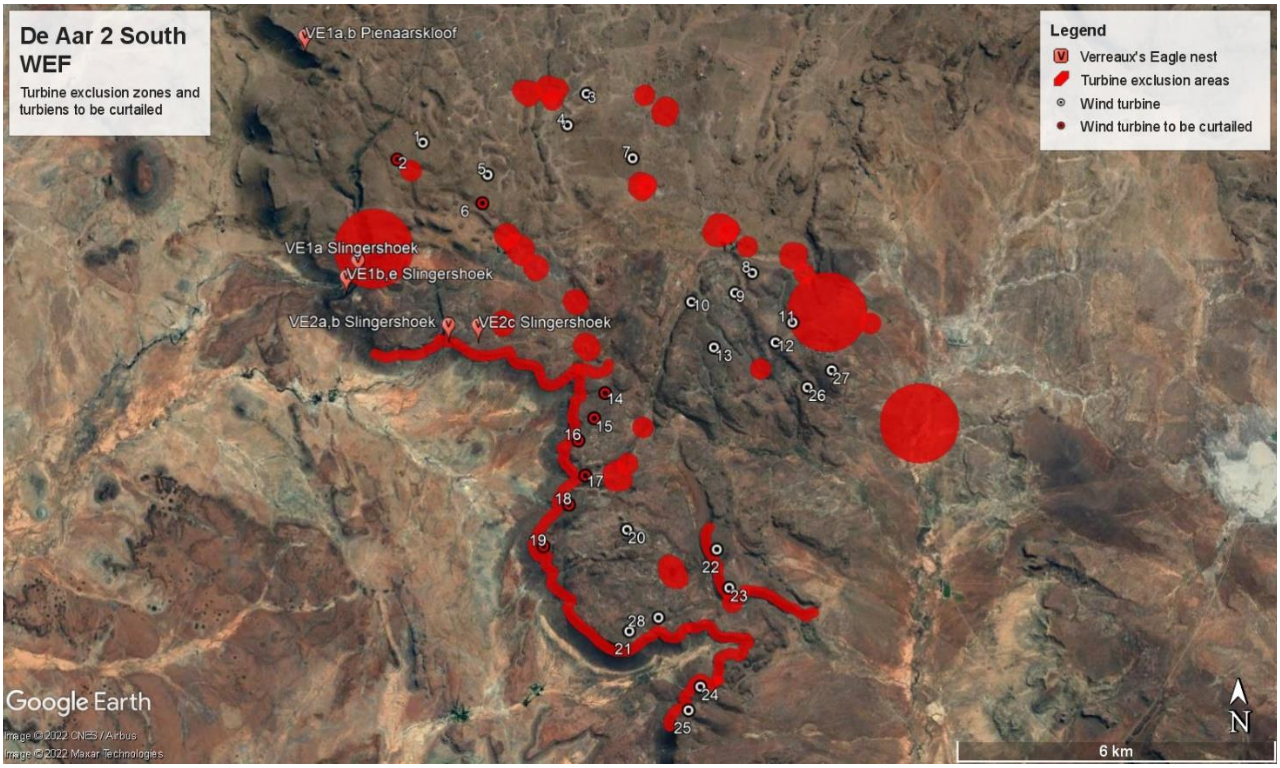

Figure 9: The proposed turbine exclusion zones Jackal Buzzard nests, boreholes, dams and escarpment edge, and turbines to be curtailed.

9 CONCLUSION AND IMPACT STATEMENT

The De Aar 2 South Wind Energy Facility was authorised in 2013 for a total of 103 turbines. Since then, various amendments had been applied for and granted, and the currently authorised layout comprises 61 turbines. It is now proposed to reduce this to a total of 26 turbines, which translates to a further reduction of 57.3% in the number of turbines and as a result, a significant reduction in the estimated collision risk for Verreaux's Eagle, the primary species of conservation concern at the proposed WEF.

The current turbine layout has been assessed as the most conservative layout possible in terms of avoiding VERA high risk zones, in contrast to the previous layout which was authorized prior to the release of the VERA model and Verreaux Eagle guidelines. Additionally, in order to substantially reduce the risk of collision for priority species, including Verreaux's Eagle, over and above the reduction of the total number of turbines, the applicant has committed to various additional mitigation measures. These are Shutdown on Demand (SDoD) for the entire WEF, automatic curtailment of selected turbines under certain high-risk conditions, the painting of one blade red on all turbines, and turbine exclusion zones for high-risk areas (priority species nests, the escarpment edge, dams and drainage lines).

It is recommended that the lay-out is approved, subject to the implementation of the mitigation measures as detailed in this report, to be included in the updated Environmental Management Programme (EMPr).

10 REFERENCES

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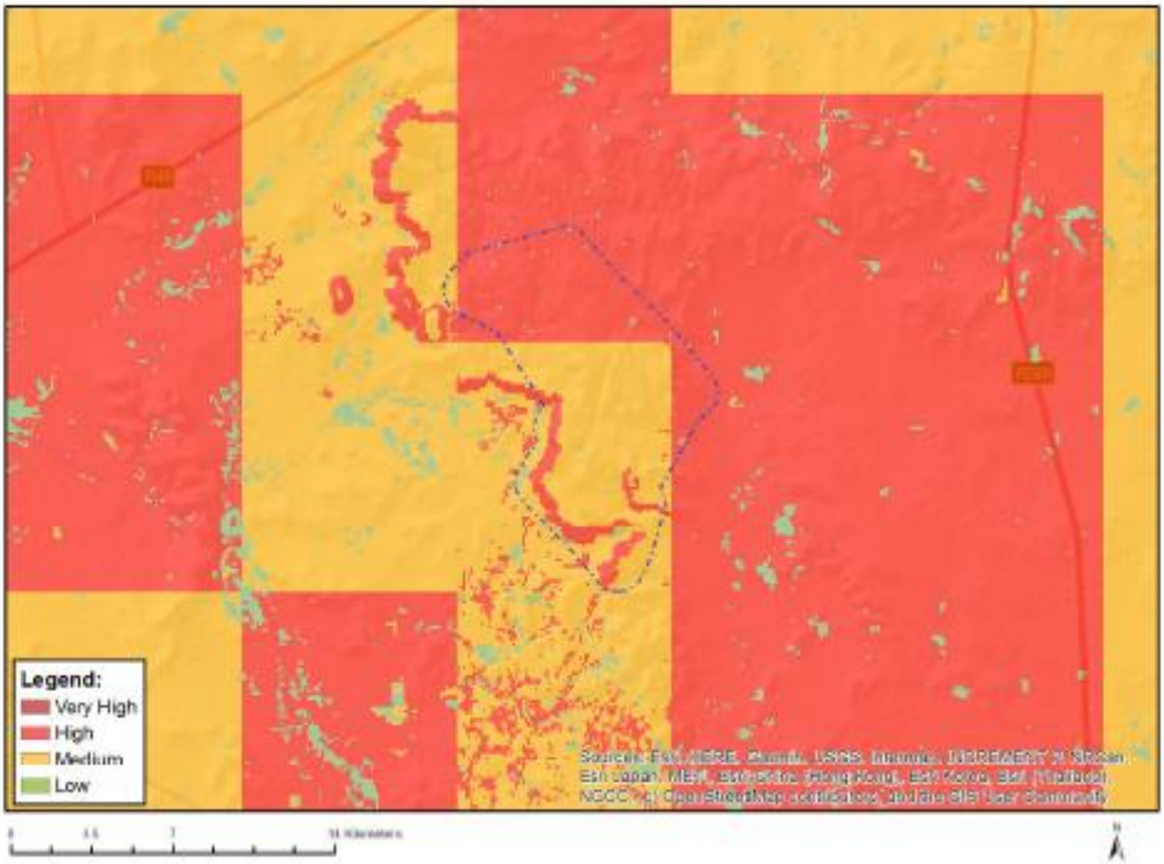
APPENDIX 1: DFFE SCREENING REPORT

MAP OF RELATIVE ANIMAL SPECIES THEME SENSITIVITY



Where only a sensitive plant unique number or sensitive animal unique number is provided in the screening report and an assessment is required, the environmental assessment practitioner (EAP) or specialist is required to email SANBI at eiadatarequests@sanbi.org.za listing all sensitive species with their unique identifiers for which information is required. The name has been withheld as the species may be prone to illegal harvesting and must be protected. SANBI will release the actual species name after the details of the EAP or specialist have been documented.

Very High sensitivity	High sensitivity	Medium sensitivity	Low sensitivity
	X		

Sensitivity Features:

Sensitivity	Feature(s)
High	Aves-Neotis ludwigii
High	Aves-Falco biarmicus
High	Aves-Aquila rapax
High	Aves-Aquila verreauxii
Low	Subject to confirmation
Medium	Aves-Ciconia nigra
Medium	Aves-Neotis ludwigii

APPENDIX 2: BIRD HABITAT

Figure 1: Typical Grassy Karoo vegetation on the plateau at the project site.

Figure 2: A dam on the plateau at the project site.

Figure 3: South-facing cliffs along the escarpment south of the project site with two Verreaux's Eagle nests.

Figure 4: A Verreaux's Eagle nest in a high voltage line at the project site.

APPENDIX 3: SPECIES LIST PRE-CONSTRUCTION MONITORING 2013 – 2014

Priority Species	
African Fish-Eagle	*Haliaeetus vocifer*
African Harrier-Hawk	*Polyboroides typus*
Amur Falcon	*Falco amurensis*
Black Stork	*Ciconia nigra*
Black-chested Snake Eagle	*Circaetus pectoralis*
Blue Korhaan	*Eupodotis caerulescens*
Blue Crane	*Anthropoides paradiseus*
Booted Eagle	*Aquila pennatus*
Grey-winged Francolin	*Scleroptila africanus*
Jackal Buzzard	*Buteo rufofuscus*
Karoo Korhaan	*Eupodotis vigorsii*
Kori Bustard	*Ardeotis kori*
Lanner Falcon	*Falco biarmicus*
Lesser Kestrel	*Falco naumanni*
Northern Black Korhaan	*Afrotis afraoides*
Ludwig's Bustard	*Neotis ludwigii*
Rufous-chested Sparrowhawk	*Accipiter rufiventris*
Secretarybird	*Sagittarius serpentarius*
Peregrine Falcon	*Falco peregrinus*
Sclater's Lark	*Spizocorys sclateri*
Southern Pale Chanting Goshawk	*Melierax canorus*
Steppe Buzzard	*Buteo vulpinus*
Tawny Eagle	*Aquila rapax*
Verreaux's Eagle	*Aquila verreauxii*
Non-Priority Species	
Acacia Pied Barbet	*Tricholaema leucomelas*
African Black Swift	*Apus barbatus*
African Pipit	*Anthus cinnamomeus*
African Quailfinch	*Ortygospiza atricollis*
African Red-eyed Bulbul	*Pycnonotus nigricans*
African Rock Pipit	*Anthus crenatus*
Ant-eating Chat	*Myrmecocichla formicivora*
Barn Swallow	*Hirundo rustica*
Black-chested Prinia	*Prinia flavicans*
Black-headed Canary	*Serinus alario*
Black-throated Canary	*Crithagra atrogularis*
Bokmakierie	*Telophorus zeylonus*
Cape Bunting	*Emberiza capensis*
Cape Glossy Starling	*Lamprotornis nitens*
Cape Penduline-tit	*Anthoscopus minutus*
Cape Robin-chat	*Cossypha caffra*
Cape Sparrow	*Passer melanurus*
Cape Turtle-dove	*Streptopelia capicola*
Cape Wagtail	*Motacilla capensis*

Non-Priority Species cont.	
Cape Weaver	*Ploceus capensis*
Chestnut-vented Tit-babbler	*Parisoma subcaeruleum*
Cinnamon-breasted Bunting	*Emberiza tahapisi*
Common Fiscal	*Lanius collaris*
Common Swift	*Apus apus*
Crowned Lapwing	*Vanellus coronatus*
Desert Cisticola	*Cisticola aridulus*
Dusky Sunbird	*Cinnyris fuscus*
Eastern Clapper Lark	*Mirafra [apiata] fasciolata*
Egyptian Goose	*Alopochen aegyptiaca*
Fairy Flycatcher	*Stenostira scita*
Familiar Chat	*Cercomela familiaris*
Fiscal Flycatcher	*Sigelus silens*
Greater Striped Swallow	*Hirundo cucullata*
Green-winged Pytilia	*Pytilia melba*
Grey Heron	*Ardea cinerea*
Grey Tit	*Parus afer*
Grey-backed Cisticola	*Cisticola subruficapilla*
Ground Woodpecker	*Geocolaptes olivaceus*
Hadeda Ibis	*Bostrychia hagedash*
Helmeted Guineafowl	*Numida meleagris*
House Sparrow	*Passer domesticus*
Karoo Chat	*Cercomela schlegelii*
Karoo Long-billed Lark	*Certhilauda subcoronata*
Karoo Prinia	*Prinia maculosa*
Karoo Scrub-robin	*Cercotrichas coryphoeus*
Karoo Thrush	*Turdus smithi*
Large-billed Lark	*Galerida magnirostris*
Lark-like Bunting	*Emberiza impetuani*
Laughing Dove	*Streptopelia senegalensis*
Layard's Tit-babbler	*Parisoma layardi*
Long-billed Crombec	*Sylvietta rufescens*
Long-billed Pipit	*Anthus similis*
Mountain Wheatear	*Oenanthe monticola*
Namaqua Sandgrouse	*Pterocles namaqua*
Neddicky	*Cisticola fulvicapilla*
Orange River White-eye	*Zosterops pallidus*
Pale-winged Starling	*Onychognathus nabouroup*
Pied Crow	*Corvus albus*
Pied Starling	*Spreo bicolor*
Plain-backed Pipit	*Anthus leucophrys*
Pririt Batis	*Batis pririt*
Red-capped Lark	*Calandrella cinerea*
Red-faced Mousebird	*Urocolius indicus*
Rufous-eared Warbler	*Malcorus pectoralis*
Sabota Lark	*Calendulauda sabota*
Sickle-winged Chat	*Cercomela sinuata*

Non-Priority Species cont.	
South African Shelduck	*Tadorna cana*
Southern Double-collared Sunbird	*Cinnyris chalybeus*
Southern Masked-weaver	*Ploceus velatus*
Speckled Pigeon	*Columba guinea*
Spike-heeled Lark	*Chersomanes albofasciata*
Three-banded Plover	*Charadrius tricollaris*
White-backed Mousebird	*Colius colius*
White-rumped Swift	*Apus caffer*
White-throated Canary	*Crithagra albogularis*
Yellow Canary	*Crithagra flaviventris*
Yellow-bellied Eremomela	*Eremomela icteropygialis*

APPENDIX 4: CURRICULUM VITAE

Expertise of Specialist

Curriculum vitae: Chris van Rooyen

Profession/Specialisation	:	Avifaunal Specialist
Highest Qualification	:	BA LLB
Nationality	:	South African
Years of experience	:	26 years

Key Experience

Chris van Rooyen has 26 years' experience in the assessment of avifaunal interactions with industrial infrastructure. He was employed by the Endangered Wildlife Trust as head of the Eskom-EWT Strategic Partnership from 1996 to 2007, which has received international acclaim as a model of co-operative management between industry and natural resource conservation. He is an acknowledged global expert in this field and has consulted in South Africa, Namibia, Botswana, Lesotho, New Zealand, Texas, New Mexico and Florida. He also has extensive project management experience and he has received several management awards from Eskom for his work in the Eskom-EWT Strategic Partnership. He is the author and/or co-author of 17 conference papers, co-author of two book chapters, several research reports and the current best practice guidelines for avifaunal monitoring at wind farm sites. He has completed around 130 power line assessments; and has to date been employed as specialist avifaunal consultant on more than 50 renewable energy generation projects. He has also conducted numerous risk assessments on existing power lines infrastructure. He also works outside the electricity industry and he has done a wide range of bird impact assessment studies associated with various residential and industrial developments. He serves on the Birds and Wind Energy Specialist Group which was formed in 2011 to serve as a liaison body between the ornithological community and the wind industry.

Key Project Experience

Bird Impact Assessment Studies and avifaunal monitoring for wind-powered generation facilities:

1. Eskom Klipheuwel Experimental Wind Power Facility, Western Cape
2. Mainstream Wind Facility Jeffreys Bay, Eastern Cape (EIA and monitoring)
3. Biotherm, Swellendam, (Excelsior), Western Cape (EIA and monitoring)
4. Biotherm, Napier, (Matjieskloof), Western Cape (pre-feasibility)
5. Windcurrent SA, Jeffreys Bay, Eastern Cape (2 sites) (EIA and monitoring)
6. Caledon Wind, Caledon, Western Cape (EIA)
7. Innowind (4 sites), Western Cape (EIA)
8. Renewable Energy Systems (RES) Oyster Bay, Eastern Cape (EIA and monitoring)
9. Oelsner Group (Kerriefontein), Western Cape (EIA)
10. Oelsner Group (Langefontein), Western Cape (EIA)
11. InCa Energy, Vredendal Wind Energy Facility Western Cape (EIA)
12. Mainstream Loeriesfontein Wind Energy Facility (EIA and monitoring)
13. Mainstream Noupoort Wind Energy Facility (EIA and monitoring)
14. Biotherm Port Nolloth Wind Energy Facility (Monitoring)
15. Biotherm Laingsburg Wind Energy Facility (EIA and monitoring)
16. Langhoogte Wind Energy Facility (EIA)
17. Vleesbaai Wind Energy Facility (EIA and monitoring)
18. St. Helena Bay Wind Energy Facility (EIA and monitoring)
19. Electrawind, St Helena Bay Wind Energy Facility (EIA and monitoring)
20. Electrawind, Vredendal Wind Energy Facility (EIA)
21. SAGIT, Langhoogte and Wolseley Wind Energy facilities
22. Renosterberg Wind Energy Project – 12-month preconstruction avifaunal monitoring project
23. De Aar – North (Mulilo) Wind Energy Project – 12-month preconstruction avifaunal monitoring project
24. De Aar – South (Mulilo) Wind Energy Project – 12-month bird monitoring
25. Namies – Aggenys Wind Energy Project – 12-month bird monitoring
26. Pofadder - Wind Energy Project – 12-month bird monitoring
27. Dwarsrug Loeriesfontein - Wind Energy Project – 12-month bird monitoring
28. Waaihoek – Utrecht Wind Energy Project – 12-month bird monitoring
29. Amathole – Butterworth Utrecht Wind Energy Project – 12-month bird monitoring & EIA specialist
30. PhezukomEmaya and San Kraal Wind Energy Projects 12-month bird monitoring & EIA specialist study (Innowind)
31. De Aar 2 South Wind Energy Facility 12-month bird monitoring & EIA specialist study (Mainstream)
32. Leeuwdraai Wind Energy Facility 12-month bird monitoring & EIA specialist study (Mainstream)
33. De Aar 2 South Wind Energy Facility 12-month bird monitoring (Mainstream)
34. Maralla Wind Energy Facility 12-month bird monitoring & EIA specialist study (Biotherm)
35. Esizayo Wind Energy Facility 12-month bird monitoring & EIA specialist study (Biotherm)
36. Humansdorp Wind Energy Facility 12-month bird monitoring & EIA specialist study (Cennergi)
37. Aletta Wind Energy Facility 12-month bird monitoring & EIA specialist study (Biotherm)
38. Eureka Wind Energy Facility 12-month bird monitoring & EIA specialist study (Biotherm)
39. Makambako Wind Energy Faclity (Tanzania) 12-month bird monitoring & EIA specialist study (Windlab)
40. R355 Wind Energy Facility 12-month bird monitoring (Mainstream)
41. Groenekloof Wind Energy Facility 12-month bird monitoring & EIA specialist study (Mulilo)
42. Tsitsikamma Wind Energy Facility 24-months post-construction monitoring (Cennergi)
43. Noupoort Wind Energy Facility 24-months post-construction monitoring (Mainstream)
44. Kokerboom Wind Energy Facility 12-month bird monitoring & EIA specialist study (Business Venture Investments)
45. Kuruman Wind Energy Facility 12-month bird monitoring & EIA specialist study (Mulilo)
46. Dassieklip Wind Energy Facility 3 years post-construction monitoring (Biotherm)
47. Loeriesfontein 2 Wind Energy Facility 2 years post-construction monitoring (Mainstream)
48. Khobab Wind Energy Facility 2 years post-construction monitoring (Mainstream)
49. Excelsior Wind Energy Facility 18 months construction phase monitoring (Biotherm)

50. Boesmansberg Wind Energy Facility 12-months pre-construction bird monitoring (juwi)
51. Mañhica Wind Energy Facility, Mozambique, 12-months pre-construction monitoring (Windlab)
52. Kwagga Wind Energy Facility, De Aar 2 South, 12-months pre-construction monitoring (ABO)
53. Pienaarspoort Wind Energy Facility, Touws River, Western Cape, 12-months pre-construction monitoring (ABO).

Bird Impact Assessment Studies for Solar Energy Plants:

1. Concentrated Solar Power Plant, Upington, Northern Cape.
2. Globeleq De Aar and Droogfontein Solar PV Pre- and Post-construction avifaunal monitoring
3. JUWI Kronos PV project, Copperton, Northern Cape
4. Sand Draai CSP project, Groblershoop, Northern Cape
5. Biotherm Helena PV Project, Copperton, Northern Cape
6. Biotherm Letsiao CSP Project, Aggeneys, Northern Cape
7. Biotherm Enamandla PV Project, Aggeneys, Northern Cape
8. Biotherm Sendawo PV Project, Vryburg, North-West
9. Biotherm Tlisitseng PV Project, Lichtenburg, North-West
10. JUWI Hotazel Solar Park Project, Hotazel, Northern Cape
11. Veld Solar One Project, Aggeneys, Northern Cape
12. Brypaal Solar Power Project, Kakamas, Northern Cape
13. ABO Vryburg 1,2,3 Solar PV Project, Vryburg, North-West
14. NamPower CSP Facility near Arandis, Namibia
15. Dayson Klip PV Facility near Upington, Northern Cape
16. Geelkop PV Facility near Upington, Northern Cape

Bird Impact Assessment Studies for the following overhead line projects:

1. Chobe 33kV Distribution line
2. Athene - Umfolozi 400kV
3. Beta-Delphi 400kV
4. Cape Strengthening Scheme 765kV
5. Flurian-Louis-Trichardt 132kV
6. Ghanzi 132kV (Botswana)
7. Ikaros 400kV
8. Matimba-Witkop 400kV
9. Naboomspruit 132kV
10. Tabor-Flurian 132kV
11. Windhoek - Walvisbaai 220 kV (Namibia)
12. Witkop-Overyssel 132kV
13. Breyten 88kV
14. Adis-Phoebus 400kV
15. Dhuva-Janus 400kV
16. Perseus-Mercury 400kV
17. Gravelotte 132kV
18. Ikaros 400 kV
19. Khanye 132kV (Botswana)
20. Moropule – Thamaga 220 kV (Botswana)
21. Parys 132kV
22. Simplon –Everest 132kV
23. Tutuka-Alpha 400kV
24. Simplon-Der Brochen 132kV
25. Big Tree 132kV
26. Mercury-Ferrum-Garona 400kV
27. Zeus-Perseus 765kV
28. Matimba B Integration Project
29. Caprivi 350kV DC (Namibia)
30. Gerus-Mururani Gate 350kV DC (Namibia)
31. Mmamabula 220kV (Botswana)
32. Steenberg-Der Brochen 132kV
33. Venetia-Paradise T 132kV
34. Burgersfort 132kV
35. Majuba-Umfolozi 765kV
36. Delta 765kV Substation
37. Braamhoek 22kV
38. Steelpoort Merensky 400kV
39. Mmamabula Delta 400kV
40. Delta Epsilon 765kV
41. Gerus-Zambezi 350kV DC Interconnector: Review of proposed avian mitigation measures for the Okavango and Kwando River crossings
42. Giyani 22kV Distribution line
43. Liqhobong-Kao 132/11kV distribution power line, Lesotho
44. 132kV Leslie – Wildebeest distribution line
45. A proposed new 50 kV Spoornet feeder line between Sishen and Saldanha
46. Cairns 132kv substation extension and associated power lines
47. Pimlico 132kv substation extension and associated power lines
48. Gyani 22kV
49. Matafin 132kV
50. Nkomazi_Fig Tree 132kV
51. Pebble Rock 132kV
52. Reddersburg 132kV

53. Thaba Combine 132kV
54. Nkomati 132kV
55. Louis Trichardt – Musina 132kV
56. Endicot 44kV
57. Apollo Lepini 400kV
58. Tarlton-Spring Farms 132kV
59. Kuschke 132kV substation
60. Bendstore 66kV Substation and associated lines
61. Kuiseb 400kV (Namibia)
62. Gyani-Malamulele 132kV
63. Watershed 132kV
64. Bakone 132kV substation
65. Eerstegoud 132kV LILO lines
66. Kumba Iron Ore: SWEP - Relocation of Infrastructure
67. Kudu Gas Power Station: Associated power lines
68. Steenberg Booysendal 132kV
69. Toulon Pumps 33kV
70. Thabatshipi 132kV
71. Witkop-Silica 132kV
72. Bakubung 132kV
73. Nelsriver 132kV
74. Rethabiseng 132kV
75. Tilburg 132kV
76. GaKgapane 66kV
77. Knobel Gilead 132kV
78. Bochum Knobel 132kV
79. Madibeng 132kV
80. Witbank Railway Line and associated infrastructure
81. Spencer NDP phase 2 (5 lines)
82. Akanani 132kV
83. Hermes-Dominion Reefs 132kV
84. Cape Pensinsula Strengthening Project 400kV
85. Magalakwena 132kV
86. Benficosa 132kV
87. Dithabaneng 132kV
88. Taunus Diepkloof 132kV
89. Taunus Doornkop 132kV
90. Tweedracht 132kV
91. Jane Furse 132kV
92. Majeje Sub 132kV
93. Tabor Louis Trichardt 132kV
94. Riversong 88kV
95. Mamatsekele 132kV
96. Kabokweni 132kV
97. MDPP 400kV Botswana
98. Marble Hall NDP 132kV
99. Bokmakiere 132kV Substation and LILO lines
100. Styldrift 132kV
101. Taunus – Diepkloof 132kV
102. Bighorn NDP 132kV
103. Waterkloof 88kV
104. Camden – Theta 765kV
105. Dhuva – Minerva 400kV Diversion
106. Lesedi –Grootpan 132kV
107. Waterberg NDP
108. Bulgerivier – Dorset 132kV
109. Bulgerivier – Toulon 132kV
110. Nokeng-Fluorspar 132kV
111. Mantsole 132kV
112. Tshilamba 132kV
113. Thabamoopo - Tshebela – Nhlovuko 132kV
114. Arthurseat 132kV
115. Borutho 132kV MTS
116. Volspruit - Potgietersrus 132kV
117. Neotel Optic Fibre Cable Installation Project: Western Cape
117. Matla-Glockner 400kV
118. Delmas North 44kV
119. Houwhoek 11kV Refurbishment
120. Clau-Clau 132kV
121. Ngwedi-Silwerkrans 134kV
122. Nieuwehoop 400kV walk-through
123. Booysendal 132kV Switching Station
124. Tarlton 132kV
125. Medupi - Witkop 400kV walk-through
126. Germiston Industries Substation
127. Sekgame 132kV
128. Botswana – South Africa 400kV Transfrontier Interconnector
129. Syferkuil – Rampheri 132kV
130. Queens Substation and associated 132kV powerlines
131. Oranjemond 400kV Transmission line
132. Aries – Helios – Juno walk-down

133. Kuruman Phase 1 and 2 Wind Energy facilities 132kV Grid connection
134. Transnet

Bird Impact Assessment Studies for the following residential and industrial developments:

1. Lizard Point Golf Estate
2. Lever Creek Estates
3. Leloko Lifestyle Estates
4. Vaaloewers Residential Development
5. Clearwater Estates Grass Owl Impact Study
6. Sommerset Ext. Grass Owl Study
7. Proposed Three Diamonds Trading Mining Project (Portion 9 and 15 of the Farm Blesbokfontein)
8. N17 Section: Springs To Leandra –"Borrow Pit 12 And Access Road On (Section 9, 6 And 28 Of The Farm Winterhoek 314 Ir)
9. South African Police Services Gauteng Radio Communication System: Portion 136 Of The Farm 528 Jq, Lindley.
10. Report for the proposed upgrade and extension of the Zeekoegat Wastewater Treatment Works, Gauteng.
11. Bird Impact Assessment for Portion 265 (a portion of Portion 163) of the farm Rietfontein 189-JR, Gauteng.
12. Bird Impact Assessment Study for Portions 54 and 55 of the Farm Zwartkop 525 JQ, Gauteng.
13. Bird Impact Assessment Study Portions 8 and 36 of the Farm Nooitgedacht 534 JQ, Gauteng.
14. Shumba's Rest Bird Impact Assessment Study
15. Randfontein Golf Estate Bird Impact Assessment Study
16. Zilkaatsnek Wildlife Estate
17. Regenstein Communications Tower (Namibia)
18. Avifaunal Input into Richards Bay Comparative Risk Assessment Study
19. Maquasa West Open Cast Coal Mine
20. Glen Erasmia Residential Development, Kempton Park, Gauteng
21. Bird Impact Assessment Study, Weltevreden Mine, Mpumalanga
22. Bird Impact Assessment Study, Olifantsvlei Cemetery, Johannesburg
23. Camden Ash Disposal Facility, Mpumalanga
24. Lindley Estate, Lanseria, Gauteng
25. Proposed open cast iron ore mine on the farm Lylyveld 545, Northern Cape
26. Avifaunal monitoring for the Sishen Mine in the Northern Cape as part of the EMPr requirements
27. Steelpoort CNC Bird Impact Assessment Study

Professional affiliations

I work under the supervision of and in association with Albert Froneman (MSc Conservation Biology) (SACNASP Zoological Science Registration number 400177/09) as stipulated by the Natural Scientific Professions Act 27 of 2003.

Chris van Rooyen
13 August 2022

Expertise of Specialist

Curriculum vitae: Albert Froneman (Pr.Sci.Nat Registration no: 400177/09)

Profession/Specialisation	:	Avifaunal Specialist
Highest Qualification	:	MSc (Conservation Biology)
Nationality	:	South African
Years of experience	:	24 years

Key Qualifications

Albert Froneman **(**Pr.Sci.Nat) has more than 24 years' experience in the management of avifaunal interactions with industrial infrastructure. He holds a M.Sc. degree in Conservation Biology from the University of Cape Town. He managed the Airports Company South Africa (ACSA) – Endangered Wildlife Trust Strategic Partnership from 1999 to 2008 which has been internationally recognized for its achievements in addressing airport wildlife hazards in an environmentally sensitive manner at ACSA's airports across South Africa. Albert is recognized worldwide as an expert in the field of bird hazard management on airports and has worked in South Africa, Swaziland, Botswana, Namibia, Kenya, Israel, and the USA. He has served as the vice chairman of the International Bird Strike Committee and has presented various papers at international conferences and workshops. At present he is consulting to ACSA with wildlife hazard management on all their airports. He also an accomplished specialist ornithological consultant outside the aviation industry and has completed a wide range of bird impact assessment studies. He has co-authored many avifaunal specialist studies and pre-construction monitoring reports for proposed renewable energy developments across South Africa. He also has vast experience in using Geographic Information Systems to analyse and interpret avifaunal data spatially and derive meaningful conclusions. Since 2009 Albert has been a registered Professional Natural Scientist (reg. nr 400177/09) with The South African Council for Natural Scientific Professions, specialising in Zoological Science.

Key Project Experience

Renewable Energy Facilities –avifaunal monitoring projects in association with Chris van Rooyen Consulting

1. Jeffrey's Bay Wind Farm – 12-months preconstruction avifaunal monitoring project
2. Oysterbay Wind Energy Project – 12-months preconstruction avifaunal monitoring project
3. Ubuntu Wind Energy Project near Jeffrey's Bay – 12-months preconstruction avifaunal monitoring project
4. Bana-ba-Pifu Wind Energy Project near Humansdorp – 12-months preconstruction avifaunal monitoring project
5. Excelsior Wind Energy Project near Caledon – 12-months preconstruction avifaunal monitoring project
6. Laingsburg Spitskopvlakte Wind Energy Project – 12-months preconstruction avifaunal monitoring project
7. Loeriesfontein Wind Energy Project Phase 1, 2 & 3 – 12-months preconstruction avifaunal monitoring project
8. Noupoort Wind Energy Project – 12-months preconstruction avifaunal monitoring project
9. Vleesbaai Wind Energy Project – 12-months preconstruction avifaunal monitoring project
10. Port Nolloth Wind Energy Project – 12-months preconstruction avifaunal monitoring project
11. Langhoogte Caledon Wind Energy Project – 12-months preconstruction avifaunal monitoring project
12. Lunsklip – Stilbaai Wind Energy Project – 12-months preconstruction avifaunal monitoring project
13. Indwe Wind Energy Project – 12-months preconstruction avifaunal monitoring project
14. Zeeland St Helena bay Wind Energy Project – 12-months preconstruction avifaunal monitoring project
15. Wolseley Wind Energy Project – 12-months preconstruction avifaunal monitoring project
16. Renosterberg Wind Energy Project – 12-months preconstruction avifaunal monitoring project
17. De Aar – North (Mulilo) Wind Energy Project – 12-months preconstruction avifaunal monitoring project (2014)
18. De Aar – South (Mulilo) Wind Energy Project – 12-months bird monitoring
19. Namies – Aggenys Wind Energy Project – 12-months bird monitoring
20. Pofadder - Wind Energy Project – 12-months bird monitoring
21. Dwarsrug Loeriesfontein - Wind Energy Project – 12-months bird monitoring
22. Waaihoek – Utrecht Wind Energy Project – 12-months bird monitoring
23. Amathole – Butterworth Utrecht Wind Energy Project – 12-months bird monitoring & EIA specialist study
24. De Aar and Droogfontein Solar PV Pre- and Post-construction avifaunal monitoring
25. Makambako Wind Energy Faclity (Tanzania) 12-month bird monitoring & EIA specialist study (Windlab)
26. R355 Wind Energy Facility 12-month bird monitoring (Mainstream)
27. Groenekloof Wind Energy Facility 12-month bird monitoring & EIA specialist study (Mulilo)
28. Tsitsikamma Wind Energy Facility 24-months post-construction monitoring (Cennergi)
29. Noupoort Wind Energy Facility 24-months post-construction monitoring (Mainstream)
30. Kokerboom Wind Energy Facility 12-month bird monitoring & EIA specialist study (Business Venture Investments)
31. Kuruman Wind Energy Facility 12-month bird monitoring & EIA specialist study (Mulilo)
32. Mañhica Wind Energy Facility 12-month bird monitoring & EIA specialist study (Windlab)
33. Kwagga Wind Energy Facility, De Aar 2 South, 12-months pre-construction monitoring (ABO)
34. Pienaarspoort Wind Energy Facility, Touws River, Western Cape, 12-months pre-construction monitoring (ABO).

Bird Impact Assessment studies and / or GIS analysis:

1. Aviation Bird Hazard Assessment Study for the proposed Madiba Bay Leisure Park adjacent to Port Elizabeth Airport.
2. Extension of Runway and Provision of Parallel Taxiway at Sir Seretse Khama Airport, Botswana Bird / Wildlife Hazard Management Specialist Study
3. Maun Airport Improvements Bird / Wildlife Hazard Management Specialist Study
4. Bird Impact Assesment Study - Bird Helicopter Interaction – The Bitou River, Western Cape Province South Africa
5. Proposed La Mercy Airport – Bird Aircraft interaction specialists study using bird detection radar to assess swallow flocking behaviour
6. KwaZulu Natal Power Line Vulture Mitigation Project – GIS analysis
7. Perseus-Zeus Powerline EIA – GIS Analysis
8. Southern Region Pro-active GIS Blue Crane Collision Project.
9. Specialist advisor ~ Implementation of a bird detection radar system and development of an airport wildlife hazard management and operational environmental management plan for the King Shaka International Airport
10. Matsapha International Airport – bird hazard assessment study with management recommendations
11. Evaluation of aviation bird strike risk at candidate solid waste disposal sites in the Ekurhuleni Metropolitan Municipality

12. Gateway Airport Authority Limited – Gateway International Airport, Polokwane: Bird hazard assessment; Compile a bird hazard management plan for the airport
13. Bird Specialist Study - Evaluation of aviation bird strike risk at the Mwakirunge Landfill site near Mombasa Kenya
14. Bird Impact Assessment Study - Proposed Weltevreden Open Cast Coal Mine Belfast, Mpumalanga
15. Avian biodiversity assessment for the Mafube Colliery Coal mine near Middelburg Mpumalanga
16. Avifaunal Specialist Study - SRVM Volspruit Mining project – Mokopane Limpopo Province
17. Avifaunal Impact Assessment Study (with specific reference to African Grass Owls and other Red List species) Stone Rivers Arch
18. Airport bird and wildlife hazard management plan and training to Swaziland Civil Aviation Authority (SWACAA) for Matsapha and Sikhupe International Airports
19. Avifaunal Impact Scoping & EIA Study - Renosterberg Wind Farm and Solar PV site
20. Bird Impact Assessment Study - Proposed 60 year Ash Disposal Facility near to the Kusile Power Station
21. Avifaunal pre-feasibility assessment for the proposed Montrose dam, Mpumalanga
22. Bird Impact Assessment Study – Proposed ESKOM Phantom Substation near Knysna, Western Cape
23. Habitat sensitivity map for Denham's Bustard, Blue Crane and White-bellied Korhaan in the Kouga Municipal area of the Eastern Cape Province
24. Swaziland Civil Aviation Authority – Sikhuphe International Airport – Bird hazard management assessment
25. Avifaunal monitoring – extension of Specialist Study - SRVM Volspruit Mining project – Mokopane Limpopo Province
26. Avifaunal Specialist Study – Rooikat Hydro Electric Dam – Hope Town, Northern Cape
27. The Stewards Pan Reclamation Project – Bird Impact Assessment study
28. Airports Company South Africa – Avifaunal Specialist Consultant – Airport Bird and Wildlife Hazard Mitigation

Geographic Information System analysis & maps

1. ESKOM Power line Makgalakwena EIA – GIS specialist & map production
2. ESKOM Power line Benficosa EIA – GIS specialist & map production
3. ESKOM Power line Riversong EIA – GIS specialist & map production
4. ESKOM Power line Waterberg NDP EIA – GIS specialist & map production
5. ESKOM Power line Bulge Toulon EIA – GIS specialist & map production
6. ESKOM Power line Bulge DORSET EIA – GIS specialist & map production
7. ESKOM Power lines Marblehall EIA – GIS specialist & map production
8. ESKOM Power line Grootpan Lesedi EIA – GIS specialist & map production
9. ESKOM Power line Tanga EIA – GIS specialist & map production
10. ESKOM Power line Bokmakierie EIA – GIS specialist & map production
11. ESKOM Power line Rietfontein EIA – GIS specialist & map production
12. Power line Anglo Coal EIA – GIS specialist & map production
13. ESKOM Power line Camcoll Jericho EIA – GIS specialist & map production
14. Hartbeespoort Residential Development – GIS specialist & map production
15. ESKOM Power line Mantsole EIA – GIS specialist & map production
16. ESKOM Power line Nokeng Flourspar EIA – GIS specialist & map production
17. ESKOM Power line Greenview EIA – GIS specialist & map production
18. Derdepoort Residential Development – GIS specialist & map production
19. ESKOM Power line Boynton EIA – GIS specialist & map production
20. ESKOM Power line United EIA – GIS specialist & map production
21. ESKOM Power line Gutshwa & Malelane EIA – GIS specialist & map production
22. ESKOM Power line Origstad EIA – GIS specialist & map production
23. Zilkaatsnek Development Public Participation –map production
24. Belfast – Paarde Power line - GIS specialist & map production
25. Solar Park Solar Park Integration Project Bird Impact Assessment Study – avifaunal GIS analysis.
26. Kappa-Omega-Aurora 765kV Bird Impact Assessment Report – Avifaunal GIS analysis.
27. Gamma – Kappa 2nd 765kV – Bird Impact Assessment Report – Avifaunal GIS analysis.
28. ESKOM Power line Kudu-Dorstfontein Amendment EIA – GIS specialist & map production.
29. Proposed Heilbron filling station EIA – GIS specialist & map production
30. ESKOM Lebatlhane EIA – GIS specialist & map production
31. ESKOM Pienaars River CNC EIA – GIS specialist & map production
32. ESKOM Lemara Phiring Ohrigstad EIA – GIS specialist & map production
33. ESKOM Pelly-Warmbad EIA – GIS specialist & map production
34. ESKOM Rosco-Bracken EIA – GIS specialist & map production
35. ESKOM Ermelo-Uitkoms EIA – GIS specialist & map production
36. ESKOM Wisani bridge EIA – GIS specialist & map production
37. City of Tswane – New bulkfeeder pipeline projects x3 Map production
38. ESKOM Lebohang Substation and 132kV Distribution Power Line Project Amendment GIS specialist & map production
39. ESKOM Geluk Rural Powerline GIS & Mapping
40. Eskom Kimberley Strengthening Phase 4 Project GIS & Mapping
41. ESKOM Kwaggafontein - Amandla Amendment Project GIS & Mapping
42. ESKOM Lephalale CNC – GIS Specialist & Mapping
43. ESKOM Marken CNC – GIS Specialist & Mapping
44. ESKOM Lethabong substation and powerlines – GIS Specialist & Mapping
45. ESKOM Magopela- Pitsong 132kV line and new substation – GIS Specialist & Mapping

Professional affiliations

South African Council for Natural Scientific Professions (SACNASP) registered Professional Natural Scientist (reg. nr 400177/09) – specialist field: Zoological Science. Registered since 2009.

Signature of the Specialist

Albert Froneman
13 August 2022

APPENDIX 5: VEREAUX'S EAGLE RISK ASSESSMENT (VERA)

Verreaux's Eagle Risk Assessment
Site: DE Aar 2, Mulilo. DEFF ref: 12/12/20/2463/1/AM6
Processed on: 2020 Aug 28

Project background: Ten Verreaux's eagle nests have been located during EIA monitoring at the De Aar 2 (operational and proposed) wind energy development. This document outlines the Verreaux's Eagle Risk Assessment (VERA) modelling which has been used to predict collision risk for Verreaux's eagle at the development, using these nest locations. Two nest locations (VE4 -30.51094, 24.22694; VE10 -30.52080, 24.37513) have not been recorded as occupied since monitoring in 2013 (VE4) or at all during monitoring (VE10), thus two scenarios have been presented: Scenario 1 (Fig. 3i) includes all nest locations and Scenario 2 excludes VE4 and VE10 (Fig. 3ii). In addition, a short duration (2014-02-12 until 2014-05-06) of tracking data (n= 1122 fixes) is available for one Verreaux's eagle and has been overlaid on the map figures (Fig. 3).

Model background: The VERA model is built from 57,285 at-risk GPS fix locations from 15 Verreaux's eagles each tracked between 18–895 days each, equivalent to a total of 13.6 bird-years of tracking data. For each nest, the VERA model calculates the collision risk potential on a 90x90m resolution in a 12km buffer around the nest location, nests within 1.5km of each other are treated as alternative nests of the same pair. The model takes into account the distance from the nest, distance to all other conspecific nests within 12km of a given nest, topographic slope, elevation and distance to slope. The model gives collision risk potential as a probability (a continuous value between zero and one). Collision risk potential is then re-classified as high, medium or low using model derived (Youden) thresholds calculated by cross-validating the results on territories of tracked eagles.

Model thresholds: The impacts of using different model thresholds can be checked using predictions from tracked eagles (Fig. 1) and from operational developments where collisions have occurred (Fig. 2).

<u>High collision risk potential area:</u> The high risk area is the area predicted to be most intensively used by eagles; for tracked eagles it incorporates 73% of the area used (Fig.1 – dashed line). 50% (7 of 14) of the known collisions have occurred in this area (Fig. 2 – dashed line). Development of wind turbines should not occur in these areas.

<u>Medium collision risk potential:</u> The medium risk area is also likely to be used by eagles; for tracked eagles it represents an additional 12% of the area used, thus protection of the high and medium risk areas can be expected to offer protection to 85% of an eagle's home range (Fig. 1 – dotted line). 79% (11 of 14) of the known collisions have occurred in the medium and high risk areas combined (Fig. 2 – dotted line). Development in this area should be avoided where possible and only proceed with additional specialist input.

<u>Low collision risk potential:</u> The low risk area (with ordinal risk predictions less 0.13) is the area predicted to be least used by eagles and development here poses the lowest risk to eagles within the 12km buffer. However this area is not without risk, and three collisions have occurred at operational wind energy sites, within areas that would be predicted to be low risk.

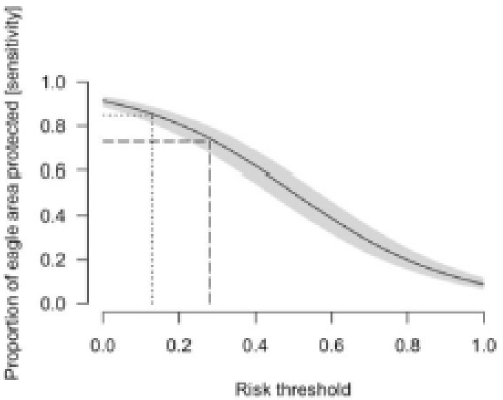


Figure 1. Proportion of the area used by tracked Verreaux's eagles which is protected along a gradient of thresholds used to classify collision risk, this is calculated on a 90x90 m cell basis and is equivalent to the model 'sensitivity'. Lines represent two risk thresholds; i.e. if a risk threshold of 0.13 is applied (dotted line) then 0.85 of the area used by eagles is protected (covered by medium and high risk areas). if a higher threshold of 0.28 (dashed line) is applied then 0.73 of the area used by eagles is protected (covered by high risk only).

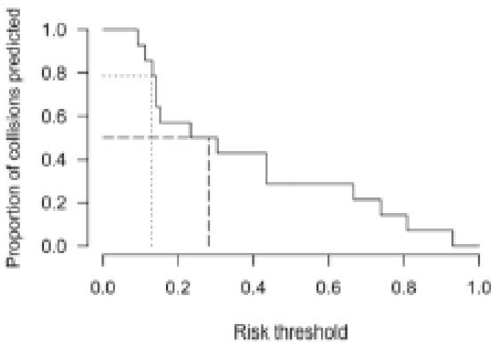


Figure 2. Proportion of known Verreaux's eagles collisions (n=14) correctly predicted by the model along a gradient of risk thresholds. 0.79 collisions were above the medium risk threshold (dotted line), while 0.5 were in the area considered to be high risk (dashed line).

Model results: The collision risk estimates are dependent on accurate information on nest locations and will only be reliable if all nest locations have been found and provided for this analysis. Recommendations are intended to minimise collision risk to resident adult eagles but will not be relevant to non-breeding eagles using the area. The modelling methods used here are currently being compiled for scientific publication and may be subject to further refinements. The final published VERA model may differ from the one used here, but it is unlikely to significantly change the overall patterns of risk outlined in this report. Risk classes of the proposed individual turbines (Fig. 3) were extracted from an 80 m radius buffer around the point location of each turbine (i.e. the turbine blade footprint).

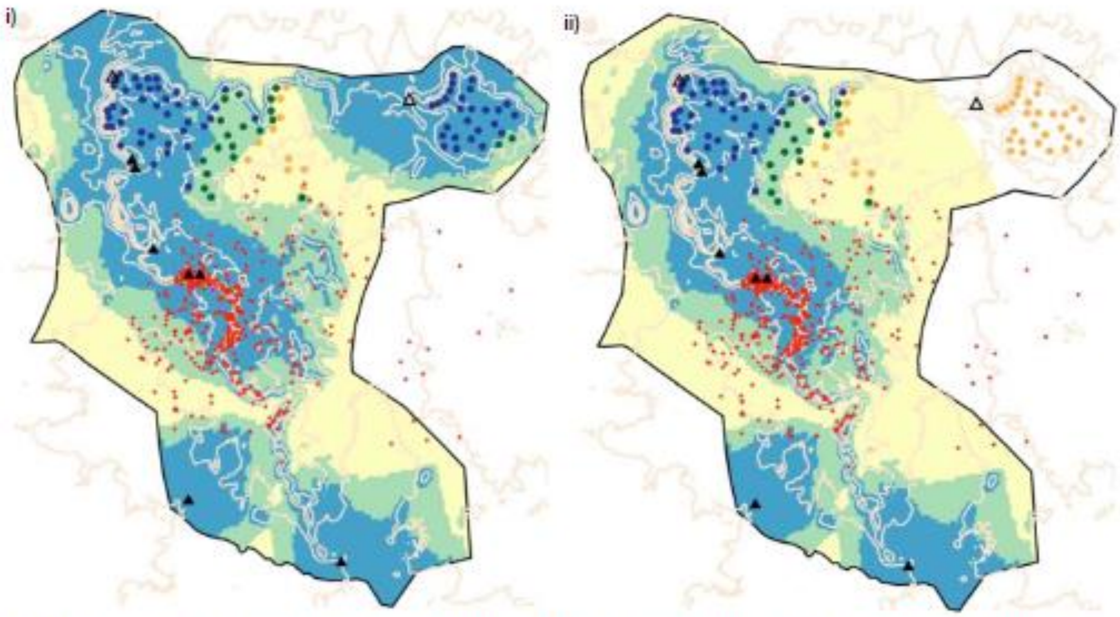


Figure 3. Verreaux's eagle collision risk potential for De Aar 2 wind energy development. Nest locations are shown by triangles, VE4 and VE10 which are likely unoccupied are empty triangles [Δ], while likely occupied nests are filled triangles [▲]. i) Includes all nest locations in the modelling and ii) does not includes VE4 and VE10 in the modelling. Collision risk potential is represented in high risk [blue]; medium risk [green] and low risk [yellow]. White is either more than 12 km from a known nest or outside of the development footprint. Operational turbine locations are also colored by risk category; i) Scenario 1 turbine risk: high risk (n=66); medium risk (n=20); low risk (n=10). ii) Scenario 2 turbine risk: high risk (n=42); medium risk (n=15); low risk (n=39). Tracking data from one Verreaux's eagle (n= 1122 fixes), fitted with a transmitter for a short duration (2014-02-12 until 2014-05-06) is show in red.

APPENDIX 6: BLADE PAINTING AS MITIGATION STRATEGY

Coloured-blade mitigation at Africa's wind farms to reduce eagle deaths: implementation, challenges and solutions

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Introduction

The recent publication of the ground-breaking experimental study of black-blade mitigation at an operational wind farms in Norway (May et al. 2020) has opened up a new and exciting method that could reduce avian fatalities at wind farms in other, more biologically diverse area of the world where renewable energies are being rolled out. This contribution :

- Explains what black/coloured-blade mitigation is
- Outlines the theory behind the black-blade mitigation
- Outlines the field test of the idea
- Summarises the challenges for rolling it out in Africa
- Assesses what it could mean for reducing raptor fatalities in Africa

Figure 1: The single black-blade in the process of being painted in situ, at the Smøla Wind Farm. Painting white blades black after they are erected is more expensive than producing them at source.

Rationale

Research around the world has shown that avian populations are declining due to climate change effects arising from increasing temperature and decreased rainfall in arid areas (www.ipcc.ch/, Thomas et al. 2004, Simmons et al. 2004, Phipps et al. 2017). In the USA, non-renewable fossil fuel energy sources are estimated to kill ~14.5 million birds annually, whereas green wind energy kills about 234 000 birds per year (Sovacool 2013, Loss et al. 2013). That is a 62-fold difference and a powerful environmental argument in support of renewable energy for our future needs. But while wind farms have many positive effects, they also pose some environmental challenges, particularly where wind farms are poorly positioned (on migration corridors for example Smallwood references).

In Africa two data sets on avian fatalities indicate that an average of 2.0 bird (adjusted) fatalities occur per MW per year in South Africa (Perold et al. 2020), and at one farm 1 raptor per month is killed of which 17% are breeding red data raptors (Simmons and Martins 2018). With about 2294 MW already being produced by 27 operational farms here in 2019 (energy.org.za), the cumulative impacts of South African wind farms alone are in excess of 4500 birds annually. If about 36% (>1600 birds per annum) are predicted to be raptors (Ralston-Paton et al. 2017) and about 17% (Simmons and Martins 2018) are known to be red data species, then an estimated 280 red data raptors are likely to be killed per year in South Africa in 2020. Since taller and longer-bladed turbines kill significantly more birds (Loss et al. 2013) and bats (Barclay et al. 2007) then Africa's threatened birds face increasing risks.

The need for urgent mitigations to reduce these costs is at a premium. Enter the coloured-blade mitigation.

What is coloured-blade mitigation?

This is a new mitigation technique in which one of the three white blades on a wind turbine are painted black (figure 1). About two thirds of the blade to the tip is painted this way. This is designed to increase visibility and decrease avian impacts (May et al. 2020). Since Civil Aviation in South Africa does not allow black but does allow "Signal Red" we propose that this is used in experiments here in South Africa. The amount of paint required can also be reduced by using the two-strip patterning shown in the experiments of McIsaac (see below).

Why black-blade mitigation?

Several innovative mitigation measures have recently been proposed for wind farms (flashing UV lights, automated shut-down-on demand, habitat management: May et al. 2017) and in a few cases have reduced collisions. However, developers are reticent to implement these.

The idea for **Black-blade mitigation** arose from work by Hodos (2003) who argued that a bird's retina views moving objects differently at different distances and as the bird gets close to a fast-moving object, the retinal image is moving so fast that the birds' brain can no longer process it. This was dubbed "motion smear" and means that birds approaching a fast-moving object no longer see it, with disastrous consequences. He suggested that a single coloured-blade may break up the motion smear. This is supported by recent work from Sweden (Potier et al. 2018) who show that raptors, despite their very high visual acuity, have very poor contrast abilities (poorer than humans). So, a coloured blade may be even better than a black one. So, a light (white) blade against a bright background is unlikely to be seen. But a black or coloured one is.

What is the evidence that it works?

Black-blade mitigation was field-tested by May et al. (2020) at the Smøla wind farm in 2013 in Norway over 3.5 years. On Smøla, White-tailed Eagles *Haliaeetus albicilla* are being killed at a very high rate by collision with the turbine blades. Four turbines were painted with a single black-painted blade in summer 2013. The black-painted turbines killed (i) 71% fewer total birds and (ii) 100% fewer eagles relative to unpainted blades.

Even more exciting in 2020 still no eagles have been killed at the coloured-blade turbines since 2013. In other words, no more eagles were killed in the 11-year experiment (starting 7.5 years before painting (2006-2013) and in situ 3.5 years after painting (2013-2016) (May et al.

2020). This despite 45-50 territorial pairs present on the island of Smøla (Dahl et al. 2012). The white-bladed turbines, however, are still killing birds at an average of 6 eagles per year (B. Iuell in litt.).

We see little reason why coloured blade – in the form of **Signal-red**, approved by Civil Aviation, would not work as well. This is because raptors see well in the colour spectrum (i.e. with the cones in the retina as opposed to the rods which see in black and white).

What are the visual impacts?

Discussions with wind farm managers in South Africa and Kenya suggest that visual effects are among the possible negative perceptions. We, therefore, requested the Smøla managers to supply us with images and videos of the turning blades to determine the effects.

Figure 1: The black-blade set up on a cloudy day in Norway is shown left. The black-blade (far turbine) is little different to the shadow cast by the all-white blades in the foreground © Bjorn Iuell.

The effect can be seen in the video kindly provided by Arild Soleim at www.birds-and-bats.com/specialist-studies. This shows little to no visual flicker or intrusion on the landscape from a single coloured-blade, and this concern is largely negated for all but the most sensitive human observer. It also has the effect of making the blade appear slower as one follows the black blade itself.

We argue that the benefits (no eagles killed) far outweigh the costs (initial costs to produce the coloured-blades). And once the blades are installed there will be no further costs as there are with competing mitigations (DT bird, or observer-operated shut-downs).

Black blade and Civil Aviation – white blades are not the most conspicuous

South African Civil Aviation state that white is "to provide the maximum daytime conspicuousness" However this statement was tested by McIsaac (2003) and he found that white is NOT the most conspicuous colour for either a moving blade or a stationary one

Embedded in the experiments undertaken by McIsaac's (2003) on kestrels is this very revealing graphic showing how human observers perceive the same patterns (including pure white).

Raptor Acuity and Wind-Turbine Blade Conspicuity

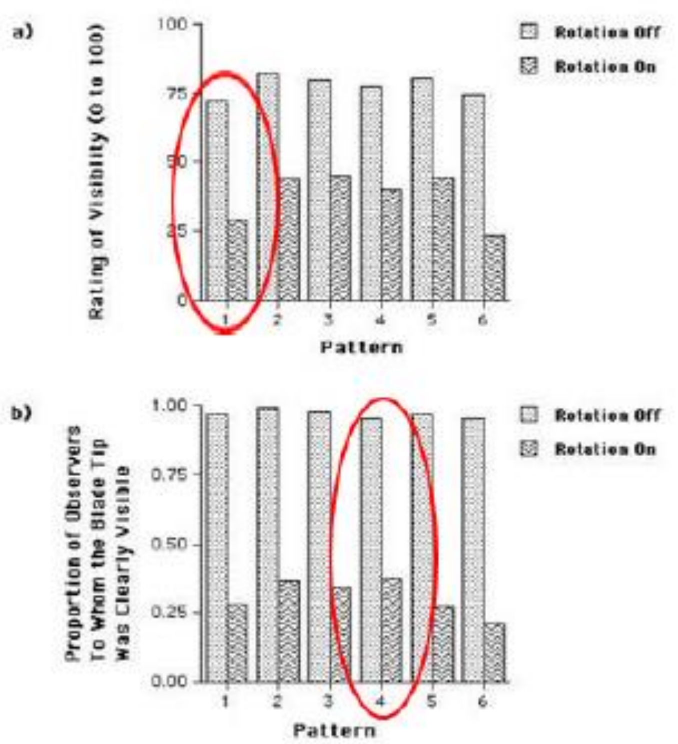

FIGURE 10. Human-perceived blade-pattern conspicuity: two-factor interactions of pattern and rotation. *These diagrams show the relationship between blade-pattern conspicuity and the effects of rotation. Illustrations of the blade patterns are presented in Fig. 9. Both blade pattern and rotation significantly affected conspicuity. Two ratings of pattern conspicuity are presented, a) full-blade visibility ratings, b) blade-tip visibility ratings.*

- **The pure white blade [pattern 1] was perceived as <u>less visible</u> by human observers than 5 of the other 6 patterns used whether the blades were spinning or not (top graph)**
- The <u>tip</u> of the pure white blade [pattern 1] was also perceived as less visible by human observers than 4 of the other 6 patterns used whether the blades were spinning or not (bottom graph)
- Like the Kestrels being tested, human observers saw patterned blades (patterns 2,3,4,5,6) better than pure white [pattern 1].

So, the CAA assumption that white is the most conspicuous colour for humans is not supported by experimentation with either raptorial birds or humans.

Patterned blades are better for both humans and raptors.

It is very important the South African Civil Aviation Authority is aware of these findings. Why? Because their guiding documents on painting of tall structures (**139.01.30 OBSTACLE LIMITATIONS AND MARKINGS OUTSIDE AERODROME OR HELIPORT (effective 1 August 2012)**) makes the following statement under section in **1.14. Wind turbine generators (Windfarms)**

- (4) Windfarm Markings (page 12 of 16)
  Wind turbines shall be painted bright white to provide the maximum daytime conspicuousness. The colours grey, blue and darker shades of white should be avoided altogether. If such colours have been used, the wind turbines shall be supplemented with daytime lighting, as required.

While this assumption that "bright white" would be most obvious to pilots and others, the experiments of McIsaac (2001) indicate that this is a false assumption. The pure white blade performed very poorly in the experiments of McIsaac (2001) and the patterned blade (No. 4 below) performed best of all.

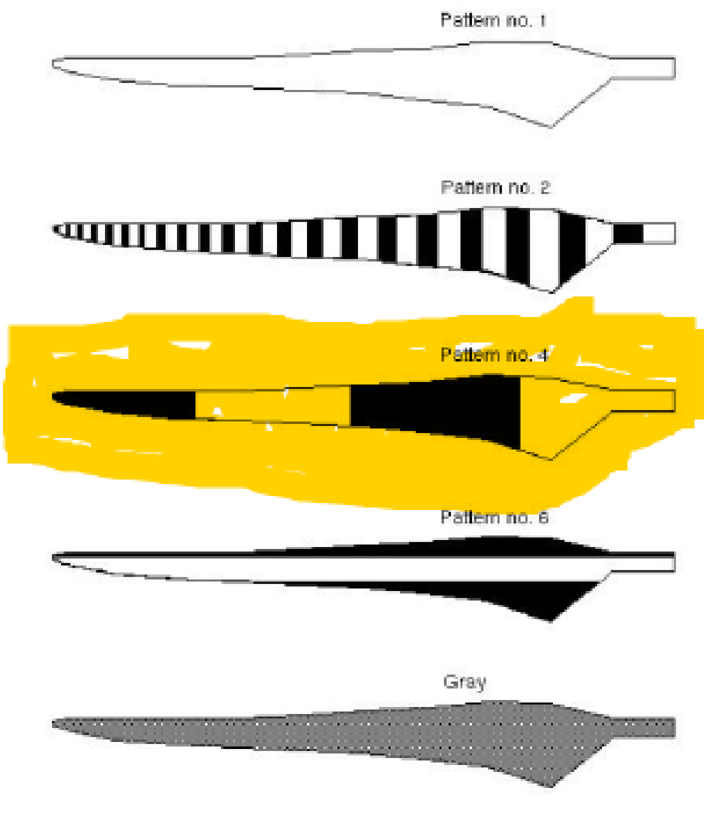

FIGURE 12. Kestrel-perceived blade-pattern conspicuity: stimulus blade patterns. *Depicted are the four black-and-white test patterns and the gray control pattern that were used to determine pattern conspicuity as perceived by a kestrel.*

Can it be applied in an African setting?

Given that eagles and raptors the world over probably see the landscape in similar ways there is a high probability that African eagles will see coloured-blades similarly well. Recent research on other raptors shows that despite their high visual acuity they see contrast more poorly than do humans (Potier, Milbus & Kelber 2019). This nicely explains why raptors take no avoiding action and are struck by white blades in the first place, and second why painting a blade black (increasing the contrast) increases the avoidance of those blades by eagles.

It also breaks up the "motion smear" researched by Hodos (2003) because he predicted a single black or coloured blade would increase the ability of birds to see movement in a set of fast-moving blade (the same effect can be seen by pilots of prop-driven planes, where one blade is painted differently). In an African setting the same can be seen on farmers' metal windmills where a blade is missing or painted on the rapidly spinning blades. Both increase the visual contrast and effect of movement.

The coloured-blade mitigation has yet to be rolled out in Africa – where it is urgently needed, given that we have over 100 species of raptors – more than any other continent (Clark and Davies 2018). Red blade tips have, however, already been used at the Ysterfontein Wind farm in the Western Cape, setting a precedent for their use elsewhere in South Africa.

Figure 2: Red-tipped turbine-blades on turbines at the Ysterfontein wind farm north west of Clanwilliam in the Western Cape (S 32° 9'23.42" E 18°49'7.10"). While these mitigations are not used in the correct single-blade configuration used by the Norwegians, they set a precedent for turbine blades to be red-painted in South Africa © RE Simmons

We have been informed that this mitigation is indeed being rolled out at the Kobe wind farm site in Japan. And there are plans for testing it in the Netherlands (Arjen Schultinga of Innogy, to Iuell Bjorn, Senior Environmental Advisor at Smøla Wind farm.)

This suggests that General Electric Renewables (GE), a manufacture of wind turbine blades, are already in the market for coloured blades. Attempts to engage with GE Renewables through the internet have proven unsuccessful despite contact with officials there.

We as avian specialist recommend the coloured-blade version of the black blade mitigation because (i) it is likely to be seen even more clearly by raptors than black, (ii) South African Civil Aviation (Lizell Stroh) in correspondence with Birdlife SA and Birds & Bats Unlimited have suggested that "signal red" would be preferable to black as it already used for marking structures such as towers, and is approved by them and (iii) the red paint may heat up less than a black blade in an African environment.

Four more aspects to consider from experience at the Smøla wind farm:

(i) It will cost a fraction to paint while the rotor blades are still on the ground instead of installed at the hub. At Smøla the painting was done with the blades up on the tower in situ and proved quite costly. The cost of painting one blade (with the crane lift and specialised personnel) was K55,000 ($5900). For all four blades and all fees and disbursements included over 2 weeks (due mainly to inclement weather) the total cost was c. K750 000 ($79 000). This would have been negligible had the blades been painted on the ground or come pre-painted (B. Iuell pers comm).

(ii) Although not an issue at Smøla, potentially a black blade may increase the blade temperature with potential consequences for blade quality and operation. We noticed that the temperature in the turbine tower at ground level with a painted tower base was high in summer (Stokke et al. 2020); there the surface area is large and more localized, and, of course, is not moving. No such effect was noticed for the black-painted turbine blades and there was no effect of any imbalance of the blades from differential heating of the black blade.

(iii) Smøla wind farm was not allowed to paint turbines which were constructed in the second construction stage due to insurance issues. Thus, guarantees with the blade manufacturers must be secured before the painting takes places – and preferably come pre-manufactured with a blade already painted red or black.

(iv) Each blade weighed 9 tonnes and the blade were painted with Carboline Windmastic TopCoat HSX. Two coats were applied and weighed approximately 60 kg. This is about 0.66% the weight of the blade and no mechanical effects were apparent. On inspection of the paint there was no wear or cracking apparent (B Iuell pers comm).

It is for influential players such as those in the South African Wind Energy Association and other wind farm developers, their governing bodies and avian conservation organisations to lobby the main players such as General Electric and Siemens to roll out this form of mitigation to reduce to a minimum the thousands of raptors deaths likely in future years. Without black or coloured blades on Africa's turbines we will continue to see the high fatality rates already apparent at some wind farms in South Africa (Simmons and Martins 2018, Perold et al. 2020).

With black-blade mitigation now shown to be highly effective in reducing eagle deaths in Norway, there is a great incentive for wind farm developers elsewhere to enact the coloured blade mitigation to reduce raptor deaths, particularly since it has no operational costs once installed.

Acknowledgments

Grateful thanks to Bjorn Iuell (Environmental Advisor to Smøla wind farm) for answering our numerous questions and providing extra information and photographs on Smøla's black blade project. Also to Arild Soleim at Smøla for the video clip of the moving blades, and to Lizell Stroh of SA Civil Aviation for valuable inputs.

Figure 3: A 4-year old Martial Eagle, struck by a white-bladed turbine, plummets to the earth at an Eastern Cape wind farm. Deaths like this could be reduced or avoided with black/coloured blade mitigation . © RE Simmons

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APPENDIX 7: CURTAILMENT STRATEGY

FALX

ARTIFICIAL INTELLIGENCE

Modelling of Verreaux Eagle Flight Patterns

A report outlining the Verreaux Eagle GPS data and Vantage Point for De Aar 1, De Aar 2S and De Aar 2N wind farms in the Northern Cape, South Africa

MULILO RENEWABLE ENERGY

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Contents

1 Introduction

The purpose of this modelling exercise was to provide under which conditions the Verreaux Eagles are most likely to fly to support the decision-making process on when to curtail the facility that is being developed at DA2S.

2 Data Acquisition

Mulilo provided the FALX team with gathered data as outlined in the table below.

Item Name	Description	Start date	End date	Location	Resolution
DA1 VE tracking 290517 to 290717.xlsx	GPS data	29/05/2017	29/07/2017	De Aar 1	Approx. 15 mins
DA2s_Precon_vp_data_2013.xlsx	Vantage point data	08/04/2013	15/04/2013	De Aar 2 South	45 observations
DA2s_V1-5_all_vp_data_2020-2021.xlsx	Vantage point data	12/10/2020	08/12/2020	De Aar 2 South	35 observations
		04/05/2021	19/05/2021	De Aar 2 South	
VEagle De Aar North 5th May 2014.xlsx	GPS data	12/02/2014	25/02/2014	De Aar North	1 hour
VE_GPS_2022.csv	GPS data	01/03/2022	05/07/2022	De Aar 1	Approx. 15 mins
VP Data – De Aar 1 Post construction	Vantage point data	18/12/2017	10/11/2021	De Aar 1	128 observations
VP Data – De Aar 2 Pre-construction	Vantage point data	06/04/2013	16/01/2014	De Aar 2 North	33 observations
VP Data – De Aar 2 Post-construction	Vantage point data	05/01/2018	27/09/2021	De Aar 2 North	34 observations

The meteorological data for the above time periods was also provided as below:

- DA1_RMM1 and DA1_T45 met-mast data for 2022
- DA2_RMM1 and DA2_T56 met-mast data for 2017 – 2021 (previous supplied)
- Castle met-mast 2012 – 2020

3 The Brief

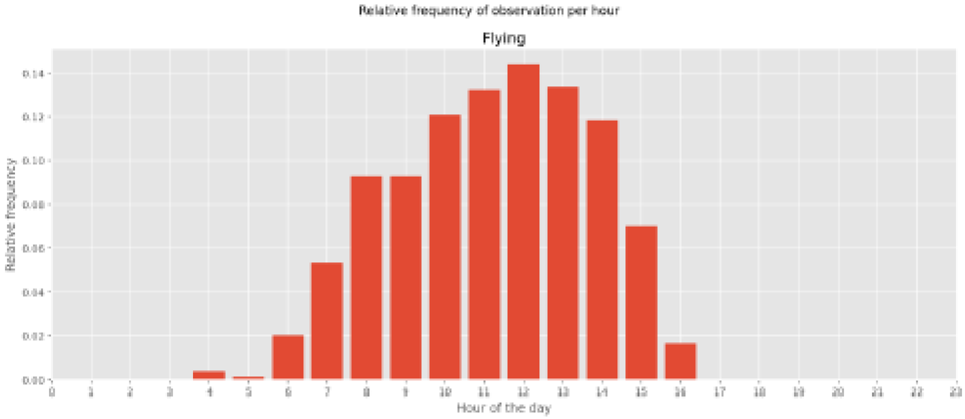
The team at Mulilo requested for the development of a static model that can be used to determine the conditions under which the Verreaux Eagles (VEs) are most likely to fly. It was agreed that a static model (a model that will not be deployed to run live on new data) would be developed to satisfy this requirement. The output was to be in the form of a representation that would indicate the amount of curtailment expected and under which conditions.

4 Statistical Analysis – Resolution Review

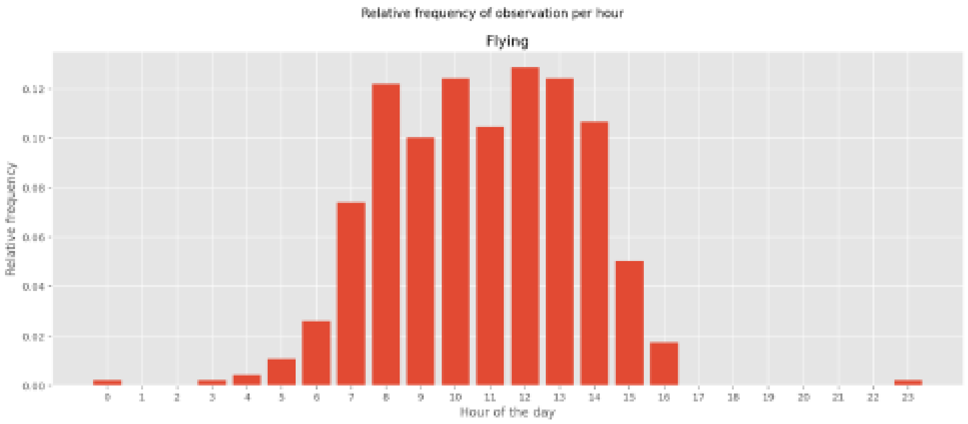
It was requested that the GPS data that has lower resolution (De Aar 1 2017 and 2022) be reviewed to determine if the hourly flight rhythm graphs change. These are shown below.

4.1 De Aar 1 – 2022

4.1.1 Hourly Rhythm at 15-minute resolution



4.1.2 Hourly Rhythm at 60-minute resolution



5 Building the Model

5.1 Assumptions

Key assumptions were made during the model building phase, these were discussed and agreed with the Mulilo team.

- Missing GPS data – any missing GPS data point will be classified as the bird is not flying
- Flying altitudes (above sea level) – collision risk – the VEs will be declared a collision risk below the heights shown below:
    - De Aar 1
        - Ground height = 1521 m
        - Collision risk <= 1751 m
    - De Aar 2N
        - Ground height = 1690 m
        - Collision risk <= 1920 m
    - De Aar 2S
        - Ground height = 1570 m
        - Collision risk <= 1800 m
- VE is declared to be a collision only if it is flying and if it is flying below the height zone mentioned above
- The development site (DA2S) would curtail 6/25 turbines during high-risk conditions

5.2 Building the Model

The model was built using deep neural network techniques. It was trained on a data-set that contained all the GPS and vantage point data provided combined with the met-mast data. It was designed to take 10-minute met-mast data as an input and provide a probability of flying under those conditions. The model developed had a resulting accuracy of 86%.

Multiple versions of the model were created, and the following variables were found to be the most influential – these are to be used as inputs to the model:

- WS_SD_36m – wind speed standard deviation at 36m (m/s)
- RH_AVG_5m – average relative humidity at 5m (%)
- TEMP_AVG_5m – average temperature at 5m (°C)
- BP_AVG_5m – average barometric pressure at 5m (millibar)
- DATE_TIME – time of day
- WS_AVG_36m – average wind speed at 36m
- WS_MAX_36m – max wind speed at 36m
- WD_AVG_36m – average wind direction at 36m

- DATE_TIME – time of day
- WS_AVG_36m – average wind speed at 36m
- WS_MAX_36m – max wind speed at 36m
- WD_AVG_36m – average wind direction at 36m

A simulation data set, of which the vast majority of data points the model had never seen was generated using the met-mast data from the Castle met-mast that spans from 2012 to 2020.

5.3 The Static Model

As the model is static, not designed to run live a large table was developed. A live model works more like a "black-box" in that it will predict the met-mast data for the upcoming period and use that prediction to give a resultant probability and based on agreed thresholds advise exactly when to curtail the plant. In order to make this usable without being a live model this table is the be used. The table consists of 10-minute intervals of the met-mast data and the corresponding probability of flight under those conditions. A summary of the outcome is shown in Table 1 below.

Table 1: Overall Summary of Expected Curtailment per Probability Threshold

	Probability >50%	Probability >60%	Probability >70%	Probability >80%	Probability >90%
Predicted Number of High-risk Collision Points	33000	15141	9161	4731	1423
Total Number of Points	430248	430248	430248	430248	430248
Predicted High-Risk Collision Rate [%]	7.67	3.52	2.13	1.10	0.33
Portion of Facility to be Curtailed (8/26) [%]	31	31	31	31	31
Total Loss for Curtailment [%]	**2.36%**	**1.08%**	**0.66%**	**0.34%**	**0.10%**

The table containing all the data is has been handed to Mulilo and is called *"DA2S_Curtailment_Prediction_Model_Table_20220816.xlxs"*