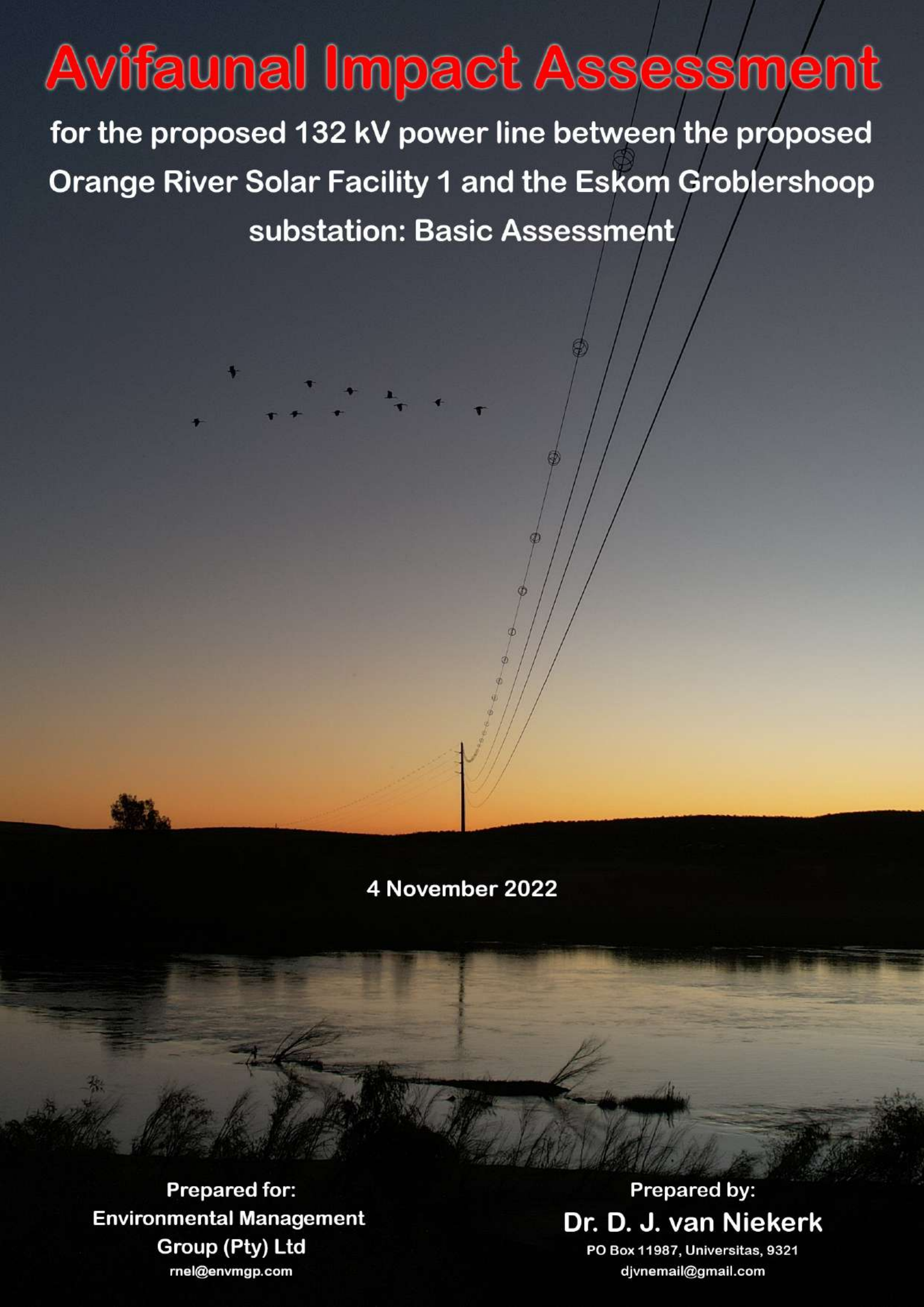
# Avifaunal Impact Assessment

## for the proposed 132 kV power line between the proposed Orange River Solar Facility 1 and the Eskom Groblershoop substation: Basic Assessment



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## Glossary of terms, abbreviations & acronyms

**Accident** Refer to an incident involving the project infrastructure which could lead to the injury or death of birds, typically when the facility is completed and operational.

**AEWA** The African-Eurasian Waterbird Agreement (see page 43).

**CMS** Convention on the Conservation of Migratory Species of Wild Animals (see page 42).

**Cumulative impact** The impact of an activity that in itself may not be significant, but may become significant when added to the existing and potential impacts eventuating from similar or diverse activities or undertakings in the area (National Environmental Management Act (Act No. 107 of 1998), Environmental Impact Assessment Regulations 2014).

**Disturbance** Refers to any action by humans which deprives a bird species of its habitat. This includes the physical destruction or alteration of habitat in a way that causes displacement, as well as disturbance which have a negative impact on breeding success. In general this type of disturbance is primarily associated with the construction phase of the project.

**EIA** Environmental Impact Assessment.

**ha** Hectare.

**kV** Kilovolt = 1 000 volts.

**mamsl** Metres above mean sea level.

**ORSF1** Orange River Solar Facility 1

**ORSF1 power line** The 132 kV power line that will connect the ORSF1 to Eskom's High Voltage Groblershoop substation,

**PV** Photovoltaic.

**Pylon** A structure that supports a power line.

**Raptor MOU** CMS Memorandum of Understanding on the Conservation of Migratory Birds of Prey in Africa and Eurasia (see page 43).

**RDB:** Red Data Book.

**Resident:** Any bird species, including migrant and nomadic taxa, utilising the indicated area at least once a week for an extended period of time (a month or more).

**Vertical collision risk zone** The distance between the top and the bottom wire of a power line set.

**Waterbird** All species associated with aquatic habitats as per Harrison *et al*. (1994).

**Wetland:** "land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil." (National Water Act (No. 36 of 1998)); "Areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt. ... Also land where the water table is, at least periodically, at or above the land surface for long enough to promote the formation of hydric (waterlogged) soils and the growth of aquatic plants" (Mucina & Rutherford 2006).

# Executive summary

Orange River Solar Facility 1 (Pty) Ltd proposes the development of a 50 MW photovoltaic solar facility (ORSF1) on Portion 18 of the farm Rooi Sand 387 near Groblershoop in the Northern Cape, South Africa. An avifaunal impact assessment was already conducted for the solar field of the project, including on-site substations and inverter stations, as part of the Basic Assessment Process (Nuttall & Vermeulen 2022).

The present report focuses on potential avifaunal impacts of a 3.88 km long, 132 kV power line (ORSF1 power line) that will connect this facility to Eskom's High Voltage Groblershoop substation. This report is also part of the Basic Assessment Process.

## Birds-overhead power line interactions

A review of the literature highlights the following:

- Our knowledge of bird-overhead power line interactions is incomplete and destined to be so for the foreseeable future, given the difficulty of adequately conducting bird mortality rate studies.
- A collision-causal web consists of a universe populated by constellations of collision-causal web factors. The constellations reviewed include species-specific, site-specific, light and weather-specific, and power line-specific constellations of factors..
- Electrocution can occur through physical contact with power line hardware and via bird excreta, called streamers.
- Habitat alteration associated with power lines can have positive and negative consequences for birds.
- Birds can have a negative impact on power line infrastructure.

## Receiving environment

The ORSF1 power line will run from within a prominent bend in the Orange River, across the river, to the Groblershoop substation. Along its route, the ORSF1 power line will traverse (successively from its origin at the planned ORSF1 substation) natural veld on undulating rocky and gravelly terrain as well as two dunes, riparian vegetation, the Orange River, riparian vegetation, agricultural fields, and natural vegetation on a slight slope. The natural vegetation consists of a heterogeneous assembly of dwarf shrubveld, shrubveld and bushveld units, all partially dominated by *Senegalia mellifera*. Except for the part where the ORSF1 power line crosses the agricultural fields, the rest of its route is classified by the Northern Cape Critical Biodiversity Area Map as CBA1 (Orange River) or CBA2.

### Study approach & methods

This assessment is based partly on a 5-day site visit and literature survey. More details can be found in the report.

### Avifauna

The distributions of 234 bird species overlap with the Groblershoop study area:

- Red Data species (n = 15): Present indications are that the territory of at least one Karoo Korhaan R235 group overlaps marginally with the footprint itself. A few other Red Data species could also be residents in the area. However, they likely roam over a relatively wide area, and their use of the footprint area is provisionally considered to be primarily transitory (Secretarybird R118, Lanner Falcon R172, Kori Bustard R230 & Ludwig's Bustard R232). The Abdim's Stork R085 is a non-breeding trans-equatorial intra-African migrant expected to visit the agricultural fields in relatively large numbers during summer. The remainder of the Red Data species is all expected to be infrequent visitors to the area.
  - Six Red Data species also appear in CMS lists A1, W, R1 & R2. Only Abdim's Stork R085, a non-breeding trans-equatorial intra-African migrant, and Lanner Falcon R172 are considered relatively common in the area (see status above). The remaining four are expected to be infrequent visitors to the area.
- Endemic species (n = 18): Include four Red Data species. The Karoo Korhaan R235, Karoo Thrush R577a, Karoo Scrub Robin R614, Namaqua Warbler R687, Fiscal Flycatcher R698 and Fairy Flycatcher R706 are the only endemic species which are probably resident in the proposed footprint area. None of the remaining 12 endemic species appears to be residents in the footprint area. However, some may be residents in adjacent areas and/or visit the footprint area occasionally.
  - The only endemic CMS species is the Black Harrier R168 (R1), possibly an infrequent transitory visitor to the study area.
- Other species (n = 205): Many utilise or are expected to utilise, the footprint area.
  - They include 42 CMS species, many of which are relatively common in the study area.

## Impact assessment and mitigation

A separate chapter is dedicated to each development phase (construction, operational & decommissioning). In each, potential impacts are first investigated and summarise, followed by an assessment of impact significance for each of the following three categories:

- **Biological significance**: "An impact is significant if it results in a change that is measurable in a statistically sound sampling program and if it persists, or is expected to persist, more than several years at the population, community, or ecosystem level."

- **Public significance**: "... a change or impact in agreement with societal norms. Put another way, an "unacceptable" impact in someway flaunts the public's (or portion thereof) system of values."
- **Legal significance**: This refers to the acknowledgement of the importance of environmental resources in government policy, law or plans. It is also called wildlife policy. The impact on Red Data and Convention on the Conservation of Migratory Species of Wild Animals (CMS) species were specifically assessed for this category.

After assessing impact significance, mitigation and its effect on impact significance was considered.

## Construction phase

The construction phase will be of short duration. Negative impacts are primarily associated with disturbance and displacement of birds in the affected area.

- *Impact significance*:
  - **Biological significance**: ORSF1 power line: None
    - **Cumulative impact**:
      - ORSF1 & ORSF1 power line: Moderate to high significance for *individuals* of the species in the affected area only, but inconsequential at the population level. The cumulative impact is insignificant.
  - **Public significance**: Construction activities will likely draw the public's attention.
  - **Legal significance**:
    - Red Data species: Impact unlikely.
    - CMS species: No impact
- **Mitigation**:
  - Minimal mitigation is possible.
  - Recommended mitigation can reduce the impact somewhat.

## Operational phase

The operational phase of the ORSF1 power line will likely be several decades.

**Positive impacts:** Include roosting and nesting on pylons, which could result in collusion, electrocution, or bird streamer-induced flashovers.

**Collisions:** Many individual birds of different species will probably collide with the ORSF1 power line during its operational phase. This assessment is based on the following:

- Power lines represent a well-known permanent collision hazard to birds.
- Numerous species known to collide with power lines occur in the study area.
- A nearby roost implies daily movement of birds in the vicinity of the ORSF1 power line.
- Another potential roosting and resting area in the Orange River and near the ORSF1 power line implies the daily movement of potentially large numbers of birds during certain times of the year;
- The route of the power line intersects several flyways, including
  - a flyway up and down the Orange River;
  - a flyway along the agricultural fields next to the river;
  - flyways from one end of the river bend to the other across the dry-land part of the ORSF1 power line route;
  - various flyways between roosting and foraging areas;
- *Impact significance*:
  - **Biological significance**: ORSF1 power line: None
    - **Cumulative impact**:
      - ORSF1 & ORSF1 power line: The main operational phase impact will be associated with the ORSF1 power line collisions. The cumulative impact is insignificant.
      - ORSF1 power line & solar facilities in the Northern Cape: Increase in the total length of power lines could, in the long run, have negative consequences for non-resident species such as the Endangered Ludwig's Bustard R232. It is concluded that the ORSF1 power line will contribute to this cumulative impact.
  - **Public significance**: The ORSF1 power line will traverse private property and open public areas. There is always the chance of someone from the public encountering one or more dead birds underneath the power line. In a worst-case scenario, this could lead to a public relations nightmare.
  - **Legal significance**:
    - Red Data species: Six are known to collide with power line infrastructure. In addition, they are *more* than transient, irregular visitors to the affected area or are otherwise expected to be exposed to collisions with the ORSF1 power line.
    - CMS species: A total of 28 species (including two of the Red Data species included above) are known to collide with power line infrastructure and are

        *more* than transient, irregular visitors to the affected area or are otherwise expected to be exposed to collisions with the ORSF1 power line.

- **Mitigation**:
  - Mitigation options were reviewed. A proven, reliable, cost-effective collision mitigation strategy that works for all species all the time does not yet exist.
  - A combined mitigation strategy for the operational phase is presented. If it is implemented, the following effects on impact significance are predicted:
    - *Biological significance*: Mitigation is irrelevant.
      - *Cumulative impact*: The proposed mitigation measures are unlikely to alter the fate of the Endangered Ludwig's Bustard R232 significantly.
    - *Public significance*: While it may be difficult to predict how the public will respond to the ORSF1 power line, dead birds below it are more likely to elicit a response than would otherwise be the case. Many individual birds of different species will likely collide with the ORSF1 power line during its operational phase (see page 67). If implemented as recommended above, the mitigation measures are expected to reduce collision risk, at least moderately (see Section 7.2.6, page 7.2.6 *ff.*). Surely, this should count for something in the public eye — they cannot say you did not try.
    - *Legal significance*: It is expected that implementation of the recommended mitigation measures will reduce collision risk, at least moderately.

**Electrocution via physical contact:** The design of the proposed ORSF1 power line will be similar to that of the existing 132kV Garona–Groblershoop power line, which utilises metal monopoles as pylons.

- Limitation: No technical drawings of the design of ORSF1 pylons were available when this report was compiled. It was only known that the pylons would be similar to those of the existing 132kV Garona–Groblershoop power line. The measurements used here are based on elevation meta-data from photographs taken with a drone, examination of photographs, and guesstimates of the dimensions of the Garona–Groblershoop pylons.
- The proposed design of the ORSF1 power line, specifically the support structures (*i.e.* pylons), is not considered safe for larger birds because a bird perched on an insulator could come into simultaneous contact with an energised conductor and grounded component, which could result in electrocution.
- Records of electrocution incidents via physical contact with power line infrastructure were found for 47 bird species with distributions overlapping with the study area. The dimensions of 16 (34.0%) of these species are considered too small to physically bridge the air gap between components of the planned infrastructure.
  - *Impact significance*

        - **Biological significance**: ORSF1 power line: None
            - **Cumulative impact**:
            - ORSF1 & ORSF1 power line: The main operational phase impact will be associated with the ORSF1 power line collisions. The cumulative impact is insignificant.
            - ORSF1 power line & solar facilities in the Northern Cape: Cumulative impact is insignificant.
        - **Public significance**: The ORSF1 power line will traverse private property and open public areas. There is always the chance of someone from the public encountering one or more dead birds underneath the pylons. In a worst-case scenario, this could lead to a public relations nightmare.
        - **Legal significance**:
            - Red Data species: The only Red Data species potentially exposed to electrocution on the ORSF1 pylons (two vulture and three eagle species) are all likely only rare transient visitors.
            - CMS species: About half of the thirteen species potentially exposed to electrocution on the ORSF1 pylons are relatively common in the area.
- **Mitigation**:
    - Mitigation options were reviewed. Electrocution can be effectively mitigated.
    - A combined mitigation strategy for the operational phase is presented. If it is implemented, the following effects on impact significance are predicted:
        - *Biological significance*: Mitigation is irrelevant.
            - Cumulative impact: Mitigation is irrelevant.
        - *Public significance*: Similar to collisions (see page 15), except that implementation of the recommended mitigation measures will reduce electrocution risk to virtually zero.
        - *Legal significance*: Implementing the recommended mitigation measures will reduce electrocution risk to virtually zero.

**Electrocution via bird streamers:** The pylons of the proposed ORSF1 power line provide perching opportunities less than 3 m above the conductors, which is within the range of bird streamers.

- Only 27 species were considered capable of producing streamers that could potentially cause flashovers and, rarely, electrocution.
- Impact significance
    - **Biological significance**: ORSF1 power line: None
        - **Cumulative impact**:

      - ORSF1 & ORSF1 power line: The main operational phase impact will be associated with collisions involving the ORSF1 power line. The cumulative impact is insignificant.
      - ORSF1 power line & solar facilities in the Northern Cape: Cumulative impact is insignificant.
    - **Public significance**: The ORSF1 power line will traverse private property and open public areas. There is always the chance of someone from the public encountering one or more dead birds underneath the pylons. In a worst-case scenario, this could lead to a public relations nightmare.
    - **Legal significance**:
      - Red Data species: The only Red Data species potentially exposed to electrocution on the ORSF1 pylons (two vulture and three eagle species) are all likely only rare transient visitors.
      - CMS species: About half of the thirteen species potentially exposed to electrocution on the ORSF1 pylons are relatively common in the area.
- **Mitigation**:
  - Mitigation options were reviewed. Electrocution can be effectively mitigated.
  - A combined mitigation strategy for the operational phase is presented. If it is implemented, the following effects are predicted:
    - *Biological significance*: Mitigation is irrelevant.
      - Cumulative impact: Mitigation is irrelevant.
    - *Public significance*: Similar to collisions (see page 15, except that implementing the recommended mitigation measures will reduce electrocution risk to virtually zero.
    - *Legal significance*: Implementing the recommended mitigation measures will reduce electrocution risk to virtually zero.

## Decommissioning phase

The decommissioning phase will be of short duration.

- Decommissioning activities could cause disturbance and possibly displacement of birds in the surrounding area.
- A direct impact during the decommissioning phase will be the destruction of any nests on the pylons at the time.
- Removing the ORSF1 power line implies eliminating any collision and electrocution hazards directly associated with it.

- Impact significance:
    - **Biological significance**: ORSF1 power line: None
        - **Cumulative impact**:
            - ORSF1 & ORSF1 power line: Cumulative impact is insignificant.
            - ORSF1 power line & solar facilities in the Northern Cape: Cumulative impact is insignificant.
    - **Public significance**: If a pylon destined for removal also has an active nest, it may elicit a response from the public.
    - **Legal significance**:
        - Red Data species: Of the five species known to breed on pylons, the Lanner Falcon R172 is the only one likely to breed on the ORSF1 pylons (see below). The others prefer larger metal lattice structures.
            - CMS species: Three species are known to breed on pylons.
- **Mitigation**:
    - If birds are actively breeding on a pylon, delay decommissioning until after the breeding is completed.
    - Other mitigation measures are also provided.
        - *Biological significance*: Mitigation is irrelevant.
            - Cumulative impact: Mitigation is irrelevant.
        - *Public significance*: Delaying decommissioning until after breeding is completed will greatly reduce public significance.
        - *Legal significance*: Delaying decommissioning until after breeding is completed will greatly reduce legal significance.

## Conclusions

The ORSF1 power line will be a permanent collision hazard to the area's birds, probably for decades. The proposed power line route intersects several flyways and passes near a known roost, as well as another spot in the Orange River that is likely to attract large numbers of birds during certain times of the year. There is, thus, a high probability that collisions will occur.

Although biologically significant impacts are improbable, collision incidents could trigger a public response, which may become a public relations nightmare in a worst-case scenario. Even more importantly, the ORSF1 power line poses a real collision risk to a few Red Data species and a number of species listed in various CMS lists.

Collision impacts are the most significant concern, with electrocutions in a distant second place. Whereas a proven, reliable, cost-effective strategy that works for all species all the time does not currently exist for collision mitigation, mitigation strategies for electrocution have most, if not all, of these features.

The only significant cumulative impact identified relates to the increase in the total length of power lines throughout the Northern Cape. The ORSF1 power line will contribute 3.88 km to this. A sustained increase over time could have negative consequences for non-resident species such as the Endangered Ludwig's Bustard R232.

Collision and electrocution impacts are only relevant during the operational phase of the ORSF1 power line. There are also impacts associated with this line's construction and decommissioning phases. These phases are of short duration, and their respective impacts pale compared to the operational phase.

In conclusion, it is recommended that the activity is authorised on the condition that the proposed mitigation measures are strictly implemented.

# 1. Introduction

Orange River Solar Facility 1 (Pty) Ltd proposes the development of a 50 MW photovoltaic solar facility on Portion 18 of the farm Rooi Sand 387 near Groblershoop in the Northern Cape, South Africa. An avifaunal impact assessment was already conducted for the solar field of the project, including on-site substations and inverter stations, as part of the Basic Assessment Process (Nuttall & Vermeulen 2022).

The present report focuses on a 3.88 km long, 132 kV power line that will connect the proposed Orange River Solar Facility 1 to Eskom's High Voltage Groblershoop substation and its impact on the avifauna. The location and route of this new power line are indicated in Figures 1 (page 128), 2 (page 129), and 3 (page 130). This assessment is part of the Basic Assessment Process.

After detailing the planned infrastructure and terms of reference below, an overview of bird and overhead power line interactions is presented in Section 2. That is followed by two sections, one on the receiving environment (Section 3) and another on study approach and methods (Section 4). In Section 5 you'll meet the main cast: all 15 Red Data, 18 Endemic, and 205 other bird species occurring in this part of South Africa. In the following three Sections impacts are assessed, mitigation reviewed and recommended separately for the construction phase (Section 6), operational phase (Section 7) & decommissioning phase (Section 8).

## 1.1. Planned infrastructure

A 132 kV transmission line (henceforth the ORSF1 power line):

- From the project substation, to be located approximately 300 m north of the Destination River Resort Groblershoop Sports Grounds, a 3.88 km long 132 kV power line is to be constructed to the existing Groblershoop substation located to the south-west (Fig. 4, page 131; Fig. 5, page 132; Fig. 6, page 133).
- The power line support structures (*i.e.* pylons) will be 22 m high and spaced approximately 80 m apart.
- The design of the pylons will be metal monopoles similar to that of the existing 132kV Garona–Groblershoop (1 GAR/GRO) power line (Fig. 7, page 134; Fig. 8, page 135), to which it will be running parallel to; the existing 22 kV Groblershoop–Padkloof (GPF) power line follows a similar route (Fig. 9, page 136). There is a distinct difference between pylons at turning points and pylons along straight sections of the power line, both with regards to the configuration of the earth wire and conductors, and how the conductors are affixed to the pylons (see Figures 7 & 8):
  - Straight section pylons: Each conductor hangs from the end of a near-horizontal post insulator, with the three conductors arranged in an alternating pattern. The earth wire is located at the top.
  - Turning point pylons: Each conductor is connected to the pylon via a strained insulator, with a horizontal jumper wire connecting the conductor around the pylon

via a horizontal isolator. The earth wire is located at the top.

## 1.2. Terms of reference

The terms of reference for the Avifaunal Impact Assessment were as follow:

- Desktop study;
- Site survey;
- Review of literature;
- Identification of high-risk species, particularly Red Data species and other priority species that might be impacted by the proposed development;
- Description and assessment of the significance of likely impacts on priority avifauna; and
- Recommend mitigation measures to reduce the envisaged impacts.

# 2. Birds and overhead power lines: the good, the bad, and the ugly

This section aims to present an overview of the interactions between birds and overhead power lines, focusing on aspects relevant to the study area. It was restricted to documents publicly available, accessible online, and written in English. Assessment specific to the potential impacts of the ORSF1 power line on birds, as well as mitigation, are considered later (page 59 *ff.*).

## 2.1. Habitat alteration

### 2.1.1. Roads

Where there is a power line there is also likely to be a road that provides access for maintenance personnel. Roads are known to have various negative impacts on the environment (for reviews, see Forman & Alexander 1998; Trombulak & Frissell 2000). Its construction may cause disturbance or destruction of active nesting sites. Dust mobilised and spread by road traffic could potentially have a negative impact on nearby plants (Trombulak & Frissell 2000). Roads can also change the habitat in ways that could render it unsuitable for resident species. On the other hand, some bird species are attracted to it, which is a double edge sword since this may also place them on a collision course with the vehicles using it.

Once in place, a road can change the routing of shallow groundwater and surface flow in ways that may trigger erosion (Forman & Alexander 1998; Trombulak & Frissell 2000). It can also provide optimal habitat for invasive/exotic plant species (Forman & Alexander 1998; Kuvlesky *et al.* 2007; Trombulak & Frissell 2000). These, in turn, may provide suitable habitat for birds and their prey. Moisture and sediment deposits from road drainage may also benefit patches of local plants (Forman & Alexander 1998), which is likely to foster habitats where insects to flourish, no doubt to be exploited by their many avian nemeses.

### 2.1.2. Vegetation management

The vegetation underneath power lines requires management to ensure safe clearance space, adequate access for inspection, maintenance, and repair activities, and to reduce the fuel for potential fires that may result from flashover events (Vosloo 2009). Consider, for example, that vegetation fires cause approximately 20% of line faults on high-voltage transmission lines ($\geq 132$ kV) in South Africa, amounting to an estimated annual financial impact of around R80 000 000 (Vosloo *et al.* 2008).

Vegetation management activities during the construction phase could potentially destroy active nesting sites and lead to the displacement of resident species. At the same time, prey items such as insect larvae exposed through these activities are likely to be exploited by birds.

Depending on the habitat, the initial vegetation management could entail a radical transformation of habitat along the power line route (Vosloo 2009; Fig. 10, page 137; Fig. 11, page 138). The effect of the resulting habitat change is likely to be species-specific, dependent on the original habitat and extent of the modification, and other factors (see, for example, Anderson 1979; King *et al.* 2009). Towards the one extreme, certain species may vacate the area, while others could colonise the newly created habitat. The outcome could be a new (relative to the original status quo) community, including altered predator-prey relationships (*e.g.* DeGregorio *et al.* 2014).

### 2.1.3. Power line infrastructure

Power lines and their support structures (*i.e.* pylons) add elevated elements to the environment, and birds frequently use it for a variety of reasons (for a recent review, see D'Amico *et al.* 2018). During the day, it may function as a convenient vantage point, a safe resting place, a song or feeding perch (*e.g.* Brown & Lawson 1989; Knight & Kawashima 1993; Kucherenko *et al.* 2014; Morelli *et al.* 2014). In the case of predatory species such as crows and raptors, their close association with power line infrastructure (e.g. Fig. 12, page 139) could be detrimental to prey species in the area (*e.g.* DeGregorio *et al.* 2014). At night, power line infrastructure can also function as a secure roosting site (*e.g.* Brown & Lawson 1989; Fig. 13, page 140). Several species even use pylons for nesting (in addition to Fig. 14 (page 141), see Section 4.6 on page 38 for literature references for southern African species; For elsewhere, see APLIC 1996, 2006; Infante & Peris 2003; Knight & Kawashima 1993; Moreira *et al.* 2017; Steenhof *et al.* 1993).

Given the widespread use of power lines by birds, it is reasonable to assume that it could contribute positively to the avifaunal diversity of an area, as some studies seem to suggest (e.g. Morelli 2013). However, certain species may avoid otherwise suitable habitats adjacent to power line infrastructure (*e.g.* Pruett *et al.* 2009). Tyler *et al.* (2014) suggested that this may be related to the ability of such species to see the ultraviolet light associated with corona discharge on energised conductors.

## 2.2. Electrocution

The electrocution of a bird may be via physical contact and via bird streamers. For general reviews on bird electrocution, see APLIC (1996, 2006); Lehman *et al.* (2007)

### 2.2.1. Physical contact

Electrocution is possible in birds with dimensions large enough to physically bridge the air gap between energised or energised and grounded components, thereby causing an electrical short circuit (Beutel *et al.* 2019; Bevanger 1998; Van Rooyen 2003). The resulting current flowing through the bird's body is lethal (Van Rooyen 2003).

The likelihood of electrocution is more closely related to line configuration than to voltage rating (APLIC 1996). According to APLIC (2006), electrocution under dry conditions may occur where horizontal separation of energised/grounded components is less than wrist-to-wrist (flesh-to-flesh) distance of a bird's wingspan (see also Dwyer *et al.* 2015), or where vertical separation of energised/grounded components is less than a bird's length from head-to-foot (flesh-to-flesh) (Fig. 15, page 142).

However, when feathers are wet, their conductivity are substantially increases, as is the bird's risk of electrocution (APLIC 1996; Bevanger 1998). Under such conditions, electrocution may occur when horizontal separation of energised/grounded components is less than wing tip-to-wing tip distance (*i.e.* wingspan; Fig. 15). Likewise, vertical separation less than a bird's length from head to end of tail also comes into play (Fig. 15).

Electrocution typically occur at pylons were birds perch (*e.g.* Fig. 16, page 143). It also occur on wires between pylons, either involving a bird(s) perched there (*e.g.* Fig. 17, page 144; Anderson 1933), or when a bird in flight first collide with a wire, and then bridge the air gap between wires, resulting in electrocution (*e.g.* Fig. 18, page 145; Lano 1927; Pomeroy 1978).

Metal pylons, the presence of connector wires and exposed conductors in dominant places are some of the factors most frequently associated with electrocution incidents (Mañosa 2001; Tintó *et al.* 2010); pylons in prominent positions also tend to have higher electrocution rates (Mañosa 2001). Conversely, unearthed pylons, suspended conductors and alternate cross-arms generally posses less risk of electrocution (Ferrer *et al.* 1991; Haas *et al.* 2005; Mañosa 2001; Tintó *et al.* 2010).

While a given power line may incorporate all of the lowest risk design features over most of its length, it is their point features, for example dead-end structures and pylons with transformers, which are often associated with bird electrocutions. This type of infrastructure typically have an increased number of energised components and reduced spatial separation between them. (APLIC 1996; Harness 1996; Harness 2000; Harness & Wilson 2001).

### 2.2.2. Bird streamers

Electrocution is also possible in birds that produce relatively long excreta, called a streamer (see, for example, https://www.flickr.com/photos/davidbygott/7242492034). If the streamer is long enough to create a conductive path which partially or totally bridge the air insulation between energised conductors and the power line tower structure, then it could cause a flashover (Michener 1928; Van Rooyen *et al*. 2003; see Figure 19 on page 146).

The distance between power line components over which a bird streamer can cause a flashover may exceed 3 m (Van Rooyen *et al*. 2003; Vosloo & Van Rooyen 2009b; see also Vosloo *et al*. 2011). If the bird gets caught up in the resulting flashover, it could result in the injury or even death of the bird (Michener 1928; Sundararajan *et al*. 2004; Van Rooyen 2003; Van Rooyen & Taylor 2000; Vosloo & Van Rooyen 2009b); however, this appears to be an infrequent mode of electrocution (Van Rooyen *et al*. 2003). Only relatively large birds, including vultures, storks, herons and larger raptors, are capable of producing streamers which could cause flashovers (Michener 1928; Van Rooyen *et al*. 2003; Vosloo *et al*. 2011).

## 2.3. Collision

A bird will collide with an overhead wire when it is on a collision course with it and when it subsequently fails to *successfully* perform (if it does it at all) collision avoidance manoeuvrers. Behind any particular collision incident is a complex web of factors, the disentanglement of which is complicated by ignorance of all the factors involved, imperfect knowledge of identified factors, and even ignorance of the web itself. Competent collision risk assessment requires comprehension of these collision causal webs.

### 2.3.1. Mortality rates

One of the most fundamental requirements for predicting collision risk, which is a requisite to mitigation, is accurate mortality rates estimation (Thompson 1978). Loss *et al*. (2014) correctly notes that for the mortality rate estimation, the "most useful data will be collected in prospective studies that base sampling on randomization and replication, that sample all groups of birds, and that sample during all months of the year." However, in their comprehensive review of the literature, they failed to find any mortality rate estimate study that fulfilled all these standards (Loss *et al*. 2014).

#### 2.3.1.1. It's no easy task

Besides ignorance of the importance of randomization and replication in research in general (see Bauernfeind 1968; Carver 1993; Johnson 1999, 2002a,b), there are also many other factors that conspire to hinder the collection of the "most useful data", including the significant challenge of satisfying all the sample size, methodological, logistical, manpower, time, and financial requirements that these type of studies entail. For example, concerning the time dimension, Thompson (1978) notes that the most dramatic bird kills caused by collisions with overhead wires are often catastrophic, irregular in time, and hence unpredictable, being the result the chance juxtaposition of a particular set of circumstances (see also Brown & Drewien 1995). This led Thompson (1978) to conclude that "it may be argued that specific mortality rates cannot be quantified, except after many decades of exhaustive study."

Obtaining unbiased estimates of bird mortality through ground searches is no easy task. Given any facility where birds collide with infrastructure, a ground search will typically not detect all the collision victims in the searched area. The main reasons for this well-known phenomenon are that at the time of a carcass search, collision victims are either present but overlooked by the observer (detection bias, *e.g.* Bernardino *et al.* 2022; Howe & Atwater 1999; Kerlinger 2000; Kerlinger & Curry 2000; Ponce *et al.* 2010; Smallwood 2007; Strickland *et al.* 2000; Strickland *et al.* 2001; Visser *et al.* 2019), or were injured and moved outside the search zone (crippling bias, *e.g.* Bech *et al.* 2012; Murphy *et al.* 2016), or scavengers consumed them (scavenger bias, *e.g.* Balcomb 1986; Bernardino *et al.* 2022; Borner *et al.* 2017a,b; Costantini *et al.* 2017; Crawford & Engstrom 2001; Hager *et al.* 2012; Higgins *et al.* 1995; Howe & Atwater 1999; Kerns 2005; Ponce *et al.* 2010; Prosser *et al.* 2008; Smallwood 2007; Strickland *et al.* 2000; Strickland *et al.* 2001; Visser *et al.* 2019; Winkelman 1992; Wobeser & Wobeser 1992).

Therefore, in order to obtain an accurate estimate of fatality rates, the result of carcass searches — conducted frequently at each site, possibly as frequent as more than once every seven days (Borner *et al.* 2017a,b; Costantini *et al.* 2017; Erickson *et al.* 2014; Pain 1991; Ponce *et al.* 2010; Smallwood 2017; Van Niekerk 2012; Visser *et al.* 2019) — must be adjusted by correction factors based on observer efficiency and scavenging rate studies (Borner *et al.* 2017a,b; Huso 2011; Korner-Nievergelt *et al.* 2011; Loss *et al.* 2014; Morrison 2002; Murphy *et al.* 2016; Ponce *et al.* 2010; Wobeser & Wobeser 1992), as well as 24-hour monitoring to assess crippling bias (Murphy *et al.* 2016). Site-specific, seasonal and vegetation factors all influence these studies (Anderson *et al.* 2000; Bernardino *et al.* 2022; Higgins *et al.* 1995; Smallwood 2007; Smallwood 2013; Strickland *et al.* 2001; Visser *et al.* 2019). Therefore, separate field trails necessary to determine these correction factors should be conducted concurrently with carcass searches, separately for each site and habitat, and repeated several times each year to account for seasonal factors (Morrison 2002; Smallwood 2007).

Furthermore, larger carcasses are more detectable by a human observers than smaller carcasses, and smaller carcasses tend to be removed more readily by scavengers (Smallwood 2007; Visser *et al.* 2019). Therefore, each field trail will require bird carcasses of different sizes. In addition, limited studies have shown that using surrogate species for those killed at infrastructure may give misleading results for search detection and scavenger removal trials (Smallwood 2007). Also, scavengers remove fresh carcasses sooner than frozen/thawed carcasses (Kerns 2005). Therefore, carcasses used in trails should be representative of the species actually occurring in the area, and must be fresh in the case of scavenger removal trials (Smallwood 2007).

#### 2.3.1.2. Is it practicable?

There are at least three reasons why accurate determination of fatality rates as outlined above may not be practicable for any given project.

Firstly, obtaining a sufficient number of fresh carcasses for each species group and each field trail is problematic. There is a practical difficulty in acquiring the relevant specimens when needed. In addition, the studies may require more birds than would otherwise be affected by the facility/infrastructure itself, which could be challenging to justify, especially if it involves Red Data species.

Secondly, because an accurate assessment of collision rates requires a frequent fieldwork schedule, likely involving several fieldworkers over an extended period to account for seasonal and inter-annual variation, the implied time, human resources and financial requirements are likely to be prohibitive. Regarding the assessment of observer efficiency and scavenging rates, there is a limit to the number of carcasses that one can deploy at a time (Smallwood 2007). Consequently, one set of trails is likely to span several weeks. In practice, and regardless of all these requirements, financial constraints will always play an important role when defining the actual research effort (Bernardino *et al*. 2013).

Thirdly, even if one manages to resolve the two points mentioned above, one still must deal with various other methodological issues that may lead to unreliable results. For example, the reliability of observer bias estimates may be questionable if the type and state of carcasses used in the tests reflect different characteristics to those of corpses typically found under normal circumstances. Observers aware of test conditions are also likely to increase their vigilance relative to routine monitoring searches (Visser *et al*. 2019). Another example, a critical (often unstated) assumption, is that the presence of the observer(s) in the area, and the handling of carcasses, does not influence scavaging rates.

#### 2.3.1.3. Something is better than nothing

Without correction for searcher bias, carcass removal bias, *etc.*, one is unlikely to obtain an accurate estimate of fatality rates. However, that does not render carcass searches without these details worthless, as some seem to imply (*e.g.* Jenkins *et al*. 2017). The reality is that opportunistically collected data, often involving single incidents, is responsible for much of what we know today about bird fatalities at power lines (Bevanger 1994; Jenkins *et al*. 2010; Lehman *et al*. 2007).

Until studies collecting the “most useful data” becomes more common, the words of Coues (1876) will loom large over bird and power line interactions: “My observations [of dead birds below telegraph wire] do not enable me to form even an approximate estimate of the annual mortality, and I suppose we shall never possess accurate data”.

With so many questions remaining unanswered, the remainder of this overview will focus on a selection of potential components of a collision causal web. This information will guide our efforts toward mitigation. For general reviews on bird collisions with power lines, see APLIC (2012); Bernardino *et al*. (2018); Bevanger (1994); Jenkins *et al*. (2010); Thompson (1978).

### 2.3.2. Who

Even though species-specific factors such as sensory perception, morphological features, flight behaviour, phenology and circadian habits, age, sex, and health could, theoretically at least, play a role, any bird capable of flight — literally "from hummingbirds to swans" (Thompson 1978) — are at risk of colliding with power lines, at least in principle (Bernardino *et al*. 2018; Bevanger 1998; Demerdzhiev 2014; Haas *et al*. 2005; Hunting 2002; Janss 2000; Jenkins *et al*. 2010; Scott *et al*. 1972). Species-specific factors merely constitute one of several constellations of collision causal web factors, which may include, amongst others, those considered in the sections below.

### 2.3.3. Where

The proximity to locations where birds tend to congregate and flight paths (*e.g.* between roosting and feeding areas) is an essential factor to take into account when planning the route of a new power line, as this is often where most collision incidents occur (Andriushchenko & Popenko 2012; APLIC 2012; Brown *et al*. 1987; Crivelli *et al*. 1988; Faanes 1987; Henderson *et al*. 1996; Prinsen *et al*. 2011). For example, in agricultural fields used as feeding areas, collision problems may develop when birds have to make daily, low-altitude flights to and from the fields across power lines (APLIC 1994; Brown & Drewien 1995). Human disturbance of birds near power lines could also increase collision risk (APLIC 1994; James & Haak 1979; Murphy *et al*. 2009; Thompson 1978).

### 2.3.4. Light & weather

Bird collisions with power lines have been recorded under all types of light conditions, from instances where visibility was optimal during the day (*e.g.* Lee 1978; Thompson 1978), to instances where power lines were enveloped by the darkness of night (e.g. Baasch *et al*. 2022; Brown & Drewien 1995; Dwyer *et al*. 2019; Murphy *et al*. 2016; Pandely *et al*. 2008).

Various factors influence the visibility of a power line during the day. Even under clear sky conditions, a power line may blend into the background below the skyline (Fig. 20, page 147). In addition, the angle at which the sun's rays strike a wire can also affect its visibility (Fig. 20).

Weather conditions associated with collisions are mainly related to reduced visibility due to fog or precipitation, reduced flight control due to strong winds, and behavioural changes due to these phenomena (Anderson 1978; APLIC 1994; Bevanger 1994; Brown & Drewien 1995; Brown *et al*. 1987; Henderson *et al*. 1996; Hunting 2002; Scott *et al*. 1972). The presence of suspended particles of dust or water droplets in the air can decrease the visibility of power line infrastructure. In the case of water droplets, fog (essentially a cloud on the earth's surface) includes all occasions when visibility is less than 1 km, as opposed to the term mist, which is otherwise used (Elkins 2004). In addition to an impact on power line visibility, thick fog, as well as strong wind, are also known to change the general flying height, usually forcing birds to fly at a lower altitude, even close to the ground (APLIC 1994; Bevanger 1994). Under the right circumstances, this could put birds on a collision course with power lines ahead.

### 2.3.5. Wire issues

The physical configuration of the wires in space is also considered to be important in determining the risk of bird collisions (Thompson 1978).

It seems intuitive to assume that bird collision risk is at least partly dependent on the number of vertical levels of wires and the spacing between them (see Figure 8; APLIC 1994, 2012; Bevanger 1994; Bevanger & Brøseth 2001; Drewitt & Langston 2008; Haas *et al.* 2005; Jenkins *et al.* 2010). The few studies investigating this issue gave conflicting results and had methodological problems that complicated the interpretation of the data (see Bernardino *et al.* 2018). That was until Marques *et al.* (2021) recently presented what appears to be the first robust evidence of this effect based on data from southern Portugal. They found that a relatively large power line configuration with four levels of wires, and a rather sizeable vertical collision risk zone, posed a much higher collision risk to the Little Bustard *Tetrax tetrax* than two smaller configurations with only two wire levels and a much smaller vertical collision risk zone.

Earth wires (also called ground, static or shield wires) on top of electricity infrastructure — which is supposed to protect the phase conductors from lightning strikes (APLIC 2012; Hunting 2002; Thompson 1978) — are often the wires with which birds collide (Brown *et al.* 1987; Faanes 1987; James & Haak 1979; Jenkins *et al.* 2010; Lee 1978; Murphy *et al.* 2009; Murphy *et al.* 2016; Pandely *et al.* 2008; Savereno *et al.* 1996; Scott *et al.* 1972; Thompson 1978; Van Rooyen 2003). In the few instances where this has been specifically quantified, collisions with earth wires occurred in 56.1% to 100% of the cases where observation periods were limited to the time between dawn and dusk or a few hours after dusk, and in 68.0% and 72.6% of cases in the two instances where observations were conducted 24 hours a day (Table 2, page 126). Observations of collision incidents suggest that birds often see the conductors but not the earth wires (Bevanger 1994; Faanes 1987; James & Haak 1979; Savereno *et al.* 1996; Scott *et al.* 1972; Thompson 1978), which is typically thinner and less obvious than the conductors (APLIC 2012; Thompson 1978; Fig. 20).

Tyler *et al.* (2014) noted that earth wires don't facilitate corona discharge. Corona discharge is an electromagnetic phenomenon associated with energised electrical devices, including high-voltage power lines. It occurs when the electric field close to a high voltage-carrying conductor becomes sufficiently strong to create a local dielectric breakdown of the air. The result is the localised ionisation of air, creating a region of plasma in which electrons and positive ions recombine and release photons of light (Institute of Electrical & Electronics Engineers (IEEE) 2002; Khalifa 1990; Riba & Bas-Calopa 2022; Tyler *et al.* 2016). The most prominent peaks in recorded emission of optical radiation from corona discharge fall in the ultraviolet spectrum (316–377 nm; Koziol *et al.* 2019; Riba 2022). Consequently, Tyler *et al.* (2014) (see also Tyler *et al.* 2016) suggested "that in darkness these animals [that can see ultraviolet light, which includes many bird species (to be discussed later, on page 73)] see power lines not as dim, passive structures but, rather, as lines of flickering light stretching across the terrain". However, mortalities also occur due to collisions with the conductors below earth wires (Baasch *et al.* 2022; Murphy *et al.* 2016; Pandely *et al.* 2008), and in the absence of earth wires (Bevanger 1990, 1994; Brown *et al.* 1987; Janss & Ferrer 1998).

Audible noise resulting from corona discharge (see Bian *et al.* 2011; Jiang *et al.* 2015; Lee & Griffith 1978) could potentially alert a bird in flight to the presence of nearby power lines (Lee & Griffith 1978). Whether such information assists birds in avoiding collisions with power lines is still unknown (Lee 1978).

### 2.3.6. Pylon issues

Under certain circumstances, birds tend to avoid the airspace around pylons. In a study conducted in North Dakota, USA, Faanes (1987) stated that "Observations [at power lines ≥230 kV] of flying birds and of dead bird distribution suggested that birds tended to avoid the airspace within about 50 m of the towers", and that "Most of the observed birds appeared to fly over the lines in the mid-span region, and birds were found beneath the mid-span areas." Faanes (1987) did not specifically quantify this. Data collected at a site in Nebraska, USA, clearly showed that Sandhill Crane *Antigone canadensis* carcasses found below power lines were least frequent near pylons of both distribution and transmission lines (Ward & Anderson 1992).

In another North Dakota study, Pandely *et al.* (2008) recorded the distance at which bird carcasses were detected from each pylon, and presented the data in a simple bar graph showing the total number of bird carcasses recorded in each 7.62 m (25 feet) interval; this data is presented in a modified format in Figure 21 (page 148). The 429 bird fatalities recorded during their surveys on foot included 67 species of all sizes, with relatively fewer carcasses found closer to the pylons than in the mid-span region (Fig. 21; Pandely *et al.* 2008). In southern Africa, Shaw *et al.* (2010) found a similar pattern in the Western Cape, as did Shaw (2013) during two separate studies in the Northern Cape, and Pallett *et al.* (2022) for six different power lines ranging from 66 kV to 400 kV in Namibia, Northern Cape and Western Cape. This apparent avoidance of the area around pylons is perhaps understandable given the high visibility of these structures.

Avoidance of the airspace around pylons is not universal. Birds have also been observed to fly randomly across power lines and pylons, with the location of collisions / dead birds found beneath these lines also reflecting this random pattern (*e.g.* Baasch *et al.* 2022; Faanes 1987).

## 2.4. The impact of birds on power lines

The preceding showed many opportunities for birds to interact with power line infrastructure. In some instances, these interactions can negatively affect power line infrastructure. In South Africa, an analysis of faults occurring on the power transmission system (132 kV to 765 kV) over 16 years indicated that birds accounted for 38% of the 12 229 faults, with lightning in a distant second place at 26% (Minnaar *et al.* 2012). These faults may seriously affect system reliability and have economic impacts (Bevanger 1994; Brown & Lawson 1989; Michener 1928). Bird-related faults are caused in one of five ways, namely via bird streamers, bird pollution, electrocution (see Section 2.2 on page 23), nests (Minnaar *et al.* 2012), and dropped objects (Bevanger 1994):

- Bird streamers (see page 24) is one of the major bird related causes of faults on power lines in South Africa (*e.g.* Bekker 2003; Smallie & Van Rooyen 2005; Van Rooyen *et al.* 2003) and elsewhere (*e.g.* Michener 1928; Taklaja *et al.* 2013).
- A fault caused by bird pollution refers to a case where the insulation properties of the insulator was initially compromised by the accumulation of bird droppings — for example excreta of nest occupants (Vosloo & Van Rooyen 2009c), or roosting birds (Brown & Lawson 1989) — which under appropriate wet conditions caused a phase-earth flashover across the insulator string (Vosloo & Van Rooyen 2009b; Vosloo *et al.* 2011).
- Bird electrocutions may seriously affect the reliability of energy systems and may have significant economic impacts (APLIC 2006; Bevanger 1994).
- Nesting material, including wires and plant material, can also result in flashovers, particularly during wet conditions (Anderson 2013; Brown & Lawson 1989; Sundararajan *et al.* 2004; USAID Southern Africa Energy Program & Endangered Wildlife Trust 2022; Van Rooyen 2003; Vosloo & Van Rooyen 2009c). Fire resulting from this could also damage infrastructure and cause bushfires (Jenkins *et al.* 2013; USAID Southern Africa Energy Program & Endangered Wildlife Trust 2022).
- Conductor-conductor or conductor-earth flashovers may result from dropped nesting materials or prey items (APLIC 2006; Bevanger 1994).

# 3. General description of the receiving environment

From its source in the highlands of Lesotho, the Orange River flows westwards, forming the southern border of the Free State (Fig. 1). Shortly after entering the Northern Cape, the Vaal River joins it from the east, near Douglas. From Douglas the Orange River flows in a south-westerly direction, reaching its most southerly point in the Northern Cape at Prieska. From there it flows in a north-westerly direction past Groblershoop, which is located approximately 540 km, as the crow flies, from the Orange River's ultimate destination, the Atlantic Ocean at Alexander Bay in the west (Fig. 1).

The town Groblershoop is located in the southern aspect of a prominent bend in the Orange River, which here flows through the 850 metres above mean sea level (mamsl) mark (Fig. 3). Based on a 76-year dataset (1939–2014), the average annual precipitation is 201 mm (range = 25–478 mm), with occasional relatively dry and wet years (Tfwala *et al.* 2018). The most rain falls from February to April (Mucina *et al.* 2006).

Based on the vegetation classification of Mucina & Rutherford (2006), this area is located in the Nama-Karoo Biome, specifically, Bushmanland Arid Grassland, which forms part of the Bushmanland Bioregion (Fig. 1; Fig. 2). Bushmanland Arid Grassland covers a relatively large area (approximately 41 085 km$^2$) from around Aggeneys in the west to Prieska in the east (Mucina *et al.* 2006; Fig. 1). In the Groblershoop area, this vegetation unit is bisected by Lower Gariep Alluvial Vegetation, which, of course, is closely associated with the Orange River (Fig. 2). Approximately half of the Lower Gariep Alluvial Vegetation has been transformed for agricultural purposes (Mucina *et al.* 2006). In the Groblershoop area, irrigated agricultural fields occur along a narrow strip (<1 km wide) on either side of the Orange River, mainly within the flood plain below the 5 m flood line (*cf.* Figures 4 & 22, page 149).

The proposed solar facility is planned a few kilometres from Groblershoop and north of the Orange River in the western aspect of the river bend (Fig. 3). The ORSF1 power line will originate at a substation to be located at the southern end of the proposed solar facility, and approximately 300 m north of the Destination River Resort Groblershoop Sports Grounds. From there, it will head to the Groblershoop Substation located 3.4 km to the south-west (Fig. 4; Fig. 6). The route's elevation profile is illustrated in Figure 23 (page 150).

Starting at approximately 905 mamsl, the terrain over which the ORSF1 power line will run within Portion 18 of the farm Rooi Sand 387 is over undulating rocky terrain, two prominent dunes and other sandy areas (Fig. 23; Fig. 24, page 151). This contrasts with the relatively flatter terrain found a short distance to the north-east (Fig. 23; Fig. 25, page 152). Drainage is south-westwards to the Orange River by well-defined rocky drainage lines (Fig. 3; Fig. 4; Fig. 5), all of which are only likely to flow immediately after heavy rain has fallen. On the other side of the river, the power line will first cross agricultural fields on the Orange River floodplain before ascending to the Groblershoop substation across a drainage line (Fig. 6; Fig. 26, page 153).

Along its route, the power line will traverse (successively from its origin at the planned ORSF1 substation) natural veld on undulating rocky and gravelly terrain as well as two dunes (Fig. 10; Fig. 24; Fig. 27, page 154), riparian vegetation, the Orange River, riparian vegetation, agricultural fields, and natural vegetation on a slight slope (Fig. 6; Fig. 23; Fig. 26).

According to Mucina & Rutherford (2006), Bushmanland Arid Grassland is "Least threatened" with very little of it transformed, and erosion is mostly low to very low. However, in contrast to the "sparsely vegetated by grassland" description of Bushmanland Arid Grassland by Mucina & Rutherford (2006), within the footprint area of the ORSF1 power line, the habitat is a heterogeneous assembly of dwarf shrubveld, shrubveld and bushveld units, all at least partially dominated by *Senegalia mellifera* (formerly *Acacia mellifera*: see Kull & Rangan 2012; Moore *et al.* 2011) (Van Rooyen & Van Rooyen 2018; Fig. 6; Fig. 10; Fig. 24; Fig. 28, page 155; Fig. 29, page 156). *Senegalia mellifera*, and *Rhigozum trichotomum*, one of the dominant species in certain areas (Van Rooyen & Van Rooyen 2018), are declared indicators of bush encroachment in South Africa (Turpie *et al.* 2019). Bush encroachment involving these two species is common in this part of the Northern Cape, and elsewhere (e.g. Dougill *et al.* 2016). The ORSF1 power line's crossing over Lower Gariep Alluvial Vegetation along the Orange River includes alluvial terraces and riverine islands supporting a complex of riparian thickets (including riparian forest), reed beds, and vegetated sand banks (Fig. 11; Fig. 29).

## 3.1. Areas of conservation concern

### 3.1.1. Convention on Wetlands

The Convention on Wetlands of International Importance especially as Waterfowl Habitat is an intergovernmental treaty adopted on 2 February 1971 in the Iranian city of Ramsar and is also known as the Ramsar Convention. The Convention entered into force in 1975 and currently has 172 Contracting Parties, or member States, in all parts of the world (https://www.ramsar.org/). The mission of the Ramsar Convention, as adopted by the Parties in 1999 and refined in 2002, is "the conservation and wise use of all wetlands through local, regional and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world". South Africa ratified the Ramsar Convention in 1975 and has 28 Ramsar sites. Only the Orange River Mouth Ramsar site is located downstream from Groblershoop, approximately 540 km to the west; the nearest Ramsar site is Baberspan located more than 400 km to the north-east (https://www.ramsar.org/wetland/south-africa).

### 3.1.2. South African Critical Biodiversity Areas

The National Environmental Management: Biodiversity Act (2004) allows for the publishing of bioregional plans. The purpose of a bioregional plan is to provide a map of critical biodiversity areas (CBAs) with accompanying land-use planning and decision-making guidelines, to inform land-use planning, environmental assessment and authorisations, and natural resource management by a range of sectors whose policies and decisions impact on biodiversity (Department of Environmental Affairs 2011). A CBA is defined as an area showing terrestrial and aquatic features in the landscape that are critical for conserving biodiversity and maintaining ecological processes; these areas should remain in a natural or near-natural state (Department of Environmental Affairs 2011). In addition to CBAs, a bioregional plan may also identify ecological support areas (ESAs) that support the ecological functioning of critical biodiversity areas and/or deliver ecosystem services and should remain in at least an ecologically functional state (Department of Environmental Affairs 2011).

Except for the part where the ORSF1 power line crosses the agricultural fields (Fig. 26), the rest of its route is classified by the Northern Cape Critical Biodiversity Area Map either as CBA1 (Orange River) or CBA2 (Fig. 30, page 157; Holness & Oosthuysen 2016; https://bgis.sanbi.org/Projects/Detail/203). Various criteria were used by Holness & Oosthuysen (2016) to determine CBA1 and CBA2 classification in the Northern Cape. Those most relevant to the study area include the following:

- Ecosystem threat: Using the standard National Biodiversity Assessment (Driver *et al*. 2012) method for evaluating threat status, the Lower Gariep Alluvial Vegetation triggered CBA status, classified as "Endangered with known under-mapped degradation and transformation."
- Larger rivers: According to Holness & Oosthuysen (2016), "Larger rivers provided a

structure, ecosystem function and landscape linkage backbone for this arid region." Consequently, "Areas in close proximity [to] larger rivers were prioritized. 500m buffer was used."

- Intact riparian vegetation: Holness & Oosthuysen (2016) classified all such areas as CBA1.
- Areas supporting climate change resilience: River corridors are included here by Holness & Oosthuysen (2016).
- Threatened plant, butterfly, and reptile species: "All planning units with confirmed records of threatened species were included" as "CBA1 minimum" (Holness & Oosthuysen 2016). The Lower Gariep Alluvial Vegetation is considered endangered (Mucina *et al*. 2006). In addition, a botanical assessment of Portion 18 of the farm Rooi Sand 387 found several "protected" plant species (*e.g. Vachellia erioloba*, formerly *Acacia erioloba* (see Kull & Rangan 2012; Moore *et al*. 2011)), and a Vulnerable species: *Dinteranthus pole-evansii*. (Van Rooyen & Van Rooyen 2018). The Near-Threatened *Hoodia officinalis* was also recently discovered on the site (R. Nel, personal communication).

The following criteria were also considered by Holness & Oosthuysen (2016), however, they are all irrelevant to the present study area:

- Important Bird Areas (Marnewich *et al*. 2015; https://bgis.sanbi.org/Projects/Detail/10): The function of the Important Bird Areas programme is to identify and protect a network of sites critical for the long-term viability of naturally occurring bird populations, across the range of those bird species for which a site-based approach is appropriate. The IBA programme was initiated in Europe in 1985, Africa in 1993, and southern Africa in 1995 (Barnes 1998). The nearest IBA is Augrabies Falls National Park located more than 150 km west of the study area.
- Distance buffers of up to 10 km around protected areas: The nearest formally protected area is Witsand Provincial Nature Reserve located more than 50 km north-east of the study area (see https://bgis.sanbi.org/Projects/Detail/144).
- National Protected Areas Expansion Strategy (NPAES) focus areas for protected area expansion (Balfour *et al*. 2018; Government of South Africa 2010; https://bgis.sanbi.org/Projects/Detail/144): The current study area does not form part of any such area.
- Freshwater Ecosystem Priority Area (FEPA) (Driver *et al*. 2011; https://bgis.sanbi.org/Projects/Detail/48): The study area is not located within a river FEPA. Instead, it is classified as a "Fish Support Area", which means that it is *not* essential for protecting threatened and near-threatened freshwater fish that are indigenous to South Africa (Driver *et al*. 2011). The "Fish Support Area" designation "also include sub-quaternary catchments that are important for migration of threatened or near-threatened fish species" (Driver *et al*. 2011).

- Various other criteria also considered are irrelevant to the present study; see Holness & Oosthuysen (2016) for more details.

## 4. Study approach & Methods

For ease of reference, the so-called Roberts number as per Maclean (1985), is included with the name of bird species whenever they are mentioned, *e.g.* Cape Robin-Chat R601. Thus given, it is easy to locate the species in Table 1 (page 113), where the birds within each group (see below) are sorted by their Roberts number. In cases where changes in taxonomy after Maclean (1985) resulted in a taxon being split into more than one species, a number was improvised, *e.g.* Orange River White-eye (R796a). Bird names follows Hardaker (2022). The term 'resident' is used here to mean species present at (or at least regularly visiting) the indicated area for an extended period of time (a month or more a year) and includes migrating species.

Tables and figures are arranged in order towards the end of this report starting on pages 113 & 128, respectively. In specific figures with photographs, a yellow line is used to indicate the route of the proposed new power line. This line is meant for general orientation only and may not be 100% accurate. A similar situation holds for the compass rose included in some figures.

### 4.1. Assumptions, uncertainties and gaps in knowledge

Assumptions, uncertainties and gaps in knowledge applicable to this investigation appear in context as underlined text throughout this report. The following is a summary of the main issues:

- Details about the proposed development layout incorporated into this report are based on information available in August 2022. Subsequent changes could potentially require adjustments to be made.

- No technical drawings of the design of pylons were available when this report was compiled. It was only known that the pylons would be similar to those of the existing 132kV Garona–Groblershoop power line. The measurements used here are based on elevation meta-data from photographs taken with a drone, examination of photographs, and guesstimates of the dimensions of the Garona–Groblershoop pylons.

- Knowledge of bird distribution and movement patterns in and around the proposed development area is incomplete, and it is difficult to assess if, when and how these patterns will change over time.

- Our understanding of bird and power line interactions is incomplete (see Section 2).

- This report is partly based on one site survey at the end of August 2022. It is to be expected that further surveys will lead to a refinement of results.

- The present study assesses the potential impact of a power line on birds. The occurrence and behaviour of bird species in any given area are influenced by both internal factors (*e.g.* circadian and circannual clocks) and external factors (*e.g.* amount and timing of rainfall) (Van Niekerk 2009). While factors such as day-length change predictably throughout the year — day-length is the environmental factor showing the most consistent seasonal change from year to year (Berthold 1996; Brandstätter 2003) — the temporal occurrence of other factors such as rainfall are less predictable. For example, a specific wetland may be inundated in December of one year but dry the next. Consequently, within EIA time-frames, covering all possible environmental conditions during fieldwork will never be possible. Therefore, decisions made within these time-frames are necessarily based on incomplete data, regardless of the thoroughness of any fieldwork on which these decisions are based. However, in addition to data collected during fieldwork (see below), other supplementary information from other sources, such as literature and experience, could help fill in some knowledge gaps.

- It is assumed that this report will be distributed and consulted in its entirety. The specialist who compiled this report does not accept any responsibility for subsequent amendments effected without his specific and written consent. In case of any uncertainty, please direct enquiries to Dr Johan van Niekerk at djvnemail@gmail.com.

## 4.2. Field observations

A site visit was conducted from 22 to 27 August 2022 with a focus on an area of 5 km around the ORSF1 power line (Fig. 31, page 158). The aim was to gain first-hand knowledge of site-specific issues related to the potential impact of the ORSF1 power line on birds. Throughout this period, birds heard and or seen were recorded on a custom Android app which automatically recorded the date, time and observer location for each observation. The fieldwork included the following:

- Bird activity at the Orange River crossing site. During the late afternoon of the 22nd and the early morning of 23 August 2022, the movement patterns of birds were recorded at the Destination River Resort campsite riverfront (Fig. 11). Miscellaneous observations were also made at or near this site at other times.

- Transects were conducted on foot, with the area covered indicated in Figure 31. At least 5 minutes was spent in each 12-second block traversed, even if a transect only cuts through a small part of a block.
  - Power line transects were conducted to check on power line-related bird casualties. Details about the sections along the ORSF1 power line are illustrated in Figure 9.
    - 132kV Garona–Groblershoop power line: From pylon 1 GAR/GRO 82 at the Orange River north-eastwards to pylon 1 GAR/GRO 68, a total distance of 3.5 km.

    - 22 kV Groblershoop–Padkloof (GPF) power line: From pylon GPF 15 at the Orange River north-eastwards to pylon GPF 58, a total distance of 4.0 km.

- Vehicle transects. Transects were conducted by vehicle on various roads up to 5 km from the ORSF1 power line (Fig. 31). In most cases, at least 5 minutes was spent in each 1-minute block traversed, even if a transect only cuts through a small part of a block.

### 4.3. Species list

A list of bird species likely to be found in the proposed development site and environs is at the core of any avifaunal impact assessment. Because the ORSF1 power line will be in operation for at least a few decades, it would be ideal to consider all species which would occur in the area over that period. However, two factors make this difficult: 1) Current knowledge of the distribution and movement patterns of birds in and around the proposed development area is incomplete; 2) The distribution of species may change over time and for any given species, it is difficult to predict if, when and how this will happen. The analysis presented in this report attempts to draw reasonable inferences from what is presently known.

In the absence of detailed long-term studies over several years, it is often not possible to accurately assess the (potential) utilisation of an area by specific bird species. Instead, the data from the first Southern African Bird Atlas Project (SABAP1: 1987-1991; Harrison *et al.* 1997a,b) and the second Southern African Bird Atlas Project (SABAP2: 2007-present; `sabap2.adu.org.za`) were combined to produce for each bird species recorded in South Africa a distribution map with a minimum resolution of one quarter degree grid cell (QDGC), *i.e.* 15' latitude by 15' longitude. Each map was then examined, and species with distributions overlapping the study area were selected. Also selected were species where the QDGC of the study area (*i.e.* 2821DD) was just outside the SABAP1/SABAP2 distribution or where it fell within the general area of occurrence in species that were patchily recorded. This was done to compensate for imperfections in the SABAP1 & SABAP2 datasets. While a detailed discussion of all the issues involved is beyond the scope of this report, it is nonetheless instructive to briefly examine the situation in the Groblershoop area.

SABAP1 (5 years) & SABAP2 (15 years) represent about 20 years of data collection on the distribution of birds in southern Africa. If this data collection effort was comprehensive, records of new bird species for any given area should be rather exceptional by now — but it is not. Before the August 2022 field survey, a preliminary list of 231 bird species was compiled for the Groblershoop area using the abovementioned method. During the present 5 km field survey (Fig. 31) three new species were recorded (Fig. 32, page 159). While the SABAP1/2 data indicated a gap around Groblershoop in the distribution of the White Stork R083 and Lilac-breasted Roller R447, the Purple Roller R449 record is a bit south-west of their recorded SABAP1/2 distribution. This is a 'best case scenario'; things get much worse the closer one looks.

For example, in their avifaunal impact assessment for the proposed Orange River Solar Facility 1, Nuttall & Vermeulen (2022) utilised a consolidated SABAP2 data set (2007–2020, including species recorded during their fieldwork for the project) from 9 pentads (which they referred to as the broader area) within which the proposed development is to be located in (Fig. 33, page 160). This resulted in a list of 163 bird species (Nuttall & Vermeulen 2022). Now, during the August 2022 survey in the 5 km study area (Fig. 31), 20 of the 129 bird species positively identified were not on their list at all, with more than half of them likely residents there (*e.g.* xsdfr; Pearl-spotted Owlet R398).

The species list for the current assessment amounts to 234 species and is presented in Table 1, where species are arranged in groups and within each group by Roberts's number. Each species is listed only once. The groups are the following:

- A) Red Data species (arranged by category);
- B) Additional endemic species;
- C) Additional species potentially negative impacted by power lines;
- D) Additional species potentially positively impacted by power lines;
- E) Additional species listed under CMS;
- F) Additional waterbirds;
- G) Additional species.

The list includes 71 species not listed by Nuttall & Vermeulen (2022).

## 4.4. Distribution patterns

The distribution pattern of each species was classified into one of 19 categories based on its directional occurrence pattern in the general vicinity of the study area. Eighteen of these potential patterns are diagrammatically illustrated in Figure 34 (page 161); cases where the study area falls outside the normal distribution of a species (OOR) are not illustrated. This classification is based on incomplete data, partly because this part of South Africa was poorly covered during SABAP1 and SABAP2. Consequently, several species have unclear distribution patterns around the study area. In each of these cases, species was nonetheless placed into one of the categories based on the distribution of suitable habitat and other factors. Despite these shortcomings, it seems reasonable to assume that the patterns revealed are helpful indicators of habitat distribution/utilisation around the study area (see below).

## 4.5. Habitat preference

Although birds are highly mobile, many species utilise only specific habitats, with habitat diversity playing an important role in determining the avifaunal diversity of any given area (Cody 1985).

The hierarchical habitat classification system of Harrison *et al.* (1994) was used to characterise the habitat preferences of each species. Only their primary habitat levels were used, which include marine (MA), aquatic (AQ), montane/rocky (RC), grassland (GR), scrub (SC), woodland (WO) and forest (FR) habitats. In addition, "habitat-unspecific" species were placed into a 'habitat generalist' (HG) category. In the few cases where Harrison *et al.* (1994) did not assess the habitat preferences of a species, where taxonomic changes occurred after the publication of Harrison *et al.* (1994), or where new species were admitted to the Southern African list, appropriate habitat associations were assigned based on information in Hockey *et al.* (2005), and/or personal experience. For this assessment, the term 'waterbird' refers to all species associated with aquatic habitats according to the system of Harrison *et al.* (1994). The habitat preferences of all species are indicated in Table 1 and summarised in Figures 35 (page 162) and 36 (page 163). In addition, the distribution patterns of birds from the respective habitats are summarised in Figure 37 (page 164).

## 4.6. Breeding on pylons

Bird species with distributions overlapping with the study area and which are known to breed on power line pylons are indicated in the "Pbr" column of Table 1. This is based on the following: (Anderson 2000a, 2013; Anderson & Hohne 2007; Boshoff & Fabricius 1986; Boshoff *et al.* 1983; Brown & Lawson 1989; Dean 1975; Jenkins *et al.* 2013; Kemp 1972; Ledger & Hobbs 1985; Ledger & Hobbs 1999; Machange 2003; Tarboton & Allan 1984; Van Rooyen & Ledger 1999; Vosloo & Van Rooyen 2009c); D. J. van Niekerk, personal observations.

## 4.7. Impact significance

According to Rossouw (2003), there are three broad categories of determining impact significance, namely technical, public & legal:

- Technical: In the context of avifaunal impact assessment, this is commonly referred to as biological significance, which Buffington (1976) defines as follows: "*An impact is significant if it results in a change that is measurable in a statistically sound sampling program and if it persists, or is expected to persist, more than several years at the population, community, or ecosystem level.*" Subsequent authors had similar definitions (e.g. APLIC 2012; Willard 1978)

- Public: Buffington (1976) defines this category as follows: "… *a change or impact in agreement with societal norms. Put another way, an "unacceptable" impact in someway flaunts the public's (or portion thereof) system of values.*" In referring to Buffington (1976), Thompson (1978) terms it social acceptability. It is also sometimes called "political significance" (*e.g.* Amend 1978; APLIC 1994; Brown 1993; Willard 1978).

- Legal: This refers to the acknowledgement of the importance of environmental resources in government policy, law or plans (Rossouw 2003). APLIC (2012) calls this "wildlife policy". Those most relevant to the present investigation is considered in Section 3.1 (page 32 *ff.*).

In the remainder of this section we elaborate on each category.

### 4.7.1. Biological significance

> "The extent of our knowledge today is such that we may not be able to perceive or measure changes in carrying capacity attributable to wire strikes, even if they are sizable and long-term." (Thompson 1978)

In general, determining demographic parameters, such as survival and productivity, is extremely difficult to measure directly and link these to variations in external factors (Alves 2013). Improvements in the modelling capacity at the disposal of scientists are partly credited to the advances made in the study of demography over the last few decades (Alves 2013). Large, spatial data sets collected over a long time — for example, SABAP1 & 2 (see Section 4.3 on page 36) — are considered crucial for studying the role of risk factors in driving shifts in species ranges, *etc.* (Wijewardhana *et al*. 2020). However, these datasets should be approached with caution as they might not be as comprehensive as is often assumed (see, for example, Section 4.3, page 36).

Our understanding of the scale and demographic consequences of avian power line collisions could be better (Jenkins *et al*. 2010). While it is recognised that detailed demographic analyses are needed to assess the threat of power line mortality for each species with any confidence, such data does not exist, and it is likely to remain so for the foreseeable future (Shaw 2013). At the core of this problem is the difficulty of obtaining accurate counts of biological entities in space and time frames that would enable meaningful and accurate demographic analyses. For example, in order to accurately assess the impact of power line collisions on any particular species, one would need to know, as an absolute minimum, the population size and the number of individuals within that population that get killed by collisions with power lines. Neither of these numbers is easily obtained: the difficulty of determining mortality rates was already discussed in an earlier section (page 24 *ff.*); determining population size is likewise beset with difficulties (Van Niekerk 2009).

As far as we know, collisions with power lines are not a biologically significant source of mortality in thriving species (APLIC 1994; Brown & Drewien 1995; Drewitt & Langston 2008; Faanes 1987; Willard 1978). Collision and/or electrocution incidents involving power line infrastructure are claimed to be a significant factor (*e.g.* Shaw 2015), or at least one of the major factors (*e.g.* Peacock 2015c), or a contributing factor (*e.g.* Taylor 2015d), in presumed declines of certain Red Data species. However, actual demonstration of such effects remains elusive. The Ludwig's Bustard *Neotis ludwigii* is an excellent example of this.

Based on the fact that this species is highly susceptible to collisions with overhead power lines (Jenkins & Smallie 2009; Jenkins *et al*. 2011; Shaw 2013; Shaw *et al*. 2021), Anderson (2000b)claimed that it "is declining as a result of powerline collisions and hunting, such that 20% of the population may be lost in three generations ... ". Subsequently, Shaw (2013) replicated an earlier Ludwig's Bustard population estimate study (Allan 1994) and concluded that there is "no evidence for a population decline over the past two decades. ... These results ... suggest that the South African [Ludwig's Bustard] population is not decreasing rapidly, despite the large numbers estimated to be killed by power line collisions." It is essential to point out that Shaw (2013) acknowledged "considerable uncertainty in the two estimates" and that "the population estimates are probably not accurate enough to detect a change between the two census counts." Such is the science of demographic analyses today — not much has changed since Thompson's (1978) day.

Except for the extreme cases — such as the California Condor *Gymnogyps californianus,* of which there were only 22 individuals left in the wild at one point in time (Walters *et al.* 2010) — it is generally considered improbable that any single project, on its own, would have a biologically significant impact on any species (Amend 1978; Drewitt & Langston 2008; Faanes 1987).

#### 4.7.1.1. Cumulative impact

> Cumulative impact: The impact of an activity that in itself may not be significant, but may become significant when added to the existing and potential impacts eventuating from similar or diverse activities or undertakings in the area (National Environmental Management Act (Act 107 of 1998), Environmental Impact Assessment Regulations 2014).

Given the difficulties of obtaining accurate mortality rates at any particular site (see page 24), let alone many sites scattered over a wide area, one may be forgiven for being pessimistic about measuring cumulative impacts accurately. However, several researchers suggest that the cumulative effect of mortality sustained from collisions with power lines at many locations may be significant, particularly when combined with other factors and if it involves rare or endangered species (Amend 1978; Drewitt & Langston 2008; Faanes 1987). Here we propose that this impact will be more significant for a mobile species than a more sedentary one.

##### 4.7.1.1.1. A significant cumulative impact scenario

Let us assume two hypothetical bird species equally prone to flying into power lines. The only significant difference between them is that one is a migrant and the other a resident. Further, assume they coexist in the same geographical area, Theoryland, where the resident species' family groups occur everywhere. In contrast, the migratory species migrate annually on an east-west axis from one part of Theoryland to the other. Also, assume that power lines running throughout all parts of Theoryland covers 5% of it and that this percentage is proportional to the population of the resident species, *i.e.* 5% lives with power lines, and 95% does not.

Now, whereas individuals of the resident species living in the 5% with power lines are constantly exposed to colliding with it, the rest of the population living in the other 95% without power lines will not have any such risk. Their situation is in stark contrast to that of the migratory species, where virtually all will likely encounter power lines en route during their annual travels.

Given this scenario, what would happen when the power line network expands to cover 10% of Theoryland? In the resident species, *10%* of the population would now have to live with the power lines. By contrast, in the migratory species, *all* the individuals will still be exposed to the power lines, only the frequency of encounters with it has increased. Consequently, the migratory species will likely experience a more significant decline in numbers than the resident species.

### 4.7.2. Public significance: the eyes and ears on the ground

> "The public simply does not want to see birds killed by power lines, regardless of the biological significance of such losses." (Thompson 1978).

APLIC (1994) points out that public concerns can force mitigation action, even if there is little or no biological significance. Nowadays, anyone with a smartphone can instantly transmit a message, a photo, or a video worldwide. It behoves developers always to keep this in mind.

### 4.7.3. Legal significance

#### 4.7.3.1. National Legislation

**The Constitution**

The Constitution of the Republic of South Africa (Act 108 of 1996) was approved by the Constitutional Court on 4 December 1996 and took effect on 4 February 1997. The Constitution is the supreme law of the land. No other law or government action can supersede the provisions of the Constitution. In Section 24 Environment (`https://www.gov.za/documents/constitution/chapter-2-bill-rights#24`), the Constitution provides that everyone has the right

a. to an environment that is not harmful to their health or well-being; and

b. to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that

    i. prevent pollution and ecological degradation;

    ii. promote conservation; and

    iii. secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

**National Environmental Management Act (NEMA) (Act 107 of 1998)**

> "To provide for co-operative, environmental governance by establishing principles for decision-making on matters affecting the environment, institutions that will promote co-operative governance and procedures for co-ordinating environmental functions exercised by organs of state; and to provide for matters connected therewith."

NEMA is the statutory framework to enforce Section 24 of the Constitution. NEMA Section 2 sets out several principles that apply throughout the Republic to the actions of all organs of state that may significantly affect the environment. For example:

- Principle 3: Development must be socially, environmentally and economically sustainable.
- Principle 4: (a) Sustainable development requires the consideration of all relevant factors including the following:
    - (i) That the disturbance of ecosystems and loss of biological diversity are avoided, or, where they cannot be altogether avoided, are minimised and remedied:
    - (viii) that negative impacts on the environment and on people's environmental rights be anticipated and prevented, and where they cannot be altogether prevented. are minimised and remedied.

NEMA Chapter 6 (*i.e.* Sections 25, 26 & 27) makes provision for international environmental instruments, defined as "any international agreement, declaration, resolution, convention or protocol which relates to the management of the environment".

**National Environmental Management: Biodiversity Act (Act 10 of 2004)**

> "To provide for the management and conservation of South Africa's biodiversity within the framework of the National Environmental Management Act, 998; the protection of species and ecosystems that warrant national protection; the sustainable use of indigenous biological resources; the fair and equitable sharing of benefits arising from bioprospecting involving indigenous biological resources; the establishment and functions of a South African National Biodiversity Institute; and for matters connected therewith."

One of the objectives of the act is "to give effect to ratified international agreements relating to biodiversity which are binding to the Republic." (Section 2(b)).

#### 4.7.3.2. International conventions and agreements

There are presently eight international conventions focusing on biodiversity issues (see https://www.cbd.int/brc/). Relevant to the present study are the Convention on the Conservation of Migratory Species of Wild Animals (CMS; Year of entry into force: 1979) and the Convention on Biological Diversity (CBD; 1993).

##### 4.7.3.2.1. Convention on the Conservation of Migratory Species of Wild Animals (CMS)

The CMS (see https://www.cms.int/) was concluded in Bonn, Germany, on 23 June 1979, and is thus also known as the Bonn Convention, which is not to be confused with the Bern Convention, which relates to the conservation of European wildlife and natural habitats (https://www.coe.int/en/web/bern-convention/home). It is the only global (and UN-based) intergovernmental organization established exclusively for the conservation and management of migratory terrestrial, marine and avian species. CMS parties acknowledge the need to take action to avoid any migratory species becoming endangered. In particular, the parties shall endeavour to:

- provide immediate protection for migratory species included in Appendix I of the convention, which includes migratory species threatened with extinction [Species with distributions overlapping with the study area are indicated as '**A1**' in the CMS column of Table 1 based on the latest version of Appendix 1 (22 May 2020; https://www.cms.int/en/species/appendix-i-ii-cms];
- conclude Agreements covering the conservation and management of migratory species included in Appendix II of the convention ( https://www.cms.int/en/species/appendix-i-ii-cms), which include migratory species that need or would significantly benefit from international cooperation [Species with distributions overlapping with the study area are indicated as '**A2**' in the CMS column of Table 1].

For this reason, the Convention encourages the Range States to conclude global or regional Agreements. In this respect, CMS acts as a framework Convention. The Agreements may range from legally binding treaties (called Agreements) to less formal instruments, such as Memoranda of Understanding, and can be adapted to the requirements of particular regions. South Africa ratified the Convention in 1991.

- The *African-Eurasian Waterbird Agreement* (AEWA; www.unep-aewa.org) is pertinent to the present report. It is an international agreement aiming at the conservation of migratory waterbirds. Like other migratory species, AEWA waterbirds cross international boundaries during their migrations, facing a wide range of threats. Without international cooperation, the conservation efforts of one country can be nullified if the species is not protected in another country along the flyway. AEWA is the largest Agreement developed so far under CMS auspices. The Agreement was concluded on 16 June 1995 in The Hague, the Netherlands, and entered into force on 1 November 1999; South Africa ratified the Agreement on 1 January 2000. As a regional agreement, AEWA focuses on 255 waterbird species ecologically dependent on wetlands for at least part of their annual cycle (https://www.unep-aewa.org/en/species). AEWA species with distributions overlapping with the study area is indicated with a '**W**' in the CMS column of Table 1.
- The CMS *Memorandum of Understanding on the Conservation of Migratory Birds of Prey in Africa and Eurasia* (Raptors MOU) aims to promote internationally coordinated actions to achieve and maintain the favourable conservation status of migratory birds of prey throughout their range in the African-Eurasian region, and to reverse their decline when and where appropriate (see https://www.cms.int/raptors). It was signed by South Africa on 4 December 2008. It is recognised that birds of prey face various human-induced threats such as habitat loss and degradation, illegal shooting and poisoning, collisions with aerial structures and electrocution by power lines. The species are assigned within the following three categories:
  - Category 1: Globally threatened, and Near Threatened species as defined according to the latest IUCN Red List and listed as such in the BirdLife International World Bird Database. Species with distributions overlapping with the study area are indicated by an '**R1**' in the CMS column of Table 1 A.

- Category 2: Species considered to have Unfavourable Conservation Status at a regional level within the Range States and territories listed in Annex 2 to the MOU Category. Species with distributions overlapping with the study area are indicated by an '**R2**' in the CMS column of Table 1 A.
- Category 3: All other migratory species. Species with distributions overlapping with the study area are indicated by an '**R3**' in the CMS column of Table 1 C & D.

#### 4.7.3.2.2. Convention on Biological Diversity (CBD)

Opened for signature at the Earth Summit in Rio de Janeiro in 1992, the CBD (see www.cbd.int) is the international framework for the conservation and sustainable use of biodiversity and the equitable sharing of its benefits. The CBD seeks to address all threats to biodiversity and ecosystem services. In keeping with their commitments under the CBD, South Africa – who ratified the Convention in 1995 – developed a National Biodiversity Strategy and Action Plan (NBSAP) in 2005 (www.cbd.int/doc/world/za/za-nbsap-01-en.pdf). The goal of the NBSAP is to conserve and manage terrestrial and aquatic biodiversity to ensure sustainable and equitable benefits to the people of South Africa, now and in the future. In support of this goal, five key strategic objectives have been identified, each with a number of outcomes and activities. For example, Activity 1.4.7: "Integrate biodiversity considerations in Strategic Environmental Assessment, Integrated Environmental Management and Environmental Impact Assessment".

Activity 2.5.2 of the NBSAP involves updating South African Red Data lists. Barnes (2000) provides the following perspective on the function of Red Data Books (RDB). During the 1970s and 1980s, most efforts to preserve biological diversity focused on species, especially those highlighted by Red Data Books. However, species cannot survive in isolation from their environments. This appreciation shifted emphasis away from species to site and habitat conservation in the 1990s, with efforts also increasingly focused at the ecosystem level. However, continued concern with species, which are the components of these systems, is essential. The Red Data Book concept explicitly attempts to document and highlight potential losses from the global stock of biodiversity at the species level (Barnes 2000). Since their inception in 1976, South African Red Data Books on birds (Barnes 2000; Brooke 1984; Siegfried *et al.* 1976; Taylor *et al.* 2015) all followed the lead of the International Union for Conservation of Nature and Natural Resources (IUCN).

## 4.8. Species of special concern

### 4.8.1. Focus species

Particular emphasis is placed on to following species:

- Red Data species (both Regional (Taylor *et al.* 2015) and Global (IUCN 2022)),
- Species endemic or at least near-endemic to South Africa, Lesotho and Swaziland (all will be referred to as 'endemic' in the text; No restricted-range species occur in the study

area (Marnewich *et al.* 2015)),

- CMS species (including AEWA & Raptors MOU),
- Species which may potentially interact with, or be affected by, the ORSF1 power line development.

For each species, all this information is indicated in Table 1. Waterbirds are highlighted in Table 1 by printing their risk assessment in blue, except in cases where the risk is high in which case it appears in red print.

### 4.8.2. Disturbance and Accidents

A distinction is made between the risk of disturbance and accidents. **Disturbance** refers to any human action depriving a bird species of its habitat. It includes the physical destruction or alteration of habitat in a way that causes displacement, as well as disturbance which have a negative impact on breeding success. In general, this type of disturbance is primarily associated with the project's construction phase. In Table 1, the probability of disturbance is indicated as either low, moderate or high, based on an informed opinion for each species.

**Accidents** refer to any incident involving the project infrastructure which could lead to the injury or death of birds, typically when the facility is completed and operational. Information on confirmed collision and electrocution accidents involving power lines and associated infrastructure were obtained for species occurring in South Africa, Lesotho and or Swaziland from published sources referring to incidents recorded in southern Africa — (Anderson 2000a, 2013; Anderson & Hohne 2007; Anonymous 2008; Boshoff & Fabricius 1986; Boshoff *et al.* 1983; Brown & Lawson 1989; Dean 1975; Diamond 2008; Diamond *et al.* 2010; Jenkins *et al.* 2013; Jenkins *et al.* 2011; Kemp 1972; Kruger 2000; Ledger & Hobbs 1985; Ledger & Hobbs 1999; Machange 2003; Pallett *et al.* 2022; Prinsen *et al.* 2011; Shaw 2013; Shaw *et al.* 2010; Shaw *et al.* 2021; Smallie 2011; Tarboton & Allan 1984; Van Niekerk 2013; Van Rooyen & Ledger 1999; Vosloo & Van Rooyen 2009a,c) — and elsewhere in the African-Eurasian region (Barrientos *et al.* 2012; Ferrer 2012; Janss 2000; Janss & Ferrer 1998; Prinsen *et al.* 2011; Scott *et al.* 1972; Shobrak 2012; Thompson 1978). It is assumed that the data contained in these references are correct.

The *negative* accident risk categories distinguished below refer to the situation before consideration of mitigation measures, and it is indicated in Table 1. A solitary x signifies cases where the type of incident (either collision or electrocution, but probably the former in most cases) was not specified.

For *collisions* with power line infrastructure, the following categories are distinguished:

- Unlikely (–): There are no known collision cases involving this species on record.
- Low (C1): The species is known (or expected) to collide with power line infrastructure. However, the species is probably a transient, irregular visitor to the affected area or is otherwise unlikely to be affected.

- High (C3): The species is known (or expected) to collide with power line infrastructure. In addition, it is *more* than a transient, irregular visitor to the affected area or is otherwise expected to be affected.

For *electrocution* involving power line infrastructure, the following categories are distinguished based on biometric characteristics of the species (Fig. 15), and the distances between power line components of the proposed ORSF1 power line (Fig.7; Fig. 8) (see Figure 38 (page 165) for an example of each category):

- –: No electrocution incidents involving this species could be found in the literature.
- E.: The species is likely too small to bridge air gaps between different infrastructure components.
- Ec: Electrocution in this species is probably limited to instances where it follows on collision (*e.g.* Figure 18).
- El: The species have relatively long legs — in a perched bird, the head-to-tail measurement is shorter than the head-to-foot measurement (Fig. 15) — which, together with the overall large size, could cause the birds to bridge an air gap between infrastructure components, potentially resulting in electrocution.
- Et: The tail of a perched bird extends below the perch — *i.e.* the head-to-tail measurement is longer than the head-to-foot foot measurement in a perched bird (Fig. 15) — and could make contact with a conductor below it. If another part of the bird also touches grounded infrastructure at the same time, electrocution may result, especially when the feathers are wet.
- Ex: The species could bridge air gaps between infrastructure components but do not fit in any of the categories above.
- !: Appended to the codes above if the species can produce streamers that could cause flashovers. Partly based on Hoogstad & Leeuwner (noyr).

In Table 1, the C and E categories detailed above may be followed by the following:

- *: Incidents recorded in the African-Eurasian region outside southern Africa;
- ?: Species for which no confirmed incidents could be found but where it may possibly occur based on incidents involving similar species, site-specific factors, *etc*. This was necessary because it is likely that a large number of incidents go unreported (Pandely *et al*. 2008; Shaw *et al*. 2010; Vosloo & Van Rooyen 2009a; Willard 1978). For example, the carcasses of smaller species may be easily overlooked, and scavengers remove the carcasses of dead birds at a relatively rapid rate (Borner *et al*. 2017a,b; Drewitt & Langston 2006; Flint *et al*. 2010; Hunting 2002; Johnson *et al*. 2000; Martin *et al*. 2022; Ponce *et al*. 2010; Scott *et al*. 1972; Shaw 2013; Smallwood 2007, 2022; Van Niekerk 2012; Visser *et al*. 2019; Yee 2007).

Allocation of species to the categories above is provisional as it is based on incomplete knowledge regarding the avifauna of the project site and interactions between birds and power line infrastructure.

# 5. Receiving environment from an avifaunal perspective

In its current state, the habitat in the footprint area is utilised or is at least expected to be utilised, by a range of bird species, including a few Red Data and endemic species. The 234 species listed in Table 1 represent cases where distribution overlap with the study site and environs (see Section 4.3 on page 36). Here we will examine each habitat with which these species are associated (see Section 4.5 on page 37); habitat generalists are considered separately at the end. Within each habitat, Red Data species are introduced first, with a paragraph of relevant information for each species, starting with the main reasons for declines. Red data species are followed by a section on endemic species followed by other species. CMS species are also indicated (see Section 4.7.3.2.1 on page 42 for an explanation of codes used, *i.e.* A1, A2, W, R1, R2, R3).

## 5.1. Summary

Only 43.6% of the 234 bird species have a widespread distribution around the study area. For the rest of the species, the study area is at or near the local limit of their range, with more than a quarter of the species (27.4%) limited to the Orange River in this part of their range.

### 5.1.1. Red Data species

The 234 include 15 (6.4%) Red Data species, with the study area being located at or near the edge of the distribution of eight (53.3%) of them (Table 1 A). Red Data species include one Critically Endangered species, five Endangered species, four Vulnerable species, and five Near-Threatened species (Table 1 A). Four Red Data species are also endemic to South Africa, Lesotho & Swaziland (Table 1 A).

Present indications are that the territory of at least one Karoo Korhaan R235 group overlaps marginally with the footprint itself. A few other Red Data species could also be residents in the area. However, they likely roam over a relatively wide area, and their use of the footprint area is provisionally considered to be primarily transitory (Secretarybird R118, Lanner Falcon R172, Kori Bustard R230 & Ludwig's Bustard R232). The Abdim's Stork R085 is a non-breeding trans-equatorial intra-African migrant expected to visit the agricultural fields in relatively large numbers. The remainder of the Red Data species is all expected to be infrequent visitors to the area.

Six Red Data species also appear in CMS lists A1, W, R1 & R2. Only the Abdim's Stork R085, a non-breeding trans-equatorial intra-African migrant, and Lanner Falcon R172 are considered relatively common in the area (see status above). The remaining four are expected to be infrequent visitors tot the area.

### 5.1.2. Endemic & Restricted-Range species

There is a total of 18 endemic species (7.7%) with distributions overlapping with the study area, including four Red Data species and no Restricted-Range species (Table 1 A & B). Only six of them (33.3%) have a widespread distribution around the study area (Table 1 A & B).

The Karoo Korhaan R235, Karoo Thrush R577a, Karoo Scrub Robin R614, Namaqua Warbler R687, Fiscal Flycatcher R698 and Fairy Flycatcher R706 are the only endemic species which are probably resident in the proposed footprint area. None of the remaining 12 endemic species appears to be residents in the footprint area. However, some may be residents in adjacent areas and/or visit the footprint area occasionally.

The only endemic CMS species is the Black Harrier R168 (R1), possibly an infrequent transitory visitor to the study area.

### 5.1.3. Other species

The vast majority of the 234 species with distribution overlapping with the study area are neither threatened nor endemic (87.6%; n = 205 species; Table 1 C–F). Many utilise, or are expected to utilise, the footprint area, including the 39 species listed in Table 1 C1, most of which have either a widespread distribution around the study area, or are limited to the Orange River in this part of their respective ranges.

A total of 42 CMS species are neither threatened nor endemic, including 23 A2, 31 W, and 5 R3 species (Table 1 C2 & E). Many of them are relatively common in the study area.

## 5.2. Woodland

One-third of bird species with distributions overlapping the study area prefer woodland habitats (Fig. 35). Several of these species are also associated with scrub, and some others with grassland and other habitats (Fig. 36). Woodland-type habitats are widespread in and around the proposed development area, particularly along the ephemeral drainage lines, dunes and the Orange River (Fig. 26; Fig. 28; Fig. 24; Fig. 11).

The study area is located at or near the south-western local limit of many bird species preferring woodland habitats (Fig. 37), coinciding with the proximity of the limit of the Savanna Biome (Fig. 1). Riparian vegetation along the Orange River also provides suitable habitat for a significant number of woodland species (Fig. 37; Fig. 39, page 166).

### 5.2.1. Red Data species

The three Red Data species associated with woodland habitats include one Critically Endangered species, one Endangered species, and one Near-threatened species (Table 1 A):

#### 5.2.1.1. Critically Endangered

- White-backed Vulture R123 (CMS:A1,R1). Poisoning, often motivated by the masking of poaching operations and harvesting for the traditional health industry, and collision and electrocution incidents involving power lines are regarded as the main drivers for apparent declines (Allan 2015a). The study area is located along the south-western edge of their current known distribution. In the Northern Cape, breeding is mainly confined to the Kgalagadi Transfortier Park, and private farmland in the Askam, Vanzylzrus, and the greater Kimberly areas (Anderson 2004; Anderson & Maritz 1997; Murn *et al*. 2002; R. Visagie (Platberg Karoo Raptor Project, EWT), personal communication). These areas are all located more than 200 km from the proposed development. They typically nest on top of a tree canopy and often in loose colonies with one nest per tree (Steyn 1982). Breeding has also been recorded on power line pylons of the metal lattice type (Anderson 2013; Anderson & Hohne 2007; Ledger & Hobbs 1985). In the Northern Cape, they typically nest on *Vachellia erioloba* trees (Anderson & Maritz 1997), but also on metal lattice-type power line pylons (Anderson 2013; Anderson & Hohne 2007). The pylon designs in the study area are unsuitable for breeding in this species. However, in Portion 18 of the farm Rooi Sand 387, several *Vachellia erioloba* trees occur at scattered localities on deep sand (see Van Rooyen & Van Rooyen (2018); Fig. 28). Therefore, while there is currently no known breeding activity in the vicinity of the ORSF1 power line, the possibility of future colonisation cannot be excluded. Even though the White-backed Vulture may not be presently breeding in the study area, they range extensively and generally travel in a nomadic manner (Phipps *et al*. 2013; Spiegel *et al*. 2013). Based on present evidence, it is concluded that they could be rare transitory visitors to the study area.

#### 5.2.1.2. Endangered

- Lappet-faced Vulture R124 (CMS:A1,R1). Poisoning, often motivated by the masking of poaching operations and harvesting for the traditional health industry, is considered the primary concern with declining numbers, with electrocution and collisions with power lines and drowning being contributing factors (Allan 2015b). The study area is located along the south-western edge of their current known distribution. In 2003, there were less than 50 breeding pairs in the Northern Cape, most of them on farmland, of which many were located in the Vanzylsrus area (Anderson 2004; Anderson & Maritz 1997). Most of the nests found in the Northern Cape was located on top of large *Vachellia erioloba* trees (Anderson & Maritz 1997). While there is currently no known breeding activity in the vicinity of the ORSF1 power line, the possibility of future colonisation cannot be excluded. Even though the species may not be breeding in the study area, they range extensively (Spiegel *et al*. 2013). Based on present evidence, it is concluded that they could be rare transitory visitors to the study area.

#### 5.2.1.3. Near-threatened

- Kori Bustard R230. Habitat destruction is regarded as the main threat to this species; collisions with overhead power lines may be an underestimated threat (Peacock 2015b). This species has a widespread distribution around the study area. Home ranges vary from one to a few square kilometres for females with chicks to tens, hundreds or more square kilometres otherwise (Osborne & Osborne 1998; Senyatso 2011). While they are sedentary in certain parts of their distribution range, *e.g.* Botswana (Senyatso 2011), local/nomadic movements are evident elsewhere, especially during drought conditions (*e*/*g.* Osborne 1998). This species has been recorded in the general area of the ORSF1 power line during the survey (Fig. 40, page 167), and is likely to utilise the study area (except the riparian vegetation and agricultural fields), at least occasionally. Breeding is also possible in the area.

### 5.2.2. Endemic species

Three species are endemic to South Africa, Lesotho & Swaziland (Table 1 B). Whereas one species appears to be primarily associated with Orange River in this part of their range, the other two are more widespread (Table 1 B). All three species have been recorded in the general area during the surveys and is probably residents.

### 5.2.3. Other species

Most of the remaining 73 woodland-associated bird species are only associated with woodland (n = 56 species; 76.7%). A number of them are (probably) residents in the footprint area, for example, Fawn-colored Lark R497 (Fig. 41 A, page 168), Sabota Lark R498 and Kalahari Scrub Robin R615. Sociable Weaver R800 nesting on a nearby telephone pole (Fig. 41 B) visits the power line footprint area daily to forage. An old abandoned nest of this species found next to the route of the ORSF1 power line is currently utilised by an Egyptian Goose R102 for nesting (Fig. 28). Species such as the Red-eyed Dove R352 & Pearl-spotted Owlet R398 occur in riparian and other woodlands. Two migrant species are also listed in CMS:A2.

The remaining 17 species are associated with other habitats besides woodland, primarily scrub. Some of these species are resident in the footprint, e.g. Pygmy Falcon R186 (Fig. 41 B), Chestnut-vented Tit-babbler (R621), Long-billed Crombec (R651) and Black-chested Prinia (R685).

## 5.3. Aquatic

Wetlands typically represent discrete habitats within landscapes, *e.g.* rivers, dams and pans. When they have water, they attract various animals, leading to a concentration of biota. Most prominent among these are birds, particularly waterbirds, many of which are also known to colonise ephemeral wetlands soon after receiving water. Because of its potential to attract birds to a specific location, a wetland in an area often implies increased bird movements there.

The Orange River represents the most prominent open water feature in the footprint area (Fig. 39; Fig. 26). Other natural water courses in the area are all ephemeral (Fig. 5) and unlikely to retain water for long after any particular rain event.

There are a few artificial wetlands near the ORSF1 power line. Those relying on pumped water include the ponds at the Destination River Resort (Fig. 42, page 169; Fig. 5-C) and the Sports Grounds (Fig. 5-B), as well as the watering troughs at the livestock kraal (Fig. 24; Fig. 5-D). By contrast, the rehabilitated quarry at the sports grounds (Fig. 5-A) is likely to retain water only after rain. Along the Orange River, the irrigation of agricultural fields via irrigation channels above the fields (Fig. 26) or pump stations creates wetlands in these fields. Further afield, the most prominent open water is the Groblershoop water treatment works, which is located 3.4 km south-southeast of the Groblershoop substation (Fig. 43, page 170).

Approximately one-fifth of the bird species with distributions overlapping with the study area are associated with aquatic habitats (21.5%, Fig. 35). Two of these species are also associated with grassland (Fig. 36). Most of the aquatic species are associated with the Orange River in this part of their range (Fig. 37). All species associated with marine habitats are also associated with freshwater habitats, except the Common Tern (R327), which is a nonbreeding migrant associated with marine habitats, but with occasional vagrants recorded at inland freshwater habitats (Fig. 36). Alan Collett photographed a bird on the Boegoeberg Dam, approximately 30 km south-east of the study area, in November 2019.

### 5.3.1. Red Data species

No Red-Data aquatic taxa are presently known to occur near the study area (Table 1 A).

### 5.3.2. Endemic species

The Namaqua Warbler (R687) is the only aquatic species that is endemic (Table 1 B). They are common along the Orange River, where they are probably residents.

### 5.3.3. Other species

There are an additional 47 aquatic species, of which 13 (27.7%) are CMS:A2 and 25 (53.2%) CMS:W (Table 1 D & E). It is expected that most of them will be closely associated with Orange River and that moving up and down the river would be typical. Indeed, during the field observations, several species were recorded flying up or down the river at the site where the ORSF1 power line would cross it. Although not yet recorded to do so along the Orange River, the White-breasted Cormorant R055, Reed Cormorant R058, and African Darter R060 are known to perch/roost on power lines and/or their support structures, *i.e.* pylons (Brown & Lawson 1989; Daniel *et al*. 2020; D. J. van Niekerk, personal observations).

It is furthermore to be expected that some waterbirds would regularly take a shortcut across the dry land part of the river bend. This type of movement was observed during the August 2022 field observations, where the species included the Egyptian Goose R102, South African

Shelduck R103, Spur-winged Goose R116 & African Fish Eagle R148. Some waterbirds may even breed in the dry part of the river bend. For example, the Egyptian Goose was found nesting on top of a disused Sociable Weaver R800 nest along the route of the ORSF1 power line (Fig. 28).

Meanwhile, a few of the smaller waterbirds breeding along the river may regularly forage in and over dry land areas, particularly the White-throated Swallow R520, Brown-throated Martin R533 and Southern Red Bishop R824Åll three of these species were, in fact, so, observed during the August 2022 site visit. While the bishop roost and likely breeds colonially in nearby reed beds along the Orange River, the swallow is a solitary nester with pairs building their mud nests on vertical surfaces. Moreover, as for the martins, a huge roosting/breeding site was discovered 1.2 km north-west from the starting point of the ORSF1 power line (Fig. 5; Fig. 44, page 171). The site was discovered around sunset when many martins came in to roost. Later examination of photographs of the sandbank indicates the presence of approximately 2 000 burrows entrances. However, how many of these burrows are completed and actively utilised for roosting/breeding is unknown. Even so, this number far exceeds Maclean's (1985) statement that "up to 500 burrows [may be found] together".

## 5.4. Scrub

20.1% of species with distributions overlapping with the study area are associated with scrub habitats, of which 23.4% are endemics (Fig. 35). For a fair proportion of these species, the study area is located at or near the north-eastern aspect of their range (Fig. 37). Most of the scrub species are associated with other habitats, particularly grassland and woodland (Fig. 36). In the footprint of the proposed development, scrub-type habitats are one of the most prominent habitat features (Fig. 29; Fig. 10; Fig. 24).

### 5.4.1. Red Data species

The six Red-Data scrub-associated taxa include two Endangered species, one Vulnerable species, and three Near-threatened species (Table 1 A).

#### 5.4.1.1. Endangered species

- Black Harrier R168 (CMS:R1): Near-endemic. This species's main threats include habitat loss and fire (Taylor 2015b). Even though no records of fatal incidents involving power lines could be found for this species, a modelling study based on morphological and behavioural factors categorised this species into a high collision risk category (Smallie 2011). The status of the Black Harrier in the Northern Cape has been described as "irruptive ... in response to food availability, being abundant one year and completely absent the next" (Taylor 2015b). Although not yet recorded in the immediate area around Groblershoop, non-breeding individuals from the south-western parts of South Africa (see Garcia-Heras *et al.* 2019; Simmons 1997) could potentially visit the area given that they have been recorded to the north of Groblershoop. However, any potential use of the footprint and environs is likely transitory.

- Ludwig's Bustard R232. Mortalities related to collisions with power lines and telephone lines are regarded as the main threat to the regional population (Shaw 2015). This species has a widespread distribution around the study area. In addition to scrub-type habitats, they are also known to utilise agricultural fields (Allan 1994, 2005; Shaw 2013; Van Niekerk 2007). The results from a GPS satellite tracking study on eight birds in the Northern Cape confirmed an earlier suggestion by Allan (1994) that these birds are nomadic and partially migratory, with at least part of the population moving along an east-west axis in the Northern Cape (Shaw 2013). It also indicated that most travelling flights were in the early morning and late afternoon, often in low light, and even (rarely) at night (Shaw 2013). This species is likely to utilise the study area (outside of riparian vegetation) at least occasionally; Nuttall & Vermeulen 2022 have recorded them in the footprint area of ORSF1. In addition, birds in transit may also pass through the area, as Bird 8 of the study mentioned above apparently did during its eastward movement in the spring of 2012 (see Appendix 5.A4 in Shaw 2013).

#### 5.4.1.2. Vulnerable species

- Burchell's Courser (R299). The nature, extent and causes of the apparent rapid decline in the range of this species are poorly understood (Peacock 2015a). This widespread species favours open habitats with bare ground or short or burned grass (Maclean 1985). Any potential use of the footprint and environs is likely to be transitory.

#### 5.4.1.3. Near-threatened

- Kori Bustard (R230). This species is also associated with woodland and was already considered there (see page 50).

- Karoo Korhaan (R235): Near-endemic. Collisions with power lines count amongst the few general threats this species faces (Peacock 2015c). They usually live in pairs that maintain territories throughout the year (Boobyer 1989). This species is relatively common in the area (Fig. 45, page 172). At least one pair has a territory which overlaps with the proposed development footprint east of the Orange River.

- Sclater's Lark (R510): Near-endemic. No pertinent threat is known for this species; its inclusion into the regional Red Data Book has been based on a small and fragmented range, which "appears to be contracting" (Peacock 2015d). The study area is located near the north-eastern limit of their range. They could potentially utilise the footprint area.

### 5.4.2. Endemic species

There are 11 endemic species. The three Red Data species were already mentioned above. The rest of the endemic species could all potentially utilise the footprint area, but only the Karoo Scrub Robin R614 and Fairy Flycatcher R706 have so far been confirmed to occur.

### 5.4.3. Other species

For several of the remaining 33 scrub species the footprint may constitute at least part of their territory, for example Pygmy Falcon R186, Namaqua Sandgrouse R344, Karoo Long-billed Lark R500d, Chestnut-vented Warbler R621, Long-billed Crombec R651, Yellow-bellied Eremomela R653 & Dusky Sunbird R788.

## 5.5. Grassland

Only 15.0% of bird species with distributions overlapping with the study area are grassland-associated (Fig. 35). Many of them are associated with other habitats, mainly scrub (Fig. 36). Within the footprint of the proposed development, grassland consists of patches of grass interspersed with various densities of scrub and woodland (Fig. 10; Fig. 28; Fig. 24; Fig. 6).

### 5.5.1. Red Data species

Only 3 (20.0%) of the 15 Red Data species are associated with grassland, including one Endangered species, one Vulnerable species and one Near-threatened species (Table 1 A).

#### 5.5.1.1. Endangered:

- Black Harrier R168 (CMS:R1): Near-endemic. This species is also associated with scrub habitats and is considered there (see page 52).

#### 5.5.1.2. Vulnerable:

- Burchell's Courser R299. This species is also associated with scrub habitats and is considered there (see page 53).

#### 5.5.1.3. Near-threatened:

- Karoo Korhaan R235: Near-endemic. This species is also associated with scrub habitats and is considered there (see page 53).

### 5.5.2. Endemic species

A total of six of the species associated with grassland are endemic (Fig. 35). The three Red Data endemics were already considered above. The status of the remaining three endemic species in the footprint is presently unclear.

### 5.5.3. Other species

In addition to the species considered above, another 29 grassland species have distributions that overlap with the study area, including six CMS species (A2, W, R3) (Table 1 E). Only a few of them are likely to be residents in the footprint of the proposed development, most notably the Crowned Lapwing R255.

## 5.6. Montane/Rocky

Only 3.8% (n = 9 species) of the bird species are associated with montane and rocky habitats (Fig. 35). One of them, the Cape Bunting (R885), is additionally also associated with scrub and grassland (Fig. 36). Part of the eastern section of the route of the ORSF1 power line is over rocky undulating terrain, with low hills to its north-west terminating with low cliffs along the Orange River (Fig. 27; Fig. 46, page 173). More substantial hills occur from approximately 4 km north of the origin of the ORSF1 power line (Fig. 25). Further afield hills and low mountains of the Lower Gariep Broken Veld are found (Fig. 2; Fig. 27).

### 5.6.1. Red Data species

Only two species are associated with montane/rocky habitats, including one Vulnerable species and one Near-threatened species.

#### 5.6.1.1. Vulnerable

- Verreaux's Eagle R131. Within South Africa, the primary threat faced by this species is direct persecution by farmers (Taylor 2015c). Collision and electrocution incidents involving power line infrastructure have also been recorded (Anderson 2000a; Diamond 2008; Prinsen *et al.* 2011; Shaw *et al.* 2021; Smallie 2011; Van Rooyen & Ledger 1999). It is typically associated with rocky or mountainous terrain where its presence almost invariably coincides with its principal prey, the Rock Hyrax (Dassie) *Procavia capensis* (Steyn 1982). In the Prieska area, breeding birds are closely associated with Lower Gariep Broken Veld, *i.e.* the same vegetation type found just south-west of the study area (Fig. 2; Fig. 27). Breeding is likely in the mountains and hills there and likely also in similar terrain elsewhere. The nearest prey source is Rock Hyrax inhabiting the cliffs located just north of the proposed route of the power line (Fig. 27; Fig. 46). These eagles may occasionally hunt at these cliffs.

#### 5.6.1.2. Near-threatened

- African Rock Pipit R721: Endemic. The study area is located on the western edge of their distribution. It is probably resident in nearby mountains and hills.

### 5.6.2. Endemic species

The African Rock Pipit R721 mentioned above is the only species that is endemic.

### 5.6.3. Other species

The remaining seven species could all potentially visit the footprint area, with the Mountain Wheatear R586 being the only species that presently is resident.

## 5.7. Forest

Only 1.7% (n = 4 species) of the species are associated with forest habitats (Fig. 35). They are also associated with scrub and/or woodland (Fig. 36). The study area is located on the edge of their respective distributions (Table 1 D). Narrow strips of closed canopy forest habitats occur along the banks of the Orange River (Fig. 39; Fig. 26).

### 5.7.1. Red Data species

None.

### 5.7.2. Endemic species

The Southern Double-collared Sunbird R783 is near-endemic. Any potential footprint use by this species is likely to be transitory.

### 5.7.3. Other species

Any use of the proposed footprint by the Green Wood Hoopoe R452 or Fork-tailed Drongo R541 is likely transitory. The Cape Robin-Chat R601 is probably resident along the river.

## 5.8. Habitat generalists

More than one-fifth of all bird species with distributions that overlap the study area are considered habitat generalists (Fig. 35). Species diversity is the least south-west of the study area, with a notable concentration around the Orange River (Fig. 37).

### 5.8.1. Red Data species

Habitat generalists include two Endangered species, two Vulnerable species, and one Near-threatened species.

#### 5.8.1.1. Endangered

- Tawny Eagle R132 (CMS:R1). Poisoning, persecution and drowning are considered to be the primary reasons for the apparent decline of this species (Barnes 2000a; Taylor 2015a). Collision and electrocution incidents involving power line infrastructure have also been recorded (Anderson 2000a; Prinsen *et al*. 2011; Shaw 2013; Shaw *et* *al.* 2021; Smallie 2011; Van Rooyen & Ledger 1999; Vosloo & Van Rooyen 2009a). The study area is located along the south-western limit of their range. They hunt either from a perch or on the wing, with their diet including carrion, mammals, birds, reptiles and insects (Steyn 1982). Based on present evidence, it is concluded that they could be rare transitory visitors to the study area.

- Martial Eagle R140. Fatal interactions with power line infrastructure via collisions and electrocution count among several major threats to this species (Barnes 2000b). This widespread species does most of its hunting on the wing and feed mainly on mammals, birds and reptiles (Steyn 1982). Based on present evidence, it is concluded that they could be rare transitory visitors to the study area.

#### 5.8.1.2. Vulnerable

- Secretarybird R118. Habitat loss is considered the primary threat to this species (Retief 2015). This species appears on may lists recording collision incidents involving power line infrastructure (Brown & Lawson 1989; Diamond 2008; Diamond *et al.* 2010; Pallett *et al.* 2022; Prinsen *et al.* 2011; Shaw 2013; Shaw *et al.* 2021; Smallie 2011; Van Niekerk 2013; Van Rooyen & Ledger 1999; Vosloo & Van Rooyen 2009a). This widespread raptor roosts in trees and forages while walking tens of kilometres a day through the veld in search of prey (Steyn 1982). Any potential use of the footprint and environs is likely to be transitory, possibly as an occasional visitor to open natural areas and agricultural fields.

- Lanner Falcon R172 (CMS:R2). While loss or transformation of habitat is considered the primary threat to this species (Barnes & Jenkins 2000), collisions with power lines are considered a secondary threat (Taylor 2015d). Electrocution incidents involving power line infrastructure have also been recorded (Anderson 2000a; Prinsen *et al.* 2011; Smallie 2011). The prey of this widespread raptor consists mainly of birds, but its diet also includes small mammals, reptiles and insects (Jenkins 2005; Steyn 1982). In the Highveld region of the former Transvaal, Tarboton & Allan (1984) noted that this species has probably increased in numbers and range due to crop production The latter greatly increased both the number of crows (which provides the falcons with nesting sites, mainly on the pylons of power lines; See also Anderson 2013; Kemp 1972; Ledger & Hobbs 1999; Vosloo & Van Rooyen 2009c), and prey, especially pigeons and doves (Tarboton & Allan 1984). In the study area, this falcon is expected to be particularly associated with the agricultural fields, where an immature bird was also found feeding on its avian prey during the August 2022 survey (Fig. 12).

#### 5.8.1.3. Near-threatened

- Abdim's Stork R085 (CMS:W). Non-breeding trans-equatorial intra-African migrant (Anderson 1997, 2005). The reasons for the apparent decline in numbers are unknown; "As a precautionary measure, the species is assessed as regionally Near Threatened" (Taylor 2015e). Collisions with power lines have been recorded (Prinsen *et al.* (2011);

Smallie (2011); D. J. van Niekerk, Fig. 47, page 174). They are highly gregarious, with flocks often numbering hundreds of birds (Earlé & Grobler 1987; Maclean 1985; Penry 1994). They roost in trees or on cliffs (Maclean 1985). Local movements occur in southern Africa in response to temporally and spatially abundant food supplies related to rainfall events (Anderson 1997; Maclean 1985). Cultivated fields are one of the main habitats for this species in southern Africa (Cyrus & Robson 1980; Earlé & Grobler 1987; Maclean 1985; Penry 1994; Tarboton *et al.* 1987; Van Niekerk 2012). Distribution data from SABAP1/2 indicates that in this part of their range, they are mainly associated with the Orange River. This association is undoubtedly related to the many irrigated agricultural fields along the river (e.g. Fig. 26). For example, during fieldwork in the Douglas area (December 2019 and January 2020), Van Niekerk (2020) found them to be common in irrigated fields where as many as 933 individuals were once counted (Fig. 47). It is to be expected that this species will utilise the agricultural fields in and around the footprint of the ORSF1 power line.

### 5.8.2. Endemic species

Among the habitat generalists, there are only two endemic species. The Jackal Buzzard R152 occur in hilly or mountainous terrain, but they also hunt in habitats some distance from mountains (Steyn 1982). The study area is located on the eastern limit of their local range, and any potential use of the footprint and environs is likely transitory. The study area is located along the north-western limit of the Pied Starling's R759 range, and they have not yet been recorded in the area during the survey.

### 5.8.3. Other species

Nine of the remaining 44 habitat generalists are CMS species in three categories (A2, W & R3).

Several species are likely to be resident in the footprint and environs, including all three species listed in Table 1 C1, and many of those listed in Table 1 C2. A number of these species is likely to be associated with the agricultural fields, including the Black-headed Heron R063, White Stork R083, African Sacred Ibis R091, Hadada Ibis R094, Black-winged Kite R127, Helmeted Guineafowl R203, Speckled Pigeon R349, Ring-necked Dove R354, Laughing Dove R355 & Namaqua Dove R356. During the August 2022 survey, Black-headed Heron R063, African Sacred Ibis R091, Hadada Ibis R094, Helmeted Guineafowl R203 roosted in trees on the island between the two existing power lines (Fig. 11). A flock of approximately 350 African Sacred Ibiss R091 was found at the Groblershoop water treatment works (Fig. 43). Wattled Starlings R760 were also very common in the area, and numerous flocks were seen flying across the route of the ORSF1 power line at various locations. It was obvious that there were one or more roosts nearby. Flocks of Southern Masked Weaver R814 & Red-billed Quelea R821 were also common in the area; they likely roost in reed beds along the Orange River, from where they disperse daily into surrounding areas. During summer, it is excepted that

Barn Swallows R518(an abundant nonbreeding Palaearctic migrant) would be foraging over the site. Finally, the Spotted Thick-knee R297, Western Barn Owl R392 & Spotted Eagle-Owl R401 all represent common nocturnal species in the area.

# Impact assessment and mitigation

Section 2 (page 21 *ff.*) highlighted issues relevant to the interaction between birds and power lines. In the following three chapters, we assess the potential impact of the ORSF1 power line on the area's birds and present recommendations separately for the construction (Chapter 6), operational (Chapter 7) and decommission (Chapter 8) phases of the ORSF1 power line.

## 6. Construction phase

The construction phase will be of short duration. The potential impacts during the construction phase of the ORSF1 power line include the following:

- *Feeding opportunities*: During the initial clearing of vegetation, some species could exploit prey items (*e.g.* insect larvae) that become available through these activities. However, this is likely to be of short duration.
- *Nesting material*: Birds may use loose pieces of wire and string picked up from the construction site to incorporate into their nests, which may be on nearby power line infrastructure.
- *Nest destruction*: Construction activities could destroy any nests used at the time.
- *Displacement*: The clearance of the vegetation along the course of a new power line implies permanent habitat alterations (Fig. 10; Fig. 6; Fig. 11; Fig. 42), which may force birds present at the time to relocate (temporarily?). These birds could resettle successfully in adjacent areas. The displacement of individuals of territorial species may have a ripple effect, causing temporary upheaval in the surrounding area (or places further afield) as the displaced males/pairs/family groups compete with established individuals elsewhere for territories.

### 6.1. Impact significance

In general, displacement is unlikely to be a significant factor given that the affected area would entail a narrow strip through widespread habitat components, but nest destructions could be an issue. Potentially impacted Red Data species include the three bustard/korhaan species (Table 1 A), all likely to utilise the development area outside riparian vegetation. However, the route of the proposed ORSF1 power line is unlikely to intersect with the nests of these species. A similar situation holds for six non-threatened endemic species (Table 1 B), as well as 39 other species (Table 1 C1). No CMS species are involved here.

### 6.1.1. Biological significance

On its own, the construction phase of the ORSF1 power line will not have a biologically significant impact on any species.

#### 6.1.1.1. Cumulative Impact:

It would be a mistake to evaluate the potential impact of the ORSF1 power line in isolation since it represents an integral part of ORSF1. Therefore, the following construction phase impacts described in Nuttall & Vermeulen (2022) should also be considered: Displacement due to disturbance and habitat transformation. The area affected by this is approximately 178 ha, to which we should add 3.88 km of the ORSF1 power line.

Radical habitat transformation during the construction phase implies a moderate to high impact on *individuals* of species in the affected areas. However, the resulting displacement is unlikely to result in any short- or long-term negative consequences for local populations of any species involved since the affected habitat components are widespread and displaced individuals are likely to resettle there.

In addition to displacement, it is also possible the active nests present at the time could experience disturbance or destruction. Even if this is to happen, the consequences for the affected species' local populations are likely to be negligible.

In conclusion, while the cumulative impact of the construction phase may have moderate to high significance for *individuals* of the species in the affected area, it is most likely inconsequential when measured at the population level. The cumulative impact is, therefore, insignificant.

### 6.1.2. Public significance

Construction activities will likely draw the public's attention. Perhaps the most likely place where this could happen is at the Destination River Resort, where visitors would be particularly close to the action (Fig. 4; Fig. 11).

### 6.1.3. Legal significance

The route of the proposed ORSF1 power line is unlikely to intersect with the nests of any of the Red Data species. No CMS species is likely to be impacted during the construction phase either.

## 6.2. Mitigation

The following mitigation actions are recommended for the construction phase:

- As far as is reasonably possible, restrict all activities to the footprint area of the infrastructure.

- The creation of additional roads anywhere must be avoided. The part of the route inside the river bend already has a road associated with the two existing power lines (Fig. 10). On the other end, there is also a road to the Groblershoop substation along the current power line (Fig. 6).
- The probability of nest destruction is considered to be low and no specific mitigation is required in this regard.
- Crows and other birds often incorporate foreign objects into their nests; this could lead to flashovers and even fire (see Section 2.4 on page 29). Therefore, throughout the construction phase, all wires and string must be disposed of in an approved manner as soon as it is no longer needed. This will help to reduce the chances of flashovers caused by nesting material on pylons.

### 6.2.1. Effect on impact significance

Impact significance before mitigation is high for individuals of the species in the affected area, but inconsequential for the populations involved. The mitigation recommended can reduce impact somewhat.

In the case of wires and strings, the recommended mitigation will effectively reduce the availability of these items.

# 7. Operational phase

The operational phase of the Orange River Solar Facility 1 will likely last several decades. After that, the existing components will likely be replaced with more modern technology, or it will be decommissioned, and the area will return to its natural state. The associated 3.88 km long 132 kV power line to the Groblershoop substation (*i.e.* the ORSF1 power line) constitutes an essential component of this project and is the focus of this report. Each of the sections below assesses the potential impacts of the ORSF1 power line on birds.

## 7.1. Positive impacts

Power line infrastructure adds elevated elements to the environment and is frequently utilised by birds from small to large for various reasons. For example, during the day, it may function as a convenient vantage point, a safe resting place, a display or a feeding perch. Figures 32 (A & B), 41 (A) & 12 illustrate some such cases from the study area and elsewhere. Various species will similarly utilise the new infrastructure.

At night, certain species also utilise power line infrastructure for roosting. The Helmeted Guineafowl R203 and Pied Crow R548are two of the species for which this behaviour is pervasive in South Africa (Fig. 13). The remains of three guineafowls found below pylon GPF55 (Fig. 16) probably represent an electrocution incident involving roosting birds. Along the Orange River, it is also likely that some of the larger waterbirds could roost on the pylons.

At least 18 of the species with distributions overlapping with the study area are known to breed on power line pylons (see the Pylons column in Table 1 & Section 4.6 on page 38). Figure 14 illustrates examples of a few of them. While there are presently no nests on existing power lines near the route of the ORSF1 power line, nesting can nonetheless occur at any time. Given the type of structures currently present (see Figures 28 &16), and considering that the proposed new power line will be similar to the existing 132kV Garona–Groblershoop power line (Figs. 7 & 8) the two most likely candidates to initiate nesting on existing/future pylons are the Pied Crow R548 and the Sociable Weaver R800. Both of these species are very adaptable, and capable of constructing their nests in various types of situations (Figures 16 & 14). Once these nests are present, other species are likely to utilise them too. In the case of Pied Crow nests, they are known to be utilised by Hadada Ibis R094 (Vosloo & Van Rooyen 2009c), Black-winged Kite R127 (Vosloo & Van Rooyen (2009c); D. J. van Niekerk personal observations, Fig. 14), Lanner Falcon R172 (Kemp 1972; Tarboton & Allan 1984), , Rock Kestrel R181 (Ledger & Hobbs 1999), and Greater Kestrel R182 (Anderson (2013); Brown *et al.* (1987); Hustler (1983); Tarboton & Allan (1984); Vosloo & Van Rooyen (2009c); D. J. van Niekerk personal observations, Fig. 14). Sociable Weaver R800 nests are likewise utilised by several other bird species for roosting and breeding (Maclean 1973; Plowes 1946). While smaller species may occupy nest chambers — most notably the Pygmy Falcon R186, which lives there throughout the year (Dieter Oschadleus (2022); Maclean (1970); Fig. 41) — larger species utilise larger cavities or depressions in the nest superstructure for nesting, for example, the Martial Eagle R140 and Egyptian Goose R102 (Maclean 1973; Plowes 1946; Fig. 28).

It is assumed that vegetation management will be similar to that evident along the existing power lines (Fig. 6; Fig. 10; Fig. 11; Fig. 42). In the area within the river bend, it seems likely that this would merge with equivalent areas of the two neighbouring power lines (Fig. 10) to form a relatively wide strip of open habitat without tall vegetation. As such, it could potentially benefit grassland and scrub species, for example, the Spike-heeled Lark R506, Desert Cisticola R665 & African Pipit R716.

### 7.1.1. Impact significance

The positive impacts assessed above indicate that birds will likely come into physical contact with the ORSF1 power line electrical hardware and their support structures. Consequently, these birds may be exposed to collision and electrocution risks, which are closely examined in Sections 7.2 & 7.3 below.

#### 7.1.1.1. Biological significance

See Sections 7.2.5 (page 67 *ff.*) & 7.3.3 (page 79 *ff.*).

#### 7.1.1.2. Public significance

Birds and their nests are very obvious on pylons (Fig. 12; Fig. 13; Fig. 14) and could spark the interest of someone to learn more about them. But since there is no shortage of these type of structures, the addition of the ORSF1 power line adjacent to a similar one is not likely to spark the interest of anyone that is not sparked up already.

#### 7.1.1.3. Legal significance

See Sections 7.2.5.3 (page 69 *ff.*) & 7.3.3.3 (page 80 *ff.*).

### 7.1.2. Mitigation

- For mitigation related to collisions, see page 70.
- For mitigation related to electrocution, see page 81.

## 7.2. Collisions

Many individual birds of different species will probably collide with the ORSF1 power line during its operational phase. This assessment is based on the following:

- Power lines represent a well-known permanent collision hazard to birds (see Section 2.3, page 24 *ff.*).
- Numerous species known to collide with power lines occur in the study area (Table 1 A, B & C).
- A nearby roost implies daily movement of birds in the vicinity of the ORSF1 power line (Section 7.2.1, page 64).
- Another potential roosting and resting area in the Orange River and near the ORSF1 power line implies the daily movement of potentially large numbers of birds during certain times of the year (Section 7.2.1, page 64).
- The route of the power line intersects several flyways, including
  - a flyway up and down the Orange River.
  - a flyway along the agricultural fields next to the river.
  - flyways from one end of the river bend to the other across the dry-land part of the ORSF1 power line route.
  - various flyways between roosting and foraging areas.
- It is to be expected that birds will utilise the pylons for various reasons, including roosting and breeding (Section 7.1, page 61).

The sections below detail movement patterns separately for Red Data, endemic, and other species. But first, a note or two on roosts.

### 7.2.1. Roosts

An island close to the western bank of the Orange River, between the 132 kV Garona-Groblershoop and 22 kV Groblershoop-Padkloof power lines (Fig. 11), functions as a roost for several bird species (see page 66). Birds roosting there are already exposed to a relatively high collision risk due to the proximity of the two existing power lines (Fig. 11). The proposed route of the ORSF1 power line passes approximately 27 m north of the Garona-Groblershoop power line, *i.e.* further away from the island (Fig. 11).

A few hundred metres north (downstream) of the ORSF1 power line route is an extensive flat and rocky area in the Orange River (Fig. 4; Fig. 46; Fig. 39). Rising and falling water levels (see Figure 22) are likely to provide a range of habitats for various bird species, which may forage, rest, and roost there. This periodic concentration of birds also implies increased movements across the power lines.

### 7.2.2. Red Data species

Cases of collisions with electrical infrastructure are known for 11 of the 15 Red Data species with distributions overlapping with the study area (Table 1 A; See Section 5, page 47 *ff.*). Based on the most recent version of the South African Red Data book (Taylor *et al.* 2015), the only species for which collisions are considered the main threat is Ludwig's Bustard R232. For another three species, power line collisions are one of the main threats (White-backed Vulture R123, Martial Eagle R140 & Karoo Korhaan R235). In the case of the Lappet-faced Vulture R124 & Lanner Falcon R172, collisions are considered to be a contributing factor to declines. Collisions with power lines are considered to be an underestimated threat for the Kori Bustard R230. Although collisions incidents are known for the Black Stork R084, Secretarybird R118, Verreaux's Eagle R131 & Tawny Eagle R132, it is apparently not having a notable impact on their numbers. No collision incidents are known for the remaining four Red Data species (Black Harrier R168, Burchell's Courser R299, Sclater's Lark R510 & African Rock Pipit R721).

We can divide the Red Data species into two groups. Based on present evidence, the first group consists of five species that are, at best, only rare transitory visitors to the study area. Consequently, their risk of colliding with the power line is considered low (Table 1 A; see Section 5). Although the situation for each of the remaining six species is unique, they were all regarded to be exposed to a high collision risk:

- Ludwig's Bustard R232 (page 53): Having one of the worst, if not the worst, avian collision risk profile on record (Jenkins & Smallie 2009; Jenkins *et al.* 2011; Shaw 2013; Shaw *et al.* 2021), this species is likely an occasional visitor to the proposed development footprint.

- Secretarybird R118 (page 57): Possibly an occasional visitor to the study area, primarily to open natural areas and also the agricultural fields.

- Lanner Falcons R172 (page 57): Could hunt over any habitat in the study area but is perhaps more likely to do so in and around the agricultural fields.

- Kori Bustard R230 (page 50): Confirmed to occur near the ORSF1 power line (Fig. 40) and is likely to utilise the study area (all except the riparian vegetation and agricultural fields), at least occasionally.
- Abdim's Stork R085 (page 57): This gregarious species is likely to feed in the agricultural fields along the river, at which times they may frequently cross the ORSF1 power line.
- Karoo Korhaans R235 (page 53): The territory of at least one pair overlaps with the footprint of the ORSF1 power line east of the Orange River.

### 7.2.3. Endemic species

Collision records are known for only three of the 18 endemic species (Table 1 A & B). As a Red Data species, the Karoo Korhaan R235 was already mentioned above. The risk of collisions is considered to be low for the remaining two species. Any use of the footprint area by the Jackal Buzzard R152 is likely to be transitory. Based on distribution data from SABAP1/2, the Cape Spurfowl R195 appears to be associated with the Orange River in this part of their range, where they are associated with dense riverine scrub (Anderson 2006; Maclean 1985).

### 7.2.4. Other species

Excluding Red Data and endemic species (see above; Table 1 A & B), bird species with distributions overlapping with the study area include 75 with confirmed records of collisions with power lines (Table 1 C2; See Section 4.8 on page 44 for source material). To them we added nine species where collisions possibly occur based on incidents involving similar species, site-specific conditions, *etc*. That brings the total to 84 species (Table 1 C). For 64 (76.2%) of these species, the risk of colliding with the ORSF1 power line was evaluated high (Table 1 C). They include the overlapping groups highlighted below:

#### 7.2.4.1. Aquatic species

Aquatic species feature particularly prominent in this list. For most of them, the assessment is based on the assumption that they would be flying relatively frequently up and down the Orange River across the route of the ORSF1 power line (see Figure 26). In addition, at least some of them will be flying over the dry-land part of the route, particularly across the inside of the river bend, as was observed for the Egyptian Goose R102, South African Shelduck R103 & Spur-winged Goose R116 during the August 2022 field survey. Some ducks and geese, particularly the last three mentioned species, also forage in agricultural fields (Jarvis *et al*. 1989; Van Niekerk 2007, 2012; Viljoen 2005).

#### 7.2.4.2. Agricultural fields

Indeed, the utilisation of agricultural fields was another reason why some species were assigned a high collision risk as the route of the ORSF1 power line intersects this habitat (Fig. 26). In addition to the duck and geese highlighted above, this also includes the Black-headed Heron R063, White Stork R083, African Sacred Ibis R091, Hadada Ibis R094, Black-winged Kite R127, Helmeted Guineafowl R203, Speckled Pigeon R349, Red-eyed Dove R352, Ring-necked Dove R354, Laughing Dove R355 & Namaqua Dove R356. Apart from flight paths along the agricultural fields, these species could also fly from one end of the river bend to the other via the dry-land area in between, as was observed with the Hadada Ibis R094, for example.

#### 7.2.4.3. Daily movement between roosting, foraging, and drinking locations

This list includes many of the species already mentioned above. In addition, during the August 2022 survey, the following species roosted in trees on the island between the two existing power lines (Fig. 11; See Section 7.2.1 on page 64): Black-headed Heron R063, African Sacred Ibis R091, Hadada Ibis R094, Helmeted Guineafowl R203 & Red-eyed Dove R352. These power lines pose a definite collision hazard to birds using this roost.

Wattled Starlings R760 were widespread during the August 2022 survey, with numerous flocks flying across the route of the ORSF1 power line at various locations. It was obvious that there were one or more roosts nearby.

Flocks of Southern Masked Weaver R814, Red-billed Quelea R821 & Southern Red Bishop R824 were also common in the area; they likely roost in reed beds along the Orange River from where they disperse daily into surrounding areas.

The Namaqua Sandgrouse R344 is a gregarious species with a prominent daily routine, which includes an early morning flight from roost to a drinking site and from there to a feeding site where the birds remain until the late afternoon when they fly back to their roost (Knight 1989; Lloyd 1998; Maclean 1968). During one particular study, observations in June 1994 indicated that as many as 1 943 of these birds came to drink on the banks of the Orange River (Lloyd 1998) at a site approximately 10 km (as the sandgrouse flies) upstream from where the ORSF1 power line will be crossing the river. During the August 2022 survey, this species was encountered both on the ground and in flight over the study area.

#### 7.2.4.4. Other species

Various other species known to collide with power lines are presumed to be present in the study area and environs relatively frequently, at least during certain times of the year. Applying the precautionary principle, they are all assigned to the high-risk category and include all those listed in Table 1 C not explicitly mentioned above.

### 7.2.5. Impact significance

#### 7.2.5.1. Biological significance

No restricted-range species (*i.e.* species with global distributions of less than 50 000 km$^2$ (Marnewich *et al.* 2015)) occur in the Groblershoop study area. In other words, the global distribution of each species occurring in the Groblershoop area is greater than 50 000 km$^2$ (equivalent to a circle with a radius of approximately 126 km). Unless the study area is situated at a concentration point, it is improbable that the 3.88 km long ORSF1 power line will have a biologically significant impact on any of these species.

Runge *et al.* (2014) point out that priority conservation areas for migratory species may not be breeding or non-breeding grounds. Instead, migration corridors, bottlenecks, or refugia are the regions that could be crucial to a large proportion of a population at some comparatively brief point in their life cycle (Runge *et al.* 2014) . There are no such narrow migration corridors or bottlenecks in South Africa — the southern tip of the African continent represents the starting and ending points of the journeys of many long-distance migrant species (Moreau 1972; Turpie 1996).

However, the ORSF1 power line cuts across the Orange River (Fig. 11). This river represents a narrow, linear green corridor that snakes westwards through the relatively arid Northern Cape (Fig. 1; Fig. 4; Fig. 26). For many bird species, it is the primary or only suitable habitat in this part of South Africa. This trend is evident in the distribution patterns of birds occurring in the Groblershoop area, especially for aquatic species and to a less degree for others (Fig. 37).

Abdim's Stork R085, a near-threatened, non-breeding intra-African migrant species (see page 57; Fig. 47), is the only Red Data species that show this pattern (Table 1 A). They often occur in large numbers, and in this part of their range, the narrow strips of agricultural fields along the Orange River are its primary habitat. It is also a known collision victim (Prinsen *et al.* 2011; Smallie 2011; Fig. 47). However, it is improbable that the ORSF1 power line will have any measurable impact on the population of this species for the following two reasons:

- Widespread distribution in southern Africa, with the study area located on the western limit of their range (`https://sabap2.birdmap.africa/species/78`);
- Population estimates on breeding grounds (e.g. Christensen *et al.* 2008), and non-breeding grounds (*e.g.* Gula *et al.* 2022) indicate a healthy population.

In conclusion, on its own, collisions with the ORSF1 power line will not have a biologically significant impact on any bird species.

##### 7.2.5.1.1. Cumulative impact

It would be a mistake to evaluate the potential impact of the ORSF1 power line in isolation since it represents an integral part of the ORSF1. Nuttall & Vermeulen (2022) determined the following operational phase impacts:

- Collisions with the solar panels

- Entrapment in perimeter fences
- Electrocutions in the on-site substations and inverter stations

They considered all three of these impacts either low or very low (Nuttall & Vermeulen 2022). That is in sharp contrast to the impact of the ORSF1 power line, where collisions are very likely to occur. Therefore, the main operational phase impact of the ORSF1 project is likely to be associated with the ORSF1 power line.

The Northern Cape is an important area for developing renewable energy facilities, as evident from the South African Renewable Energy EIA Application (REEA) Database (Fig. 48, page 175). The results from studies at some operational solar facilities are starting to trickle in. Accurate determination of mortality rates was once again a significant issue (Jeal 2017; Van Heerden 2020-03-01; Visser 2016). Nevertheless, these studies did produce some valuable data.

- Concentrated Solar Power (CSP) facility Khi Solar One near Upington (Van Heerden 2020-03-01): A wide variety of dead/injured bird species detected, including species that also feature on the ORSF1 power line list, most notably the Lanner Falcon R172, which was one of only two Red Data species; Groblershoop is outside the distribution range of the Great White Pelican *Pelecanus onocrotalus*. These falcons were also observed to "scoping the corridors among the heliostats of the CSP tower facility and surrounds in search of prey".
- In another study involving the Bokpoort trough CSP facility, located approximately 18 km northern of Groblershoop, four Western Barn Owls R392, a Ring-necked Dove R354, an unidentified lapwing, and another two unidentified birds were the only dead birds found (Jeal 2017).
- And finally, at the Jasper PV Solar Facility near Postmasburg, only 12 fatalities involving six species were recorded (Visser 2016). Another impact involved the entrapment of Red-crested Korhaan R237 and Orange River Francolin *Scleroptila gutturalis* between fencing (Visser 2016).

These data points are too few to draw any definite conclusions. The cumulative impact of renewable energy facilities has yet to be proven.

The studies highlighted above focused on the impact of the primary solar infrastructure during its operational phase. Like the Orange Rivers Solar Facility 1, these and other renewable energy facilities require connection to the Eskom grid via power lines. In addition, Eskom may also need to expand its network to accommodate these and future developments. It is reasonable to expect that the total length of power lines in the Northern Cape and elsewhere will steadily increase in the coming years and beyond. As indicated earlier (see Section 4.7.1.1 on page 40), this could, in the long run, have negative consequences for non-resident species such as the Endangered Ludwig's Bustard R232. It is concluded that the ORSF1 power line will contribute to this cumulative impact.

#### 7.2.5.2. Public significance

The ORSF1 power line will traverse private property and open public areas. There is always the chance of someone from the public encountering one or more dead birds underneath the power line. In a worst-case scenario, this could lead to a public relations nightmare.

#### 7.2.5.3. Legal significance

As we have seen earlier (Section 7.2.2), six Red Data species are regarded to be exposed to high collision risk.

See Section 4.7.3.2.1 (page 42 *ff.*) for an introduction to CMS. The data of CMS species in Table 1 are summarised in Table 3 (page 126).

- Appendix 1 species (A1 in Tables 1 & 3): Both the White-backed Vulture R123 and Lappet-faced Vulture R124 have known collision and electrocution records. However, they are both considered to be only rare transitory visitors to the study area.

- Appendix 2 species (A2): 20 (87.0%) of the 23 species have collision records, of which 13 have high risk. Electrocution incidents are known for 7 of the 23 species, but three of them are too small to be at risk on the ORSF1 power line infrastructure.

- AEWA species (W): The distributions of a total of 32 AEWA species overlap with the study area. Collision records were found for all except three of them (Table 1 E). Most (75.0%) of the 32 AEWA species were evaluated to be exposed to a high collision risk. Records of electrocution were also found for 8 species, of which 7 were regarded as potentially exposed to electrocution on the prosed ORSF1 pylons.

- Raptor MOU (R1, R2 & R3): Only one of the 9 species, the Black Harrier R168, does not have collision or electrocution records. The data for the rest is summarise below.
    - Category 1 (R1): All three species (two vultures and one eagle) have both collision and electrocution records, however they are all considered to be at best only rare transitory visitors to the study area.
    - Category 2 (R2): As the only species in this category, the Lanner Falcon R172 is expected to be relatively common in the study area and are evaluated to be exposed to a high collision risk. The separation distance on the planned infrastructure appears to be sufficient to prevent electrocution in this species.
    - Category 3 (R3): Collision incidents are known for all five species. However, the risk is low because they are all considered infrequent transitory visitors to the study area. All five species also have electrocution records. However, two are considered too small to bridge air gaps on the proposed power line infrastructure.

It is concluded that many individuals of diverse CMS species will likely collide with the ORSF1 power line during its operational phase.

### 7.2.6. Mitigation Review

The bird species that could potentially collide with the proposed ORSF1 power line constitute a diverse array of species. Here we review mitigation options. Combined recommendations for the operational phase are represented in Section 7.4.

Despite worldwide efforts to curb bird mortality resulting from collisions with power line infrastructure, a proven, reliable, cost-effective collision mitigation strategy remains elusive (Jenkins *et al*. 2010). In general, mitigation revolves around three aspects: avoiding problematic areas, minimising the extent of the vertical collision risk zone, and increasing the wires' visibility.

#### 7.2.6.1. Avoid problematic areas

- The Groblershoop substation is the most practical way of connecting the ORSF1 to the Eskom grid (Fig. 3; Fig. 6). Any overhead power line route between the facility and this substation have to cross the same flyways/movement corridors associated with the Orange River and its floodplains (see Section 7.2.5 on page 67). In other words, there is no way for an overhead power line to avoid these flyways/movement corridors.
- Roosts (see page 64):
    - There is one confirmed roost on the island close to the western bank of the river between the two existing power lines (Fig. 11).
    - A few hundred metres north (downstream) of the ORSF1 power line route is another likely roosting and resting site (Fig. 4; Fig. 46; Fig. 39).

If the ORSF1 power line were the only power line in the area, one could have considered an alternative route further away from the abovementioned areas. However, the presence of the existing power lines complicates the situation, and we will consider this further once that is taken into account (see below).

#### 7.2.6.2. Minimise the vertical collision risk zone

The surest way of preventing birds from colliding with power lines is to place the lines underground (Hunting 2002; Thompson 1978). Technical feasibility of undergrounding has been demonstrated for power lines up to 500 kV (APLIC 1994; Elinfrastrukturudvalget (Denmark) 2008; Rosa 2010; Umeda *et al*. 2007). For example, a Danish study concluded that undergrounding of 132 kV power lines can be done without any significant technological problems (Elinfrastrukturudvalget (Denmark) 2008). A 24.6 km long, 132 kV underground power line was installed in Botswana in 2000-2001 using cross-linked polyethylene (XLPE; also called solid dielectric) cables (ABB 2006). The use of underground cables is gaining momentum in Europe (Energinet DK 2009) and the USA (Hall 2012), and installation guides are available (*e.g.* Williams 2013).

However, even if undergrounding is technically feasible, overhead power lines are typically preferred for financial and/or environmental reasons (*e.g.* Zitholele Consulting 2014). In the case of the ORSF1 power line, the Orange River (Fig. 26), as well as rocky substrate elsewhere, is likely to present formidable technical challenges to undergrounding. In addition, the proposed ORSF1 power line will run parallel to an existing power line (Fig. 9), which could be advantageous (see below).

Removing earth wires can substantially reduce collision incidents (Bevanger 1994; Bevanger & Brøseth 2001; Brown *et al.* 1987). However, mortalities also occur due to collision with the wires below the earth wires (Murphy *et al.* 2016; Pandely *et al.* 2008), and even in the absence of earth wires (Bevanger 1990, 1994; Brown *et al.* 1987; Janss & Ferrer 1998). Regardless, Groblershoop is located in a "severe" lightning strike risk zone (Gijben 2012), necessitating using earth wires.

The smaller vertical collision risk zone inherent in horizontal designs where conductors are all on the same height is considered safer (APLIC 2012; Bevanger 1994; Drewitt & Langston 2008; Marques *et al.* 2021; See also Figure 8). If the ORSF1 power line were the only power line in the area, one could have considered a horizontal design as part of the mitigation strategy. However, the presence of the existing power lines complicates the situation, and we will consider this further once that is taken into account (see below).

#### 7.2.6.3. Increase the visibility of wires

Another set of mitigation measures aims at increasing the visibility of wires, the idea being that this would decrease the probability that birds would collide with them.

##### 7.2.6.3.1. The thicker, the better?

It has been suggested that thicker cabling, especially the earth wires, would enhance their visibility and thereby "would theoretically decrease the probability of birds colliding with the wires" (Thompson 1978). Jenkins *et al.* (2010) went so far as to assert that "there is general agreement that ... cabling used should be as thick as possible". However, the sources they cite seem to contradict this:

- "More than doubling ground wire diameter proved completely ineffective" (Hunting 2002),
- "Researchers concluded that there was no significant effect on bird response to the presence of the two different sized [groundwires]" (APLIC 1994),
- This one stated explicitly that "empirical data to show whether or not there is a general inverse correlation between collision rate and increasing diameter of phase conductors or earth wires are lacking" (Bevanger 1994).

More recently, Bernardino *et al.* (2018) linked the statement of Jenkins *et al.* (2010) to the sizeable contribution that earth wires often make to bird collisions with power lines (see page 28). They proceeded by noting that because earth wires "almost always run along the top of the wire array and are notably thinner (~50%) than conductors, ... there is no possibility of disentangling the effects of wire height and diameter" (Bernardino *et al.* 2018). Bernardino *et al.* (2018) concluded that there is "little scientific evidence" that thicker cables are an effective mitigation strategy. APLIC (2012) similarly concluded that studies of its effectiveness are needed before it can be recommended for reducing collision risk.

#### 7.2.6.3.2. Standard line markers

In contrast to thicker cabling, the marking of earth wires or conductors is successful to varying degrees (for a recent global review, see Bernardino *et al.* 2019). Power lines are marked with markers in the hope that a bird seeing it would visualise it as a (near) horizontal linear obstacle that needs to be avoided by flying higher, lower, or away from it. However, when a bird sees one or more makers on a power line and conceptualises it as something other than a horizontal linear obstacle, it may fly into the wire if it decides to fly around the marker(s) or into the 'gap' between markers.

Markers are frequently deployed on the earth wires only. There are at least two main reasons for this. Firstly, it is the wires with which birds often collide (see page 28; Table 2). Secondly, a marking device on a conductor can cause a corona discharge, a phenomenon that does not occur on earth wires (see page 28). These discharges can result in audible noise or radio interference (Bian *et al.* 2011; Jiang *et al.* 2015; Khalifa 1990; Lee 1978; Lee & Griffith 1978; Liu *et al.* 2015), either of which may result in complaints from nearby residents (Hurst 2004; Lee & Griffith 1978). In addition, corona discharge on a conductor can also damage the attached markers (Hurst 2004).

There are two types of line markers, namely static and dynamic. Static line markers have no moving parts; for example, the black or white helical line markers currently used in South Africa (Fig. 28; Fig. 41 A; Cover page). By contrast, dynamic (including most "suspended") devices ("bird flappers") have moving parts that move around in the wind (Fig. 49, page 176). Evidence suggests that dynamic devices may be more effective than static devices (*e.g.* Ferrer *et al.* 2020). However, dynamic devices are less durable than static devices and may even damage the power line to which it is attached (APLIC 1994; Bernardino *et al.* 2019; Brown & Drewien 1995; Dashnyam *et al.* 2016; Murphy *et al.* 2009; Sporer *et al.* 2013; Vosloo & Van Rooyen 2009a). Consequently, in order to remain effective, dynamic line markers are likely to require periodic replacement, which adds to their overall cost (Lobermeier *et al.* 2015), and requires the additional exposure of the installation helicopter pilots and crews to the dangers involved (see Helicopter Association International 2020). Concerning the latter, it has been demonstrated in recent years that drones can be used to deploy certain types of power line markers in a more cost effective and safer way (Acklen *et al.* 2020; Lobermeier *et al.* 2015).

Even though markers on wires tend to reduce bird collisions, it could be better (see Bernardino *et al.* 2019). Their effectiveness varies from study to study and is probably frequently overestimated because potential biases are rarely adequately accounted for. It also fails to reduce mortality substantially for all species at once, reflecting the diverse and complex nature of collision causal webs. For example, a recent South African study evaluating the efficacy of line markers found that while both static and dynamic line makers reduced collision rates for Blue Cranes R208, neither marker type had any discernable benefit for bustards (Shaw *et al.* 2021). The only other South African line marking experiment similarly demonstrated a lack of effect for Ludwig's Bustard R232 (Anderson 2002, referenced in Shaw *et al.* 2021).

These findings support the studies by Martin & Shaw (2010). They suggested that visual markers may have limited success in birds with narrow visual fields, such as bustards, as it can render them blind in the direction of travel when they pitch their heads downward in flight.

#### 7.2.6.3.3. Illuminating a blind spot

A notable blind spot for standard visual markers such as those illustrated in Figures 28, 41 A & 49 is their obvious shortcoming of being (potentially) visible for only a part of each 24-hour cycle. In other words, the probability of a bird in flight seeing it decreases with deteriorating light conditions and becomes particularly low between dusk and dawn. Standard markers are unlikely to reduce the number of collisions under such conditions (Baasch *et al.* 2022; Barrientos *et al.* 2011; Murphy *et al.* 2016). There have been two approaches to addressing this problem, which we will here refer to as the low-tech approach and the high-tech approach.

**Low-tech:**

The low-tech approach involves using the so-called FireFly type of markers (*e.g.* https://pr-tech.com/product/firefly-ff-bird-diverter/) with reflective stickers intended to improve daytime visibility and glow-in-the-dark stickers intended to increase nighttime visibility. Apart from the fact that the dynamic versions of it did not last that long (Murphy *et al.* 2009; Sporer *et al.* 2013), field tests on the effectiveness of these types of devices were inconclusive. Either because it could not be analysed separately from other marker types due to sampling size issues (*e.g.* Sporer *et al.* 2013) or because of inadequate study design (e.g. Murphy *et al.* 2009) or because it performed similarly to standard markers (*e.g.* Yee 2007).

Murphy *et al.* (2016) suggested that more prominent power line markers could help birds to correctly conceptualise it as representing a linear obstacle that must be avoided. The suggested modifications included incorporating materials with brighter and longer-lasting glow-in-the-dark characteristics or reduced spacing between markers (Murphy *et al.* 2016). However, they correctly noted three potential concerns with this: 1) Very prominent glowing power line markers suspended on wires may be disagreeable to the public; 2) Reduced spacing between power line markers would add weight and loading to power lines, particularly during high winds; 3) Birds can be attracted to nocturnally lit structures (for example, to exploit insects attracted to the light (Bruce-White & Shardlow 2011; Frank 1988)), so bird's reactions to markers with increased illumination may not be as desired (Murphy *et al.* 2016).

**High-tech:**

Turning to the high tech approach for mitigating nocturnal collisions, birds have tetrachromatic colour vision (Martin & Osorio 2008). In other words, their colour vision is based on four types of single cone photoreceptor cells in their eyes (Martin & Osorio 2008). In addition to short wavelength, middle wavelength, and long wavelength absorbing single cones — all three of which are also found in us humans; we are trichromatic (Ramamurthy & Lakshminarayanan 2014) — birds also have, depending on the species, ultraviolet (UV) or violet absorbing types of cones. This enables them to see ultraviolet/violet light in addition to the part of the electromagnetic spectrum visible to humans (Bowmaker *et al.* 1997; Hart & Hunt 2007; Lind *et al.* 2013; Martin & Osorio 2008; Ödeen & Håstad 2013).

The use of ultraviolet radiation for mitigating bird collisions with power lines has been suggested (Prinsen *et al.* 2012). Because humans cannot see ultraviolet wavelengths — partly because the lens of the human eye absorbs it (Ambach *et al.* 1994; Boettner & Wolter 1962; Dillon *et al.* 1999; Kessel *et al.* 2010) — it could potentially be used to alert birds to suspended obstacles, such as power lines, without increasing visibility to humans (Baasch *et al.* 2022; Dwyer *et al.* 2019). Recent UV-based mitigation on power lines at a site in Nebraska, USA, showed promising results (Baasch *et al.* 2022; Dwyer *et al.* 2019).

However, a prerequisite for the widespread adoption of this emerging strategy of mitigating avian collisions includes the following:

- Replication at other localities
- Different sets of species (the Nebraskan studies focussed mainly on the Sandhill Crane *Antigone canadensis* in a wetland setting)
- Different power line/maker configurations (the Nebraskan studies were conducted on marked lines only)
- Studies throughout the year (the Nebraskan studies were limited to February, March and April).

In addition, further research is required into potential unintended consequences. For example, the potentially detrimental effects of ultraviolet light exposure as it relates to the health of birds and humans (May *et al.* 2017; Wilson *et al.* 2012-09; Yam & Kwok 2014) and ecological light pollution and its effects on insects (Barghini & Medeiros 2012; Frank 1988; Longcore & Rich 2016; Van Langevelde *et al.* 2011). It is well-known that insects attracted to artificial light are exploited by birds and other predators as a food source (*e.g.* Frank 1988). If this occurs around power lines, it could lead to collisions. This aspect also requires further investigation at UV-based mitigation systems on power lines (Baasch *et al.* 2022; Dwyer *et al.* 2019).

#### 7.2.6.3.4. Span length

Jenkins *et al.* (2010) claim that "there is general agreement that ... span lengths should be kept as short as possible" (span = the space between adjacent pylons). However, not one of the sources they reference (*i.e.* APLIC 1994; Bevanger 1994; Hunting 2002) makes any mention of it. Bernardino *et al.* (2018) linked the statement of Jenkins *et al.* (2010) to observations which indicate that collision rates tend to be lower near pylons than at mid-span (see 2.3.6 on page 29). Bernardino *et al.* (2018) concluded that there is "little scientific evidence" that this recommendation is effective. Regardless, the placement of pylons for the ORSF1 power line is likely to be governed primarily by

- terrain (pylons are likely to be placed on high points along parts of the route; see Figure 23)

- fixed turning points
- Orange River crossing
- relatively short length of the remaining straight sections

Therefore, there will be limited options for spacing pylons as desired (Fig. 9).

### 7.2.6.3.5. More than one set of power lines

When more than one set of power lines is involved, as is presently the case (Fig. 9; Fig. 11; Fig. 20), there are additional mitigation strategies to consider.

#### Bundled conductors

Bundled conductors and their spacers (Fig. 50, page 177) are assumed to render them more visible than single conductors (Prinsen *et al.* 2011; Thompson 1978). It also obviates the need to construct a separate set(s) of power lines (Bevanger 1994). As a result, a bird in flight will need to deal with only one set wires, instead of two or more sets.

The proposed ORSF1 power line is planned to be similar to the existing 132kV Garona–Groblershoop power line and will also follow the same route (Fig. 9). Therefore, it is recommended that the feasibility of accommodating the proposed ORSF1 power line on the existing structures of the Garona–Groblershoop power line should be investigated. Preference should be given to designs that retain the current height and four levels of wires (see in particular figure 1.6 in APLIC (2012); Fig. 8).

#### Parallel lines

It has been suggested that power lines running parallel and in the same right-of-way could help to reduce collision risk (Thompson 1978). The reasoning behind it is twofold: 1) The network of wires would tend to make the lines more visible; 2) A bird would only require a single ascent and descent to cross the lines instead of more than one avoidance manoeuvre (Thompson 1978).

This suggestion has been around for more than four decades. Even though Thompson (1978) himself noted that the "relative effect on mortality rates of separate versus clustered lines depends on many site-specific factors and deserves further study", reviews touching on the subject (*e.g.* APLIC 1994, 2012; Bevanger 1994) all refer back to Thompson's (1978) original suggestion, without sighting any subsequent studies. Bernardino *et al.* (2018) is a notable exception as they do state that "few studies (*e.g.* Shaw, 2013) have attempted to evaluate the effectiveness of this measure in terms of the bird collision hazard." (Bernardino *et al.* 2018). Unfortunately, Shaw (2013) investigated power lines of different heights, and the study results were inconclusive.

Recently, Pallett *et al.* (2022) proposed a novel mitigation measure involving parallel running power lines. They based this on bird carcasses larger than a Pied Crow R548 found under power lines in Namibia and South Africa. Similar to observations elsewhere (see Section 2.3.6 on page 29), their data indicated that relatively few carcasses (only 12.7%) were found around pylons. In contrast, the rest of the carcasses were found under the rest of the line ("mid-span and intermediate sections"). Based on their findings, Pallett *et al.* (2022) suggested the following:

- Align power lines of similar size in parallel
- Place them as close as technically feasible
- Stagger the pylons such that each pylon is aligned with the mid-span of the neighbouring line

Pallett *et al.* (2022) suggested that this would make the lines more visible to birds and reduce collision risk. It is not presently known if this will work in practice (Pallett *et al.* 2022). Be that as it may, as already indicated earlier (see Section 7.2.6.3.4 above), practical considerations will likely govern the placement of pylons for the ORSF1 power line, and there will be limited scope for alternative placements.

### Horizontal or vertical design?

As indicated earlier (see page 71), horizontal designs where conductors are all on the same height are considered safer as it presents a smaller vertical collision risk zone (APLIC 2012; Bevanger 1994; Drewitt & Langston 2008; See also Figure 8). However, other factors must also be considered when additional power lines with different configurations are also present.

The vertical collision risk zones for the existing power lines are illustrated in Figures 51 (page 178) & 52 (page 179). The vertical collision risk zone of the proposed ORSF1 power line is also illustrated there, comparing vertically (illustrated at the top) and horizontally (illustrated at the bottom) arranged conductor options. For the vertically arranged conductors option, it was assumed to be the same as that of the 132 kV Garona–Groblershoop power line, and for the horizontally arranged option, it was assumed to be the same as that used for the 22 kV Groblershoop–Padkloof power line at the Orange River. In this latter case, it is acknowledged that the actual design of a horizontal arrangement may be different for the 132 kV ORSF1 power line. However the vertical collision risk zone is likely to be similar.

A further assumption in Figures 51 & 52 is that the ORSF1 power line will be constructed at the same height as the adjacent Garona–Groblershoop power line, or at least within the same vertical collision risk zone. This assumption stems from one of the leading mitigation strategies to minimise the vertical collision risk zone (see page 70). In this particular case, it is achieved by merging the zones of adjacent power lines into one that does not exceed that of any of the lines involved (Figs. 51 & 52). An intriguing consequence is that any perceived benefit of a horizontal arrangement is at least partly lost. In particular, a bird approaching the lines from the other end would first encounter the Garona–Groblershoop power line (and the lower Groblershoop–Padkloof power line before that) before it gets to the ORSF1 power line (Figs. 51 & 52).

Thompson (1978) noted that birds flying "during periods of decreased visibility" might be at a greater risk of colliding with clustered lines than separate lines. Bernardino *et al.* (2018) related this "unintended consequence" to situations where adjacent lines are at different heights but noted that it had not been eventuated yet.

If the ORSF1 power line is of the same design as the adjacent Garona–Groblershoop power line (Fig. 7), and if it is constructed to be on the same height (see top diagrams in Figures

51 & 52), then the visibility of these two lines could be mutually enhanced, regardless of the direction from which a bird may approach them. This visual enhancement will be especially likely if the markers on their respective earth wires are aligned so that the markers of the ORSF1 power line are in the centre of those on the other line (Fig. 53 A, page 180).

## 7.3. Electrocution

The design of the proposed ORSF1 power line will be similar to that of the existing 132kV Garona–Groblershoop power line, which utilises metal monopoles as pylons, both with and without guy wires (Fig. 7). Electrocution of a bird may be via physical contact with power line components, or via bird streamers (see Section 2.2 on page 23). We will assess them in that order. Since no technical drawings of the proposed infrastructure was available at the time of this report, discussion on specific infrastructure dimensions in relation to electrocution is reserved for Section 7.3.4 (page 81 *ff.*). Here we will highlight, *inter alia*, relevant maximum bird dimensions.

### 7.3.1. Physical contact

In the discussion below, it is assumed that insulator bases and/or monopoles are grounded.

At the pylons along straight sections, the proposed pylon configurations are not considered safe for larger birds because a bird perched on an insulator could come into simultaneous contact with an energised conductor and grounded component, which could result in electrocution (APLIC 1996).

Pylons at turning points appear to have even shorter space between conductors and earthed hardware (Fig. 7). Consequently, it poses an electrocution risk to birds with smaller dimensions than the pylons along straight sections.

Records of electrocution incidents via physical contact with power line infrastructure were found for 47 bird species with distributions overlapping with the study area (see the 'E' entries in the Accident column of Table 1; See also Figure 38). The data is summarised in Table 4 (page 127).

About one-third (34.0%) of these species are considered too small to physically bridge the air gap between components of the planned infrastructure (Table 1, E.). The rest of the species (n = 31) are considered at risk of electrocution and are summarised below.

- Approximately half of the 31 species (54.8%; Table 4, Et!), including five Red Data species (two vultures and three eagles) and one endemic species (Jackal Buzzard R152), perch in a way that may result in the tail touching a conductor below it. Suppose a bird perched that way opens its wings and touches an isolator base or the pylon with a wing tip. In that case, electrocution may result, especially if the feathers are wet. The Lappet-faced Vulture R124 have the longest wingspan (258–280 cm (Maclean 1993; Piper 2005)) of all electrocution species. If one of these birds is perched on the end of an isolator and opens its wings, a wing tip could reach infrastructure just over 129–140 cm away; we say "just over" because the centre line of a bird of that size would be somewhat closer to the isolator base. In other words, in a scenario where only one bird is perched on the end of an isolator with its tail touching the conductor below, the isolator base and pylon to which it is attached must be at least 150 cm away from the conductor. We will call this the **minimum horizontal clearance**.

- Species with relatively long legs are the second most common group (19.4%; Table 4, El). Most of them are relatively common in the study area and include three herons, an egret, a stork; and an ibis (Table 1, El!). Unlike the previous group, a perched bird of this group will have a shorter head-to-tail measurement than a head-to-foot measurement (Fig. 15). Due to their long legs and relatively large overall size — all of them have relatively long necks, too — a bird could potentially bridge an air gap between infrastructure components and become electrocuted. The aptly named Goliath Heron R064 is the largest species in this group, standing at more than 150 cm tall (Mock & Mock 1980). It defines the **minimum vertical clearance** required to mitigate electrocutions because it is the tallest flying bird species in the study area for which electrocution is known to occur (Smallie 2011; Fig. 15). Although not as long as some other species, its other measurements are impressive nonetheless: bill tip to end of tail: 135–150 cm (Roberts 1991; Snow & Perrins 1998; Wanless 2005); wingspan: 210–230 cm (Martínez-Vilalta *et al.* 2020; Roberts 1991; Snow & Perrins 1998).

- Species without tail 'problems' or long legs constitute the third most common group (16.1%; Table 4, Ex). All of them are residents in the proposed development area (Table 1, Ex). They were included here because of their relatively large proportions, with the Spur-winged Goose R116 being the largest of them all, measuring 74–109 cm from tip of bill to tail tip (reliable wingspan data not available) (Geldenhuys & Blom 1983).

- The final group of birds involve three Red Data species where electrocutions most likely occur only as the result of collision events (9.7%; Table 4, Ec; Table 1 A, Ec).

We will again consider all 47 species with records of electrocution incidents via physical contact with power line infrastructure, but this time separately for Red Data, endemic, and other species.

- Electrocution records were found for nine of the 15 Red Data species (Table 1 A). The two vultures and three eagles are all expected the be rare transient visitors to the area. Electrocution records for the more common Secretarybird R118, Kori Bustard R230 & Ludwig's Bustard R232 all probably refer to rare instances that followed after collision events (collisions are common in these species) since neither of these terrestrial species is known for perching on pylons. The Lanner Falcon R172 is the species most likely to utilise the pylons regularly, but it is relatively small and unlikely to experience electrocution on the proposed pylon designs.

- The Jackal Buzzard R152 & Pied Starling R759 are the only endemic species for which electrocution incidents are known (Table 1 B). The study area is located on the edge of their respective distribution ranges, and neither is expected to be frequent visitors.

- An additional 36 species are known to be electrocution victims on power line infrastructure (Table 1 C). Many of them (38.9%) are considered too small to bridge an air gap to affect electrocution. In half of the remaining species, the tails of perched birds will extend below a perch and could make contact with a conductor below it. The most common are the White-breasted Cormorant R055, African Fish Eagle R148, Pale Chanting Goshawk R162, Western Barn Owl R392, Spotted Eagle-Owl R401 & Pied Crow R548. Long-legged taxa (El) comprise 27.3% of the species and include common ones such as Black-headed Heron R063, Goliath Heron R064 & African Sacred Ibis R091. All the species without tail problems or long legs (22.7%; Ex) are common.

### 7.3.2. Bird streamers

One of the typical indicators of a bird streamer fault is that it tends to be prevalent on the conductor below the highest or most convenient perching space on the pylon (Van Rooyen *et al*. 2003; Vosloo & Van Rooyen 2009b). The pylons of the proposed ORSF1 power line provide perching opportunities less than 3 m above the conductors (Fig. 7; Fig. 8), which is within range of streamers (cf. Vosloo & Van Rooyen 2009b; See also APLIC 2006).

Only 27 species were considered capable of producing streamers that could potentially cause flashovers and electrocution (in Table 1 A, B & C, Accident column, see the E entries with an exclamation mark (!)). They include three of the electrocution categories (Table 4). The Red Data species include two vultures and three eagles, all expected the be rare transient visitors to the area, as is the only endemic species, the Jackal Buzzard R152. Most of the remaining 21 species are relatively common (*i.e.* all the high collision-rated (red) species in Table 1 C2).

### 7.3.3. Impact significance

The electrocution of birds is possible on the proposed pylons of the ORSF1 power line.

#### 7.3.3.1. Biological significance

On its own, the ORSF1 power line will not have a biologically significant impact on any species due to electrocution for the same reasons as collisions (see page 67).

##### 7.3.3.1.1. Cumulative impact:

The potential impact of electrocutions involving the ORSF1 power line on birds cannot be evaluated in isolation. First, the ORSF1 power line constitutes an integral part of the proposed Orange River Solar Facility 1. Therefore, the following operational phase impacts described in Nuttall & Vermeulen (2022) should also be considered: 1) Collisions with the solar panels; 2) Entrapment in perimeter fences; 3) Electrocutions in the on-site substations and inverter stations. Nuttall & Vermeulen (2022) considered the impact of all three of these impacts to be either low or very low. The electrocution risk on the ORSF1 pylons is probably greater than at the ORSF1. In addition, collisions involving the ORSF1 power line are likely to be main impact of the ORSF1 project during its operational phase.

The possible contribution that the solar fields of renewable solar energy facilities make towards cumulative impacts has yet to be determined. As indicated earlier (see page 67), it is reasonable to assume that the total length of power lines in the Northern Cape and elsewhere will steadily increase into the foreseeable future. If it is assumed that most of them will be bird-safe, then the cumulative impact involving electrocution will be insignificant, which would otherwise not have been established yet.

#### 7.3.3.2. Public significance

The ORSF1 power line will traverse private property and open public areas. There is always the chance of someone from the public encountering one or more dead birds underneath the pylons. In a worst-case scenario, this could lead to a public relations nightmare.

#### 7.3.3.3. Legal significance

The only Red Data species potentially exposed to electrocution on the ORSF1 pylons (two vulture and three eagle species) are all likely only rare transient visitors (see page 7.3.1).

See Section 4.7.3.2.1 (page 42 *ff.*) for an introduction to CMS. The data of CMS species in Table 1 are summarised in Table 3.

- Appendix 1 species (A1 in Tables 1 & 3): Both the White-backed Vulture R123 and Lappet-faced Vulture R124 have known collision and electrocution records. However, they are both considered to be only rare transitory visitors to the study area.
- Appendix 2 species (A2): Electrocution incidents are known for 7 of the 23 species, but three of them are too small to be at risk on the ORSF1 power line infrastructure. Of the remaining four species, the African Sacred Ibis R091 is the most abundant in the area.
- AEWA species (W): The distributions of a total of 32 AEWA species overlap with the study area. Records of electrocution were found for eight species. Seven of them were regarded as potentially exposed to electrocution on the prosed ORSF1 power line infrastructure. Most of them are relatively common in the area.
- Raptor MOU (R1, R2 & R3): Only one of the ten species, the Black Harrier R168, does not have collision or electrocution records. The data for the rest is summarise below.
    - Category 1 (R1): All three species (two vultures and one eagle) have both collision and electrocution records, however they are all considered to be at best only rare transitory visitors to the study area.
    - Category 2 (R2): As the only species in this category, the Lanner Falcon R172, a Red Data species, is expected to be relatively common in the study area and are evaluated to be exposed to a high collision risk. The separation distance on the planned infrastructure appears to be sufficient to prevent electrocution in this species.
    - Category 3 (R3): Collision and electrocution incidents are known for all five species. However, two are considered too small to bridge air gaps on the proposed power line

infrastructure, and the remaining three are probably only rare transitory visitors to the area.

It is concluded that several CMS species are at risk of being exposed to electrocution risk on the ORSF1 pylons during their operational phase.

### 7.3.4. Mitigation Review

The electrocution of birds at power line infrastructure can be effectively mitigated (Chevallier *et al.* 2015). For planned new infrastructure developments, it is more cost-effective to incorporate bird-safe designs from the start rather than developing mitigation actions after the power line is already in operation (APLIC 1996; Chevallier *et al.* 2015). The electrocution of birds is reviewed in Section 2.2 (page 23 *ff.*). Here, the literature on mitigation is reviewed separately for electrocution via physical contact and bird streamers.

#### 7.3.4.1. Physical contact

As detailed in Section 7.3.1 (page 77 *ff.*), several bird species with distributions overlapping with the Groblershoop area have been recorded as electrocution victims elsewhere (Table 1 A, B & C).

Mitigation strategies for electrocution via physical contact revolve around the following two principles (in order of effectiveness): separation and insulation (APLIC 1996, 2006), each of which is considered separately below.

##### 7.3.4.1.1. Separation

For an electrocution incident to occur at any pylon, a bird must physically bridge the air gap between energised components or between an energised and a grounded component. Thus, the most effective mitigation strategy is to ensure that the separation between energised/grounded components exceeds the dimensions of the largest bird species that could potentially be affected. In our discussion in Section 7.3.1, we learned that to mitigate electrocution effectively, the *minimum horizontal clearance* required is 150 cm, and the *minimum vertical clearance* is higher still. However, we cannot put an exact number on it.

No technical drawings of the design of ORSF1 pylons were available when this report was compiled. It was only known that the pylons would be similar to those of the existing 132kV Garona–Groblershoop power line. The measurements used here are based on elevation meta-data from photographs taken with a drone, examination of photographs, and guesstimates of the dimensions of the Garona–Groblershoop pylons.

At pylons along straight sections, it was estimated that the isolators on these pylons keep the conductors approximately 122 cm away from the pylon (horizontally) and that the vertical distance between the bottom and top conductor was 169 cm (see Figures 7 (left) & 8 B). Therefore, while the vertical separation distance is acceptable, the isolators (*i.e.* horizontal separation) need to be longer, at least 150 cm, for the ORSF1 power line. Alternatively, a bird-safe suspension configuration incorporating the features of the design recommended by

APLIC (1996), which provides adequate spacing between phases and allows for safe perching on the pole-top and all cross-arms, could be considered instead (see Figure 54, page 181).

The proposed design of the turning point pylons is similar to "bird-friendly" structures recommended elsewhere (*e.g.* EDM International 2003). Indeed, the estimated vertical separation is a good 250 cm (Fig. 8 A). However, although we did not estimate the horizontal separation of the jumper wires around these pylons, it appears to be even less than the conductor-pylon separation at the straight-section pylons (see Figure 7). Be that as it may, it is recommended that the pylons for the ORSF1 power line must all ensure a separation of at least 150 cm between all conductors and earth wire combinations.

#### 7.3.4.1.2. Insulation

Insulation refers to the covering of conductor and grounded infrastructure whenever separation is not feasible (APLIC 1996, 2006; Haas *et al*. 2005). A notable disadvantage of insulation is that it is not permanent and needs regular monitoring and repair (Tintó *et al*. 2010).

Suppose it turns out that separation, as recommended above, is not feasible. Then, in the case of straight-line pylons, all isolator-conductor connection points and at least 60 cm of conductor on either side of the connection points must be insulated. Similarly, for turning point pylons, the jumper wires around the pylons and at least 60 cm of conductor on either side must be insulated.

#### 7.3.4.2. Bird streamers

Mitigation of bird streamer-induced flashovers is perhaps more critical for the reliability of the power line than it is to the protection of the birds, as fatalities due to streamer induce flashovers are rare, according the Van Rooyen *et al*. (2003).

The most effective way of mitigating streamer-induced flashovers is the prevent birds from perching/roosting over conductors (APLIC 2006; Van Rooyen *et al*. 2003). On metal lattice-type pylons, this has been successfully accomplished with the deployment of so-called bird guards (Van Rooyen *et al*. 2003). An example of such bird guards in action is shown in Figure 19. While it may be desirable to follow a similar strategy for the ORSF1 power line, consideration should first be given to the following:

- It has been reported that where bird guards were effective in preventing birds from roosting, the birds simply moved to an adjacent power line where streamer faults then occurred (Vosloo & Van Rooyen 2009b; See also Harness 2000).
- According to Vosloo & Van Rooyen (2009b), the principle to be followed in perch management is not the prevent birds from perching/roosting on the pylon but rather to prevent them from perching/roosting on critical parts of the pylon. They claim that providing adequate alternative perching/roosting space on the pylon will enhance the success of the intervention (Vosloo & Van Rooyen 2009b). However, their advice here is probably in the context of large metal lattice pylons and may not apply to the metal monopole structures of the ORSF1 power line.

- Care should be taken to ensure that appropriate devices are fitted, and that field modifications during installation does not compromise the functionality or durability of the devices (Dwyer *et al.* 2020).
- Bird guards could exacerbate electrocution risk if birds try to balance on it instead of avoiding it (Dwyer & Doloughan 2014; Slater & Smith 2010).
- Placing perch guards on the top of vertical pylons can contribute to the electrocutions since the birds may choose to perch/roost lower on the pylon, near energised conductors (Harness 2000).

## 7.4. Mitigation

The following recommendations for the ORSF1 power line are based on the earlier reviews of mitigation strategies for collisions (Section 7.2.6) and electrocution (Section 7.3.4).

1. The ORSF1 power line will run close to other Eskom power lines. Some of the recommendations made here may also impact their systems. Therefore, it is recommended that they should be consulted on the various aspects of the design of the ORSF1 power line, including the recommendations considered here.
2. The proposed ORSF1 power line is planned to be similar to the existing 132kV Garona–Groblershoop power line and will also follow the same route (Fig. 9). It is recommended that the feasibility of accommodating the proposed ORSF1 power line on the existing structures of the Garona–Groblershoop power line should be investigated and used if possible (see in particular figure 1.6 in APLIC 2012). The design must also be assessed for bird collision and electrocution risk before approval can be granted.
3. In the event that the preceding recommendation is not feasible, then the following is recommended instead:
    a) It is recommended that pylons of the ORSF1 power line be designed to accommodate power lines in addition to the ones required by the ORSF1. This will help reduce the risk of collisions if other future renewable energy projects also need to connect to the Eskom Groblershoop substation via a similar route. The most critical area is the Orange River crossing and adjacent agricultural land.
    b) The route of the ORSF1 power line must run parallel and as close as possible to the existing 132kV Garona–Groblershoop power line. The route illustrated in Figure 9 is acceptable.
    c) The configuration of conductors and earth wire can be similar to that of the adjacent Garona–Groblershoop power line (Figs. 7 & 8). However, the design of all ORSF1 pylons must have a minimum separation of at least 150 cm between all conductor-conductor and conductor-earthed components. If this is not feasible, see the insulation section on page 82.

d) Along its entire route, the ORSF1 power line must be at the same height as the adjacent Garona–Groblershoop power line in order to minimise the vertical collision risk zone.

e) Markers must be deployed on the earth wires along the entire length of the ORSF1 power line as follows:

    i. Unless more effective devices become available, devices similar to that used on the existing 132kV Garona–Groblershoop power line should be deployed (Fig. 41 A, right; Fig. 53 B).

    ii. Spacing between marker must match that of the adjacent Garona–Groblershoop power line, but in such a way that the markers on the ORSF1 line is aligned to be in the centre of markers on the adjacent line as illustrated in Figure 53 A. In that way, the visibility of the earth wires will be maximised.

f) The deployment of bird guards as a mitigation strategy for bird streamers should be explored with Eskom since they have much experience with it. Furthermore, deploying such devices on the ORSF1 power line may also impact their systems (see on page 82). Therefore, any decisions regarding bird guards must be coordinated with them.

g) Nesting mitigation: As discussed earlier (see Section 2.4 on page 29), nesting activity on pylons can potentially cause flashovers and even fires. We have also seen that several bird species may utilise the pylons of the ORSF1 power line for nesting (see page 61). The following recommendations are based on Anderson (2013); Brown & Lawson (1989); Lee (1980):

    i. All wires must be collected and disposed of in an approved manner. This will help to limit the amount of nesting material available for crows, thereby reducing the chances of flashovers on pylons.

    ii. Any nests containing eggs or young chicks should not be disturbed. In particular, parent birds should not be kept off nests in cold or hot weather as this may have lethal consequences for the eggs/young.

    iii. Only remove nests if it is essential. The continual removal of bird nests is costly and time-consuming, and the nest owners will frequently return to rebuild them. In addition, it implies more chances for new nesting material being dropped and causing flashovers.

    iv. Limit interventions to nests which cause, or are expected to cause, a problem. Alternatives to removing problem nests include the following:

        A. Trim nesting material, for example, a wayward stick that may come into contact with conductors, without disturbing the main nest structure.

        B. Isolate conductors at problem areas around the nest.

    v. If a nest becomes unmanageable, it may only be removed as a last resort. In such a case, and keeping in mind that the birds may attempt to nest there again, the following should be considered:

  A. If possible, remove problem nests only once it is empty.
  B. If feasible, attempt to relocate the nest to a benign spot on the pylon.

4. This assessment was exclusively for the ORSF1 power line after it left the confines of the ORSF1 substation. It is noted that Nuttall & Vermeulen (2022) recommended a reactive approach concerning electrocution involving infrastructure within the ORSF1 substation. Here we wish to promote a proactive alternative instead. Electrocutions can potentially damage equipment. Therefore, all external jumper wires that cannot be sufficiently separated should be insulated. See the relevant sections on pages 2.2 & 7.3.4.

### 7.4.1. Effect on impact significance

#### 7.4.1.1. Collisions

##### 7.4.1.1.1. Biological significance

On its own, the ORSF1 power line will not have a biologically significant impact on any bird species (see page 67). Mitigation irrelevant.

**Cumulative impact**

A case can be made that the ORSF1 power line does contribute to a cumulative impact, which may become biologically significant, on collision-prone, non-resident species, such as the Ludwig's Bustard R232. Unfortunately, line markers are largely ineffective for this species (see Section 7.2.6.3.2 on page 72), and proven effective alternatives do not presently exist. Therefore, a notable change in impact significance before and after mitigation is doubtful in this case.

##### 7.4.1.1.2. Public significance

While it may be difficult to predict how the public will respond to the ORSF1 power line, dead birds below it are more likely to elicit a response than would otherwise be the case. Many individual birds of different species will likely collide with the ORSF1 power line during its operational phase (see page 67). If implemented as recommended above, the mitigation measures are expected to reduce collision risk, at least moderately (see Section 7.2.6, page 7.2.6 *ff.*). Surely, this should count for something in the public eye — they cannot say you did not try.

##### 7.4.1.1.3. Legal significance

Eleven Red Data species have known collision records. Six of them were evaluated to be exposed to a high collision risk (see page 7.2.2).

During its operational phase, the ORSF1 power line is likely to be responsible for the death of many individuals of several CMS species (see Section 7.2.5.3 on page 69; Table 3).

As indicated above, the recommended mitigation measures are expected to reduce collision risk, at least moderately.

#### 7.4.1.2. Electrocutions

##### 7.4.1.2.1. Biological significance

On its own, the ORSF1 power line will not have a biologically significant impact on any bird species, and the cumulative impact is insignificant (see page 79). Mitigation is thus irrelevant for this aspect.

##### 7.4.1.2.2. Public significance

Public significance is similar to the same heading under collisions above, except that implementation of the recommended mitigation measures will reduce electrocution risk to virtually zero.

##### 7.4.1.2.3. Legal significance

Five Red Data species, all expected to be rare transient visitors, are potentially exposed to electrocution on the ORSF1 pylons.

During its operational phase, the ORSF1 power line will pose an electrocution risk for several CMS species (see Section 7.2.5.3 on page 69; Table 3).

As indicated above, the recommended mitigation measures are expected to reduce electrocution risk to virtually zero.

# 8. Decommissioning phase

The potential impacts during the decommissioning phase of the ORSF1 power line include the following:

1. Decommissioning activities could cause disturbance and possibly displacement of birds in the surrounding area.
2. A direct impact during the decommissioning phase will be the destruction of any nests present on the pylons at the time. This is a distinct possibility given that the utilisation of the ORSF1 power line by birds for nesting is considered one of its potential positive impacts (see Section 7.1 on page 61)
3. Removing the ORSF1 power line implies eliminating any collision and electrocution hazards directly associated with it.

## 8.1. Impact significance

- In general, displacement is not expected to be a major factor given that the affected area would entail a narrow strip through widespread habitat components.
- The destruction of nests could be an issue, especially if it involves a Red Data species.
- Removing the ORSF1 power line have positive impact

### 8.1.1. Biological significance

With the possible theoretical exception of a nest of an exceptionally rare, range-restricted species, the decommissioning phase of the ORSF1 power line will not have a biologically significant impact.

#### 8.1.1.1. Cumulative impact

The potential impact of the decommissioning of the ORSF1 power line on birds cannot be evaluated in isolation because it constitutes an integral part of the proposed ORSF1. It is assumed that both the ORSF1 and the ORSF1 power line will be decommissioned simultaneously. Therefore, the following decommissioning phase impacts described in Nuttall & Vermeulen (2022) should also be considered: Displacement due to disturbance. Displacement is unlikely to result in any short- or long-term negative consequences for local populations of any species involved since the affected habitat components are widespread and displaced individuals are likely to resettle there.

In conclusion, while the cumulative impact of the decommissioning phase may be high for *individuals* of the species in the affected area, it is most likely inconsequential for the *populations* involved. Cumulative impact then insignificant.

### 8.1.2. Public significance

If a pylon destined for removal also has an active nest on it, it may elicit a response from the public.

### 8.1.3. Legal significance

Of the five Red Data species known to breed on pylons, the Lanner Falcon R172 is the only one likely to breed on the ORSF1 pylons (see below). The others prefer larger metal lattice structures (e.g. Fig. 14).

The following six CMS species are known to breed on pylons (Table 1 A & C2). See Section 4.7.3.2.1 on page 42 for an explanation of the codes A1, R1, R2, R3 & W.

- White-backed Vulture R123 (A1, R1): Monopole designs not suitable for nesting.
- Tawny Eagle R132 (R1): Monopole designs not suitable for nesting.

- Lanner Falcon R172 (R2): Known to utilise crow nests on pylons (Kemp 1972; Tarboton & Allan 1984). The Pied Crow R548 is one of the most likely species to breed in the ORSF1 pylons (see Section 7.1 on page 61).
- Egyptian Goose R102 (W): Know to breed on top of Sociable Weaver R800 nests (Maclean 1973; Plowes 1946; Fig. 28). Sociable Weavers are one of the most likely species to breed in the ORSF1 pylons (see Section 7.1 on page 61).
- Black-chested Snake Eagle R143 (R3): Monopole are designs possibly not suitable for nesting.
- Rock Kestrel R181 (R3): Known to utilise crow nests on pylons (Ledger & Hobbs 1999). The Pied Crow R548 is one of the most likely species to breed in the ORSF1 pylons (see Section 7.1 on page 61).

It is concluded that decommission could have legal significance if any one of these species are nesting on the pylons at the time.

## 8.2. Mitigation

From the forgoing it is clear that the decommissioning phase could have impacts on birds. The following mitigation measures are recommended:

1. Activities should be restricted to the footprint area of the infrastructure.
2. Vehicles should not depart from existing roads unless it is required for safety, technical or other valid reasons.
3. If birds are actively breeding on a pylon, delay decommissioning until after the breeding is completed.
4. All parts of the infrastructure, including all wires, must be removed and disposed of in an approved manner, as these could be used by birds, especially crows, to construct their nests on power line infrastructure and potentially cause flashovers as a result.

### 8.2.1. Effect on impact significance

#### 8.2.1.1. Biological significance

Decommissioning of the ORSF1 power line is unlikely to have a biologically significant impact. While the cumulative impact may be substantial for individual birds, it will most likely be inconsequential for the populations involved.

#### 8.2.1.2. Public significance

Implementation of mitigation point 3 above will greatly reduce public significance.

#### 8.2.1.3. Legal significance

Implementation of mitigation point 3 above can greatly reduce legal significance.

# 9. Conclusions

In the preceding three chapters, we assessed potential avifaunal impacts of the 3.88 km long, 132 kV ORSF1 power line planned to connect the proposed Orange River Solar Facility 1 to Eskom's High Voltage Groblershoop substation. A synopsis of the results is presented in the executive summary (page 11 *ff.*).

The ORSF1 power line will be a permanent collision hazard to the area's birds, probably for decades. The proposed power line route intersects several flyways and passes near a known roost, as well as another spot in the Orange River that is likely to attract large numbers of birds during certain times of the year. There is, thus, a high probability that collisions will occur.

Although biologically significant impacts are improbable, collision incidents could trigger a public response, which may become a public relations nightmare in a worst-case scenario. Even more importantly, the ORSF1 power line poses a real collision risk to a few Red Data species and a number of species listed in various CMS lists.

Collision impacts are the most significant concern, with electrocutions in a distant second place. Whereas a proven, reliable, cost-effective strategy that works for all species all the time does not currently exist for collision mitigation, mitigation strategies for electrocution have most, if not all, of these features.

The only significant cumulative impact identified relates to the increase in the total length of power lines throughout the Northern Cape. The ORSF1 power line will contribute 3.88 km to this. A sustained increase over time could have negative consequences for non-resident species such as the Endangered Ludwig's Bustard R232.

Collision and electrocution impacts are only relevant during the operational phase of the ORSF1 power line. There are also impacts associated with this line's construction and decommissioning phases. These phases are of short duration, and their respective impacts pale compared to the operational phase.

In conclusion, it is recommended that the activity is authorised on the condition that the proposed mitigation measures are strictly implemented.

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**Table 1:** The 234 bird species with distributions overlapping with the study area (see Section 4.3 on page 36). Each species is included in only one of seven groups (A–F) with the groups arranged in descending ordered of priority. Name: Roberts' number (Maclean 1985) followed by English and scientific name based on Hardaker (2022) (E, endemic; n-E, near-endemic); The NESW column signifies the directional local limits of a species' range relative to the study area (see Section 4.4 on page 37); Habitat: Habitat preferences according to Harrison *et al*. (1994): AQ, Aquatic; FR, Forest; GR, Grassland; HG, Generalist; MR, Marine; RC, Montane\Rocky; SC, Scrub; WO, Woodland; RDB: Red Data status regionally (Taylor *et al*. 2015), globally (IUCN): CE: Critically Endangered; EN: Endangered; VU: Vulnerable; NT: Near Threatened; LC: Least Concern; NL: Not Listed; CMS, CMS species: A1: CMS Appendix 1 species; A2: CMS Appendix 2 species; W: AEWA; R1, R2 & R3: Raptors MOU (see Section 4.7.3.2.1 on page 42); Pbr: Breed on pylons; PESrisk: Risk associated with power lines (see Section 4.8.2 on page 45).

| **Name** | **NESW** | **Habitat** | **RDB** | **CMS** | **Pbr** | **PESrisk** | |
|---|---|---|---|---|---|---|---|
| | | | | | | **Disturb.** | **Accident** |
| A. 15 Red Data Book species: | | | | | | | |
| R123 White-backed Vulture (*Gyps africanus*) | SW | WO | **CE**,CE | A1,R1 | Pbr | -- | C1 Et! |
| R124 Lappet-faced Vulture (*Torgos tracheliotos*) | SW | WO | **EN**,EN | A1,R1 | - | -- | C1 Et! |
| R132 Tawny Eagle (*Aquila rapax*) | SW | HG | **EN**,VU | R1 | Pbr | -- | C1 Et! |
| R140 Martial Eagle (*Polemaetus bellicosus*) | X | HG | **EN**,EN | - | Pbr | -- | C1 Et! |
| R168 Black Harrier (*Circus maurus*) n-E | X | GR, SC | **EN**,EN | R1 | - | -- | -- |
| **R232 Ludwig's Bustard (*Neotis ludwigii*)** | X | SC | **EN**,EN | - | - | low | **C3** Ec |
| **R118 Secretarybird (*Sagittarius serpentarius*)** | X | HG | **VU**,EN | - | - | -- | **C3** Ec |
| R131 Verreaux's Eagle (*Aquila verreauxii*) | -SW | RC | **VU**,LC | - | Pbr | -- | C1 Et! |
| **R172 Lanner Falcon (*Falco biarmicus*)** | X | HG | **VU**,LC | R2 | Pbr | -- | **C3** E. |
| R299 Burchell's Courser (*Cursorius rufus*) | X | GR, SC | **VU**,LC | - | - | -- | -- |
| **R085 Abdim's Stork (*Ciconia abdimii*)** | OR | HG | **NT**,LC | W | - | -- | **C3** - |
| **R230 Kori Bustard (*Ardeotis kori*)** | X | SC, WO | **NT**,NT | - | - | low | **C3** Ec |

Continued on next page . . .

| Name | NESW | Habitat | RDB | CMS | Pbr | PESrisk |  |
|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  | Disturb. | Accident |
| **R235 Karoo Korhaan (*Eupodotis vigorsii*) n-E** | NE | GR, SC | **NT**,LC | - | - | low | **C3** - |
| R510 Sclater's Lark (*Spizocorys sclateri*) n-E | NE | SC | **NT**,NT | - | - | -- | -- |
| R721 African Rock Pipit (*Anthus crenatus*) E | W | RC | **NT**,NT | - | - | -- | -- |
| B. 14 ADDITIONAL ENDEMIC SPECIES: |  |  |  |  |  |  |  |
| R152 Jackal Buzzard (*Buteo rufofuscus*) n-E | E | HG | **NL**,LC | - | Pbr | -- | C1 Et! |
| **R195 Cape Spurfowl (*Pternistis capensis*) n-E** | OR | SC | **NL**,LC | - | - | low | **C3** - |
| R512 Large-billed Lark (*Galerida magnirostris*) E | N | GR, SC | **NL**,LC | - | - | -- | -- |
| R517 Black-eared Sparrow-Lark (*Eremopterix australis*) n-E | NE | SC | **NL**,LC | - | - | -- | -- |
| R528 South African Cliff Swallow (*Petrochelidon spilodera*) b-E | OR | GR | **NL**,LC | - | - | -- | -- |
| R577a Karoo Thrush (*Turdus smithi*) n-E | OR | WO | **NL**,LC | - | - | low | -- |
| R591 Sickle-winged Chat (*Emarginata sinuata*) n-E | X | GR, SC | **NL**,LC | - | - | -- | -- |
| R614 Karoo Scrub Robin (*Cercotrichas coryphoeus*) n-E | X | SC | **NL**,LC | - | - | low | -- |
| R687 Namaqua Warbler (*Phragmacia substriata*) n-E | OR | AQ | **NL**,LC | **-** | **-** | **low** | -- |
| R698 Fiscal Flycatcher (*Melaenornis silens*) n-E | X | WO | **NL**,LC | - | - | low | -- |
| R706 Fairy Flycatcher (*Stenostira scita*) n-E | X | SC, WO | **NL**,LC | - | - | low | -- |
| R759 Pied Starling (*Lamprotornis bicolor*) E | NW | HG | **NL**,LC | - | - | -- | - E. |
| R783 Southern Double-collared Sunbird (*Cinnyris chalybeus*) n-E | NW | FR, SC | **NL**,LC | - | - | -- | -- |
| R876 Black-headed Canary (*Serinus alario*) n-E | X | SC | **NL**,LC | - | - | -- | -- |
| C. 127 ADDITIONAL SPECIES POTENTIALLY NEGATIVE IMPACTED BY POWER LINES |  |  |  |  |  |  |  |
| C1. 39 SPECIES WITH LOW, MODERATE OR HIGH POTENTIAL DISTURBANCE IMPACT: |  |  |  |  |  |  |  |

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| Name | NESW | Habitat | RDB | CMS | Pbr | PESrisk | |
|---|---|---|---|---|---|---|---|
| | | | | | | Disturb. | Accident |
| **R352 Red-eyed Dove (*Streptopelia semitorquata*)** | OR | WO | **NL**,LC | - | - | low | **C3?** - |
| R398 Pearl-spotted Owlet (*Glaucidium perlatum*) | SW | WO | **NL**,LC | - | - | low | -- |
| R406 Rufous-cheeked Nightjar (*Caprimulgus rufigena*) | X | WO | **NL**,LC | - | - | low | -- |
| R425 White-backed Mousebird (*Colius colius*) | X | WO | **NL**,LC | - | - | low | -- |
| R435 Brown-hooded Kingfisher (*Halcyon albiventris*) | OR | WO | **NL**,LC | - | - | low | -- |
| R451 African Hoopoe (*Upupa africana*) | SW | WO | **NL**,LC | - | - | low | - E.* |
| R454 Common Scimitarbill (*Rhinopomastus cyanomelas*) | X | WO | **NL**,LC | - | - | low | -- |
| R465 Acacia Pied Barbet (*Tricholaema leucomelas*) | X | WO | **NL**,LC | - | - | low | -- |
| R473 Crested Barbet (*Trachyphonus vaillantii*) | -SW | WO | **NL**,LC | - | - | low | -- |
| R483 Golden-tailed Woodpecker (*Campethera abingoni*) | OR | WO | **NL**,LC | - | - | low | -- |
| R486 Cardinal Woodpecker (*Dendropicos fuscescens*) | OR | WO | **NL**,LC | - | - | low | -- |
| R497 Fawn-colored Lark (*Calendulauda africanoides*) | X | WO | **NL**,LC | - | - | low | -- |
| R498 Sabota Lark (*Calendulauda sabota*) | X | WO | **NL**,LC | - | - | low | -- |
| R500d Karoo Long-billed Lark (*Certhilauda subcoronata*) | X | SC | **NL**,LC | - | - | low | -- |
| R552 Ashy Tit (*Melaniparus cinerascens*) | X | WO | **NL**,LC | - | - | low | -- |
| **R567 African Red-eyed Bulbul (*Pycnonotus nigricans*)** | X | WO | **NL**,LC | - | - | low | **C3** - |
| R586 Mountain Wheatear (*Myrmecocichla monticola*) | X | RC | **NL**,LC | - | - | low | -- |
| R589 Familiar Chat (*Oenanthe familiaris*) | X | HG | **NL**,LC | - | - | low | -- |
| R595 Ant-eating Chat (*Myrmecocichla formicivora*) | X | GR, SC | **NL**,LC | - | - | low | -- |
| R601 Cape Robin-Chat (*Cossypha caffra*) | OR | FR, SC, WO | **NL**,LC | - | - | low | -- |
| R615 Kalahari Scrub Robin (*Cercotrichas paena*) | X | WO | **NL**,LC | - | - | low | -- |
| R621 Chestnut-vented Warbler (*Curruca subcoerulea*) | X | SC, WO | **NL**,LC | - | - | low | -- |
| R651 Long-billed Crombec (*Sylvietta rufescens*) | X | SC, WO | **NL**,LC | - | - | low | -- |

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| Name | NESW | Habitat | RDB | CMS | Pbr | PESrisk | |
|---|---|---|---|---|---|---|---|
| | | | | | | Disturb. | Accident |
| R653 Yellow-bellied Eremomela (*Eremomela icteropygialis*) | X | SC, WO | **NL**,LC | - | - | low | -- |
| R685 Black-chested Prinia (*Prinia flavicans*) | X | SC, WO | **NL**,LC | - | - | low | -- |
| R703 Pririt Batis (*Batis pririt*) | X | WO | **NL**,LC | - | - | low | -- |
| R732 Southern Fiscal (*Lanius collaris*) | X | HG | **NL**,LC | - | - | low | -- |
| R741 Brubru (*Nilaus afer*) | X | WO | **NL**,LC | - | - | low | -- |
| R743 Brown-crowned Tchagra (*Tchagra australis*) | SW | WO | **NL**,LC | - | - | low | -- |
| R746 Bokmakierie (*Telophorus zeylonus*) | X | SC | **NL**,LC | - | - | low | -- |
| R764 Cape Starling (*Lamprotornis nitens*) | X | WO | **NL**,LC | - | - | low | -- |
| R788 Dusky Sunbird (*Cinnyris fuscus*) | X | SC, WO | **NL**,LC | - | - | low | -- |
| R796a Orange River White-eye (*Zosterops pallidus*) | OR | WO | **NL**,LC | - | - | low | -- |
| **R803 Cape Sparrow (*Passer melanurus*)** | X | HG | **NL**,LC | - | - | low | **C3** - |
| R804a Southern Grey-headed Sparrow (*Passer diffusus*) | -SW | WO | **NL**,LC | - | - | low | -- |
| R842 Red-billed Firefinch (*Lagonosticta senegala*) | OR | WO | **NL**,LC | - | - | low | -- |
| R846 Common Waxbill (*Estrilda astrild*) | X | AQ | **NL**,LC | **-** | **-** | **low** | -- |
| R870 Black-throated Canary (*Crithagra atrogularis*) | X | WO | **NL**,LC | - | - | low | -- |
| R878 Yellow Canary (*Crithagra flaviventris*) | X | GR, SC | **NL**,LC | - | - | low | -- |

### C2. 86 ADDITIONAL SPECIES WITH KNOWN, OR EXPECTED, COLLISION OR ELECTROCUTION RECORDS:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| R006 Great Crested Grebe (*Podiceps cristatus*) | OOR | AQ | **NL**,LC | **W** | **-** | **--** | C1* - |
| R008 Little Grebe (*Tachybaptus ruficollis*) | OR | AQ | **NL**,LC | **W** | **-** | **--** | C1* - |
| **R055 White-breasted Cormorant (*Phalacrocorax lucidus*)** | OR | AQ, MR | **NL**,LC | **-** | **-** | **--** | **C3** Et! |
| **R058 Reed Cormorant (*Microcarbo africanus*)** | OR | AQ | **NL**,LC | **-** | **-** | **--** | **C3** - |
| **R060 African Darter (*Anhinga rufa*)** | OR | AQ | **NL**,LC | **-** | **-** | **--** | **C3?** - |

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| **Name** | **NESW** | **Habitat** | **RDB** | **CMS** | **Pbr** | **PESrisk** | |
|---|---|---|---|---|---|---|---|
| | | | | | | **Disturb.** | **Accident** |
| **R062 Grey Heron (*Ardea cinerea*)** | OR | AQ, MR | **NL**,LC | **W** | **-** | **--** | **C3** El! |
| **R063 Black-headed Heron (*Ardea melanocephala*)** | N | HG | **NL**,LC | W | - | -- | **C3** El! |
| **R064 Goliath Heron (*Ardea goliath*)** | OR | AQ | **NL**,LC | **-** | **-** | **--** | **C3** El! |
| **R067 Little Egret (*Egretta garzetta*)** | OR | AQ, MR | **NL**,LC | **W** | **-** | **--** | **C3*** - |
| **R068 Intermediate Egret (*Ardea intermedia*)** | OR | AQ | **NL**,LC | **-** | **-** | **--** | **C3?** - |
| **R071 Western Cattle Egret (*Bubulcus ibis*)** | OR | HG | **NL**,LC | W | - | -- | **C3** El! |
| **R072 Squacco Heron (*Ardeola ralloides*)** | OR | AQ | **NL**,LC | **W** | **-** | **--** | **C3*** - |
| **R074 Striated Heron (*Butorides striata*)** | OR | AQ | **NL**,LC | **-** | **-** | **--** | **C3?** - |
| **R076 Black-crowned Night Heron (*Nycticorax nycticorax*)** | OR | AQ, MR | **NL**,LC | **W** | **-** | **--** | **C3*** - |
| **R078 Little Bittern (*Ixobrychus minutus*)** | OR | AQ | **NL**,LC | **W** | **-** | **--** | **C3?** - |
| **R081 Hamerkop (*Scopus umbretta*)** | OR | AQ | **NL**,LC | **-** | **-** | **--** | **C3** Ex! |
| **R083 White Stork (*Ciconia ciconia*)** | OR | HG | **NL**,LC | W,A2 | - | -- | **C3** El! |
| **R091 African Sacred Ibis (*Threskiornis aethiopicus*)** | OR | HG | **NL**,LC | W,A2 | - | -- | **C3** El! |
| **R093 Glossy Ibis (*Plegadis falcinellus*)** | OR | AQ | **NL**,LC | **W,A2** | **-** | **--** | **C3?** - |
| **R094 Hadada Ibis (*Bostrychia hagedash*)** | -SW | HG | **NL**,LC | - | Pbr | -- | **C3** Ex! |
| **R102 Egyptian Goose (*Alopochen aegyptiaca*)** | X | AQ | **NL**,LC | **W** | **Pbr** | **--** | **C3** Ex! |
| **R103 South African Shelduck (*Tadorna cana*)** | NE | AQ | **NL**,LC | **W** | **-** | **--** | **C3** - |
| **R104 Yellow-billed Duck (*Anas undulata*)** | OR | AQ | **NL**,LC | **W,A2** | **-** | **--** | **C3** - |
| **R105 African Black Duck (*Anas sparsa*)** | OR | AQ | **NL**,LC | **A2** | **-** | **--** | **C3?** - |
| **R108 Red-billed Teal (*Anas erythrorhyncha*)** | OR | AQ | **NL**,LC | **W,A2** | **-** | **--** | **C3** - |
| R113 Southern Pochard (*Netta erythrophthalma*) | NW | AQ | **NL**,LC | **W** | **-** | **--** | C1 - |
| **R116 Spur-winged Goose (*Plectropterus gambensis*)** | OR | AQ | **NL**,LC | **W** | **-** | **--** | **C3** Ex! |
| R126y Yellow-billed Kite (*Milvus aegyptius*) | X | HG | **NL**,LC | A2,R3 | - | -- | C1*Et!* |
| **R127 Black-winged Kite (*Elanus caeruleus*)** | -SW | HG | **NL**,LC | - | Pbr | -- | **C3** E. |

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| **Name** | **NESW** | **Habitat** | **RDB** | **CMS** | **Pbr** | **PESrisk** | |
|---|---|---|---|---|---|---|---|
| | | | | | | **Disturb.** | **Accident** |
| R136 Booted Eagle (*Hieraaetus pennatus*) | X | HG | **NL**,LC | A2,R3 | - | -- | C1*Et!* |
| R143 Black-chested Snake Eagle (*Circaetus pectoralis*) | X | HG | **NL**,LC | R3 | Pbr | -- | C1 Et! |
| **R148 African Fish Eagle (*Haliaeetus vocifer*)** | OR | AQ | **NL**,LC | **-** | **Pbr** | **--** | **C3** Et! |
| **R162 Pale Chanting Goshawk (*Melierax canorus*)** | X | SC, WO | **NL**,LC | - | Pbr | -- | **C3** Et! |
| **R169 African Harrier-Hawk (*Polyboroides typus*)** | OR | HG | **NL**,LC | - | - | -- | **C3** Et! |
| R181 Rock Kestrel (*Falco rupicolus*) | X | HG | **NL**,LC | R3 | Pbr | -- | C1* E. |
| R182 Greater Kestrel (*Falco rupicoloides*) | X | GR, SC | **NL**,LC | - | Pbr | -- | C1 E. |
| R183 Lesser Kestrel (*Falco naumanni*) | X | GR | **NL**,LC | A2,R3 | - | -- | C1 E.* |
| **R200 Common Quail (*Coturnix coturnix*)** | SW | GR | **NL**,LC | A2 | - | -- | **C3** - |
| **R203 Helmeted Guineafowl (*Numida meleagris*)** | SW | HG | **NL**,LC | - | - | -- | **C3** Ex |
| **R205 Common Buttonquail (*Turnix sylvaticus*)** | W | GR | **NL**,LC | - | - | -- | **C3** - |
| **R226 Common Moorhen (*Gallinula chloropus*)** | OR | AQ | **NL**,LC | **W** | **-** | **--** | **C3** - |
| **R228 Red-knobbed Coot (*Fulica cristata*)** | OR | AQ | **NL**,LC | **W** | **-** | **--** | **C3** - |
| R237 Red-crested Korhaan (*Lophotis ruficrista*) | SW | WO | **NL**,LC | - | - | -- | C1 - |
| R239a Northern Black Korhaan (*Afrotis afraoides*) | X | GR | **NL**,LC | - | - | -- | C1 - |
| R248 Kittlitz's Plover (*Charadrius pecuarius*) | OR | AQ | **NL**,LC | **W,A2** | **-** | **--** | C1 - |
| **R249 Three-banded Plover (*Charadrius tricollaris*)** | X | AQ | **NL**,LC | **W,A2** | **-** | **--** | **C3** - |
| **R255 Crowned Lapwing (*Vanellus coronatus*)** | X | GR | **NL**,LC | W | - | -- | **C3?** - |
| **R258 Blacksmith Lapwing (*Vanellus armatus*)** | X | AQ | **NL**,LC | **-** | **-** | **--** | **C3** - |
| **R264 Common Sandpiper (*Actitis hypoleucos*)** | OR | AQ, MR | **NL**,LC | **W,A2** | **-** | **--** | **C3*** - |
| **R266 Wood Sandpiper (*Tringa glareola*)** | OR | AQ | **NL**,LC | **W,A2** | **-** | **--** | **C3*** - |
| **R294 Pied Avocet (*Recurvirostra avosetta*)** | OR | AQ | **NL**,LC | **W,A2** | **-** | **--** | **C3*** - |
| **R295 Black-winged Stilt (*Himantopus himantopus*)** | OR | AQ | **NL**,LC | **W,A2** | **-** | **--** | **C3?** - |
| **R297 Spotted Thick-knee (*Burhinus capensis*)** | X | HG | **NL**,LC | - | - | -- | **C3** - |

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| **Name** | **NESW** | **Habitat** | **RDB** | **CMS** | **Pbr** | **PESrisk** | |
|---|---|---|---|---|---|---|---|
| | | | | | | **Disturb.** | **Accident** |
| **R301 Double-banded Courser (*Rhinoptilus africanus*)** | X | GR, SC | **NL**,LC | - | - | -- | **C3** - |
| R327 Common Tern (*Sterna hirundo*) | OOR | MR | **NL**,LC | **W,A2** | **-** | **--** | C1* E.* |
| **R344 Namaqua Sandgrouse (*Pterocles namaqua*)** | X | SC | **NL**,LC | - | - | -- | **C3** - |
| R345 Burchell's Sandgrouse (*Pterocles burchelli*) | SW | GR, WO | **NL**,LC | - | - | -- | C1? - |
| **R347 Double-banded Sandgrouse (*Pterocles bicinctus*)** | -SW | WO | **NL**,LC | - | - | -- | **C3?** - |
| **R348 Rock Dove (*Columba livia*)** | X | HG | **NL**,LC | - | - | -- | **C3** E.* |
| **R349 Speckled Pigeon (*Columba guinea*)** | X | HG | **NL**,LC | - | - | -- | **C3** E. |
| **R354 Ring-necked Dove (*Streptopelia capicola*)** | X | HG | **NL**,LC | - | - | -- | **C3** - |
| **R355 Laughing Dove (*Spilopelia senegalensis*)** | X | HG | **NL**,LC | - | - | -- | **C3** - |
| **R356 Namaqua Dove (*Oena capensis*)** | X | HG | **NL**,LC | - | - | -- | **C3** - |
| **R392 Western Barn Owl (*Tyto alba*)** | X | HG | **NL**,LC | - | - | -- | **C3** Et! |
| R397 Southern White-faced Owl (*Ptilopsis granti*) | X | WO | **NL**,LC | - | - | -- | - E. |
| **R401 Spotted Eagle-Owl (*Bubo africanus*)** | X | HG | **NL**,LC | - | - | -- | **C3** Et! |
| **R411 Common Swift (*Apus apus*)** | X | HG | **NL**,LC | - | - | -- | **C3*** - |
| **R438 European Bee-eater (*Merops apiaster*)** | OR | HG | **NL**,LC | A2 | - | -- | **C3*** E.* |
| R447 Lilac-breasted Roller (*Coracias caudatus*) | X | WO | **NL**,LC | - | - | -- | - E.? |
| R449 Purple Roller (*Coracias naevius*) | SW | WO | **NL**,LC | - | - | -- | - E.? |
| R507 Red-capped Lark (*Calandrella cinerea*) | X | GR, SC | **NL**,LC | - | - | -- | C1 - |
| **R516 Grey-backed Sparrow-Lark (*Eremopterix verticalis*)** | X | GR, SC | **NL**,LC | - | - | -- | **C3** - |
| **R518 Barn Swallow (*Hirundo rustica*)** | X | HG | **NL**,LC | - | - | -- | **C3*** - |
| R530 Common House Martin (*Delichon urbicum*) | OR | HG | **NL**,LC | - | - | -- | C1* - |
| R547 Cape Crow (*Corvus capensis*) | W | HG | **NL**,LC | - | Pbr | -- | C1 Et! |
| **R548 Pied Crow (*Corvus albus*)** | X | HG | **NL**,LC | - | Pbr | -- | **C3** Et! |
| R587 Capped Wheatear (*Oenanthe pileata*) | X | GR, SC | **NL**,LC | - | - | -- | C1 - |

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| Name | NESW | Habitat | RDB | CMS | Pbr | PESrisk | |
|---|---|---|---|---|---|---|---|
| | | | | | | Disturb. | Accident |
| R643 Willow Warbler (*Phylloscopus trochilus*) | OR | WO | **NL**,LC | A2 | - | -- | C1* - |
| R689 Spotted Flycatcher (*Muscicapa striata*) | X | WO | **NL**,LC | A2 | - | -- | x1* |
| R733 Red-backed Shrike (*Lanius collurio*) | SW | WO | **NL**,LC | - | - | -- | C1* - |
| **R760 Wattled Starling (*Creatophora cinerea*)** | X | HG | **NL**,LC | - | - | -- | **C3?** - |
| R770 Pale-winged Starling (*Onychognathus nabouroup*) | X | RC | **NL**,LC | - | - | -- | - E. |
| **R801 House Sparrow (*Passer domesticus*)** | X | HG | **NL**,LC | - | - | -- | **C3*** - |
| **R814 Southern Masked Weaver (*Ploceus velatus*)** | X | HG | **NL**,LC | - | - | -- | **C3?** E. |
| **R821 Red-billed Quelea (*Quelea quelea*)** | X | HG | **NL**,LC | - | - | -- | **C3** - |
| **R824 Southern Red Bishop (*Euplectes orix*)** | X | AQ | **NL**,LC | **-** | **-** | **--** | **C3?** - |

D. 2 ADDITIONAL SPECIES POTENTIALLY POSITIVELY IMPACTED:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| R186 Pygmy Falcon (*Polihierax semitorquatus*) | X | SC, WO | **NL**,LC | - | Pbr | -- | -- |
| R800 Sociable Weaver (*Philetairus socius*) | X | WO | **NL**,LC | - | Pbr | -- | -- |

E. 4 ADDITIONAL SPECIES LISTED UNDER CMS:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| R213 Black Crake (*Zapornia flavirostra*) | OR | AQ | **NL**,LC | **W** | **-** | **--** | -- |
| R270 Common Greenshank (*Tringa nebularia*) | OR | AQ, MR | **NL**,LC | **W,A2** | **-** | **--** | -- |
| R339 White-winged Tern (*Chlidonias leucopterus*) | OR | AQ, GR | **NL**,LC | **W,A2** | **-** | **--** | -- |
| R631 Common Reed Warbler (*Acrocephalus baeticatus*) | OR | AQ | **NL**,LC | **A2** | **-** | **--** | -- |

F. 9 ADDITIONAL WATERBIRDS:

CONTINUED ON NEXT PAGE . . .

| Name | NESW | Habitat | RDB | CMS | Pbr | PESrisk | |
|---|---|---|---|---|---|---|---|
| | | | | | | Disturb. | Accident |
| R428 Pied Kingfisher (*Ceryle rudis*) | OR | AQ | **NL**,LC | - | - | -- | -- |
| R429 Giant Kingfisher (*Megaceryle maxima*) | OR | AQ | **NL**,LC | - | - | -- | -- |
| R431 Malachite Kingfisher (*Corythornis cristatus*) | OR | AQ | **NL**,LC | - | - | -- | -- |
| R520 White-throated Swallow (*Hirundo albigularis*) | X | AQ | **NL**,LC | - | - | -- | -- |
| R533 Brown-throated Martin (*Riparia paludicola*) | OR | AQ | **NL**,LC | - | - | -- | -- |
| R635 Lesser Swamp Warbler (*Acrocephalus gracilirostris*) | OR | AQ | **NL**,LC | - | - | -- | -- |
| R677 Levaillant's Cisticola (*Cisticola tinniens*) | OR | AQ, GR | **NL**,LC | - | - | -- | -- |
| R711 African Pied Wagtail (*Motacilla aguimp*) | OR | AQ | **NL**,LC | - | - | -- | -- |
| R713 Cape Wagtail (*Motacilla capensis*) | X | AQ | **NL**,LC | - | - | -- | -- |

G. 65 ADDITIONAL SPECIES:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| R001 Common Ostrich (*Struthio camelus*) | -SW | HG | **NL**,LC | - | - | -- | -- |
| R161 Gabar Goshawk (*Micronisus gabar*) | SW | WO | **NL**,LC | - | - | -- | -- |
| R382 Jacobin Cuckoo (*Clamator jacobinus*) | SW | WO | **NL**,LC | - | - | -- | -- |
| R386 Diederik Cuckoo (*Chrysococcyx caprius*) | -SW | GR, WO | **NL**,LC | - | - | -- | -- |
| R391a Burchell's Coucal (*Centropus burchellii*) | OR | WO | **NL**,LC | - | - | -- | -- |
| R405 Fiery-necked Nightjar (*Caprimulgus pectoralis*) | OOR | WO | **NL**,LC | - | - | -- | -- |
| R412 African Black Swift (*Apus barbatus*) | W | HG | **NL**,LC | - | - | -- | -- |
| R413 Bradfield's Swift (*Apus bradfieldi*) | SW | HG | **NL**,LC | - | - | -- | -- |
| R415 White-rumped Swift (*Apus caffer*) | X | HG | **NL**,LC | - | - | -- | -- |
| R416 Horus Swift (*Apus horus*) | W | HG | **NL**,LC | - | - | -- | -- |
| R417 Little Swift (*Apus affinis*) | X | HG | **NL**,LC | - | - | -- | -- |
| R418 Alpine Swift (*Tachymarptis melba*) | OR | HG | **NL**,LC | - | - | -- | -- |

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| Name | NESW | Habitat | RDB | CMS | Pbr | PESrisk | |
|---|---|---|---|---|---|---|---|
| | | | | | | Disturb. | Accident |
| R421 African Palm Swift (*Cypsiurus parvus*) | X | HG | **NL**,LC | - | - | -- | -- |
| R426 Red-faced Mousebird (*Urocolius indicus*) | X | WO | **NL**,LC | - | - | -- | -- |
| R443 White-fronted Bee-eater (*Merops bullockoides*) | OR | WO | **NL**,LC | - | - | -- | -- |
| R445 Swallow-tailed Bee-eater (*Merops hirundineus*) | X | WO | **NL**,LC | - | - | -- | -- |
| R452 Green Wood Hoopoe (*Phoeniculus purpureus*) | OOR | FR, WO | **NL**,LC | - | - | -- | -- |
| R457 African Grey Hornbill (*Lophoceros nasutus*) | W | WO | **NL**,LC | - | - | -- | -- |
| R459 Southern Yellow-billed Hornbill (*Tockus leucomelas*) | S | WO | **NL**,LC | - | - | -- | -- |
| R474 Greater Honeyguide (*Indicator indicator*) | W | WO | **NL**,LC | - | - | -- | -- |
| R476 Lesser Honeyguide (*Indicator minor*) | OR | WO | **NL**,LC | - | - | -- | -- |
| R493 Monotonous Lark (*Mirafra passerina*) | [NE] | WO | **NL**,LC | - | - | -- | -- |
| R495a Eastern Clapper Lark (*Mirafra fasciolata*) | X | GR | **NL**,LC | - | - | -- | -- |
| R506 Spike-heeled Lark (*Chersomanes albofasciata*) | X | GR, SC | **NL**,LC | - | - | -- | -- |
| R508 Pink-billed Lark (*Spizocorys conirostris*) | S | GR | **NL**,LC | - | - | -- | -- |
| R511 Stark's Lark (*Spizocorys starki*) | -NE | SC | **NL**,LC | - | - | -- | -- |
| R523 Pearl-breasted Swallow (*Hirundo dimidiata*) | NW | HG | **NL**,LC | - | - | -- | -- |
| R524 Red-breasted Swallow (*Cecropis semirufa*) | W | GR, WO | **NL**,LC | - | - | -- | -- |
| R526 Greater Striped Swallow (*Cecropis cucullata*) | X | GR, SC | **NL**,LC | - | - | -- | -- |
| R529 Rock Martin (*Ptyonoprogne fuligula*) | X | RC | **NL**,LC | - | - | -- | -- |
| R534 Banded Martin (*Neophedina cincta*) | OOR | GR | **NL**,LC | - | - | -- | -- |
| R541 Fork-tailed Drongo (*Dicrurus adsimilis*) | S | FR, WO | **NL**,LC | - | - | -- | -- |
| R557 Cape Penduline Tit (*Anthoscopus minutus*) | X | SC, WO | **NL**,LC | - | - | -- | -- |
| R583 Short-toed Rock Thrush (*Monticola brevipes*) | SW | RC | **NL**,LC | - | - | -- | -- |
| R590 Tractrac Chat (*Emarginata tractrac*) | E | SC | **NL**,LC | - | - | -- | -- |
| R592 Karoo Chat (*Emarginata schlegelii*) | NE | SC | **NL**,LC | - | - | -- | -- |

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| **Name** | **NESW** | **Habitat** | **RDB** | **CMS** | **Pbr** | **PESrisk** | |
|---|---|---|---|---|---|---|---|
| | | | | | | **Disturb.** | **Accident** |
| R622 Layard's Warbler (*Curruca layardi*) | N | SC | **NL**,LC | - | - | -- | -- |
| R664 Zitting Cisticola (*Cisticola juncidis*) | OR | GR | **NL**,LC | - | - | -- | -- |
| R665 Desert Cisticola (*Cisticola aridulus*) | X | GR | **NL**,LC | - | - | -- | -- |
| R669 Grey-backed Cisticola (*Cisticola subruficapilla*) | X | SC | **NL**,LC | - | - | -- | -- |
| R681 Neddicky (*Cisticola fulvicapilla*) | W | SC | **NL**,LC | - | - | -- | -- |
| R688 Rufous-eared Warbler (*Malcorus pectoralis*) | X | SC | **NL**,LC | - | - | -- | -- |
| R695 Marico Flycatcher (*Melaenornis mariquensis*) | SW | WO | **NL**,LC | - | - | -- | -- |
| R697 Chat Flycatcher (*Melaenornis infuscatus*) | X | SC, WO | **NL**,LC | - | - | -- | -- |
| R716 African Pipit (*Anthus cinnamomeus*) | X | GR | **NL**,LC | - | - | -- | -- |
| R717 Nicholson's Pipit (*Anthus nicholsoni*) | X | RC | **NL**,LC | - | - | -- | -- |
| R719 Buffy Pipit (*Anthus vaalensis*) | W | GR | **NL**,LC | - | - | -- | -- |
| R731 Lesser Grey Shrike (*Lanius minor*) | -SW | WO | **NL**,LC | - | - | -- | -- |
| R739 Crimson-breasted Shrike (*Laniarius atrococcineus*) | W | WO | **NL**,LC | - | - | -- | -- |
| R758 Common Myna (*Acridotheres tristis*) | W | HG | **NL**,LC | - | - | -- | -- |
| R779 Marico Sunbird (*Cinnyris mariquensis*) | SW | WO | **NL**,LC | - | - | -- | -- |
| R799 White-browed Sparrow-Weaver (*Plocepasser mahali*) | X | WO | **NL**,LC | - | - | -- | -- |
| R802 Great Sparrow (*Passer motitensis*) | OR | WO | **NL**,LC | - | - | -- | -- |
| R806 Scaly-feathered Weaver (*Sporopipes squamifrons*) | X | WO | **NL**,LC | - | - | -- | -- |
| R834 Green-winged Pytilia (*Pytilia melba*) | -SW | WO | **NL**,LC | - | - | -- | -- |
| R845 Violet-eared Waxbill (*Granatina granatina*) | SW | WO | **NL**,LC | - | - | -- | -- |
| R847 Black-faced Waxbill (*Brunhilda erythronotos*) | X | WO | **NL**,LC | - | - | -- | -- |
| R852 Quailfinch (*Ortygospiza atricollis*) | W | GR | **NL**,LC | - | - | -- | -- |
| R856 Red-headed Finch (*Amadina erythrocephala*) | X | GR, SC, WO | **NL**,LC | - | - | -- | -- |
| R860 Pin-tailed Whydah (*Vidua macroura*) | OR | HG | **NL**,LC | - | - | -- | -- |

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| Name | NESW | Habitat | RDB | CMS | Pbr | PESrisk | |
|---|---|---|---|---|---|---|---|
| | | | | | | **Disturb.** | **Accident** |
| R879 White-throated Canary (*Crithagra albogularis*) | X | SC | **NL**,LC | - | - | -- | -- |
| R884 Golden-breasted Bunting (*Emberiza flaviventris*) | W | WO | **NL**,LC | - | - | -- | -- |
| R885 Cape Bunting (*Emberiza capensis*) | N | GR, RC, SC | **NL**,LC | - | - | -- | -- |
| R886 Cinnamon-breasted Bunting (*Emberiza tahapisi*) | W | RC | **NL**,LC | - | - | -- | -- |
| R887 Lark-like Bunting (*Emberiza impetuani*) | X | SC, WO | **NL**,LC | - | - | -- | -- |

**Table 2:** The frequency of bird collisions with the earth wires (%) of power lines based on literature references. The numbers in brackets indicate the number of collision incidents (earth wire/total). The time of day during which surveys were conducted is also indicated.

| **Source** | **Time of day** | % |
|---|---|---|
| Faanes (1987) | "Observations were made during early morning (0.5 h before sunrise to 0900 h) and evening (2 h before sunset to 0.5 h after)." | 93.6% (102/109) |
| Savereno *et al*. (1996) | "... from first light (10 lux) until 3 hours after sunrise, and from 3 hours before sunset until dark (10 lux)." | 85.0% (17/20) |
| Brown *et al*. (1987) | "primarily at sunrise and sunset" | 0% (0/0) |
| James & Haak (1979) | "from 1/2 hour before sunrise to 1/2 hour after sunset. ... Sampling periods varied between 4 and 24 hours. The 4-hour shift, 2 hours before and after either sunrise or sunset was most frequent." | 100% (11/11) |
| James & Haak (1979) | During the day. | 66.7% (8/12) |
| Pandely *et al*. (2008) | 24h (BSI) | 68.2% (105/154) |
| Murphy *et al*. (2016) | "...from 0.5 hr before sunset until 2 hr after sunset." | 64.8% (46/71) |
| Murphy *et al*. (2016) | 24h (BSI) | 72.6% (233/321) |
| Dwyer *et al*. (2019) | "from 1 hr before sunset until 4.5 hr after sunset" | 93.9% (46/49) |
| Baasch *et al*. (2022) | "from 1 h before sunset until 4.5 h after sunset" | 56.1% (36/64) |

**Table 3:** Summary of data presented in Table 1 on potential power line related impacts on CMS species. See Section 4.7.3.2.1 on page 42 for an explanation of the CMS codes, and Section 4.8.2 on page 45 for an explanation of the collision and electrocution codes.

| **CMS** | **None** | **Collision** | | **Electrocution** | | | | **n** |
|---|---|---|---|---|---|---|---|---|
| | | C1 | **C3** | E. | El! | Et! | Ex!<br>**n** | |
| A1 | - | 100.0% (2) | **-** | - | - | 100.0% (2) | - | 2 |
| A2 | 13.0% (3) | 30.4% (7) | **56.5% (13)** | 13.0% (3) | 8.7% (2) | 8.7% (2) | - | 23 |
| W | 9.4% (3) | 15.6% (5) | **75.0% (24)** | 3.1% (1) | 15.6% (5) | - | 6.2% (2) | 32 |
| R1 | 25.0% (1) | 75.0% (3) | **-** | - | - | 75.0% (3) | - | 4 |
| R2 | - | - | **100.0% (1)** | 100.0% (1) | - | - | - | 1 |
| R3 | - | 100.0% (5) | **-** | 40.0% (2) | - | 60.0% (3) | - | 5 |

**Table 4:** Summary of electrocution species in Table 1. See Section 4.8.2 on page 46 for an explanation of the codes.

| **Code** | **Species** | **%** | |
|---|---|---|---|
| | | **All** | **Excluding E.** |
| Et! | 17 | 36.2 | 54.8 |
| E. | 16 | 34.0 | - |
| El! | 6 | 12.8 | 19.4 |
| Ex! | 4 | 8.5 | 12.9 |
| Ec | 3 | 6.4 | 9.7 |
| Ex | 1 | 2.1 | 3.2 |
| **Total** | **47** | **100** | **100 (n = 31)** |

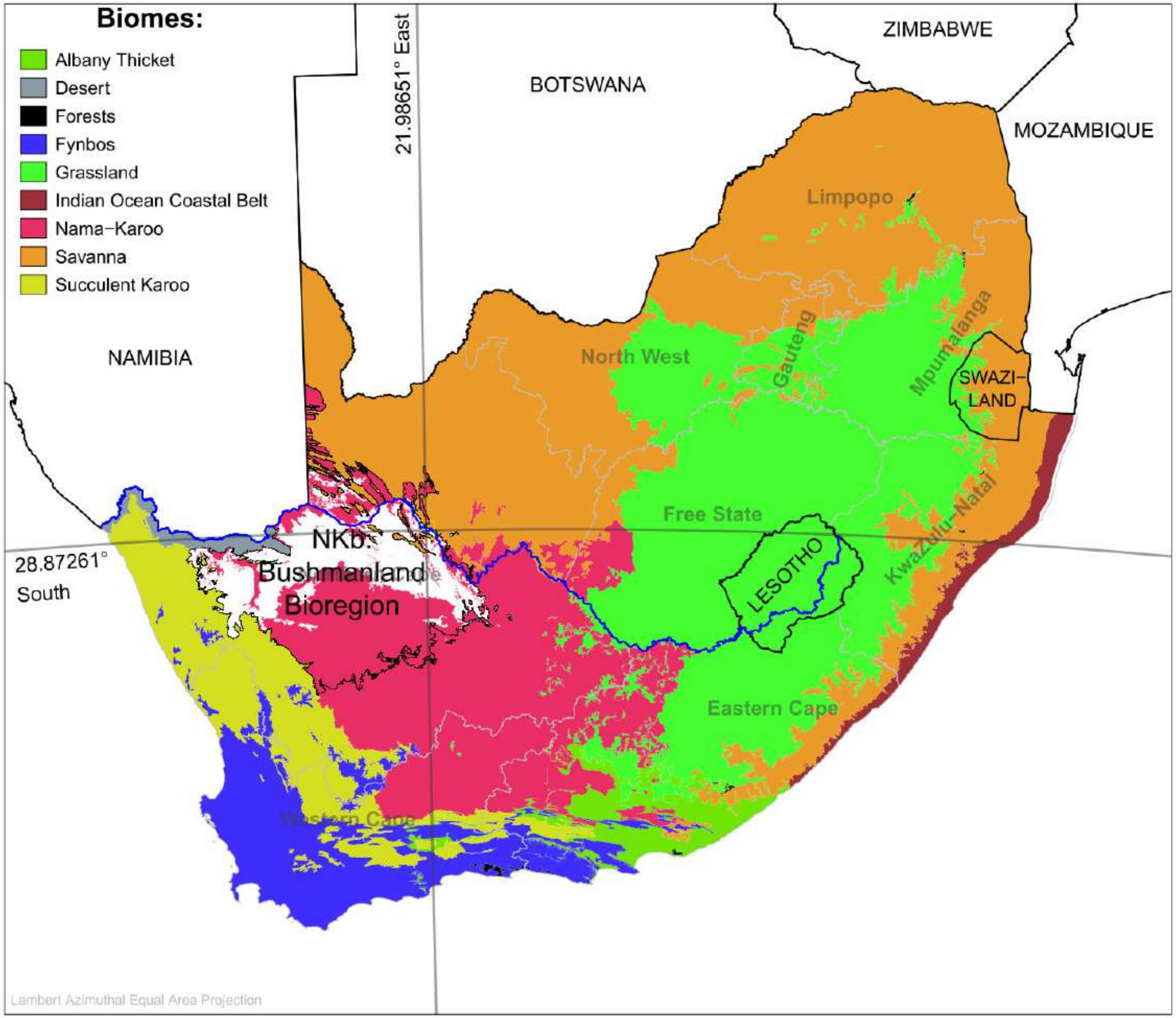


**Figure 1:** Location of the ORSF1 power line near Groblershoop, Northern Cape Province, in relation to South African biomes as classified by Mucina & Rutherford (2006). White areas within the Bushmanland Bioregion (NKb; Delineated) represent the distribution of the Bushmanland Arid Grassland (NKb 3) vegetation unit. The intersection of the pair of latitudinal and longitudinal lines indicates the average location of the power line of the project, with the surrounding yellow block indicating the area enlarged in Figure 2.

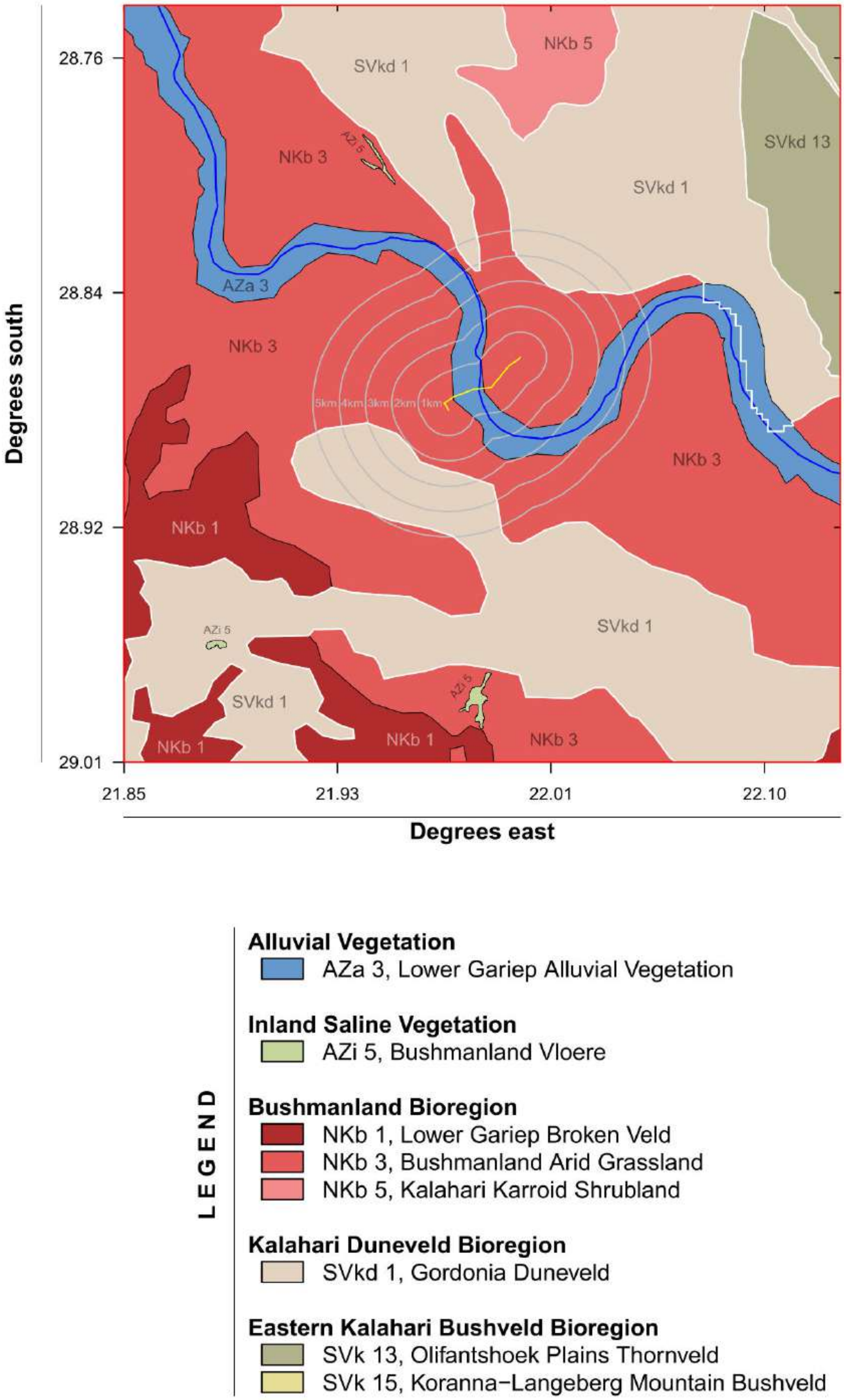


**Figure 2:** Location of the ORSF1 power line near Groblershoop, Northern Cape Province, in relation to South African vegetation units as classified by Mucina & Rutherford (2006). Concentric grey lines are spaced 1 km apart from the ORSF1 power line.

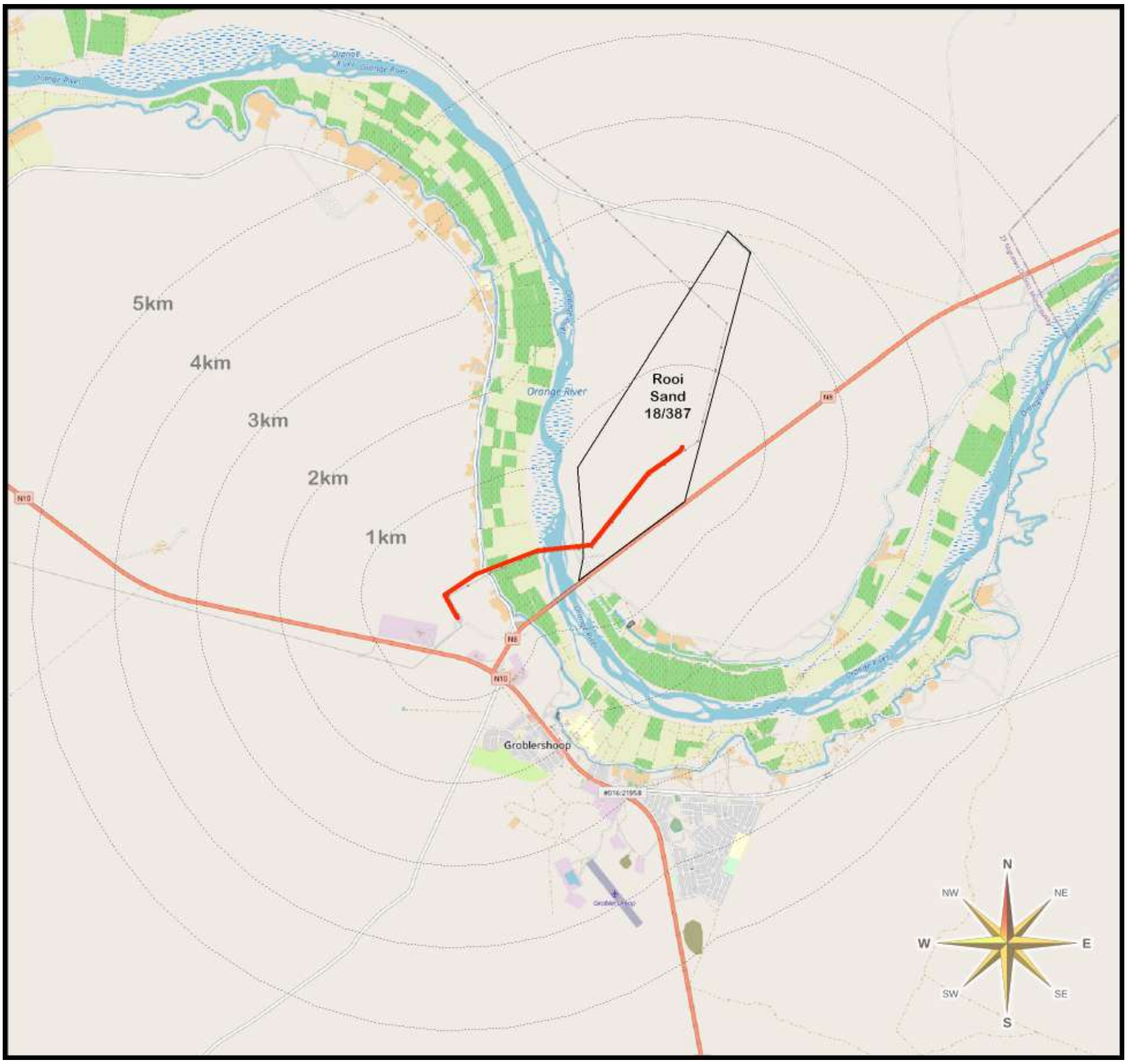


**Figure 3:** Environs of the ORSF1 power line to be situated north of Groblershoop, Northern Cape Province (see Figures 1 & 2). The power line (red line) will run from the southern end of the proposed solar facility — to be located in Portion 18 of the farm Rooi Sand 387 — across the south-western aspect of a prominent bend in the Orange River to the Groblershoop substation (Fig. 6). The stippled lines are drawn at 1 km intervals from the ORSF1 power line.

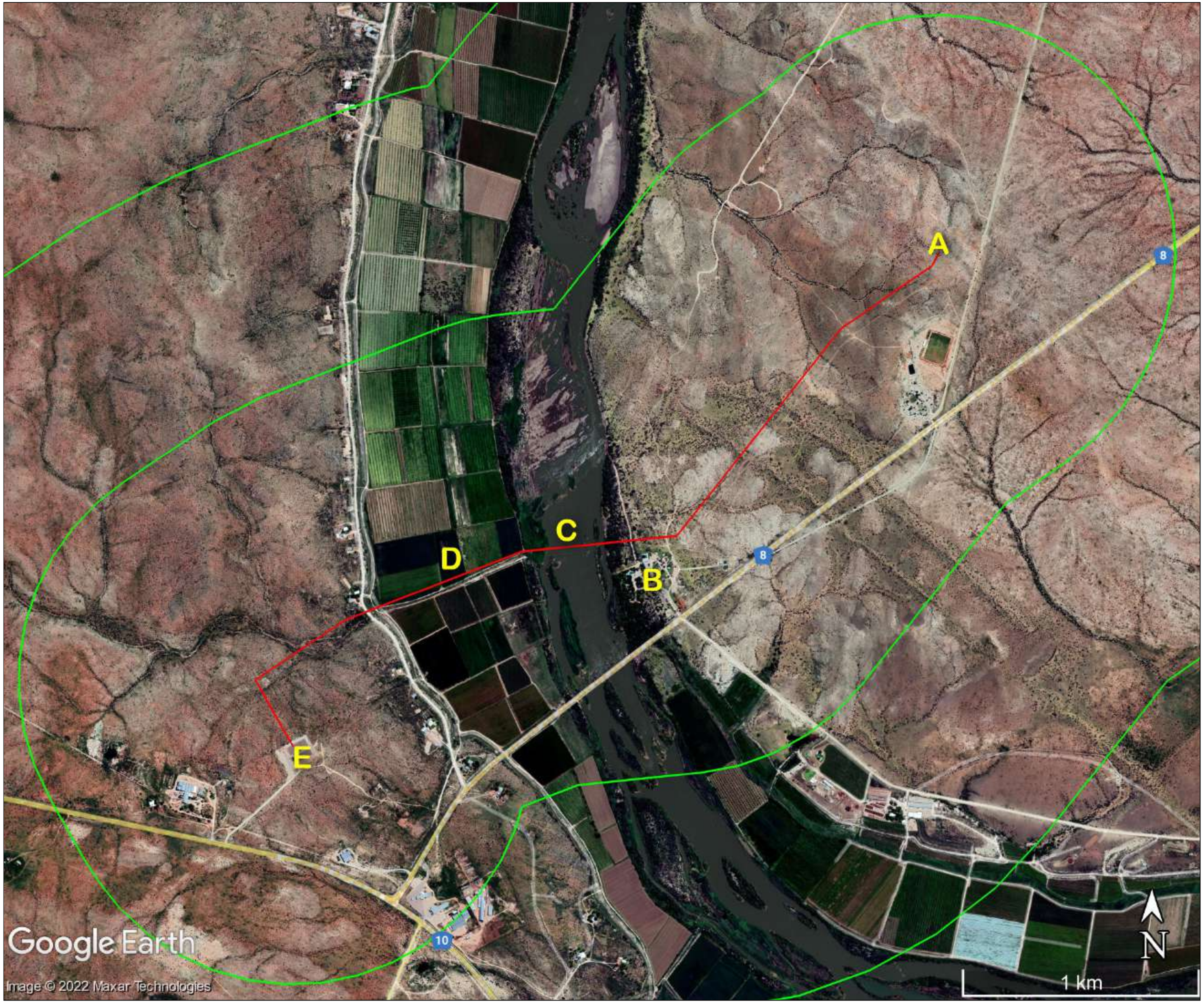


**Figure 4:** Immediate environs of the ORSF1 power line (red line). The power line will run from the southern end of the proposed solar facility (A) past the Destination River Resort (B), across the Orange River (C; Flowing in a northerly (bottom to top) direction), and agricultural fields (D) to the Groblershoop Substation (E) (Fig. 6). The green lines are drawn at 1 km intervals from the ORSF1 power line.

**Figure 5:** Aerial view across the study area looking westwards. The yellow line represents the approximate route of the ORSF1 power line. Note also the R64 tar road (left), the Destination River Resort Groblershoop Sports Grounds (left-bottom), the drainage systems, the Orange River and agricultural fields beyond that. The indicated artificial wetlands are the following: A) Rehabilitated quarry at sports grounds; B) Pond at sports grounds; C) Destination River Resort waterworks (Fig. 42); D) livestock kraal (Fig.24). The location of a Brown-throated Martin colony along the river is also indicated (R533; Fig. 27; Fig. 44).

**Figure 6:** Aerial view over Eskom's Groblershoop substation looking north-east towards the origin of the ORSF1 power line (yellow line).

**Figure 7:** The proposed ORSF1 power line design will be similar to the existing 132kV Garona–Groblershoop power line illustrated here: The typical design of pylons along straight sections (left) and at turning points (right) are shown. The insets in the top corners show the view from above. In the picture on the right, the yellow line represents an approximation of the proposed route of the ORSF1 lower line. See also Figure 8.

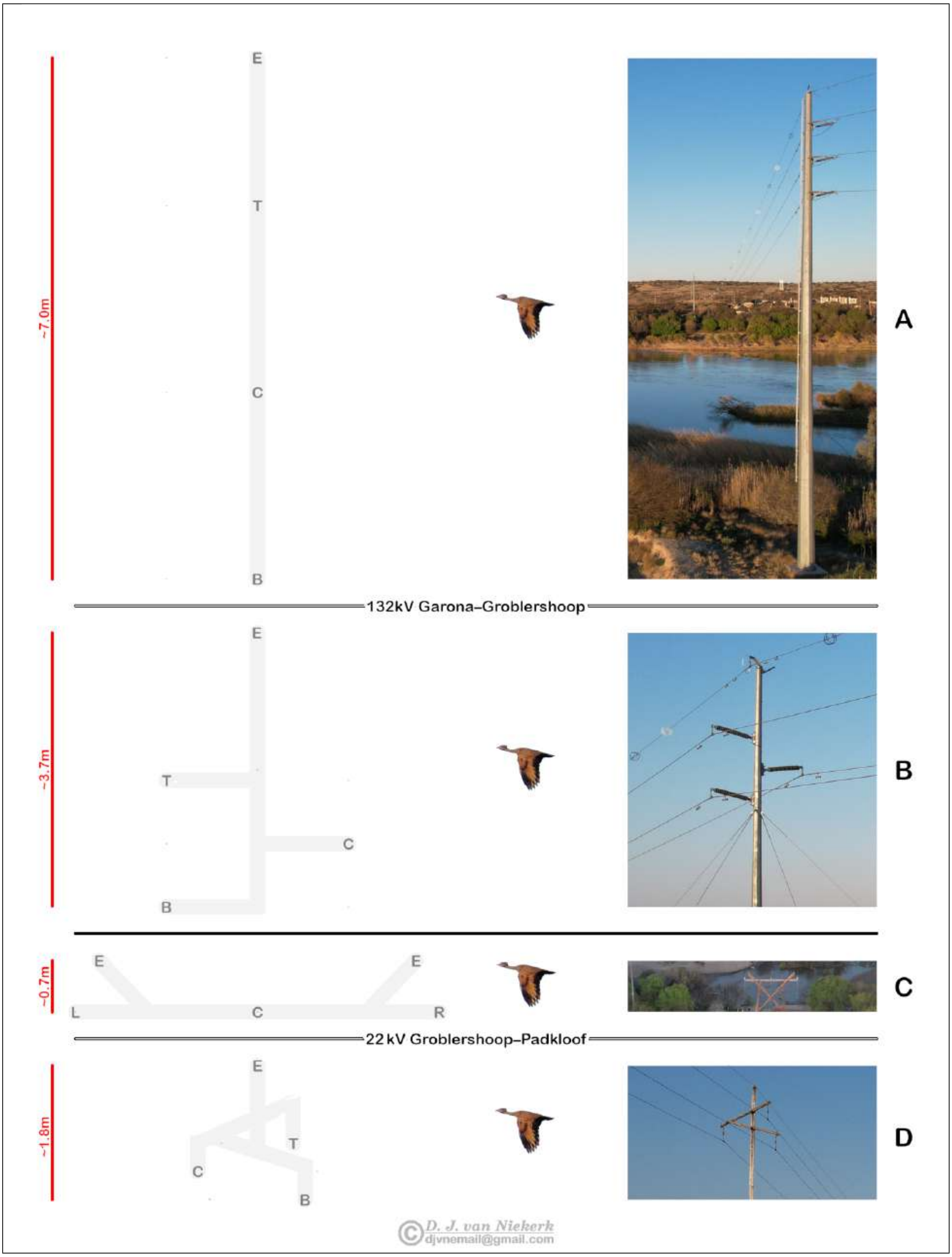


**Figure 8:** Diagrammatic head-on illustration of a selection of power line configurations found in the study area indicating differences in vertical collision risk zones (red lines). Letters in the illustrations on the left represent the relative position of the earth wire(s) (E) and conductors at the top (T), centre (C), bottom (B), left (L) & right (R). The measurements used here are based on elevation meta-data in photographs taken with a drone, examination of photographs, and guesstimates. All the illustrations on the left, and the Karoo Korhaans R235 in flight, are approximately the same scale, while the photographs on the right are not.

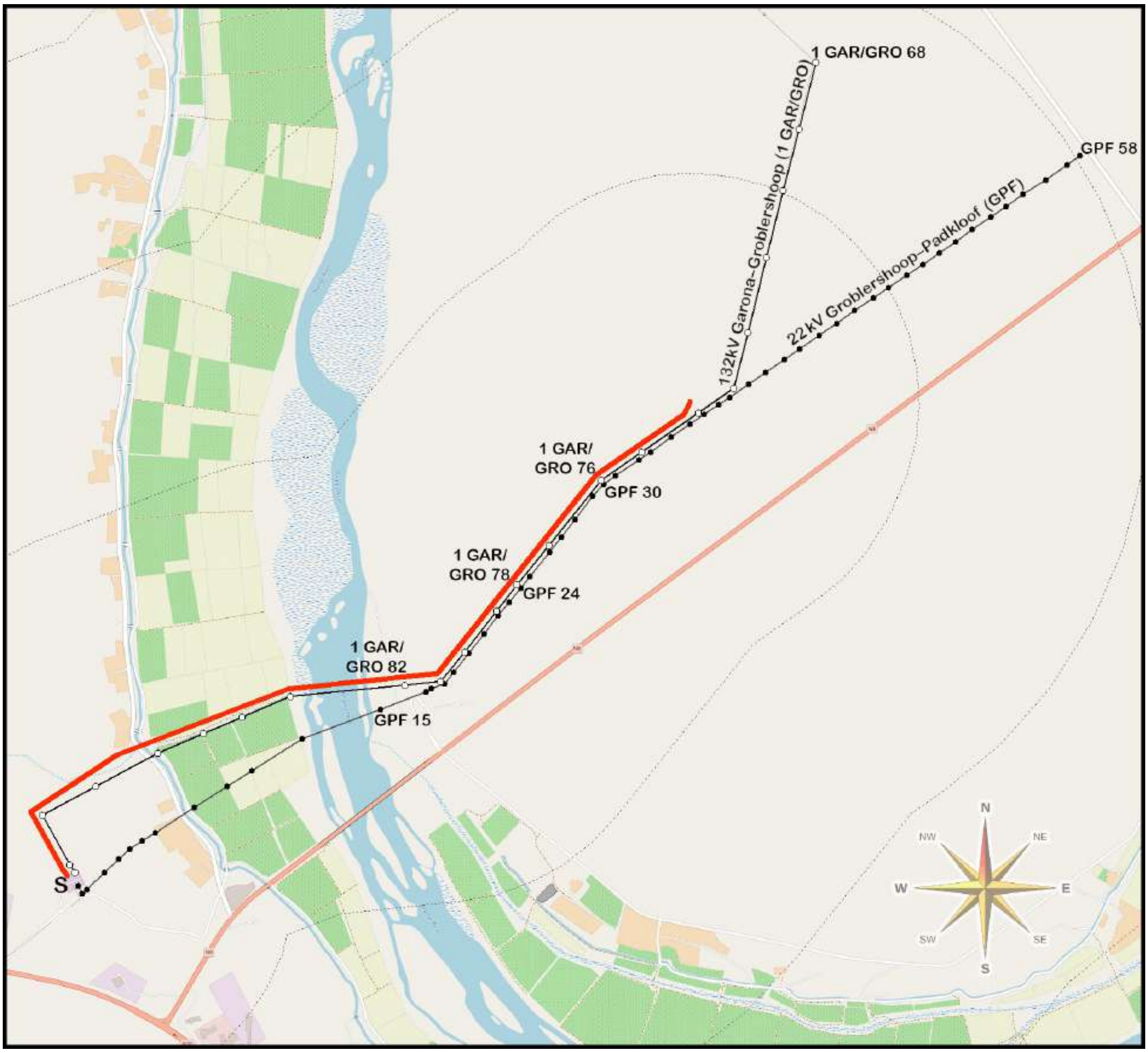


**Figure 9:** The proposed route of the ORSF1 power line (red line) relative to that of two existing power lines. S: Eskom's Groblershoop Substation. The elevation profile of the route is illustrated in Figure 23.

**Figure 10:** Habitat along the north-western part of the ORSF1 power line route (yellow line). Note the absence of shrubs/trees along the route of the two existing power lines (see Figure 9).

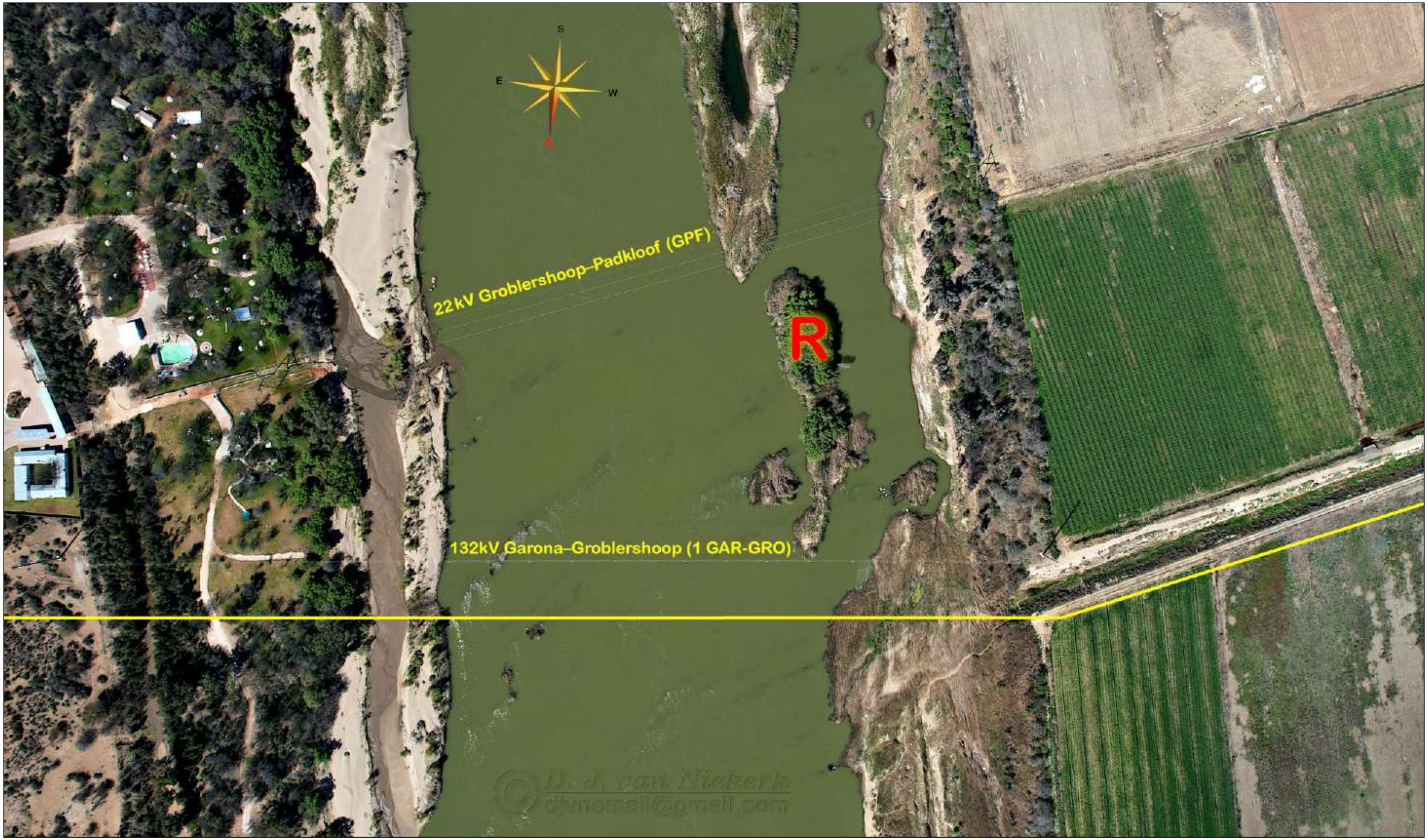


**Figure 11:** Overhead view of the Orange River crossing with the yellow line representing the approximate route of the ORSF1 power line. The Destination River Resort campsite is on the left (east), and note, in particular, the clearance of vegetation along the route of the existing power lines. The island (R) between the existing two power lines near the western (right) bank of the river is utilised as a roost by a number of bird species.

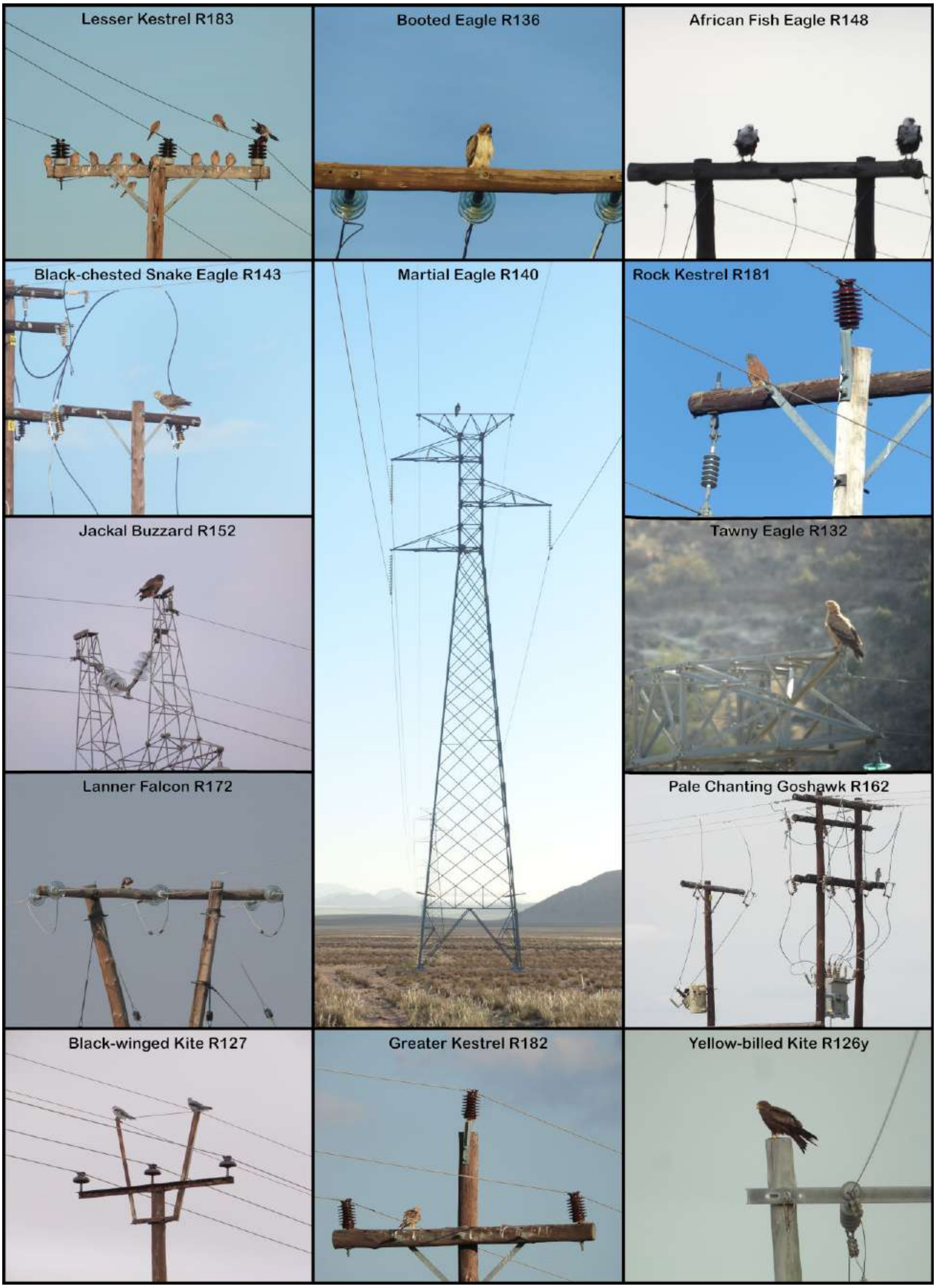


**Figure 12:** Examples of raptors perching on a variety of power line infrastructure. The distribution of all these species overlaps with the study area, but only the photo of the feeding Lanner Falcon R172 was taken there.

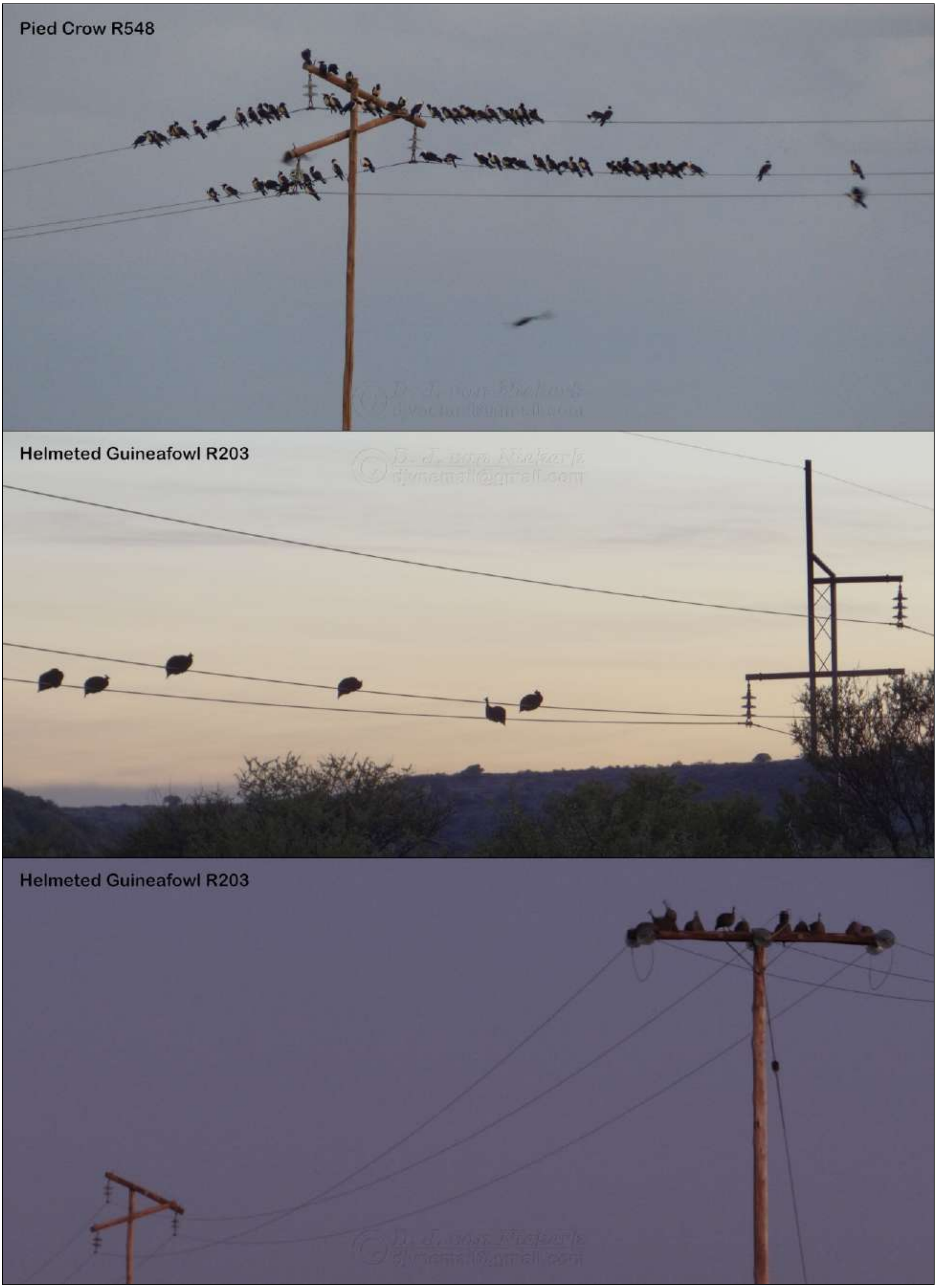


**Figure 13:** Examples of birds utilising power line infrastructure for roosting. Both species are common in the study area, but all these photos were taken elsewhere.

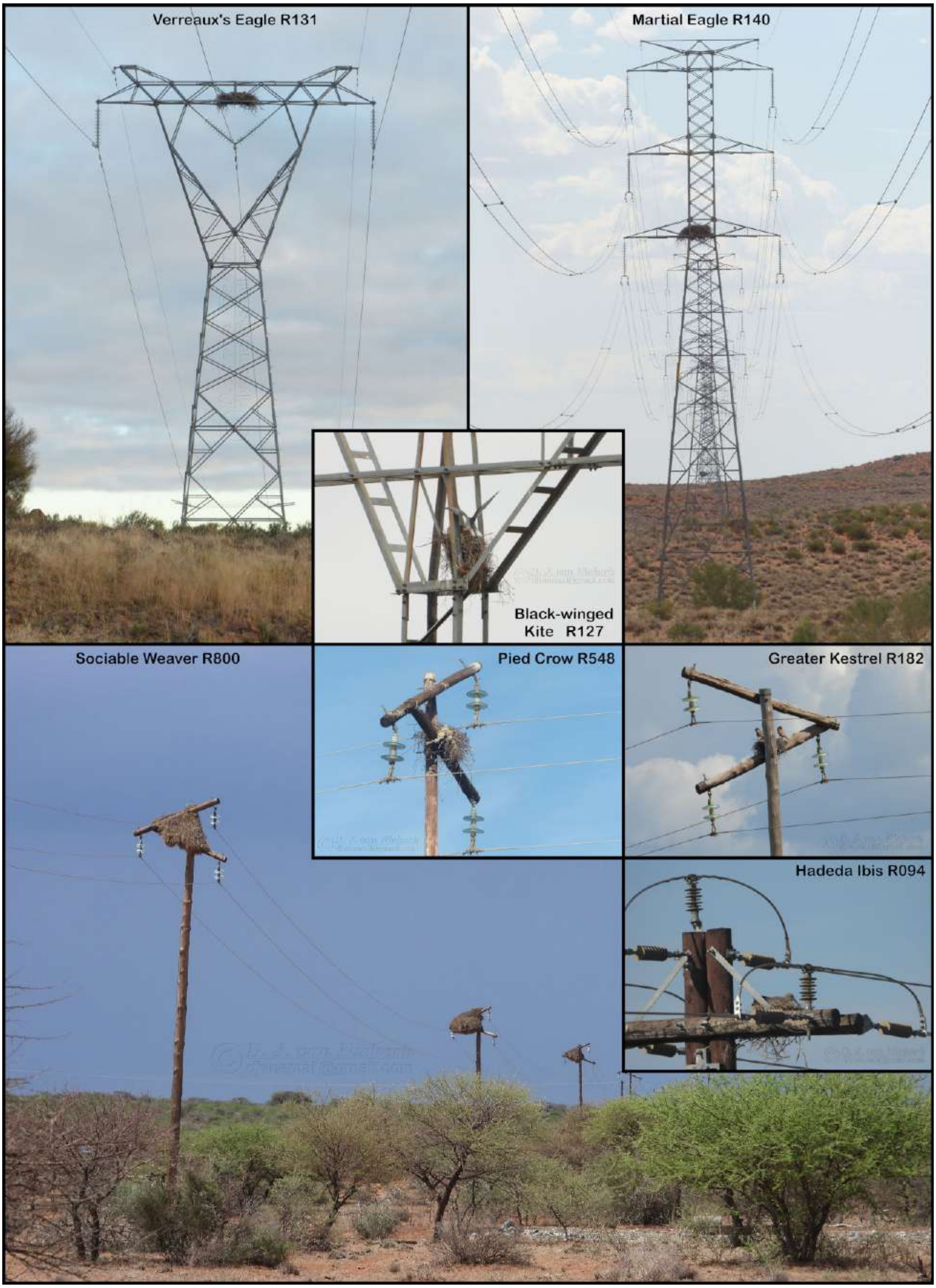


**Figure 14:** Examples of birds utilising power line infrastructure for nesting. The distribution of all these species overlaps with the study area, but all these photos were taken elsewhere.

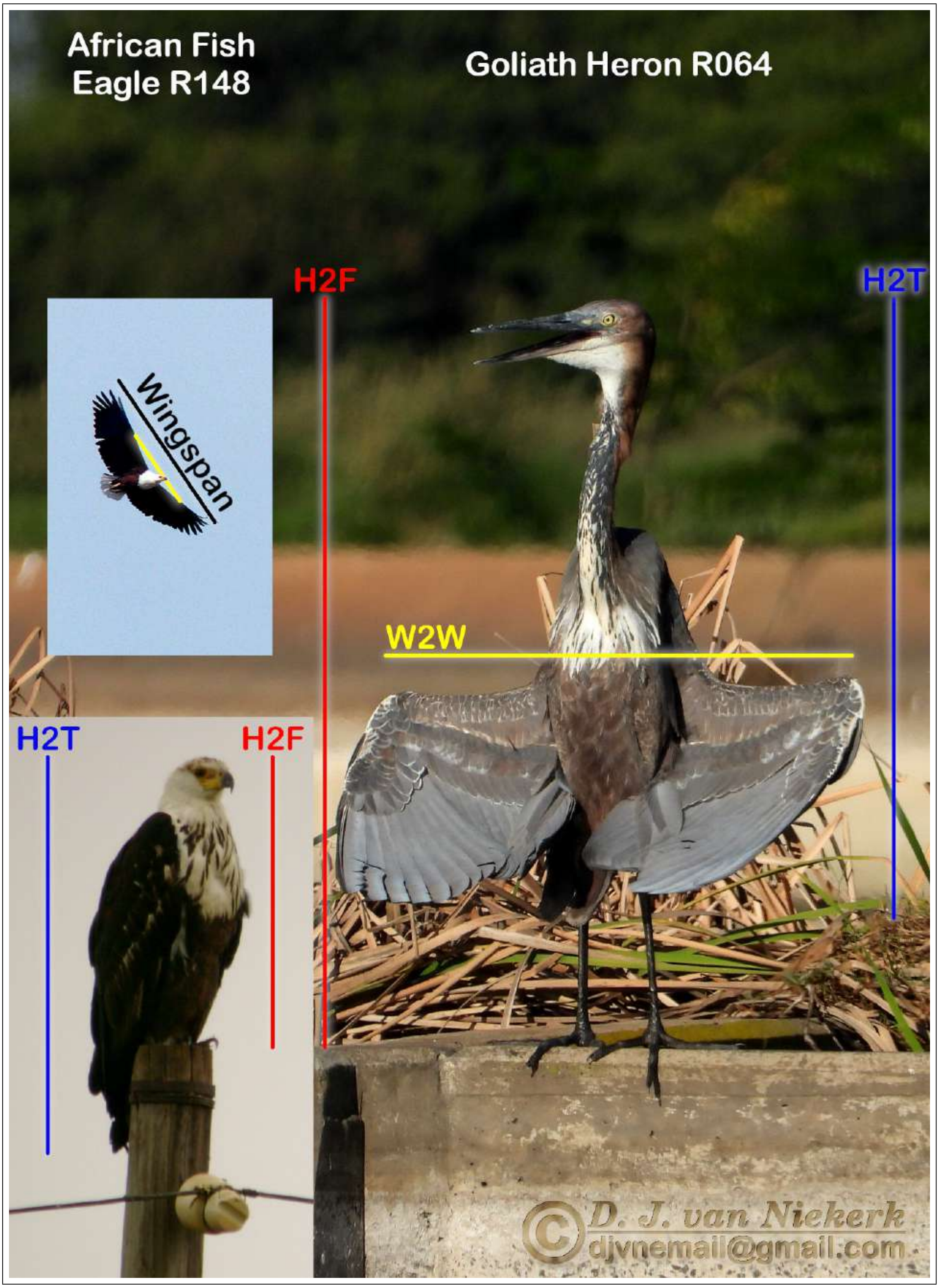


**Figure 15:** Biometric measurements most relevant to physical electrocution incidents. H2F: head-to-foot; H2T: head-to-tail; W2W: wrist-to-wrist; Wingspan. See Section 7.3.4.1 on page 81 .

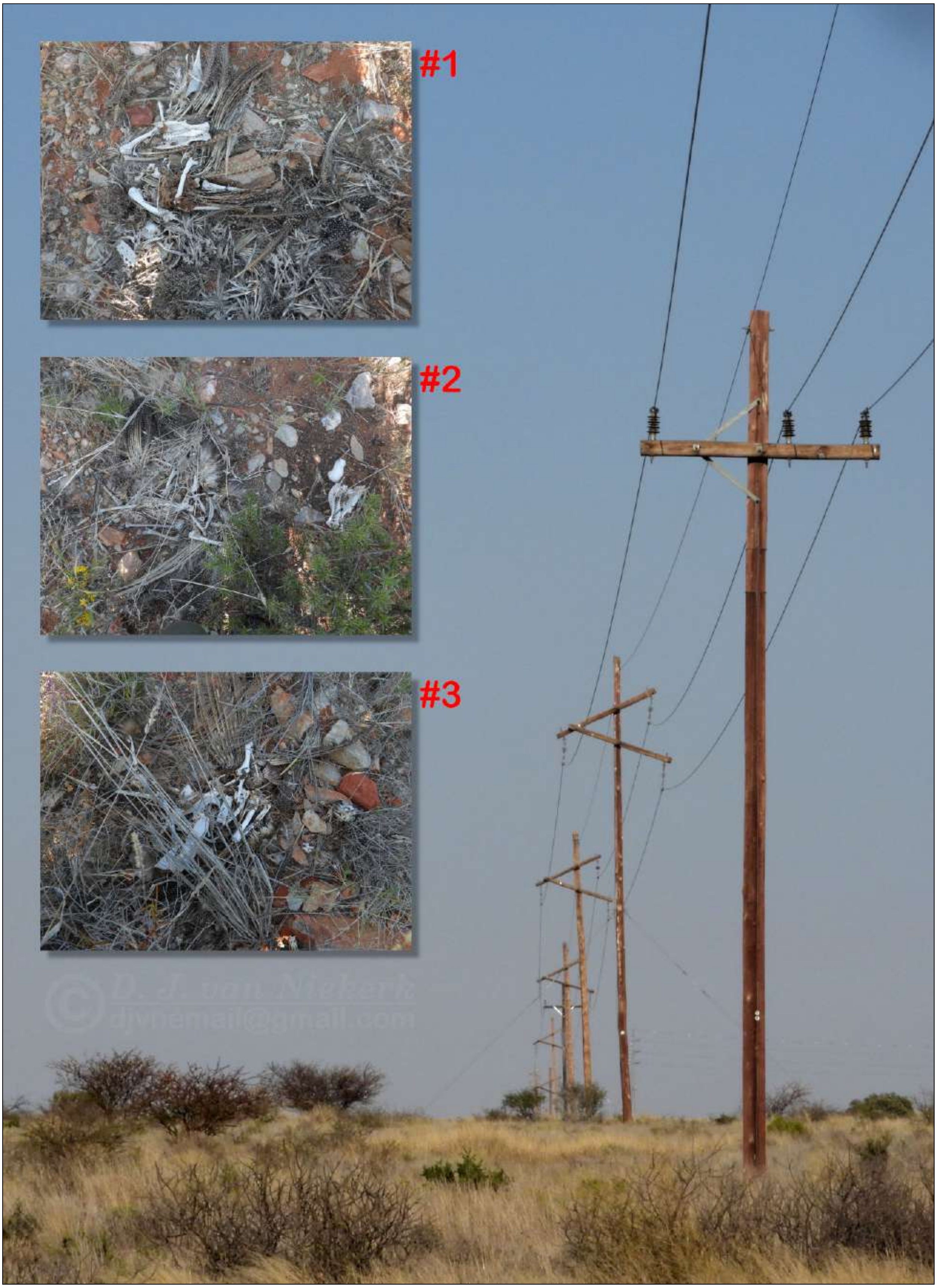


**Figure 16:** The remains of three Helmeted Guineafowl R203 found on 24 August 2022 below the pylon to the right (GPF55). It probably represents an electrocution incident involving roosting birds.

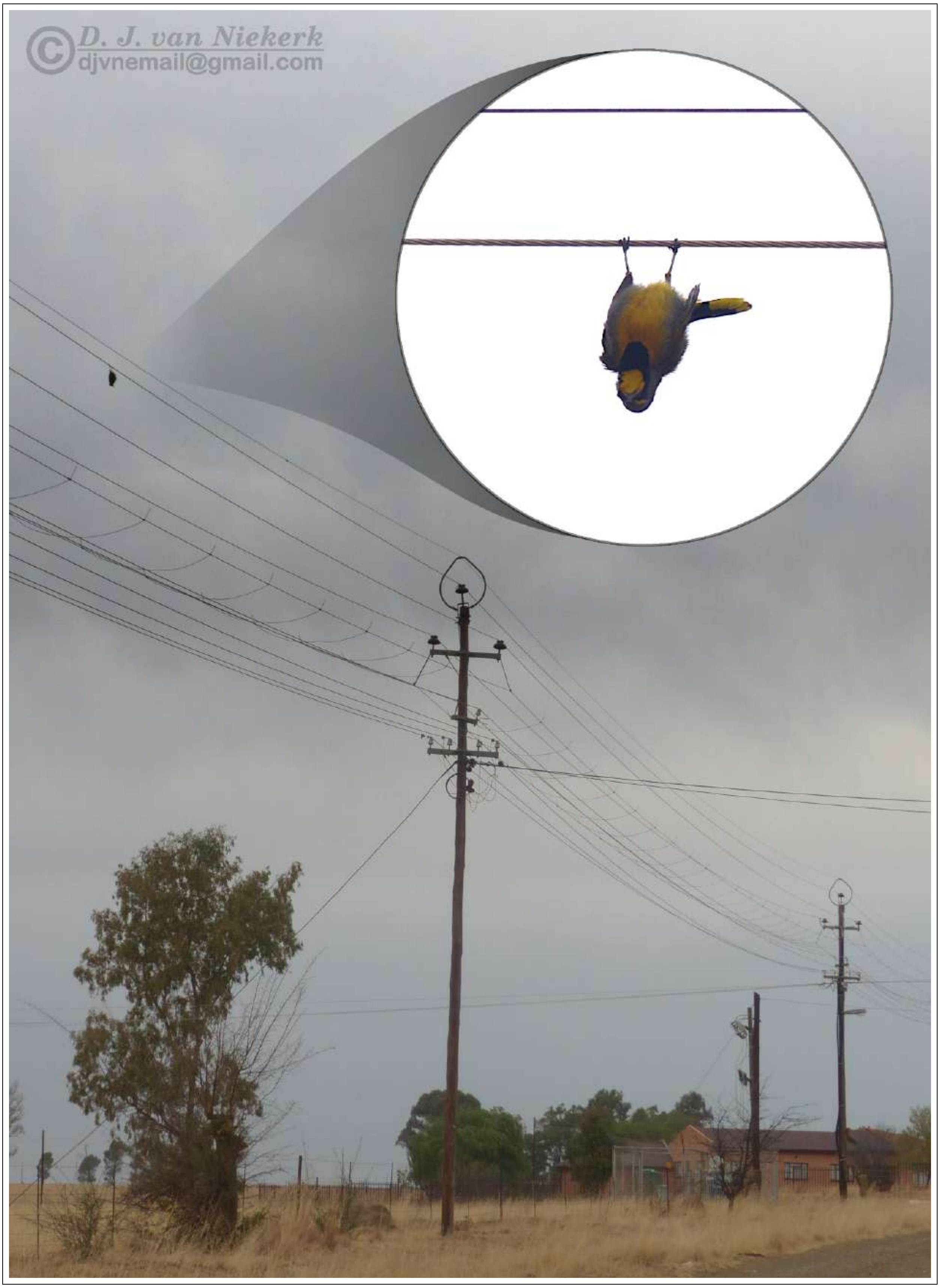


**Figure 17:** An example of an electrocution incident on wires between pylons. Note how close the two top wires are to each other. Bokmakierie R746, Hobhouse.

**Figure 18:** An example of an electrocution incident that probably followed after a collision incident. Note the singed feathers. Black-headed Heron R063, Bloemfontein.

**Figure 19:** Flashover pathways of two different flashover mechanisms (*i.e.* pollution & streamers) involving bird excreta. The bird guards (BG) on the top of the tower are meant to prevent birds from perching on critical points on the tower in order to minimise the risk of streamer-induced flashovers.

**Figure 20:** The difference in pylon and wire height of the existing 132kV Garona–Groblershoop and 22 kV Groblershoop–Padkloof power lines at pylons 1 GAR/GRO 76 and GPF 30. The effect of flight level (horizontal red line) on the visibility of wires is also illustrated with the bottom (B), central (C) and top (T) conductors, as well as the earth wire (E), of the Garona–Groblershoop power line marked at left. Note how the visibility of conductors and earth wire deteriorates when they drop below the skyline and how the angle of light falling on the lines affects their visibility. Both sets of power lines make a slight turn at these two pylons (see Figure 9). Compare the difference in the thickness and visibility of the conductors and the earth wire.

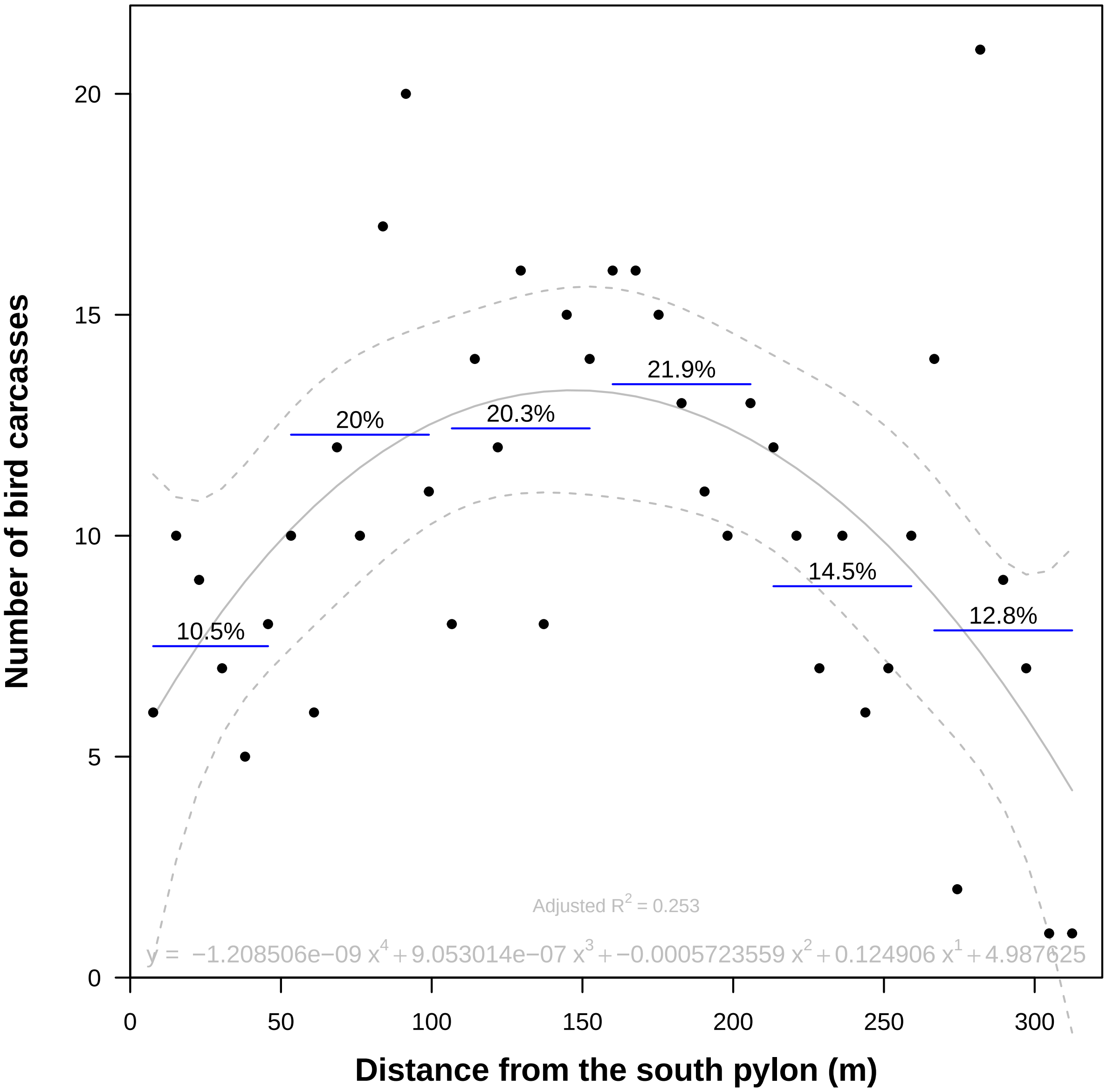
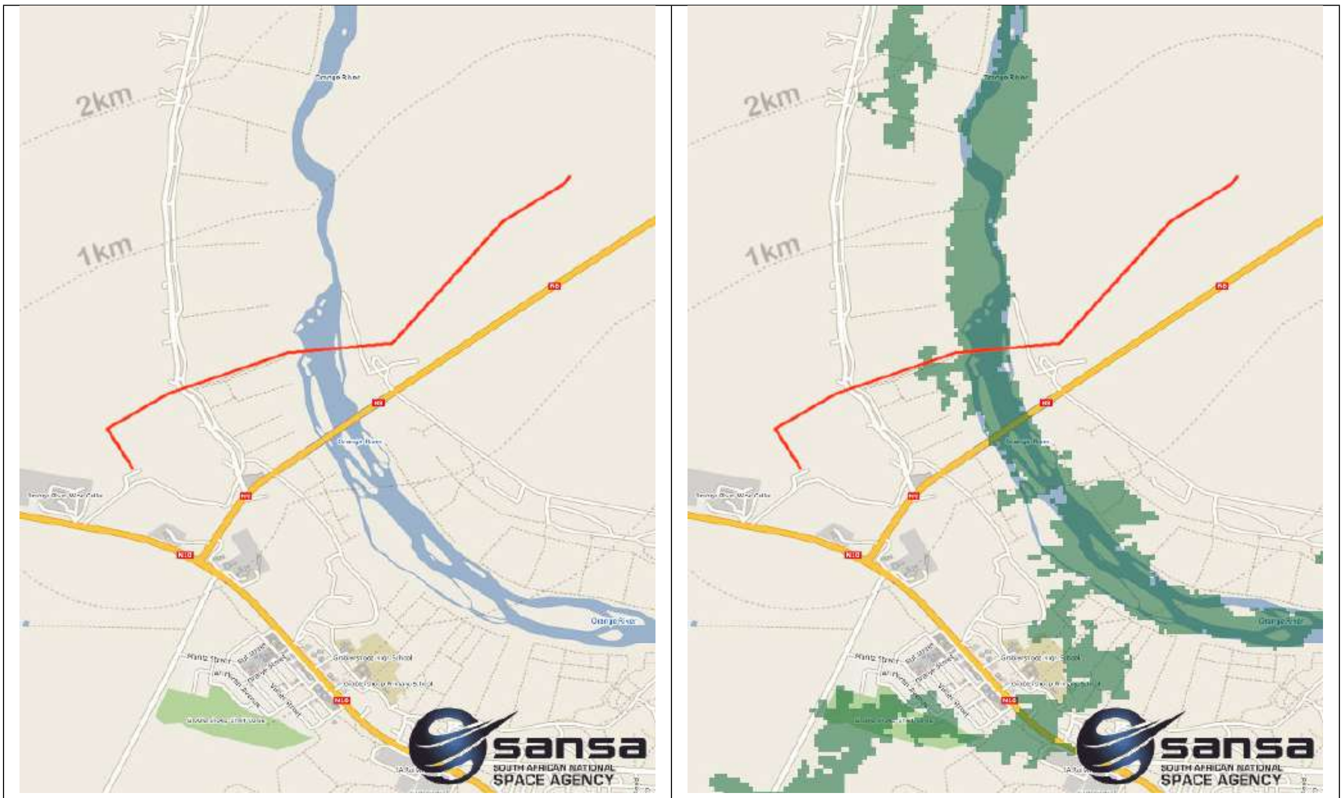


**Figure 21:** Data from Pandely *et al.* (2008) showing the distribution pattern of birds carcasses detected under power lines relative to the distance from pylon locations (pooled for each 7.62 m (25 feet) interval). Pandely *et al.* (2008) mention that each span is “approximately 1000 feet [= 304.8 m] in length”, with measurements taken from Google Earth indicating that they range between 284 and 306 metres (mean = 295 m = 967.8 feet). Therefore, this graph gives an approximate indication of the relative distribution of bird carcasses between pylons. The grey line represents a fourth-order polynomial curve fitted to the data, with the stippled lines indicating its 95% confidence interval. The horizontal blue lines indicate the mean number of carcasses found within each 1/6 section, with the percentage on top of each line indicating the percentage of the total number of carcasses in each section.



0 metre flood

1 metre flood

3 metre flood

5 metre flood

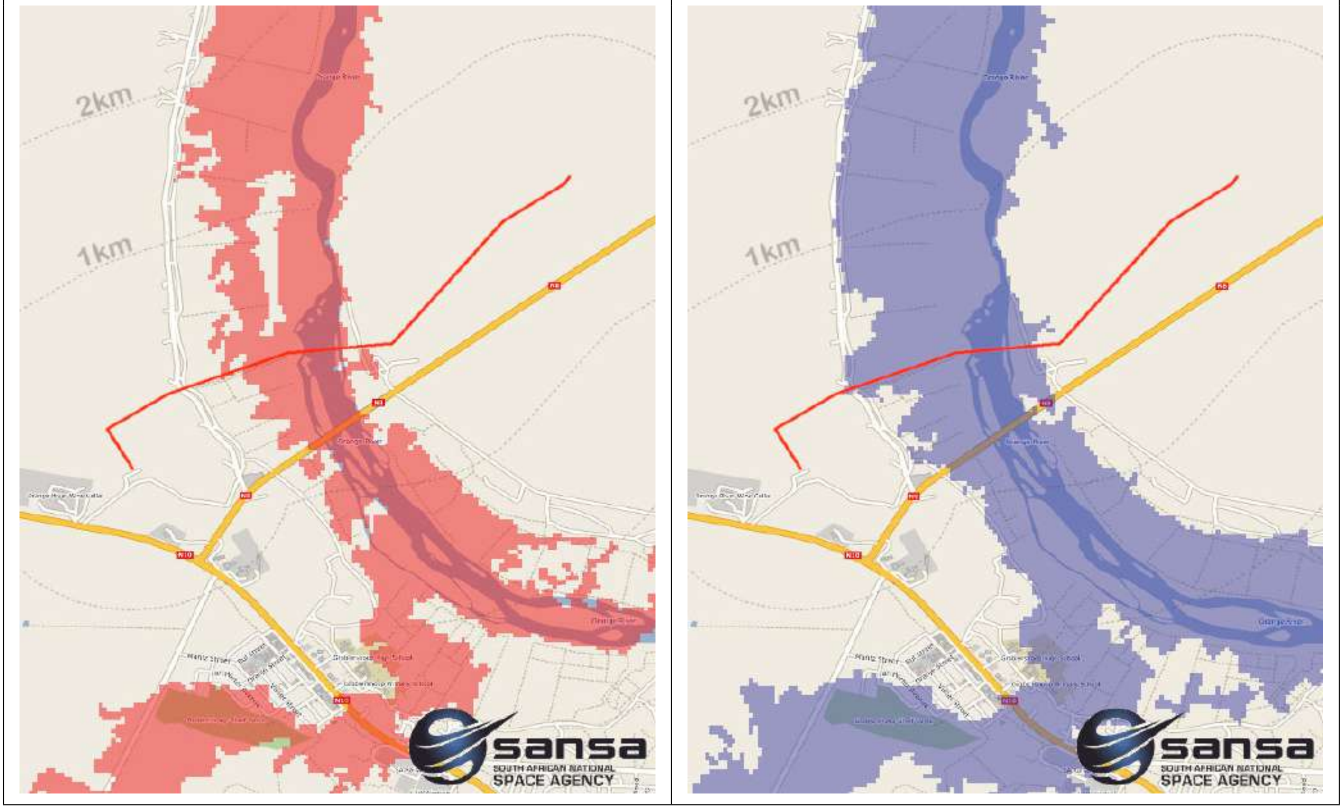


**Figure 22:** Flood-prone areas in the vicinity of the ORSF1 power line based on information available from the South African National Space Agency (SANSA; products.sansa.org.za).

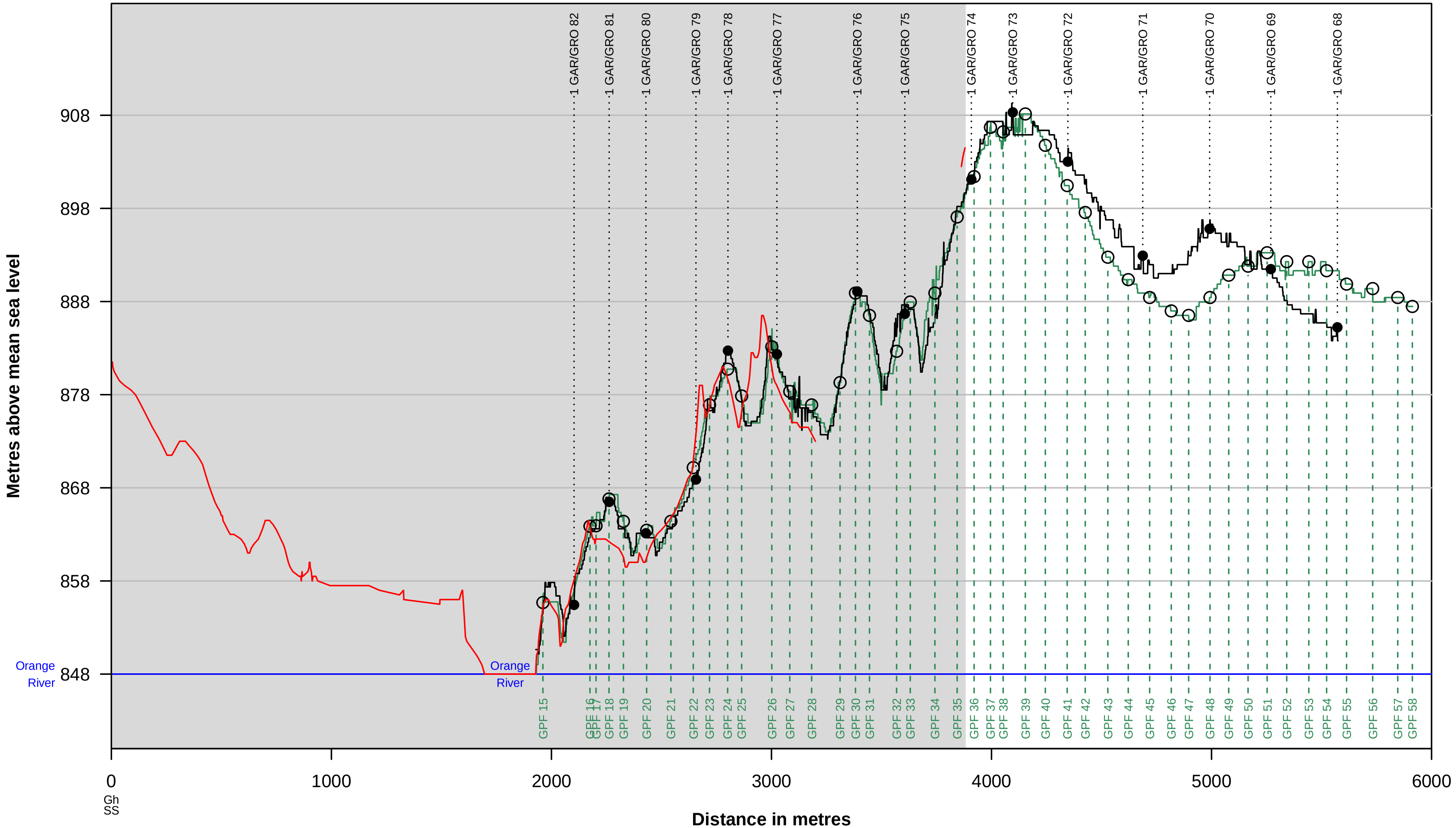


**Figure 23:** Elevation profile of the ORSF1 power line (red line; Based on surveyor data) and the two existing power lines from the Orange River north-eastwards (based on Garmin Etrex 32x elevation data logged while walking underneath the two respective power lines: GPF (Green; Open circle pylons; 22 kV Groblershoop–Padkloof) & 1 GAR/GRO (Black; Black dot pylons; 132 kV Garona–Groblershoop)). The shaded area left of GPF 36 represents the part of the route of the ORSF1 power line, which will run (nearly) parallel to the Garona–Groblershoop power line to the Groblershoop substation (see Figure 9). Note how many of the 1 GAR/GRO pylons are located on high points along its route.

**Figure 24:** Aerial view looking south-east across the two sand dune systems. The yellow line represents the route of the ORSF1 power line. Note also the livestock kraal in the foreground (see Figure 5).

**Figure 25:** View over the relatively flat open plains (cf. Fig. 27) approximately 2 km north-east of the starting point of the ORSF1 power line. The relatively dense vegetation top left represents a farm dam. Note also the hills on the horizon.

**Figure 26:** Aerial view looking southwards across the western part of the route of the ORSF1 power line (yellow line). From left to right (east to west) along the route, note, in particular, the following: Destination River Resort, riparian vegetation, Orange River, islands, riparian vegetation, agricultural fields, irrigation channel, natural veld, Groblershoop substation.

**Figure 27:** Aerial view across the study area looking southwards. The yellow line represents the approximate route of the ORSF1 power line. Note in particular (from left to right) the drainage systems, low hills terminating in cliffs along the Orange River (see Figure 46), the Orange River and agricultural fields beyond that. The R533 bottom-right indicates the location of the Brown-throated Martin sandbank (see Figure 44). The Lower Gariep Broken Veld's hills and low mountains are visible on the horizon (see Figure 2).

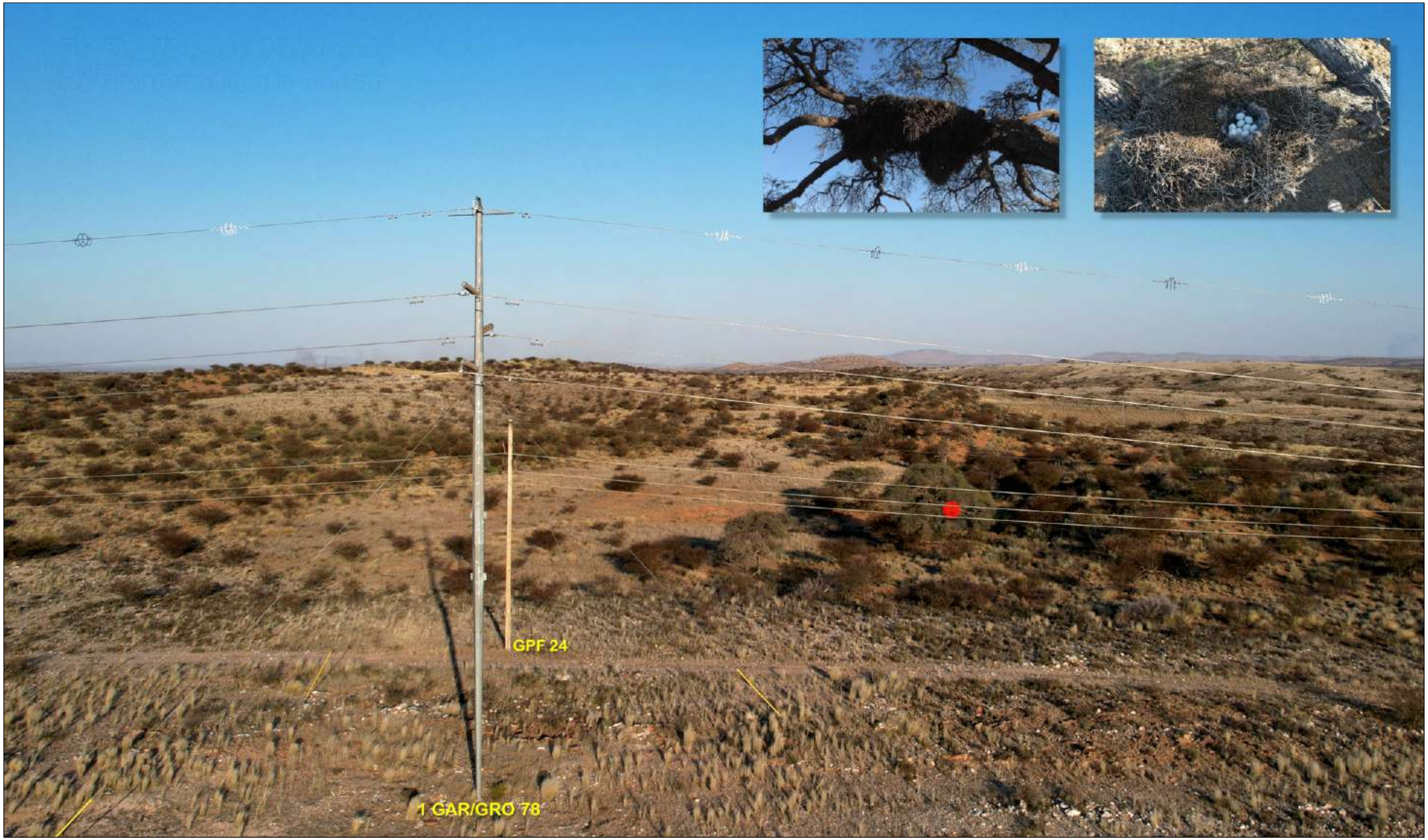
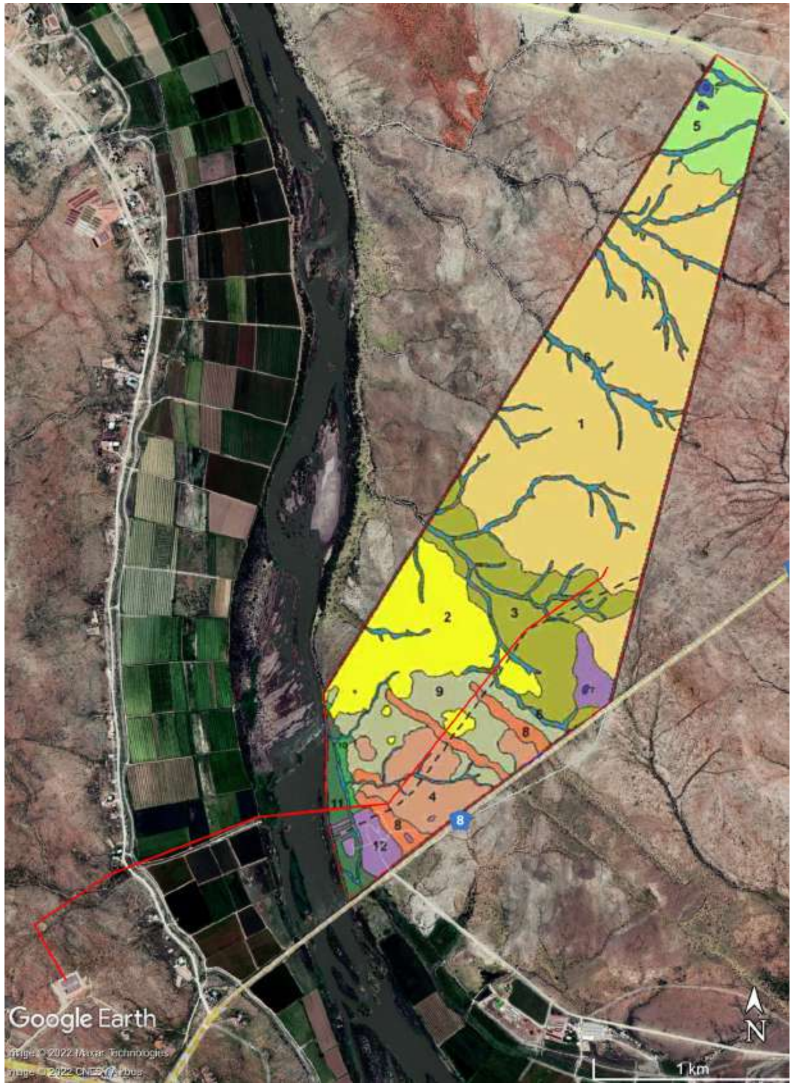


**Figure 28:** South-eastward view across the habitat with the long southern dune on the right. The insets top-right is of an active Egyptian Goose R102 nest on top of an old Sociable Weaver R800 nest in the *Vachellia erioloba* tree at right, marked with the red dot. Note also the difference in height between the two power lines.



| Legend: | | |
|---|---|---|
| 1 | 🟨 | *Aloe clavi<U+FB02>ora* - *Leucosphaera bainesii* - *Avonia papyracea* dwarf shrubveld |
| 2 | 🟨 | ***Senegalia mellifera*** - *Tetraena rigida* - *Ptycholobium bi<U+FB02>orum* dwarf shrubveld |
| 3 | 🟩 | ***Senegalia mellifera*** - *Aptosimum spinescens* - *Stipagrostis amabilis* shrubveld |
| 4 | 🟧 | ***Senegalia mellifera*** - *Tetraena rigida* - *Enneapogon desvauxii* dwarf shrubveld |
| 5 | 🟩 | *Roepera lichtensteiniana* - *Tetraena decumbens* dwarf shrubveld |
| 6 | 🟦 | ***Senegalia mellifera*** - *Ziziphus mucronata* - *Fingerhuthia africana* shrubveld |
| 7 | 🟦 | ***Senegalia mellifera*** - *Phaeoptilum spinosum* - *Cullen tomentosum* shrubveld |
| 8 | 🟧 | ***Senegalia mellifera*** - *Calobota linearifolia* - *Stipagrostis amabilis* shrubveld |
| 9 | ⬜ | ***Senegalia mellifera*** - *Vachellia erioloba* - *Justicia incana* bushveld |
| 10 | 🟩 | *Eucalyptus camaldulensis* - *Prosopis glandulosa* bushveld |
| 11 | 🟩 | *VacheIlia karroo* - *Ziziphus mucronata* - *Searsia viminale* riparian forest |
| | 🟪 | Infrastructure and disturbance |

**Figure 29:** Vegetation map of Portion 18 of the farm Rooi Sand 387 compiled by Van Rooyen & Van Rooyen (2018) as part of their botanical assessment of the area. The red line indicates the proposed route of the power line.

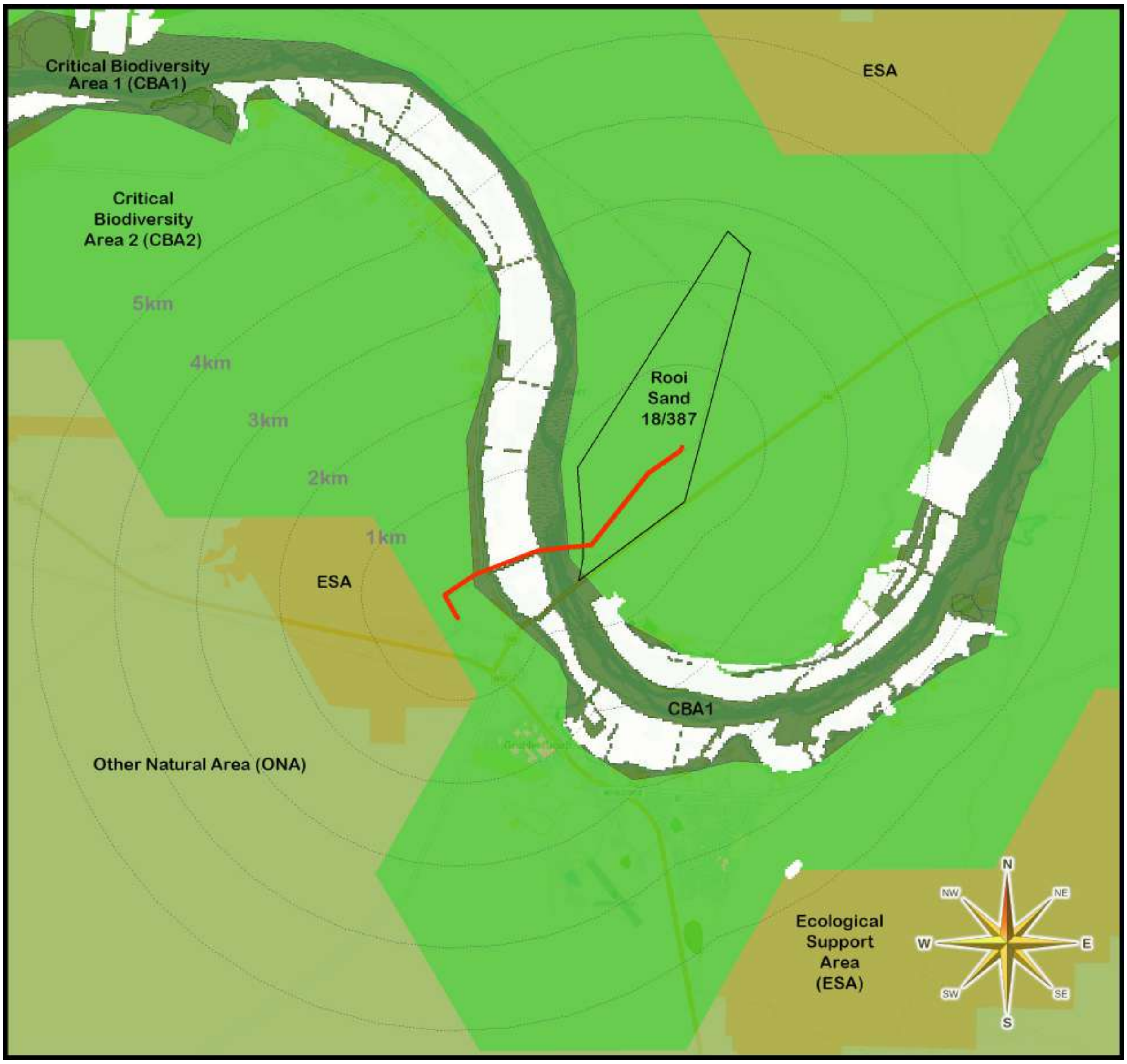


**Figure 30:** The Northern Cape Critical Biodiversity Area Map with the focus on the study area (Holness & Oosthuysen 2016; https://bgis.sanbi.org/Projects/Detail/203).

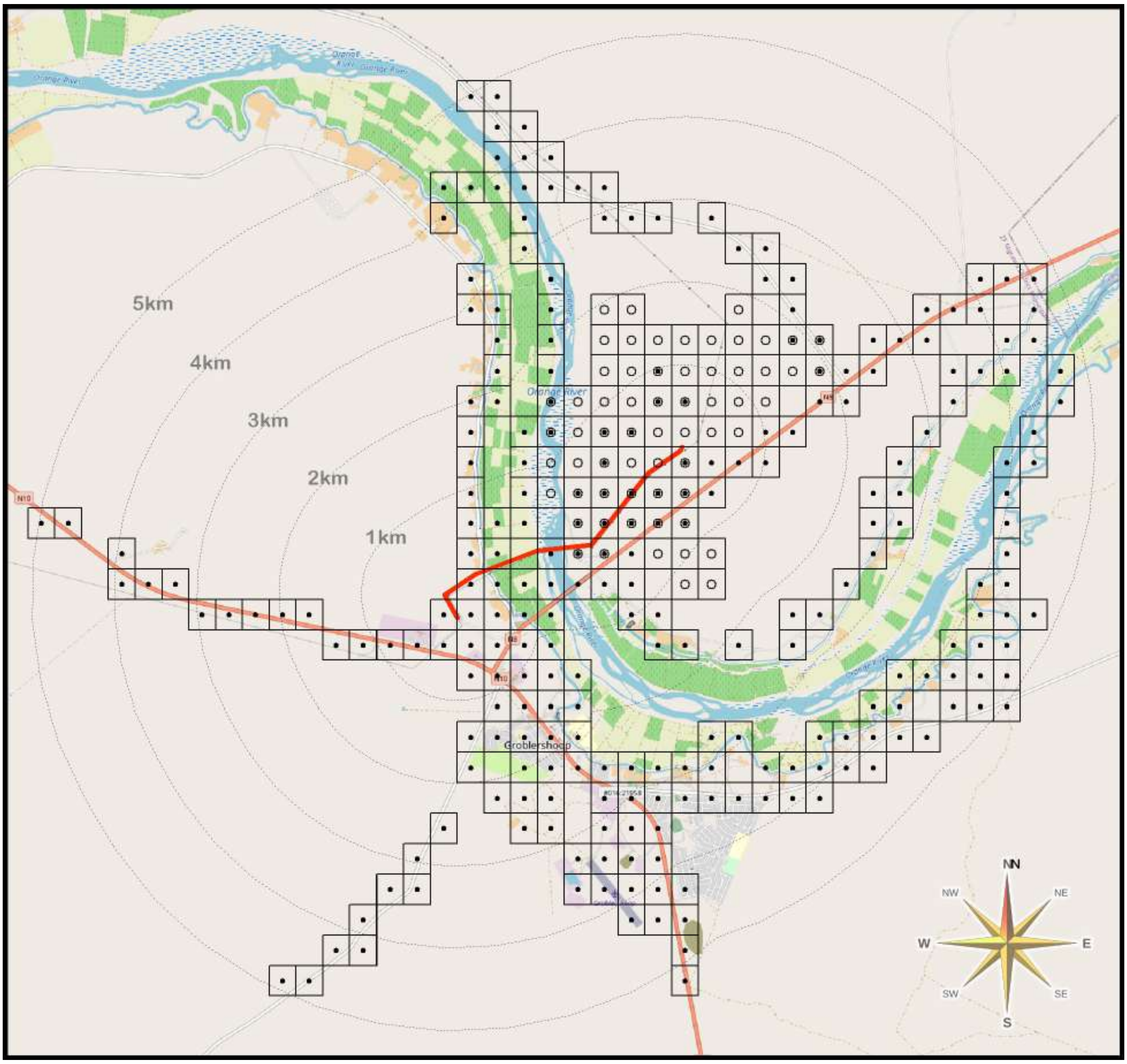
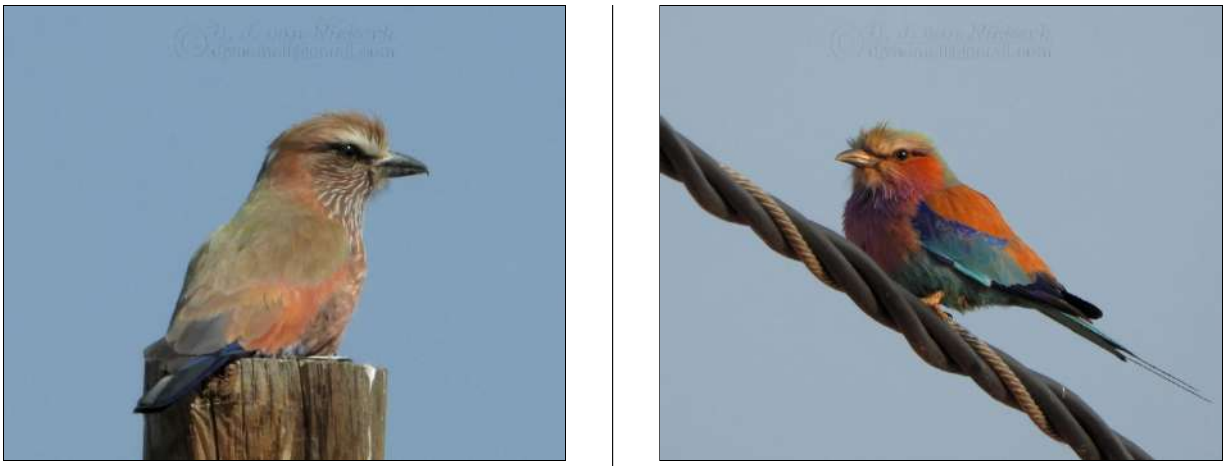


**Figure 31:** The 5 km area around the proposed route of the ORSF1 power line (red line) indicating the 12-second grid blocks in which transects were walked on foot (open circles) or driven by car (black dots) and from which birds were recorded.



A) Purple Roller R449.

B) Lilac-breasted Roller R447.

C) White Stork R083.

**Figure 32:** The three ’new’ species recorded in the Groblershoop area (see page 36).

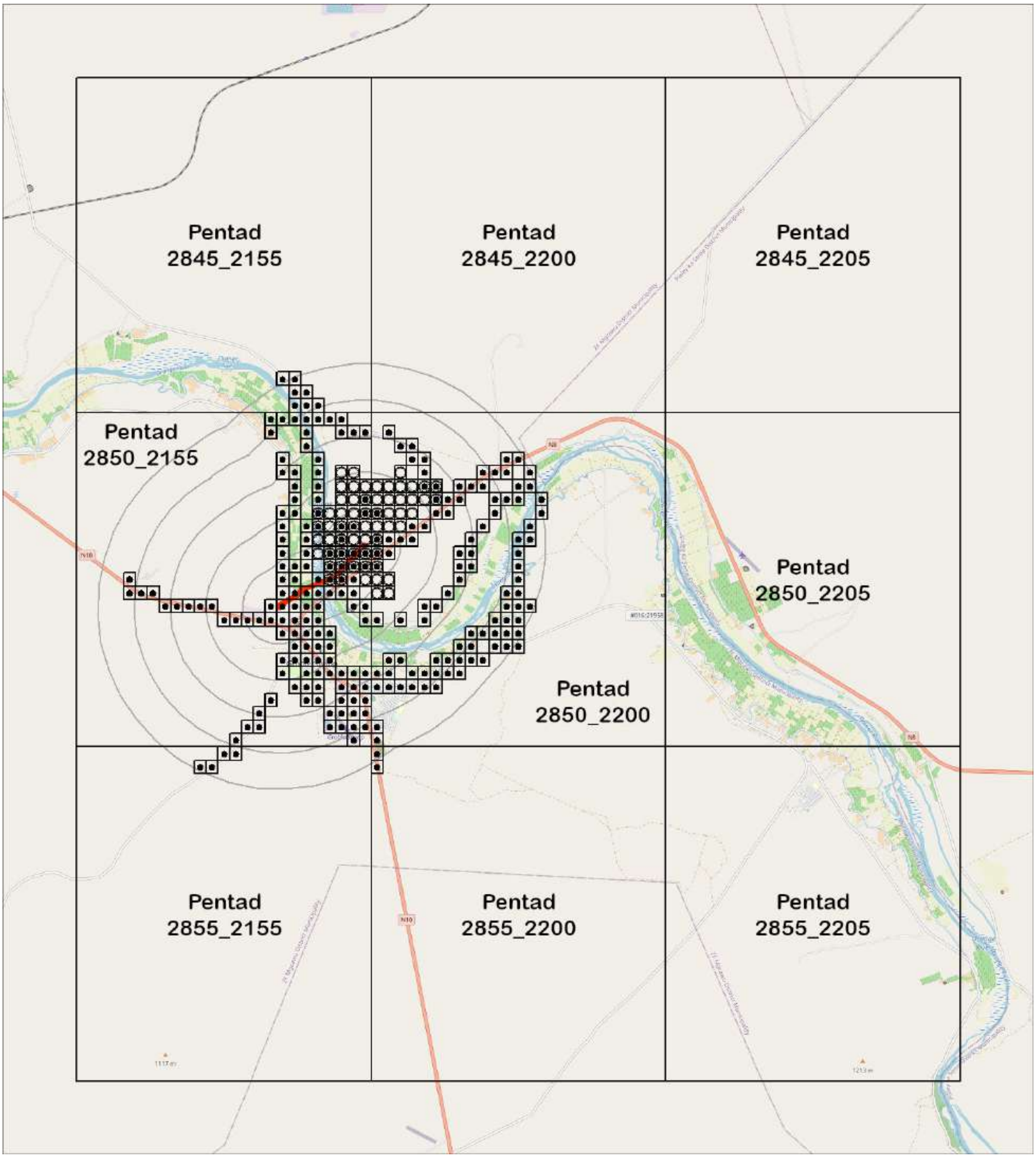


**Figure 33:** The nine SABAP2 pentads defined by Nuttall & Vermeulen (2022) as the "Broader Area" in their avifaunal impact assessment for the proposed Orange River Solar Facility 1 in relation to the present fieldwork for the associated power line (see page 36).

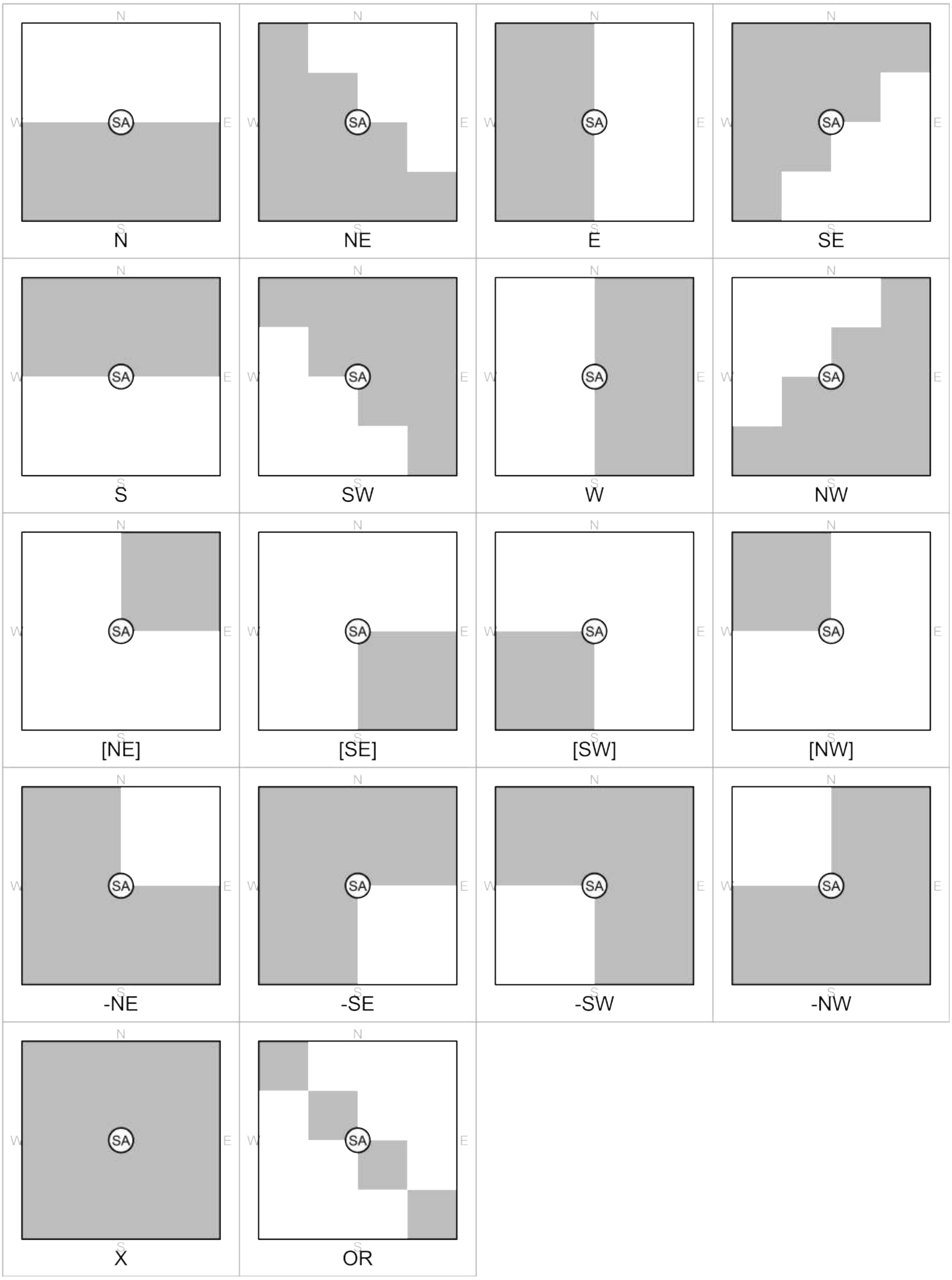


**Figure 34:** Schematic representation of distribution patterns of bird species around the study area (SA). N: North; E: East; S: South; W: West; X: Widespread; OR: Limited or primarily limited to the Orange River. See Section 4.4 on page 37.

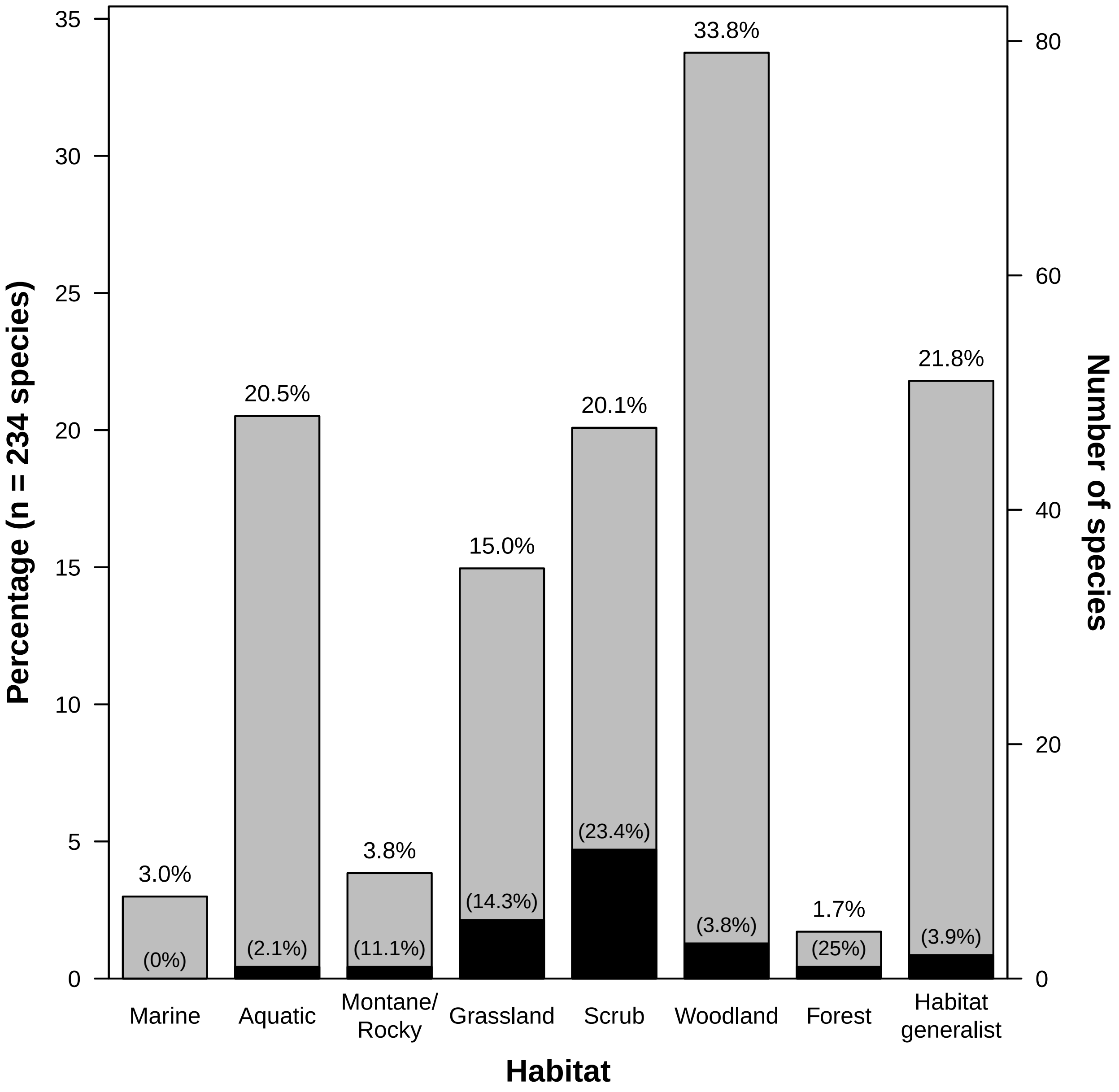


**Figure 35:** Habitat preferences of bird species with distribution patterns that overlap with the study area. The black bottom part of each bar represents endemic or near-endemic species, with the percentage that they constitute of the respective habitats indicated in brackets. Note that species may be associated with more than one habitat type. Hence the percentages do not add up to 100%. Data from Table 1 on page 113.

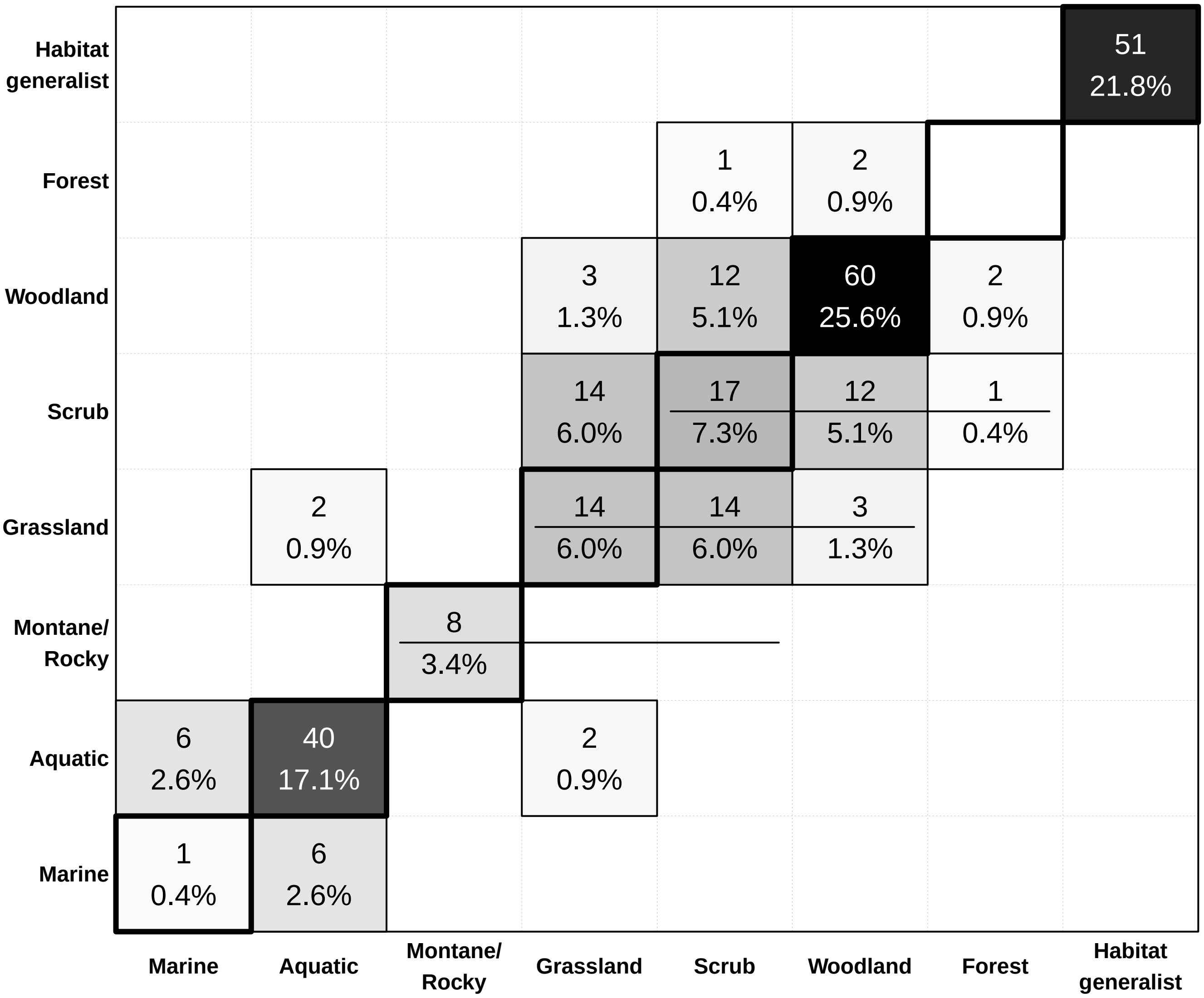
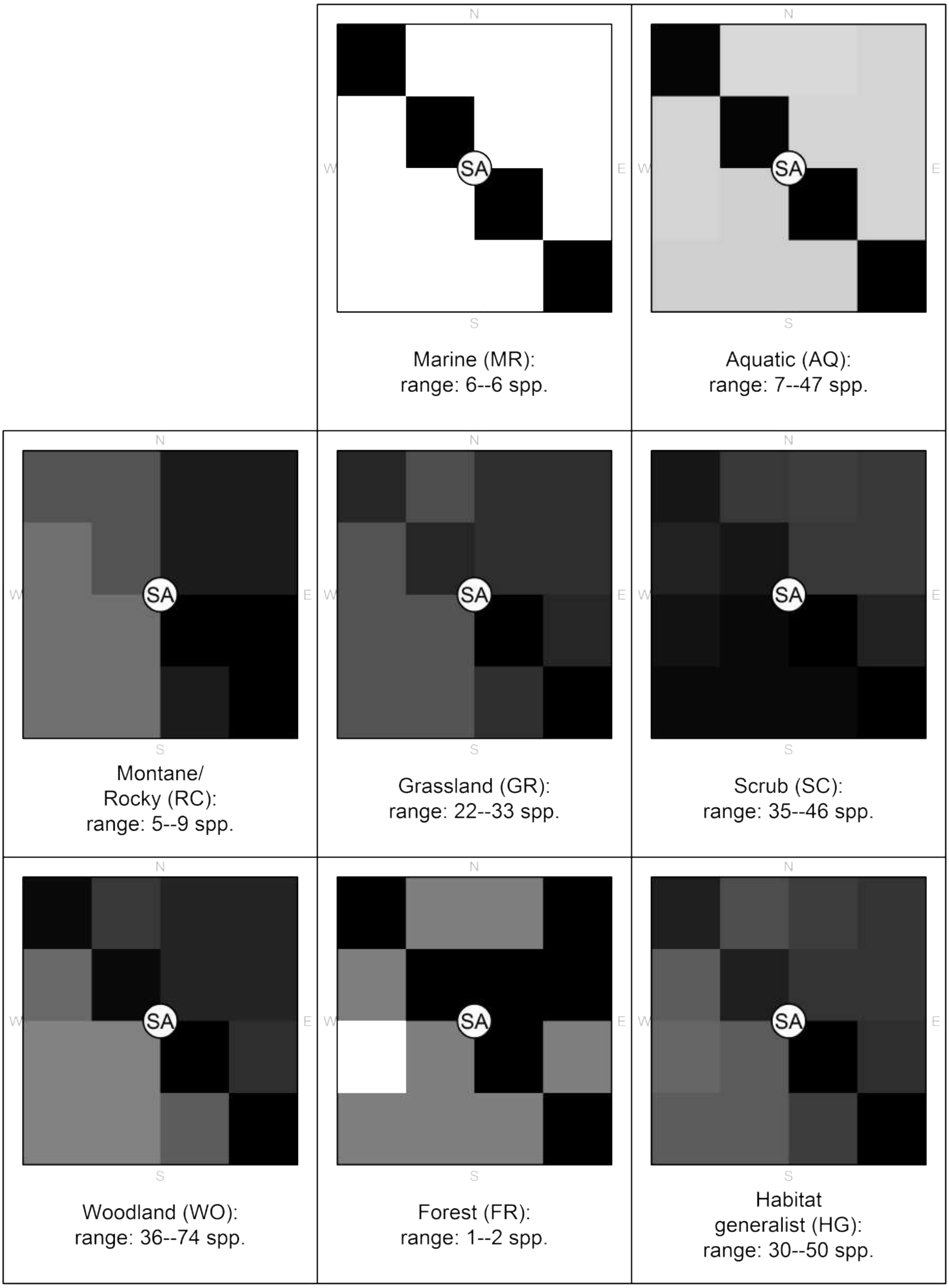


**Figure 36:** Habitat preference combinations of all species recorded in the study area. Numbers represent species totals, while percentages indicate the proportion of all species (n = 234). The three horizontal lines represent (from top to bottom) one, two and three species associated with three habitats. The shading of each block is relative to the combination with the highest proportion, woodland.



Marine (MR):
range: 6--6 spp.

Aquatic (AQ):
range: 7--47 spp.

Montane/
Rocky (RC):
range: 5--9 spp.

Grassland (GR):
range: 22--33 spp.

Scrub (SC):
range: 35--46 spp.

Woodland (WO):
range: 36--74 spp.

Forest (FR):
range: 1--2 spp.

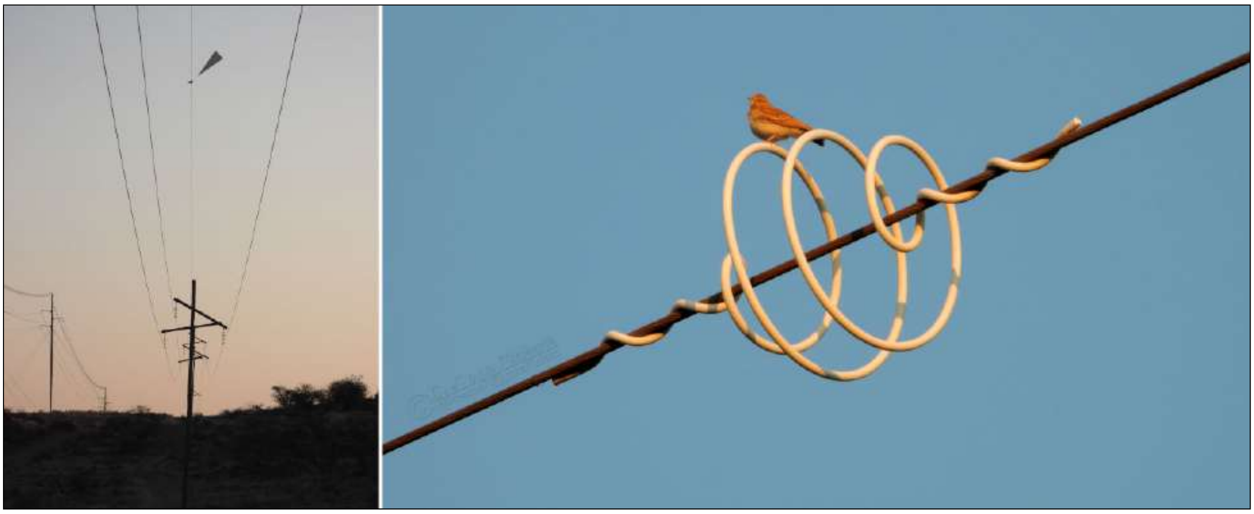
Habitat
generalist (HG):
range: 30--50 spp.

**Figure 37:** Schematic representation of the distribution of bird species associated with different habitats around the study area (SA). Shading is relative to the maximum number of species (black) for each habitat, as indicated in the range. See Section 4.4 on page 37 and Figure 34.

**Figure 38:** Examples of species assigned to the electrocution codes (in brackets) used in Table 1. See page 46 for an explanation of these codes.

**Figure 39:** Aerial view looking south-east across the study area. The yellow line represents an approximation of the route of the ORSF1 power line. From left to right, note, in particular, the drainage lines, dunes, riparian vegetation, rocky area in the Orange River (R) and agricultural fields.

**Figure 40:** Solitary Kori Bustard R230 encountered on two occasions less than 3 km from the proposed route of the ORSF1 power line. In the main picture, the 22 kV Groblershoop–Padkloof (GPF) power line is in the background.



A) Fawn-colored Lark R497.

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B) Sociable Weaver R800 nests & Pygmy Falcon R186. There is a nest of the falcon in the top weaver nest.

**Figure 41:** Examples of the utilisation of pole and wire infrastructure by birds in the immediate vicinity of the ORSF1 power line.

**Figure 42:** The waterworks at Destination River Resort. The yellow line represents an approximation of the route of the ORSF1 power line. See also Figure 5.

**Figure 43:** Aerial view from the Groblershoop water treatment works (A) looking northwards with the yellow line top-left, beyond the town, representing the approximate route of the ORSF1 power line. Point B (right) indicates what appears to be the old water treatment works. The bend in the Orange River is also visible.

**Figure 44:** Aerial view (close-up below) looking west across the sandbank with roosting/nesting holes of the Brown-throated Martin R533 located 1.3 km north-west from the start of the ORSF1 power line (see Figure 5). White-fronted Bee-eaters R443 also utilise this sand bank for roosting/nesting.

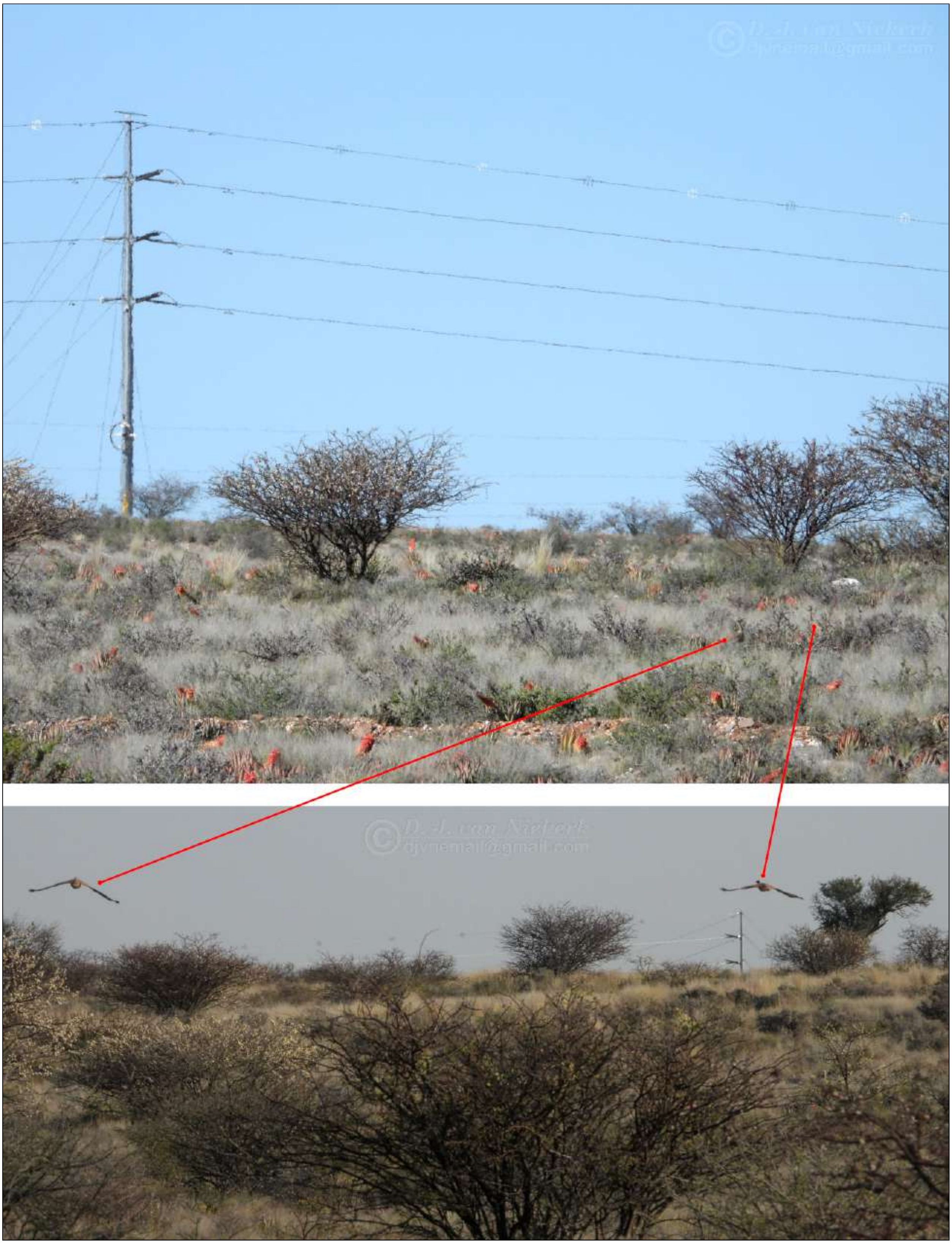


**Figure 45:** Karoo Korhaan R235 pair encountered approximately 600 m north of the staring point of the ORSF1 power line.

**Figure 46:** Cliffs, inhabited by Rock Hyrax *Procavia capensis*, located less than a kilometre downstream (north) of the proposed route of the ORSF1 power line that would cross the Orange River before the bridge seen on the horizon. See also Figures 27 & 39.

**Figure 47:** Abdim's Stork R085 near Douglas during January 2020. Left: A dead bird found below a power line; Right; Part of a congregation of 933 birds in an irrigation field.

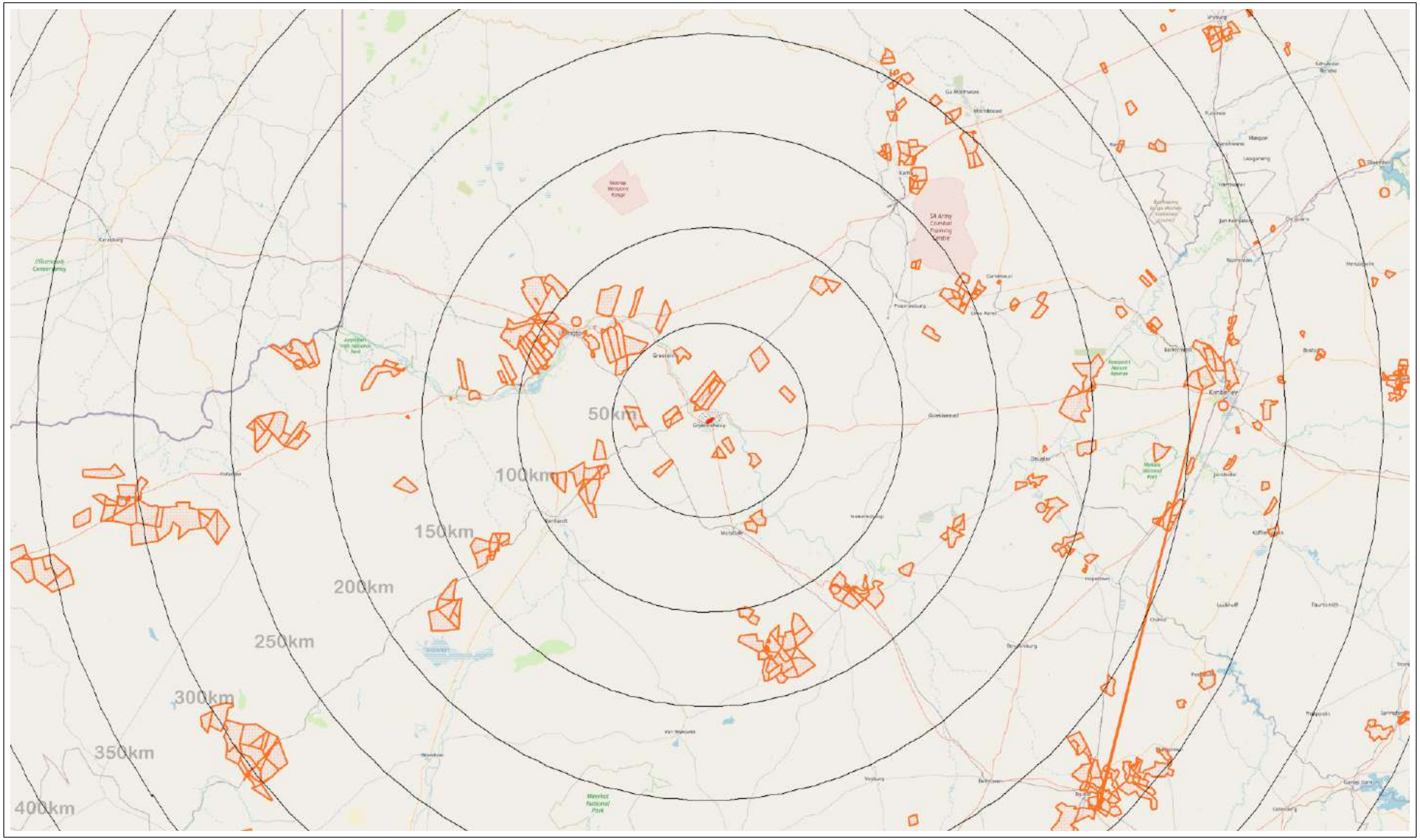


**Figure 48:** The Groblershoop study area (centre) in relation to South African Renewable Energy EIA Application Database (REEA 2022, Quarter 2) records (orange polygons; `https://egis.environment.gov.za/renewable_energy`).

**Figure 49:** Dynamic line markers deployed on a power line near a watering trough.

**Figure 50:** Example of bundling of conductors with spacers used to prevent contact between bundled conductors. Note also the markers employed on the earth wires at the top.

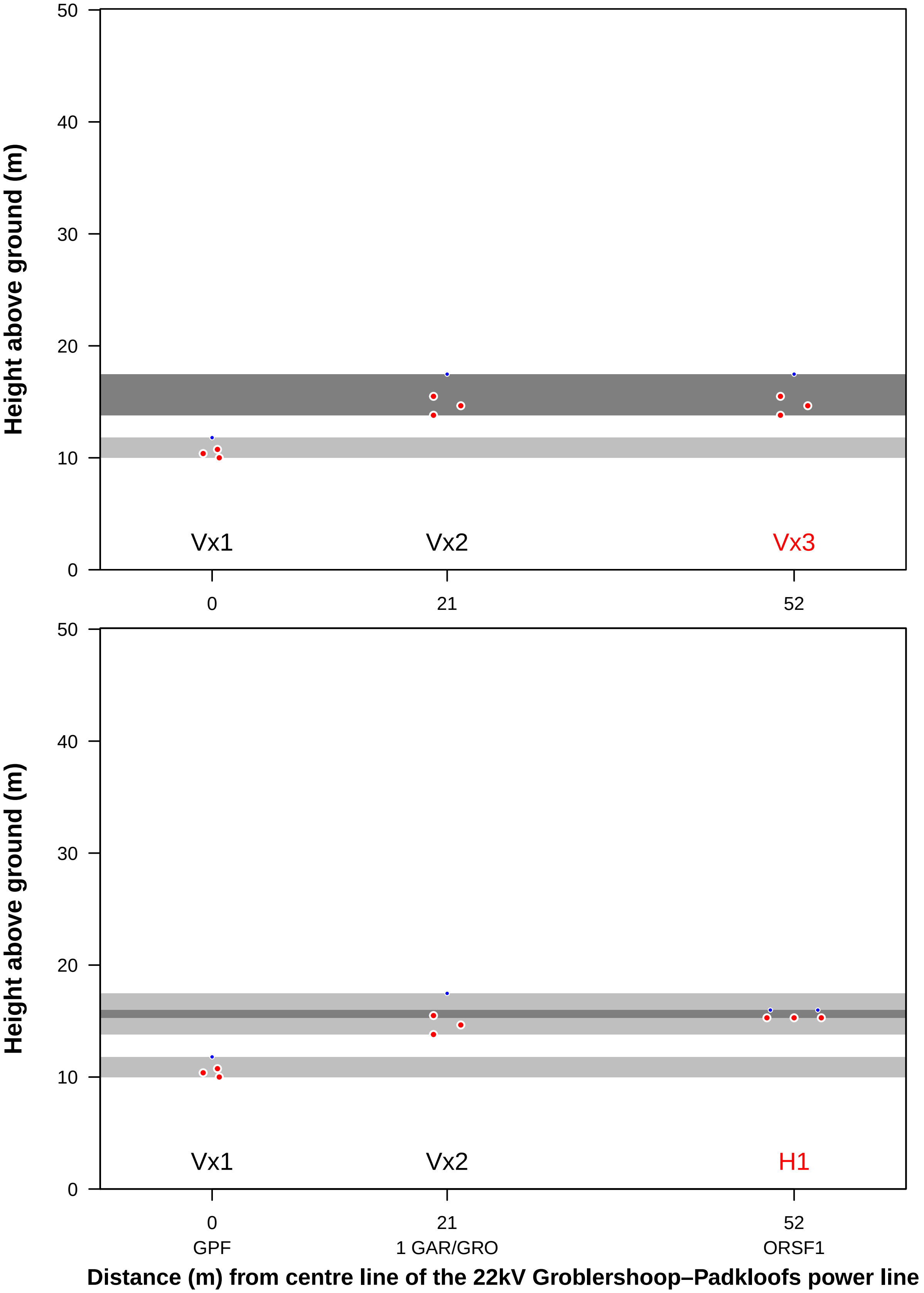


**Figure 51:** Schematic head-on view of the power lines illustrating vertical collision risk zones (grey bands) at a point along a straight section in the bend of the Orange River when the ORSF1 power line utilises vertically (top) versus horizontally (bottom) arranged conductors. Red dots: conductors; Blue dots: earth wires. A bird flying perpendicularly towards the lines will fly from left to right or right to left. Drawn to scale, except for the thickness of the wires (diameters exaggerated for enhanced visibility at this scale); the height of the GPF power line was assumed to be 10 m from the ground. See Section 7.2.6.3.5 on page 76 for further details.

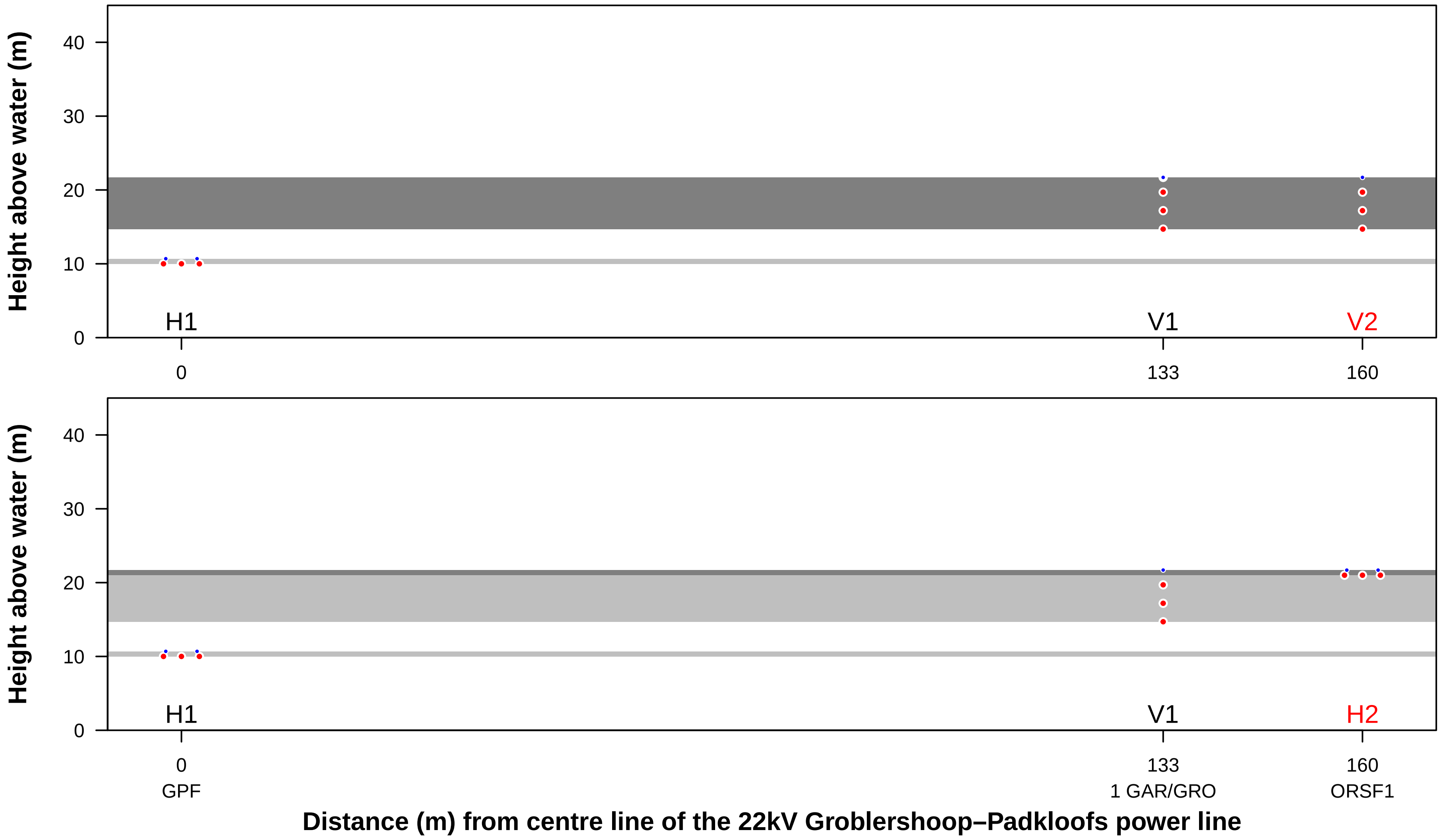
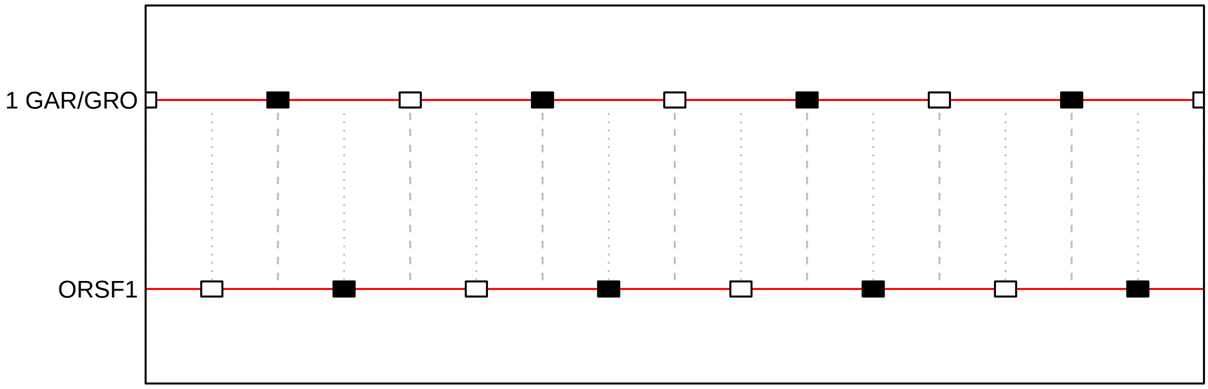


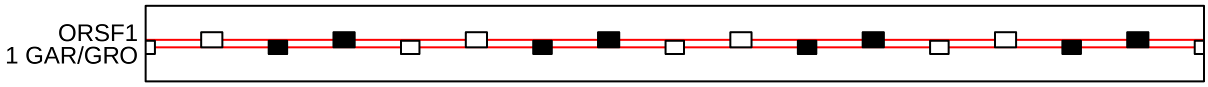
**Figure 52:** Schematic head-on view of the power lines illustrating vertical collision risk zones (grey bands) approximately in the centre of the Orange River when the ORSF1 power line utilises vertically (top) versus horizontally (bottom) arranged conductors. Red dots: conductors; Blue dots: earth wires. A bird flying perpendicularly towards the lines will fly from left to right or right to left. Drawn to scale, except for the thickness of the wires (diameters exaggerated for enhanced visibility at this scale); the difference in height between the GPF and 1 GAR/GRO power lines was assumed to be 4 m. See Section 7.2.6.3.5 on page 76 for further details.

A) Schematic representation of the proposed spacing of markers on the earth wires (conductors not shown). 1 GAR/GRO: existing power line; ORSF1: proposed power line; Red line: earth wires; Blocks on lines: black and white markers. Markers and spacing are not drawn to scale.



A1: View from the top. Stippled and dotted lines indicate the spacing of the markers relative to those on the other line.

A2: Hypothetical view of the marked earth wires (conductors not shown) from a bird flighting towards and at approximately the same height as the earth wires.



B) Markers on the existing 132kV Garona–Groblershoop (1 GAR/GRO) power line.

**Figure 53:** The proposed spacing of markers on the ORSF1 power line. See Section 7.4 (page 84).

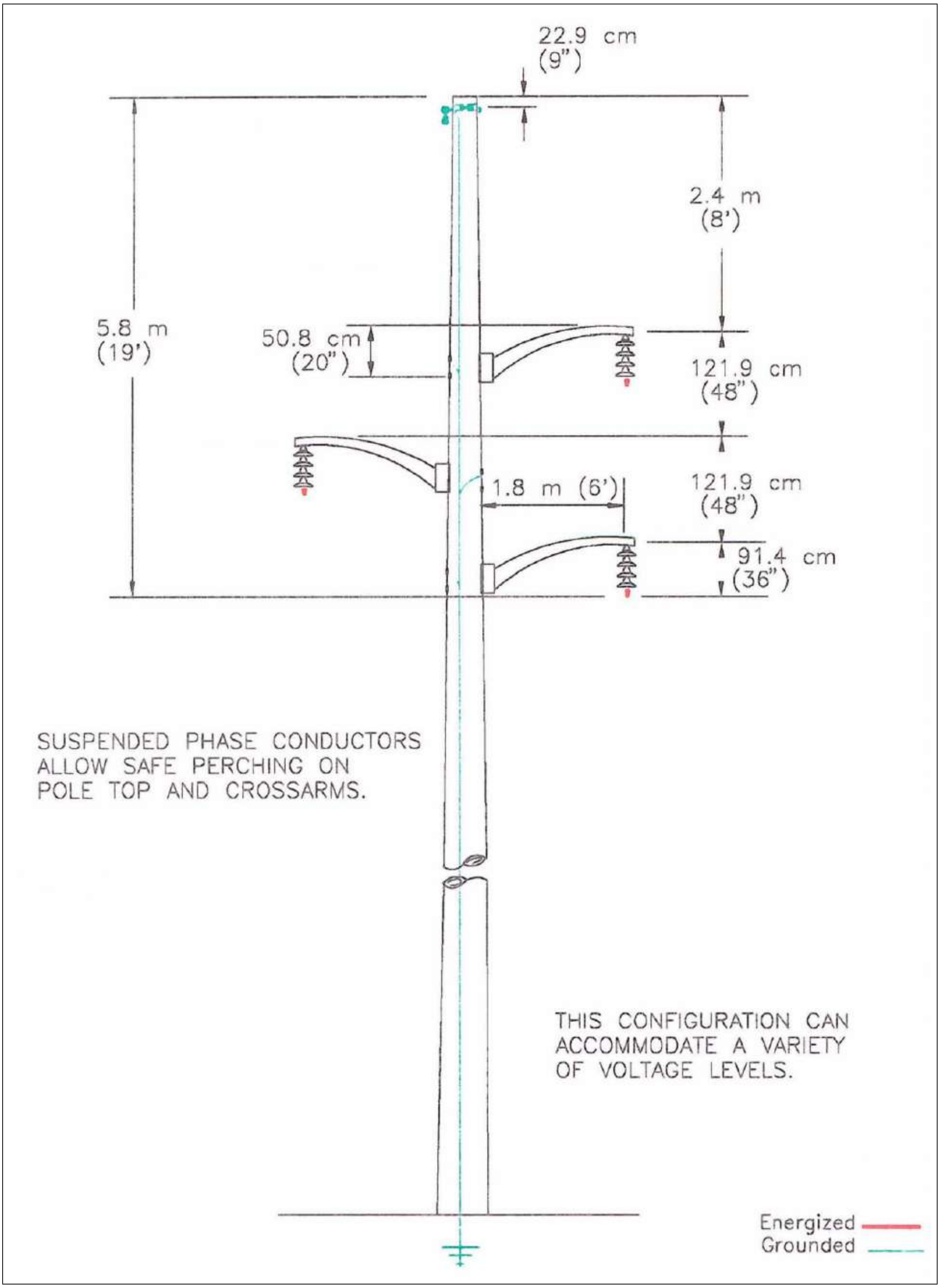


**Figure 54:** Figure 37 of APLIC (1996) illustrating a bird-safe suspension configuration for pylons.

# Appendices

## Appendix A Curriculum Vitae: Dr. D. J. van Niekerk

# *CURRICULUM VITAE*
## *(Abridged)*

# *Dr. D. Johan van Niekerk*
## Ornithologist

August 2022

## 1 Tertiary qualifications

- B. Sc. (Biochemistry and Zoology). University of the Free State (1994)
- B. Sc. Honours in Zoology. University of the Free State (1995)
- M. Sc. in Zoology with distinction. University of the Free State (2000)
- Ph. D. in Zoology. University of the Free State (2009)

*Additional courses*

- Taxidermy course. National Museum, Bloemfontein. June 1988.
- EIA, Centre for Environmental Management, University of the Free State, January 2006

## 2 Work experience

| | | |
|---|---|---|
| Environmental Management Group | Avifaunal specialist for impact assessments | Since 2022 |
| Green-Box Consulting | Avifaunal specialist for impact assessments | Since 2021 |
| Greenmined Environmental | Avifaunal specialist for impact assessments | Since 2021 |
| Spatial Solutions | Avifaunal specialist for impact assessments | Since 2020 |
| Eco-Con Environmental | Avifaunal specialist for impact assessments | Since 2019 |
| Savannah Environmental | Avifaunal specialist for impact assessments | Since 2015 |

| | | |
|---|---|---|
| Environamics Environmental Consultants | Avifaunal specialist for impact assessments | Since 2015 |
| Tlokoeng Valley Biodiversity Conservation Project (Lesotho) | Project manager for the faunal component | 2012–2015 |
| Nare Sereto CC | Avifaunal specialist for impact assessments | Since 2012 |
| Enviroworks | Avifaunal specialist for impact assessments | Since 2009 |
| Gold Fields Limited (Beatrix mine) | Avifaunal specialist for International Cyanide Management Code | 2008 |
| Syngenta | Trainer of personnel in Brazil for conducting risk assessment studies<br>Project manager for risk assessment studies. | 2010<br>2006–2007; 2010–2011 |
| Conserving Mountain Biodiversity in Southern Lesotho (UNDP project) | Project manager for bird component | 2003-2004 |
| Lesotho Highlands Development Authority | Project manager for bird component of monitoring and faunal rescue at Mohale Dam | 2002–2003 |
| University of the Free State | Research associate<br>Temporary lecturer<br>Laboratory assistant | 2010–2012<br>2006-2007<br>1995-2005 & 2008-2009 |

**Specialist reports:**

- Van Niekerk, D. J. 2002. Birds. In: Biological Resource Monitoring Contract LHDA 1053: Annual Report 2001/2002 (ed. C. Mokuku). NUL-CONSULS, Maseru, Lesotho.
- Van Niekerk, D. J. 2003. Birds. In: Contract LHDA 1053: Biological Resource Monitoring. Final report. NUL-CONSULS, Maseru, Lesotho.
- Van Niekerk, D. J. 2003. Faunal Rescue at Mohale Dam: December 2003 report on birds. NUL-CONSULS, Maseru, Lesotho.
- Van Niekerk, D. J. 2004. CMBSL bird report for the period November 2003. Report to the UNDP funded *Conserving Mountain Biodiversity in Southern Lesotho Project.*
- Van Niekerk, D. J. 2004. CMBSL bird report (May 2004 draft). Report to the UNDP funded *Conserving Mountain Biodiversity in Southern Lesotho Project.*

- Van Niekerk, D. J. 2007. The risk of wildlife consuming planted *Zea mays* seeds: A South African perspective. A study commissioned by Syngenta.
- Van Niekerk, D. J. 2008. Beatrix, Birds and BAD cyanides: First assessment for the International Cyanide Management Code Operations Principle.
- Van Niekerk, D. J. 2009. The impact of development in the Vaalbank Spruit section of Erfenis Dam on birds. Report to Enviroworks CC.
- Van Niekerk, D. J. 2009. Potential impact of proposed new 66 kV powerline in the Buffeljags area on birds. Report to Enviroworks CC.
- Van Niekerk, D. J. 2010. Potential impact of proposed installation of 2 x 20 MVA 88/11 kV transformers at the new Barcelona substation on birds. Report to Enviroworks CC.
- Van Niekerk, D. J. 2010. Potential impact of proposed 132kV inter-connector line at Thabong on birds. Report to Enviroworks CC.
- Van Niekerk, D. J. 2010. Animals on recently planted corn (*Zea mays*) fields in Brazil: An abridged report on the September 2010 survey. Report to Syngenta.
- Van Niekerk, D. J. 2011. Potential impact of the proposed 132 kV double circuit powerline at Botshabelo on birds. Report to Enviroworks CC.
- Van Niekerk, D. J. 2012. Avicta treated *Zea mays* seed: Is South African wildlife at risk? A study commissioned by Syngenta.
- Van Niekerk, D. J. 2012. Potential impact of the proposed 132 kV double circuit powerline at Botshabelo on birds: November 2012 update. Report to Enviroworks CC.
- Van Niekerk, D. J. 2012. Potential impact of the proposed SolFocus concentrator photovoltaics near Prieska, Northern Cape, on birds. Report to Nare Sereto CC.
- Van Niekerk, D. J. 2013. Potential impact of the proposed 75 MW First Solar CdTe photovoltaics development near Prieska, Northern Cape, on birds. Report to Nare Sereto CC.
- Van Niekerk, D. J. 2013. Avifaunal impact assessment for proposed Cecilia substation and power line. Report to Enviroworks CC.
- Van Niekerk, D. J. 2015. The status of birds in Tlokoeng Valley, northern Lesotho: July 2012 – June 2014. A report to the Environmental & Sustainability Education Network of Lesotho.
- Van Niekerk, D. J. 2015. Desktop Avifaunal Assessment for the proposed Harvard to Noordstad power line, Bloemfontein. Report to Enviroworks CC.
- Van Niekerk, D. J. 2015. Avifaunal Impact Assessment report for the proposed extension of the Bokamoso Photovoltaic Solar Energy Facility near Leeudoringstad, North West Province. Report to Environamics Environmental Consultants.

- Van Niekerk, D. J. 2016. Feasibility study for the proposed construction of the Semonkong Wind Farm in Lesotho: Avifauna. Report to Savannah Environmental.
- Van Niekerk, D. J. 2016. Environmental Impact Assessment for the proposed construction of the 150 MW Sol Invictus 1 photovoltaic facility near Aggeneis in the Northern Cape Province: Avifauna. Report to Savannah Environmental.
- Van Niekerk, D. J. 2016. Environmental Impact Assessment for the proposed construction of the 150 MW Sol Invictus 2 photovoltaic facility near Aggeneis in the Northern Cape Province: Avifauna. Report to Savannah Environmental.
- Van Niekerk, D. J. 2016. Environmental Impact Assessment for the proposed construction of the 150 MW Sol Invictus 3 photovoltaic facility near Aggeneis in the Northern Cape Province: Avifauna. Report to Savannah Environmental.
- Van Niekerk, D. J. 2016. Environmental Impact Assessment for the proposed construction of the 150 MW Sol Invictus 4 photovoltaic facility near Aggeneis in the Northern Cape Province: Avifauna. Report to Savannah Environmental.
- Van Niekerk, D. J. 2016. Avifaunal Scoping Report for the proposed 150 MW Noupoort Concentrated Solar Power Facility, Northern Cape Province. Report to Savannah Environmental.
- Van Niekerk, D. J. 2016. Basic assessment report on the proposed second alternative for the Sol Invictus power line near Aggeneis in the Northern Cape Province: Avifauna. Report to Savannah Environmental.
- Van Niekerk, D. J. 2016. Avifaunal Impact Assessment report for the proposed 150 MW Noupoort Concentrated Solar Power Facility, Northern Cape Province. Report to Savannah Environmental.
- Van Niekerk, D. J. 2017. Avifaunal Basic Assessment Report for the proposed New Chemie substation & power line project near Phalaborwa, Limpopo Province. Report to Savannah Environmental.
- Van Niekerk, D. J. 2017. Avifaunal Impact Assessment for the proposed Harvard to Noordstad power line at Bloemfontein, Free State Province. Report to Enviroworks.
- Van Niekerk, D. J. 2017. Avifaunal Impact Assessment for the proposed Randfontein Solar PV project at Randfontein, Gauteng Province. Report to Environamics Environmental Consultants.
- Van Niekerk, D. J. 2020. Avifaunal Impact Assessment for proposed irrigation systems near Douglas, Northern Cape Province. Report to Eco-Con Environmental.
- Van Niekerk, D. J. 2021. The effect of human-caused noise on birds, with specific reference to the potential impact of blasting on caged exotic birds. Report to GreenMinded Environmental.
- Van Niekerk, D. J. 2021. Avifaunal Impact Assessment for the proposed Diesel Depot at Swinburne, Free State Province. Report to Spatial Solutions Incorporated.

- Van Niekerk, D. J. 2021. Avifaunal Impact Assessment for the proposed PV plant Phase 1 of the Prieska Power Reserve, Northern Cape Province. Report to Green-Box Consulting.

## 3 Conference contributions

- Van Niekerk, D. J. & Kok, O. B. 1995. Daaglikse aktiwiteite van die Vlaktelewerik *Chersomanes albofasciata*. Oral presentation during S.A. Academy Symposium, Section Biology, at Stellenbosch.
- Colahan, B. D. & Van Niekerk, D. J. 2008. The Lesser Kestrel at communal roosts in the Free State, South Africa — a coordinated survey. 12th Pan-African Ornithological Congress, South Africa, 7–12 September 2008.
- Van Niekerk, D. J. 2008. The activity patterns of birds in the central Free State, South Africa. 12th Pan-African Ornithological Congress, South Africa, 7–12 September 2008.

## 4 Scientific articles in internationally accredited journals

- De Swardt, D. H. & Van Niekerk, D. J. (1996). An annotated checklist of the birds of Qwa-Qwa National Park. *Koedoe* 39(1):89–106.
- Belozerov, V. N., Van Niekerk, D. J. & Butler, H. J. B. (2003). Population structure of *Argas arboreus* (Acari: Argasidae) ticks associated with seasonally abandoned mixed heronries, dominated by Cattle Egrets (*Bubulcus ibis*), in South Africa. *Onderstepoort Journal of Veterinary Research* 70:325–330.
- Van Niekerk, D. J., Fourie, L. J. & Horak, I. G. 2006. Birds as hosts of immature ixodid ticks in Free State Province, South Africa. *Onderstepoort Journal of Veterinary Researc*h 73:123–130.

## 5 Scientific articles in other journals

- Van Niekerk, D. J. 1994. The Turnstone *Arenaria interpres* in the Orange Free State. *Mirafra* 11(1):23–24.
- Van Niekerk, D. J. 1994. Moult in immature male Lesser Kestrels *Falco naumanni*. *Mirafra* 11(2):30–31.
- Van Niekerk, D. J. 1996. Albino Pied Starling *Spreo bicolor* (Sturnidae) with some notes on albinism in the Motacillidae. *Mirafra* 13(1):9–10.
- Van Niekerk, D. J. 1996. The status and distribution of the Blackbreasted Snake Eagle *Circaetus pectoralis* (Smith) in the Orange Free State, South Africa, with some notes on movements in the rest of southern Africa. *Mirafra* 13(2):32–49.

- Kok. O. B., Haddad, C. R., Van Niekerk, D. J., Butler, H. J. B. & Nawaz, M. A. 2005. Invertebrates as a potential food source of brown bears on the Deosai Plateau, Northern Pakistan. *Pakistan Journal of Biological Sciences* 8(1):13–19.
- Van Niekerk, D. J. 2005. Nocturnal behaviour of diurnal birds when disturbed. *Afring News* 34(2):85-87

# Appendix B Specialist declaration of independence

**Consultant background and declaration of independence in accordance with the National Environmental Management Act (107 of 1998): Environmental Impact Assessment Regulations (2014):**

I, Johan van Niekerk (PhD Zoology), am an ornithologist with 21 years of experience as an independent environmental consultant specialising in birds. During this period I successfully completed a number of environmental impact assessments, bird monitoring and risk assessment studies. My curriculum vitae is included in Appendix A on page 182.

Environmental Management Group (Pty) Ltd appointed me as an independent specialist to conduct the Avifaunal Impact Assessment for the ORSF1 power line. This document represents the Avifaunal aspect of the Basic Assessment.

I declare:

- I act/acted as the independent specialist in this application;
- I will perform/preformed 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;
- There are no circumstances that compromised 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.

Johan van Niekerk
3 November 2022