BASELINE STUDY: VERTEBRATE FAUNA AND FLORA ASSOCIATED WITH THE TWIN HILLS MINE PROJECT: UPDATED INFRASTRUCTURE LAYOUT – KARIBIB AREA

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Vertebrate fauna and flora associated with the Twin Hills Mine Project: Updated infrastructure layout – Karibib area

1 Introduction

A desktop study (i.e. literature review) was conducted between 28 and 30 August 2021 on the vertebrate fauna (e.g. reptiles, amphibians, mammals and birds) and flora (larger trees and shrubs and grasses) expected to occur in the general Karibib area. The focus was on species and areas potentially affected by updated infrastructure layout – See Figures 1 and 2. A previous study was conducted by Cunningham (2021) on the vertebrate fauna and flora associated with the general area and original infrastructure layout and included rapid site assessments during February and May 2021 (i.e. summer and winter observations). The aim of this study is to determine the vertebrate fauna and flora potentially affected by the latest infrastructure layout as presented in Figures 1 and 2.

This literature review was to determine the actual as well as potential vertebrate fauna and flora associated with the general Karibib area and commonly referred to as the Semi-desert Savannah and Transition Zone [Escarpment area] (Giess 1971, Van der Merwe 1983) or the areas referred to by Mendelsohn *et al.* (2002) as the Western Highlands. This semi-desert and savannah transition zone as referred to by Giess (1971) is typified by shrubs ("fodder bushes") such as *Blepharis pruinosa*, *Leucosphaera bainesii* and *Monechma genistifolia*. Larger woody species such as *Acacia erioloba* are confined to the drainage lines. The Karibib area is characterised by *A. senegal* shrubs while *Cyphostemma currorii* and *C. bainesii* also occur in this region. The trees common in the area are *Commiphora glaucescens*, *C. virgata* and *C. dinteri* as well as *Boscia albitrunca* and *B. foetida*. The grass cover is sparse and consists of the climax grasses *Stipagrostis obtusa* and *S. uniplumis* (Giess 1971).

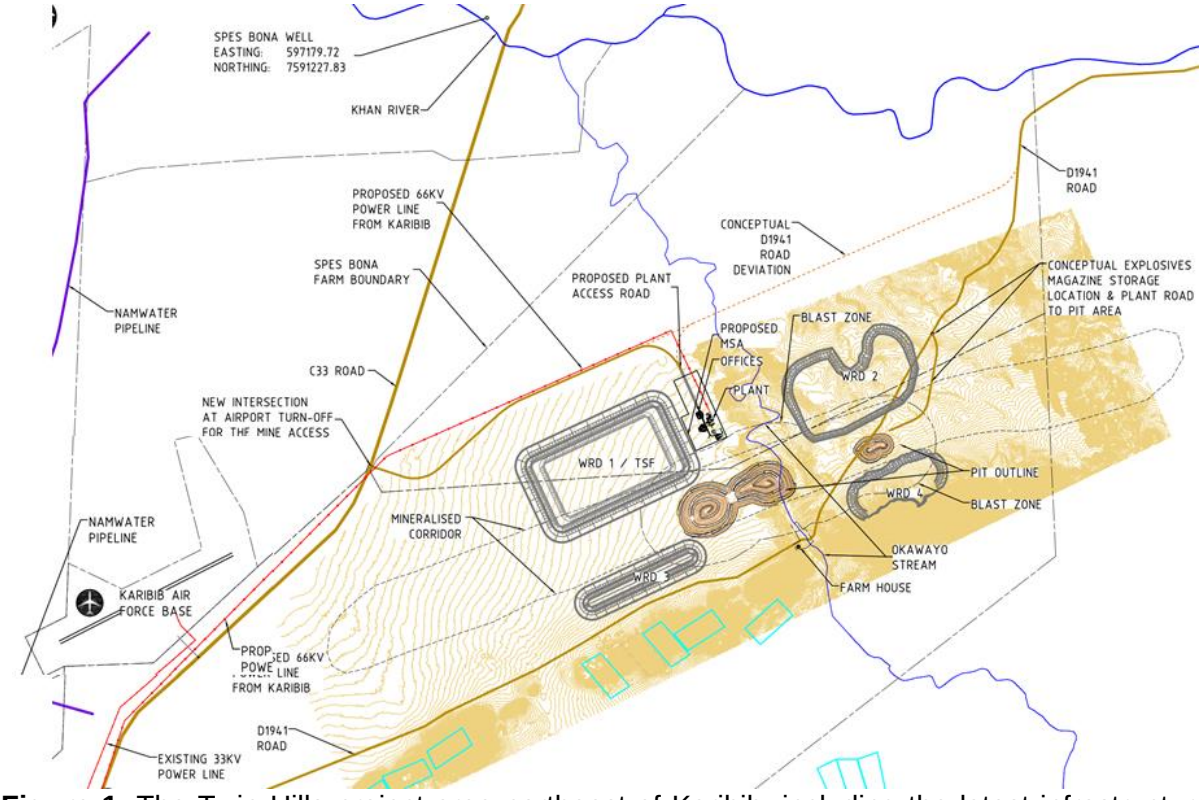

Figure 1. The Twin Hills project area northeast of Karibib, including the latest infrastructure layout (WRD 1-4; TSF; Plant and Admin block; 66kV transmission line; access route; water pipeline, etc.), in the Erongo Region.

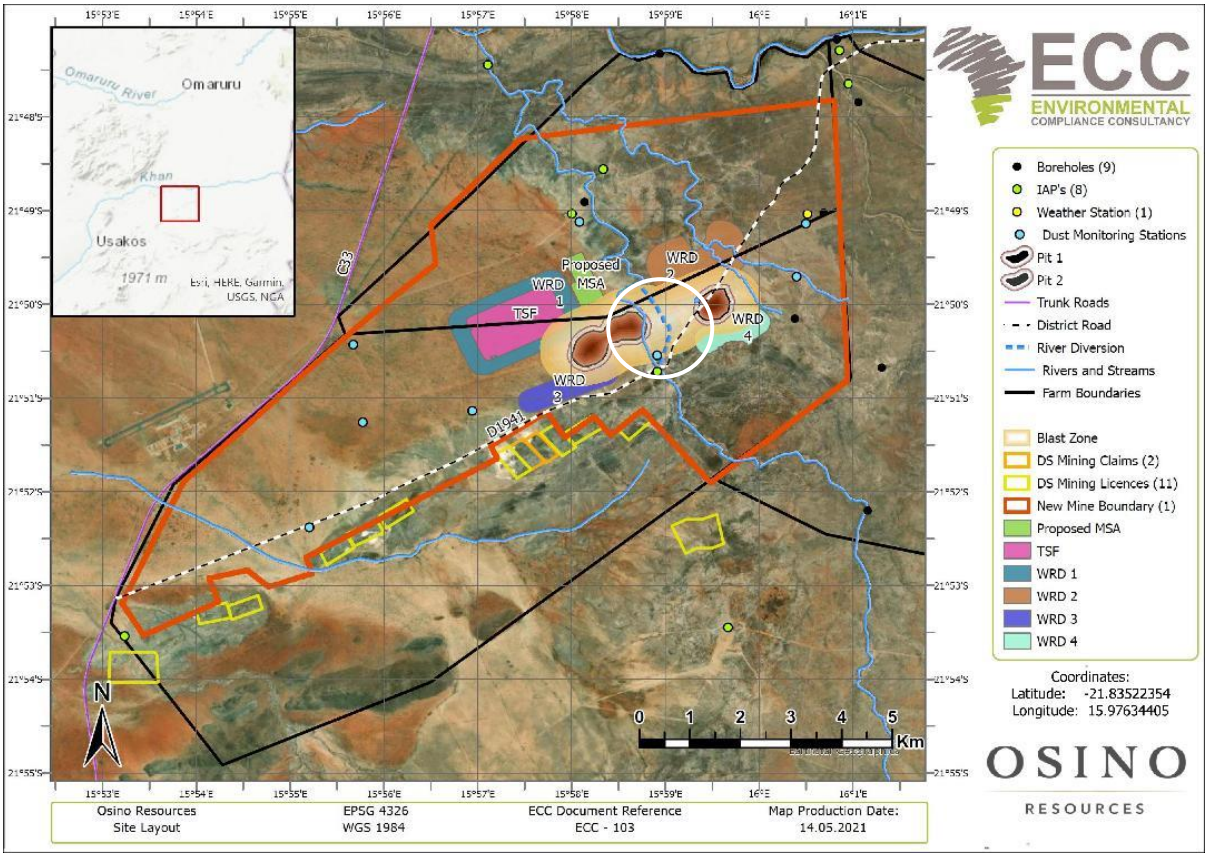

Figure 2. The proposed infrastructure layout, including the proposed Okawayo River diversion (blue dotted line – See white circle).

The Namib Desert biome is well protected with parks in this biome making up 69% of the network compared to only 7% of the Savannah biome being formally protected and the Mountain Savannah area being wholly under protected (Barnard 1998). Escarpments, mountains and inselbergs are generally considered as sites of special ecological importance with granite domes (Karibib and Omaruru districts) high in biotic richness and endemism (Curtis and Barnard 1998).

The Karibib area in general is regarded as “moderate” in overall (all terrestrial species) diversity while the overall terrestrial endemism in the area on the other hand is “high” (Mendelsohn *et al.* 2002). The overall diversity and abundance of large herbivorous mammals (big game) is viewed as “moderate” with 3-4 species expected – e.g. gemsbok, kudu, mountain zebra and springbok – while overall diversity and density of large carnivorous mammals (large predators) is viewed as “moderate” with 4 species expected – e.g. leopard, cheetah, spotted and brown hyena (Mendelsohn *et al.* 2002).

The general Karibib area is viewed as an area of importance for local endemic plant species, especially the Erongo Mountains with between 26-35 endemic species (Mendelsohn *et al.* 2002). The overall plant diversity (all species) in the general Karibib area is estimated at between 150-299 species and the Erongo Mountain area between 400-499 species (Mendelsohn *et al.* 2002). These estimates are limited to “higher” plants as information regarding “lower” plants is sparse. The greatest variants affecting the diversity of plants are habitat and climate with the highest plant diversity generally associated with high rainfall areas. Pockets of high diversity are found throughout Namibia in “unique” habitat – often transition zones – e.g. mountains, inselbergs, etc. Plant endemism, other than the Erongo Mountains, is viewed as “medium to high” – with between 6-15 endemics expected from the

general area (Mendelsohn *et al.* 2002). Furthermore, Mendelsohn *et al.* (2002) views the overall plant production as medium to low in the general Karibib area and high in the Erongo Mountains, the availability of hardwoods as medium and the grazing and browse as average in the general area. Bush thickening (encroachment) is viewed as problematic between Karibib and Omaruru with *Acacia reficiens* (red-bark Acacia) the dominant problem species (Bester 1996, Cunningham 1998, Mendelsohn *et al.* 2002).

The carrying capacity for the general area is 10-20kg/ha (Mendelsohn *et al.* 2002) or 12-15LAU/ha (van der Merwe 1983) and the risk of farming is viewed as relatively high. Sheep farming is the dominant farming activity in the Karibib area with between 70-80% of stock farmed with being sheep and 20-30% goats and cattle, respectively (van der Merwe 1983). The stock density is estimated at <3sheep/km² (1.5% of total sheep in Namibia) and <1cattle/km² (1.3% of total cattle in Namibia) (van der Merwe 1983). There are numerous existing tourism ventures in the area with the tourism potential viewed as relatively high (Mendelsohn *et al.* 2002).

The area does not fall within a Communal Conservancy with the closest being ǂGaingu located in the Spitskoppe area to the west of Karibib, neither within a Freehold (i.e. commercial) Conservancy with Okawi being the closest, east of Karibib (Mendelsohn *et al.* 2002, NACSO 2010, See: www.nacso.org.na).

It is estimated that at least 75 species of reptile, 7 amphibian, 88 mammal, 217 birds, 74-101 larger trees and shrubs and up to 80 grass species occur in the general/immediate Karibib area of which a high proportion are endemics (e.g. reptiles – 45.3%).

2 Methods

2.1 Literature review

A comprehensive and intensive literature review (i.e. desktop study) regarding the reptiles, amphibians, mammals, birds, larger trees and shrubs (>1m in height) and grasses that could potentially occur in the general Karibib area (including the proposed updated infrastructure layout areas) was conducted using as many references as manageable.

A previous study conducted on the general area, including the original proposed infrastructure layout, and fieldwork conducted by Cunningham (2021) at these infrastructure sites, was used as supplementary material.

A list of the references consulted can be viewed in the Reference section (Page 52).

3 Results

3.1 Reptile Diversity

Reptile diversity known and/or expected to occur in the Karibib area, including species confirmed from the general area (See Cunningham 2011, 2013, 2017) as well as during the recent fieldwork conducted by Cunningham (2021), is presented in Table 1.

Approximately 261 species of reptiles are known or expected to occur in Namibia thus supporting approximately 30% of the continents species diversity (Griffin 1998a). At least 22% or 55 species of Namibian lizards are classified as endemic. The occurrence of reptiles of “conservation concern” includes about 67% of Namibian reptiles (Griffin 1998a). Emergency grazing and large scale mineral extraction in critical habitats are some of the biggest problems facing reptiles in Namibia (Griffin 1998a). The overall reptile diversity and endemism in the general Karibib area is estimated at between 41-70 species and 21-28

species, respectively (Mendelsohn *et al.* 2002). Griffin (1998a) presents figures of between 21-30 and 7-8 for endemic lizards and snakes, respectively, from the general area, while the closest protected areas, the Skeleton Coast and Namib-Naukluft National Parks, have an estimated 77 and 100 species, respectively. There is currently no data for the !Dorob National Park.

Reptile species observed and/or confirmed from the Navachab Gold Mine area (approximately 40km southwest of the study area) included 1 tortoise, 1 terrapin, 5 snakes, 9 lizards, 1 monitor lizard, 2 agamas and 8 geckos (i.e. 27 species) (Cunningham 2011) while reptiles confirmed from the Helikon/Rubicon Lithium Mine (approximately 30km south of the study area) area include 2 skinks, 1 Old World lizard and 2 agamas (i.e. 5 species) (Cunningham 2013) and 1 python, 1 skink, 2 Old World lizards, 1 agama and 1 gecko (i.e. 6 species) (Cunningham (2017).

At least 75 species of reptiles are expected to occur in the Karibib area with 34 species being endemic – i.e. 45.3% endemic. These consist of at least 30 snakes (1 blind snake, 2 thread snake, 2 python, 2 burrowing snakes and 23 typical snakes), 11 of which are endemic (33.3%) to Namibia, 2 tortoises, 1 terrapin, 42 lizards (1 worm lizard, 10 skinks, 6 Old World lizards, 2 plated lizards, 1 girdled lizard, 1 monitor lizard, 3 agamas, 1 chameleon and 17 geckos), 23 (54.8%) of which are endemic to Namibia. Skink's (10 species), Old World lizards (6 species) and gecko's (17 species) are the most numerous lizards expected from the general area. Namibia with approximately 129 species of lizards (Lacertilia) has one of the continents richest lizard fauna (Griffin 1998a). Geckos have the highest occurrence of endemics in the general area with 13 of the 17 species (76.5%) expected and/or known to occur in the area, being endemic to Namibia.

According to the Namibian legislation 3 species are viewed as rare (*Rhinotyphlops lalandei*, *Limaformosa (Mehelya) vernayi*, *Afroedura africana*), 4 species as vulnerable (*Stigmochelys pardalis*, *Psammobates oculiferus*, *Python natalensis*, *Varanus albigularis*), 5 species as protected game, 4 species insufficiently known and 3 species as peripheral. The IUCN (2021) classifies 37 species as least concern although not all the reptiles have yet been assessed by the IUCN Red List. The SARDB (2004) classifies 1 species as vulnerable, 1 species as safe to vulnerable and 2 species as peripheral while CITES lists 7 species under Appendix 2 and 1 species under Appendix 3. Due to the fact that reptiles are an understudied group of animals, especially in Namibia, it is expected that more species may be located in the general area than presented above.

Cunningham (2021) confirmed 20 species during summer and winter observations from the area while a total of at least 28 species are confirmed from the general area if one includes species identified by Cunningham (2011, 2013 and 2017) – See Table 1.

Table 1. Reptile diversity expected (literature study) and confirmed by Cunningham (2021) ($\surd^S$ = summer 2021 and $\surd^W$ = winter 2021) including author's confirmed records (and farm manager sightings - √#) from other studies conducted from the general area (See: Cunningham 2011, 2013, 2017).

Species: Scientific name	Species: Common name	Cunningham, Twin Hills (2021)	Navachab Gold (2011)	Helikon Lithium (2013)	Helikon/ Rubicon Lithium (2017)	Namibian conservation and legal status	International status		
							SARDB	IUCN	CITES
TORTOISES AND TERRAPINS									
Stigmochelys pardalis	Leopard Tortoise	√#				Vulnerable; Peripheral; Protected Game		LC	C2
Psammobates oculiferus	Kalahari Tent Tortoise					Vulnerable; Protected Game			C2
Pelomedusa subrufa	Marsh/Helmeted Terrapin	$\surd^S$	√			Secure			C3
SNAKES									
Blind Snakes									
Rhinotyphlops lalandei	Delalande's Beaked Blind Snake					Insufficiently known; Rare?			
Thread Snakes									
Namibiana (Leptotyphlops) occidentalis	Western Thread Snake					Endemic; Secure	P	LC	
Namibiana (Leptotyphlops) labialis	Damara Thread Snake					Endemic; Secure		LC	
Pythons									
Python anchietae	Dwarf Python					Endemic; Insufficiently known; Protected game		LC	C2
Python natalensis	Southern African Python	√#			√	Vulnerable; Peripheral; Protected Game	V		C2
Burrowing Snakes									
Atractaspis bibronii	Bibron's Burrowing Asp					Secure			
Xenocalamus bicolour bicolor	Bicoloured Quill-snouted Snake					Secure			
Typical Snakes									
Boaedon (Lamprophis) fuliginosus	Brown House Snake								
Lycophidion capense	Cape Wolf Snake								
Lycophidion namibianum	Namibian Wolf Snake					Endemic; Secure		LC	
Mehelya capensis	Cape File Snake					Secure			
Limaformosa (Mehelya) vernayi	Angola File Snake					Insufficiently known; Rare?		LC	
Pseudaspis cana	Mole Snake	$\surd^W$				Secure			

Pythonodipsas carinata	Western Keeled Snake					Endemic; Secure		LC
Prosymna frontalis	South-western Shovel-snout					Endemic; Secure	P	LC
Hemirhagerrhis viperinus	Viperine Bark Snake					Endemic; Secure		
Dipsina multimaculata	Dwarf Beaked Snake					Endemic; Secure		
Psammophis trigrammus	Western Sand Snake					Endemic; Secure		LC
Psammophis notostictus	Karoo Sand Snake					Secure		
Psammophis leightoni namibensis	Namib Sand Snake					Secure		LC
Psammophis brevirostris leopardinus	Leopard Grass Snake					Endemic; Secure		
Philothamnus semivariegatus	Spotted Bush Snake					Secure		
Dasypeltis scabra	Common/Rhombic Egg Eater					Secure		LC
Telescopus semiannulatus polystrictus	Eastern Tiger Snake					Secure		
Aspidelaps lubricus infuscatus	Coral Snake					Secure		
Aspidelaps scutatus scutatus	Shield-nose Snake					Secure		
Naja nivea	Cape Cobra					Secure		
Naya nigricincta	Black-necked Spitting Cobra	√#				Endemic; Secure		
Bitis arietans	Puff Adder	√#				Secure		
Bitis caudalis	Horned Adder	√#				Secure		
WORM LIZARDS								
Zygaspis quadrifrons	Kalahari Round-headed Worm Lizard					Secure		
LIZARDS								
Skinks								
Typhlosaurus braini	Brain's Blind Legless Skink					Endemic; Secure		LC
Typhlacontias brevipes	FitzSimon's Burrowing Skink					Endemic; Secure		LC
Trachylepis acutilabris	Wedge-snouted Skink	√S,W	√	√		Secure		LC
Trachylepis capensis	Cape Skink					Secure		
Trachylepis hoeschi	Hoesch's Skink					Endemic; Secure		LC
Trachylepis occidentalis	Western Three-striped Skink					Secure		
Trachylepis spilogaster	Kalahari Tree Skink	√S,W				Endemic; Secure		
Trachylepis striata wahlbergi	Striped Skink	√S				Secure		
Trachylepis sulcata	Western Rock Skink		√	√	√	Secure		
Trachylepis variegata variegata	Variegated Skink	√S,W	√			Secure		
Old World Lizards								
Heliobolus lugubris	Bushveld Lizard	√W				Secure		
Meroles suborbitalis	Spotted Desert Lizard		√			Secure		LC
Pedioplanis breviceps	Short-headed Sand Lizard					Endemic; Secure		LC
Pedioplanis namaquensis	Namaqua Sand Lizard	√S,W	√		√	Secure		

Pedioplanis undata	Western Sand Lizard	√S,W	√		√	Endemic; Secure	LC	
Pedioplanis inornata	Plain Sand Lizard	√S,W		√		Endemic; Secure	LC	
Plated Lizards								
Cordylosaurus subtessellatus	Dwarf Plated Lizard					Endemic; Secure	LC	
Matabosaurus maltzahani (Gerrhosaurus validus)	Giant Plated Lizard		√			Secure	LC	
Girdled Lizards								
Karusasaurus (Cordylus) jordani	Jordan's Girdled Lizard					Endemic; Secure	LC	C2
Monitors								
Varanus albigularis	Rock or White-throated Monitor	√#	√			Vulnerable; Peripheral; Protected Game	S to V	C2
Agamas								
Agama achuleata	Ground Agama	√W	√	√		Secure		
Agama anchietae	Anchietae's Agama	√S		√		Secure	LC	
Agama planiceps	Namibian Rock Agama	√S	√	√	√	Endemic; Secure	LC	
Chameleons								
Chamaeleo namaquensis	Namaqua Chameleon	√#				Secure	LC	C2
Geckos								
Afroedura africana	African Flat Gecko					Endemic; Insufficiently known; Rare	LC	
Chondrodactylus angulifer	Giant Ground Gecko					Endemic; Secure	LC	
Lygodactylus bradfieldi	Bradfield's Dwarf Gecko	√S,W				Endemic; Secure		
Narudasia festiva	Festive Gecko					Endemic; Secure	LC	
Pachydactylus bicolour	Velvety Thick-toed Gecko					Endemic; Secure		
Pachydactylus capensis	Cape Thick-toed Gecko					Endemic; Secure		
Pachydactylus fasciatus	Banded Thick-toed Gecko		√			Endemic; Secure	LC	
Pachydactylus kochii	Koch's Thick-toed Gecko					Endemic; Secure	LC	
Pachydactylus turneri	Turner's Thick-toed Gecko		√			Secure		
Pachydactylus punctatus	Speckled Thick-toed Gecko	√S				Secure		
Pachydactylus rugosus	Rough Thick-toed Gecko					Endemic; Secure	LC	
Pachydactylus scherzi	Namib Variable Gecko					Endemic; Secure	LC	
Pachydactylus weberi	Weber's Thick-toed Gecko					Secure	LC	
Ptenopus garrulus	Common Barking Gecko					Secure	LC	
Rhoptropus afer	Common Namib Day Gecko					Endemic; Secure	LC	
Rhoptropus boultoni	Boulton's Namib Day Gecko		√		√	Endemic; Secure	LC	
Rhoptropus bradfieldi	Bradfield's Namib Day Gecko					Endemic; Secure	LC	

Namibian conservation and legal status according to the Nature Conservation Ordinance No 4 of 1975

Endemic – includes Southern African Status (Branch 1998)
SARDB (2004): S to V – Safe to Vulnerable; V – Vulnerable; P – Peripheral
IUCN (2021): LC – Least Concern [All other species not yet assessed]
CITES: CITES Appendix 2/3 species

Source for literature review: Alexander and Marais (2007), Branch (1998), Branch (2008), Boycott and Bourquin (2000), Broadley (1983), Buys and Buys (1983), Cunningham (2006), Cunningham (2011), Cunningham (2013), Cunningham (2017), Cunningham (2021), Griffin (2003), Hebbard (n.d.), IUCN (2021), Marais (1992), SARDB (2004), Tolley and Burger (2007)

The most important species expected to occur in the general area (See Table 1) are viewed as the tortoises *Stigmochelys pardalis* and *Psammobates oculiferus*; pythons – *P. anchietae* and *P. natalensis*; Namibian wolf snake (*Lycophidion namibianum*) – *Varanus albigularis* and some of the endemic and little known gecko species – e.g. *Pachydactylus* species. Tortoises, snakes and monitor lizards are routinely killed for food or as perceived threats. Other important species are those viewed as "rare" – i.e. *Rhinotyphlops lalandei*, *Mehelya vernayi* and *Afroedura africana* – although very little is known about these species.

Infrastructure impact

Plant site/waste rock dumps/ tailings storage facility (TSF)/open pits

The impact during construction, are expected to be detrimental to reptiles associated with the affected area/habitat.

The impact of aboveground plant site infrastructure is not expected to be detrimental to reptiles – i.e. would not impede their movement, etc. However, the lighting and artificial habitat is expected to attract certain reptiles to the area (e.g. certain gecko species, etc.).

The impact of the waste rock dumps is not expected to be detrimental to reptiles – i.e. would not impede their movement, etc. However, the artificial habitat is expected to attract certain reptiles to the area (e.g. certain gecko species, snakes, agamas, etc.). Furthermore, WRD 2 would cover parts of the northern tributaries of the Okawayo River and should be avoided.

The impact of the TSF is not expected to be detrimental to reptiles – i.e. would not impede their movement, etc. However, the artificial habitat is expected to attract certain reptiles to the area (e.g. certain snakes, etc.).

The impacts of the open pit(s) are expected to be detrimental to reptiles associated with the affected area/habitat and/or could act as pitfall traps. However, most reptiles known/expected to occur in the area are small lacertid and gecko species which would probably use the pit(s) as part of their habitat and/or rather be attracted to the rocky waste dumps as more suitable habitat.

The impacts of the mining activities are expected to be detrimental to reptiles associated with the affected area/habitat especially slow moving and/or sedentary species. All vehicle activities (including long hauling) should abide by the speed limits to avoid road mortalities. However, the overall low densities of all reptile species in the mining area would negate the problem.

Pipeline impact

The impact of heavy machinery during excavation of a trench to bury the proposed water pipeline is expected to be detrimental to reptiles associated with the affected area/habitat. This would affect a relatively small area over a short/limited period of time.

However, an open trench could act as a giant pitfall trap and should not be left open overnight and/or have regular exists along its route, especially at the two ends of the trench.

The impact of above/below ground pipeline infrastructure is not expected to be detrimental to reptiles – i.e. would not impede their movement, etc.

Transmission line impact (66kV)

The impact of heavy machinery during construction, and especially the excavation of holes to plant pylons for the proposed transmission line are expected to be detrimental to reptiles associated with the affected area/habitat. This would affect a relatively small area over a short/limited period of time.

However, open holes could act as pitfall traps and should not be left open overnight and/or covered.

The impact of aboveground transmission line infrastructure is not expected to be detrimental to reptiles – i.e. would not impede their movement, etc.

Access route impact
The impact of an access route is not expected to be detrimental to most reptiles as there are numerous existing tracks throughout the general area and the overall footprint is small. However, track discipline should be maintained (e.g. minimise speed (e.g. 40km/h), no off-road driving, limited nocturnal driving, etc.), speed humps and vehicle calming devices should be incorporated along the route. This should act as mitigation measure for important slow moving, especially nocturnal, reptiles.

A tarmac access route would result in less dust pollution and make installing the speed humps and vehicle calming devices, etc. easier than a gravel route. However, a tarmac access route would attract certain reptiles (e.g. nocturnal species) to it for basking due to its retention and slow release of heat, resulting in potentially more mortalities. This could be negated by limiting nocturnal vehicle activity along this route.

Furthermore, none of the unique/important species are exclusively associated with the proposed development area.

Okawayo River diversion
The impact during construction, are expected to be detrimental to reptiles associated with the affected area/habitat.

Species using the riparian vegetation habitat and/or the river system as a thoroughfare would be negatively affected although the proposed diversion would become vegetated over time and eventually serve the same purpose.

The Twin Hills project area has been heavily impacted due to current/past mining (e.g. marble quarrying) and farming activities and none of the unique reptiles are expected to be exclusively associated with this area.

3.2 Amphibian Diversity

Amphibian diversity known and/or expected to occur in the Karibib area, including species confirmed from the general area (See Cunningham 2011, 2013, 2017) as well as during the recent fieldwork conducted by Cunningham (2021), is presented in Table 2.

Amphibians are declining throughout the world due to various factors of which much has been ascribed to habitat destruction. Basic species lists for various habitats are not always available with Namibia being no exception in this regard while the basic ecology of most species is also unknown. Approximately 4,000 species of amphibians are known worldwide with just over 200 species known from southern Africa and at least 57 species expected to occur in Namibia. Griffin (1998b) puts this figure at 50 recorded species and a final species richness of approximately 65 species, 6 of which are endemic to Namibia. This “low” number of amphibians from Namibia is not only as a result of the generally marginal desert habitat, but also due to Namibia being under studied and under collected. Most amphibians require water to breed and are therefore associated with the permanent water bodies, mainly in northeast Namibia.

Table 2. Amphibian diversity expected (literature study) and confirmed by Cunningham (2021) ($\surd^S$ = summer 2021) including author's confirmed records from other studies conducted from the general area (See: Cunningham 2011, 2013, 2017).

Species: Scientific name	Species: Common name	Cunningham (2021)	Navachab Gold (2011)	Helikon Lithium (2013)	Helikon/ Rubicon Lithium (2017)	Namibian conservation and legal status	International Status: IUCN
Toads							
Amietophrynus poweri	Western Olive Toad						LC
Poyntonophrynus hoeschi	Hoesch's Pygmy Toad		√			Endemic	LC
Rubber Frog							
Phrynomantis annectens	Marbled Rubber Frog	$\surd^S$	√			Endemic	LC
Puddle Frog							
Phrynobatrachus mababiensis	Dwarf Puddle Frog						LC
Bullfrogs							
Pyxicephalus adspersus	Giant Bullfrog					Near threatened	LC
Sand Frogs							
Tomopterna tandyi	Tandy's Sand Frog						LC
Platannas							
Xenopus laevis	Common Platanna						LC

Endemic – (Griffin 1998b)
Near threatened – (Du Preez and Carruthers 2009)
IUCN (2021): LC – Least Concern

Source for literature review: Carruthers (2001), Channing (2001), Channing and Griffin (1993), Cunningham (2011), Cunningham (2013), Cunningham (2017), Cunningham (2021), Du Preez and Carruthers (2009), IUCN (2021), Passmore and Carruthers (1995), SARDB (2004)

According to Mendelsohn *et al.* (2002), the overall frog diversity in the general Karibib area is estimated at between 4-7 species. Griffin (1998b) puts the species richness in the general area at 10 species, while the closest protected areas, the Skeleton Coast and Namib-Naukluft National Parks, have an estimated 10 and 9 species, respectively. There is currently no data for the !Dorob National Park.

Amphibian species observed and/or confirmed from the Navachab Gold Mine area (approximately 40km southwest of the study area) included 1 toad and 1 rubber frog (Cunningham 2011) while no amphibians were confirmed from the Helikon/Rubicon Lithium Mine (approximately 30km south of the study area) area (Cunningham 2013, 2017).

At least 7 species of amphibians are expected to occur in suitable habitat in the Karibib area. The area is under represented, with 2 toads, and 1 species each for rubber, puddle, bullfrog, sand and platanna known and/or expected (i.e. potentially could be found in the area) to occur in the area. Of these, 2 species are endemic (*Poyntonophrynus* (*Bufo*) *hoeschi* and *Phrynomantis annectens*) (Griffin 1998b) and 1 species is classified as "near threatened" (*Pyxicephalus adspersus*) (Du Preez and Carruthers 2009) – i.e. high level (42.9%) of amphibians of conservation value from the general area.

Two species – *Poyntonophrynus hoeschi* and *Phrynomantis annectens* – were confirmed from the Navachab Gold Mine area (Cunningham 2011) while no amphibians were confirmed from the Helikon and Rubicon Mining areas south of Karibib (Cunningham 2013, 2017).

Cunningham (2021) confirmed 1 species – *Phrynomantis annectens* (Marbled Rubber Frog) – from the area.

Important species include the 2 endemics – *Poyntonophrynus hoeschi* and *Phrynomantis annectens* and *Pyxicephalus adspersus* which are classified as "near threatened" in southern Africa (Du Preez and Carruthers 2009). The latter species numbers are decreasing throughout its range in Namibia mainly due to being targeted as food (Griffin *pers. com*). Although *Phrynomantis annectens* tadpoles observed, confirmed their presence in the area, they occur widespread throughout Namibia and are not exclusively associated with the Twin Hills project area.

Infrastructure impact

Plant site/waste rock dumps/ tailings storage facility (TSF)/open pits

The impact of aboveground plant site infrastructure is not expected to be detrimental to amphibians – i.e. would not affect their habitat or impede their movement, etc.

The impact of the waste rock site is not expected to be detrimental to amphibians – i.e. would not affect their habitat or impede their movement, etc. Furthermore, WRD 2 would cover parts of the northern tributaries of the Okawayo River and should be avoided.

The impact of tailings dump site is not expected to be detrimental to reptiles – i.e. would not affect their habitat or impede their movement, etc. However, the artificial habitat could potentially attract amphibians to the area.

The impacts of the open pit(s) are not expected to be detrimental to amphibians – i.e. would not affect their habitat or impede their movement, etc. The Okawayo River (and its tributaries), pans, ground dams and farm reservoirs are all potential amphibian habitat and affecting these would affect the available habitat throughout the area.

The impacts of the mining activities are not expected to be detrimental to amphibians due to a lack of open surface water and overall marginal amphibian habitat. All vehicle activities (including long hauling) should abide by the speed limits to avoid road mortalities. However,

the lack of open surface water and overall marginal amphibian habitat in the mining area would negate the problem.

Pipeline impact
The impact of above/below ground pipeline infrastructure is not expected to be detrimental to amphibians – i.e. would not affect their habitat or impede their movement, etc.

Transmission line impact (66kV)
The impact of aboveground transmission line infrastructure is not expected to be detrimental to amphibians – i.e. would not affect their habitat or impede their movement, etc.

Access route impact
The impact of an access route is not expected to be detrimental to amphibians as there are numerous existing tracks throughout the general area; open surface water is only temporary of nature (i.e. after local flooding) and the overall footprint is small. However, track discipline should be maintained (e.g. minimise speed (e.g. 40km/h), no off-road driving, limited nocturnal driving, etc.), speed humps and vehicle calming devices should be incorporated along the route. This should act as mitigation measure for important slow moving, especially nocturnal, amphibians.

A tarmac access route would result in less dust pollution and make installing the speed humps and vehicle calming devices, etc. easier than a gravel route. However, a tarmac access route with culverts and drainage pipes could retain water and serve as artificial habitat luring amphibians to the road with potentially more mortalities. This could be negated by limiting nocturnal vehicle activity along this route.

Furthermore, none of the unique/important species are exclusively associated with the proposed development area.

Okawayo River diversion
The impact during construction, are expected to be detrimental to amphibians associated with the affected area/habitat.

Species using the riparian vegetation habitat and/or the river system as a thoroughfare would be negatively affected although the proposed diversion would become vegetated over time and eventually serve the same purpose.

The Twin Hills project area has been heavily impacted due to current/past mining (e.g. marble quarrying) and farming activities and none of the unique amphibians are expected to be exclusively associated with this area.

3.3 Mammal Diversity

Mammal diversity known and/or expected to occur in the Karibib area, including species confirmed from the general area (See Cunningham 2011, 2013, 2017) as well as during the recent fieldwork conducted by Cunningham (2021), is presented in Table 3.

Namibia is well endowed with mammal diversity with at least 250 species occurring in the country. These include the well known big and hairy as well as a legion of smaller and lesser-known species. Currently 14 mammal species are considered endemic to Namibia of which 11 species are rodents and small carnivores of which very little is known. Most endemic mammals are associated with the Namib and escarpment with 60% of these rock-dwelling (Griffin 1998c). According to Griffin (1998c) the endemic mammal fauna is best characterized by the endemic rodent family *Petromuridae* (Dassie rat) and the rodent genera *Gerbillurus* and *Petromyscus*.

Table 3. Mammal diversity expected (literature study) and confirmed by Cunningham (2021) ($\surd^{S}$ = summer 2021 and $\surd^{W}$ = winter 2021) including author's confirmed records (and farm manager sightings - √#) from other studies conducted from the general area (See: Cunningham 2011, 2013, 2017).

Species: Scientific name	Species: Common name	Cunningham, Twin Hills (2021)	Navachab Gold (2011)	Helikon Lithium (2013)	Helikon/ Rubicon Lithium (2013)	Namibian conservation and legal status	International status		
							SARDB	IUCN	CITES
Elephant Shrews									
Macroscelides proboscideus	Round-eared Elephant-shrew					Endemic; Secure			
Elephantulus rupestris	Western Rock Elephant-shrew					Secure			
Elephantulus intufi	Bushveld Elephant-shrew	$\surd^{S,W}$	√	√	√	Secure	DD		
Aardvark									
Orycteropus afer	Aardvark	$\surd^{W}$	√		√	Secure; Protected Game			
Shrews						Secure	DD		
Crocidura fuscomurina	Tiny Musk Shrew								
Crocidura cyanea	Reddish-grey Musk Shrew					Secure	DD		
Hyrax									
Procavia capensis	Rock Hyrax	$\surd^{S}$	√	√	√	Secure; Problem animal			
Bats									
Eidolon helvum	African Straw-coloured Fruit Bat					Secure (Migrant)	NT	NT	
Mops midas	Midas Free-tailed Bat					Secure			
Miniopterus natalensis	Natal Long-fingered Bat					Secure	NT		
Mimetillus thomasi	Thomas's Flat-headed Bat					Not listed			
Sauromys petrophilus	Flat-headed Free-tailed Bat					Secure			
Tadarida aegyptiaca	Egyptian Free-tailed Bat					Secure			
Neoromicia capensis	Cape Serotine Bat					Secure			
Neoromicia zuluensis	Zulu Serotine Bat					Secure			
Nycticeinops schlieffeni	Schleiffen's Twighlight Bat					Secure			
Pipistrellus rueppellii	Rüppell's Pipistrelle					Insufficiently known; Peripheral			
Pipistrellus rusticus	Rusty Pipistrelle					Not listed			
Cistugo seabrai	Namibian Wing-gland Bat					Endemic; Rare	V		
Eptesicus hottentotus	Long-tailed Serotine Bat					Secure			

Scotophilus dinganii	African Yellow Bat					Secure		
Nycteris thebaica	Egyptian Slit-faced Bat					Secure		
Rhinolophus fumigatus	Rüppell's Horseshoe Bat					Secure	NT	
Rhinolophus clivosus	Geoffroy's Horseshoe Bat					Secure	NT	
Rhinolophus darlingi	Darling's Horseshoe Bat					Secure	NT	
Rhinolophus denti	Dent's Horseshoe Bat					Secure	NT	
Rhinolophus hildebrandtii	Hildebrandt's Horseshoe Bat					Not listed		
Macronycteris (Hipposideros) commersoni	Commerson's Roundleaf Bat					Secure		NT
Hipposideros caffer	Sundevall's Roundleaf Bat					Secure	DD	
*Macronycteris (Hipposideros) gigas**	Giant Leaf-nosed Bat					Not listed		
Macronycteris (Hipposideros) vittatus	Striped Leaf-nosed Bat					Not listed		NT
Hares and Rabbits								
Lepus capensis	Cape Hare	√S	√	√		Secure		
Lepus saxatilis	Scrub Hare					Secure		
Pronolagus randensis	Jameson's Red Rock Rabbit					Secure		
Rodents								
Porcupine								
Hystrix africaeaustralis	Cape Porcupine	√#	√	√	√	Secure		
Rats and Mice								
Petromys typicus	Dassie Rat	√S,W	√	√		Endemic; Secure	NT	
Pedetes capensis	Springhare					Secure		
Xerus inaurus	South African Ground Squirrel	√W	√			Secure		
Xerus princeps	Damara Ground Squirrel					Endemic	NT	
Graphiurus rupicola/platyops	Western Rock Dormouse					Endemic; Secure	DD	
Graphiurus murinus	Woodland Dormouse					Secure		
Rhabdomys pumilio	Four-striped Grass Mouse		√			Secure		
Mus indutus	Desert Pygmy Mouse		√			Secure		
Mastomys natalensis	Natal Multimammate Mouse					Secure		
Mastomys coucha	Southern Multimammate Mouse					Secure		
Thallomys paedulcus	Acacia Rat					Secure		
Thallomys nigricauda	Black-tailed Tree Rat					Secure		
Aethomys chrysophilus	Red Veld Rat					Secure		
Micaelamys namaquensis	Namaqua Rock Mouse	√S,W	√			Secure		
Desmodillus auricularis	Cape Short-tailed Gerbil					Secure		

Gerbillurus paeba	Hairy-footed Gerbil					Secure			
Gerbillurus setzeri	Setzer's Hairy-footed Gerbil					Endemic			
Tatera leucogaster	Bushveld Gerbil	√S,W	√		√	Secure	DD		
Saccostomus campestris	Pouched Mouse				√	Secure			
Malacothrix typica	Gerbil Mouse					Secure			
Petromyscus collinus	Pygmy Rock Mouse					Endemic; Secure			
Mus musculus	House Mouse					Invasive alien			
Primates									
Galago moholi	South African Galago					Vulnerable; Protected Game			C2
Papio ursinus	Chacma Baboon	√S,W	√	√		Secure; Problem animal			C2
Hedgehog									
Atelerix frontalis angolae	Southern African Hedgehog		√			Insufficiently Known; Rare; Protected Game	NT; R		
Carnivores									
Proteles cristatus	Aardwolf	√#				Insufficiently known; (Vulnerable?) Peripheral			
Parahyaena (Hyaena) brunnea	Brown Hyena	√#				Insufficiently known; (Vulnerable?) Peripheral	NT	NT	
Crocuta crocuta	Spotted Hyena					Secure?; Peripheral	NT		
Acinonyx jubatus	Cheetah		√	√		Vulnerable; Protected Game	V	V	C1
Panthera pardus	Leopard	√S				Secure?; Peripheral; Protected Game		V	C1
Caracal caracal	Caracal					Secure; Problem Animal			C2
Felis silvestris	African Wild Cat	√S	√	√		Vulnerable			C2
Genetta genetta	Small Spotted Genet	√#				Secure			
Suricata suricatta marjoriae	Suricate					Endemic; Secure			
Cynictis penicillata	Yellow Mongoose	√S,W	√		√	Secure			
Galerella sanguinea	Slender Mongoose	√S				Secure			
Galerella flavescens (nigrata)	Kaokoland/Black Slender Mongoose					Endemic; Secure			
Otocyon megalotis	Bat-eared Fox	√#				Vulnerable?; Peripheral			
Vulpes chama	Cape Fox					Vulnerable?			
Canis mesomelas	Black-backed Jackal	√S,W	√		√	Secure; Problem animal			
Mellivora capensis	Honey Badger/Ratel		√			Secure; Protected Game	NT		
Ictonyx striatus	Striped Polecat					Secure			

Equidae									
Equus zebra hartmannae	Hartmann's Mountain Zebra		√	√		Endemic; Secure; Specially Protected Game	E	V	C2
Suidae									
Phacochoerus africanus	Common Warthog	√S,W	√			Secure; Huntable Game			
Antelopes									
Giraffa camelopardalis	Giraffe	√S	√			Vulnerable; Peripheral; Specially Protected Game		V	
Tragelaphus strepsiceros	Greater Kudu	√W;√#	√	√	√	Secure; Huntable Game			
Oryx gazella	Gemsbok	√S	√			Secure; Huntable game			
Sylvicapra grimmia	Common Duiker	√S	√			Secure			
Antidorcas marsupialis	Springbok	√S,W	√			Secure; Huntable game			
Madoqua damarensis	Damara Dik-dik					Insufficiently Known; Protected Game			
Raphicerus campestris	Steenbok	√S,W	√	√	√	Secure; Protected Game			
Oreotragus oreotragus	Klipspringer		√	√	√	Secure; Specially Protected Game			

SARDB (2004): R – Rare, E – Endangered, V – Vulnerable, NT – Near Threatened, DD – Data Deficient
IUCN (2021): V – Vulnerable, NT – Near Threatened. All other species not listed are viewed as "Least Concern" by IUCN (2021)
CITES: CITES Appendix 1/2 species
*Monadjem *et al.* (2010)

Source for literature review: Cunningham (2011), Cunningham (2013), Cunningham (2017), Cunningham (2021), De Graaff (1981), Griffin and Coetzee (2005), Estes (1995), IUCN (2021), Joubert and Mostert (1975), Monadjem *et al.* (2010), SARDB (2004), Skinner and Smithers (1990), Skinner and Chimimba (2005), Stander and Hanssen (2003) and Taylor (2000)

Overall terrestrial diversity and endemism – all species – is classified as "average" and "high" respectively in the general Karibib area (Mendelsohn *et al.* 2002). The overall diversity (5-6 species) and abundance of large herbivorous mammals is "high" in the general area with kudu, mountain zebra and oryx having the highest densities of the larger species (Mendelsohn *et al.* 2002). The overall abundance and diversity of large carnivorous mammals is "average" (4 species) in the general area with leopard and cheetah having the highest densities of the larger species (Mendelsohn *et al.* 2002). The overall mammal diversity in the general Karibib area is estimated at between 61-75 species with 5-6 species being endemic to the area (Mendelsohn *et al.* 2002). Griffin (1998c) puts the species richness distribution of endemic mammals between 7-8 species in the general area, while the closest protected areas, the Skeleton Coast and Namib-Naukluft National Parks, at 87 and 80 species, respectively. There is currently no data for the !Dorob National Park.

According to the literature at least 87 species of mammals are known and/or expected to occur in the general Karibib area of which 10 species (11.5%) are classified as endemic. The Namibian legislation classifies 2 species as "rare", 5 species as "vulnerable", 3 species as "specially protected game", 9 species as "protected game", 5 species as "insufficiently known", 4 species as "huntable game" and 4 species as "problem animals". Five species of bat are not listed – i.e. according to Monadjem *et al.* (2010) these bats potentially could occur in the general Karibib are according to a habitat modelling programme although not yet actually confirmed.

At least 31% (27 species) of the mammalian fauna that occur or are expected to occur in the general Karibib area are represented by rodents of which 5 species (18.5%) are endemic.

This is followed by bats 27.6% (24 species) of which 1 species is classified as "rare". Twenty nine species (33.3%) have IUCN, CITES and SARDB international conservation status (some species have more than one conservation status). The IUCN (2021) classifies 4 species each as vulnerable (cheetah, leopard, Hartmann's mountain zebra, giraffe) and near threatened (African straw-coloured fruit bat, Commerson's roundleaf bat, striped leaf-nosed bat, brown hyena). The SARDB (2004) classifies 1 species as rare, 1 species as endangered, 2 species as vulnerable, 12 species as near threatened and 6 species as data deficient while CITES lists 2 species as Appendix 1 and 5 species as Appendix 2. The House Mouse (*Mus musculus*) is viewed as an invasive alien species to the area. *Mus musculus* are generally known as casual pests and not viewed as problematic although they are known carriers of "plague" and can cause economic losses.

Of the 87 species of mammals known and/or expected to occur in the general Karibib area, 9 species (10.3%) are classified as endemic. Rodents (of which 5 species – 18.5% – are endemic) and bats (of which 1 species is classified as rare) are the groups least studied. Species of greatest concern in the general area are those viewed as rare in Namibia – i.e. Namibian wing-gland bat and Southern African hedgehog – and species classified as vulnerable (cheetah, leopard, Hartmann's mountain zebra, giraffe) and near threatened (African straw-coloured fruit bat, Commerson's roundleaf bat, striped leaf-nosed bat, brown hyena) by the IUCN (2021). Another important and unique species, although not observed, but known to occur in the general area, is the endemic Kaokoland slender or black mongoose (See: Cowley and Cunningham 2004, Warren *et al.* 2009).

Cunningham (2021) confirmed 26 species during summer and winter observations from the area while a total of at least 34 species are confirmed from the general area if one includes species identified by Cunningham (2011, 2013 and 2017) – See Table 3. Furthermore, small mammal trapping resulted in 3 species – *Elephantulus intufi*, *Tatera leucogaster* and *Micaelamys namaquensis* – during summer and winter although the capture success rates varied between 17.8% and 27.8%, respectively (Cunningham 2021). The increased rate of capture from summer to winter is probably due to the small mammals showing a "population

explosion" associated with the good rains and abundant grass cover – a common phenomenon.

Infrastructure impact

Plant site/waste rock dumps/tailings storage facility (TSF)/open pits

The impact during construction, are expected to be detrimental to mammals associated with the affected area/habitat.

The impact of aboveground plant site infrastructure is not expected to be detrimental to mammals – i.e. would not impede their movement, etc. However, the lighting and artificial habitat is expected to attract certain mammals to the area (e.g. certain bats, small carnivores and rodents, etc.).

The impact of the waste rock dump is not expected to be detrimental to mammals – i.e. would not impede their movement, etc. However, the artificial habitat is expected to attract certain mammals to the area (e.g. certain small carnivores and rodents, etc.). Furthermore, WRD 2 would cover parts of the northern tributaries of the Okawayo River and should be avoided.

The impact of the TSF is not expected to be detrimental to mammals – i.e. would not impede their movement, etc. However, the artificial habitat is expected to attract certain mammals to the area (e.g. certain carnivores, ungulates, etc.).

The impacts of the open pit(s) are expected to be detrimental to mammals associated with the affected area/habitat and/or could act as pitfall traps. However, most larger mammals known/expected to occur in the area would avoid the active mining areas and/or be deterred by the waste rock dump sites around the pits while the smaller mammals would probably use the pit(s) as part of their habitat and/or rather be attracted to the rocky waste dumps as more suitable habitat. Filling up of the pits after mining and/or sloping the pits would negate the pitfall problem.

The impacts of the mining activities are expected to be detrimental to mammals associated with the affected area/habitat although larger mammals known/expected to occur in the area would avoid the active mining areas. All vehicle activities (including long hauling) should abide by the speed limits to avoid road mortalities. Furthermore, larger mammals are very adaptable to disturbances, range over vast areas, and are attracted to areas with grazing after localised rainfall events (i.e. mostly avoid disturbed areas) while the overall low densities of all mammal species in the mining area would negate the problem.

Pipeline impact

The impact of heavy machinery during excavation of a trench to bury the proposed water pipeline is expected to be detrimental to mammals associated with the affected area/habitat. This would affect a relatively small area over a short/limited period of time.

However, an open trench could act as a giant pitfall trap and should not be left open overnight and/or have regular exists along its route, especially at the two ends of the trench.

Height

A detailed study on the effects of an aboveground pipeline infrastructure on vertebrate fauna was conducted by Cunningham et al. (2015) on a 40km section from the Swakopmund Base Station to the Langer Heinrich Mine junction. Heights, crossing points and species affected were assessed. It was determined that most springbok crossed the pipeline with heights between 40-70cm (91.1%) with the greatest number crossing at 50-60cm (44%) while gemsbok crossed with difficulty (e.g. individuals only) at 60cm. This indicates that a pipeline height of >70cm is an effective barrier to most springbok and >60cm for gemsbok while anything >80cm is a total barrier (e.g. only 0.4% of springbok crossings were above 80cm)

(Cunningham et al. 2015). Although springbok have been observed crossing cattle fences of 1.5m when pressed, often with fatalities, most avoid this height (Pers. obs.). Mountain zebra are expected to be similarly negatively affected while kudu, a typical jumping species, is not affected.

The effect of aboveground pipeline infrastructure >80cm is expected to be detrimental to most ungulates – i.e. would impede their movement, etc. Aboveground pipeline(s) act as a barrier to most ungulates (Cunningham et al. 2015).

Crossing Points
Ungulate activity is associated with the availability of vegetation, especially along ephemeral drainage lines. Most pipeline crossing attempts were made in the vicinity of vegetated drainage lines (Cunningham et al. 2015).

Raised – earth covered – crossing points, 30m in width were not used by ungulates while buried sections did not impede movements at all (Cunningham et al. 2015).

Pipeline infrastructure >80cm in height would be viewed as an effective barrier to most ungulates while belowground crossing points would be best situated at drainage lines.

To prevent the pipeline serving as a barrier to ungulates, it would be recommended to bury the pipeline along the entire route.

Transmission line impact (66Kv)
The impact of heavy machinery during construction, and especially the excavation of holes to plant pylons for the proposed transmission line are expected to be detrimental to mammals associated with the affected area/habitat. This would affect a relatively small area over a short/limited period of time.
However, open holes could act as pitfall traps and should not be left open overnight and/or covered.

The impact of aboveground transmission line infrastructure is not expected to be detrimental to mammals – i.e. would not impede their movement, etc. However, some mammals – e.g. small-spotted genet, mongoose – are attracted to the substations and on-pole-mounted switching gear probably for foraging and heat and may cause problems at these structures. This could be mitigated by electrostatic animal and/or squirrel guards on the bushings (Van Rooyen 2003). Other mammals that could be affected by the electrical infrastructure are baboons which often get electrocuted by various types of infrastructure and giraffe. Pole mounted transformers and bushings can be insulated and/or substations could be equipped with electric fencing to prevent baboons entering such areas while giraffe require a minimum clearance of 6,270mm for 66kV transmission lines (Van Rooyen 2003).

Access route impact
The impact of an access route is not expected to be detrimental to most mammals as there are numerous existing tracks throughout the general area and the overall footprint is small. However, track discipline should be maintained (e.g. minimise speed (e.g. 40km/h), no off-road driving, limited nocturnal driving, etc.), speed humps and vehicle calming devices should be incorporated along the route. This should act as mitigation measure for important slow moving, especially nocturnal, mammals.

A tarmac access route would result in less dust pollution and make installing the speed humps and vehicle calming devices, etc. easier than a gravel route. However, a tarmac access route would attract certain mammals (e.g. nocturnal species) to it for basking due to its retention and slow release of heat and foraging (e.g. small carnivores) resulting in potentially more mortalities. This could be negated by limiting nocturnal vehicle activity along this route.

Furthermore, none of the unique/important species are exclusively associated with the proposed development area.

Okawayo River diversion
The impact during construction, are expected to be detrimental to mammals associated with the affected area/habitat.

Species using the riparian vegetation habitat and/or the river system as a thoroughfare would be negatively affected although the proposed diversion would become vegetated over time and eventually serve the same purpose.

The Twin Hills project area has been heavily impacted due to current/past mining (e.g. marble quarrying) and farming activities and none of the unique mammals are expected to be exclusively associated with this area.

3.4 Avian Diversity

Bird diversity known and/or expected to occur in the Karibib area, including species confirmed from the general area (See Cunningham 2011, 2013, 2017) as well as during the recent fieldwork conducted by Cunningham (2021), is presented in Table 5.

Although Namibia's avifauna is comparatively sparse compared to the high rainfall equatorial areas elsewhere in Africa, approximately 658 species have already been recorded with a diverse and unique group of arid endemics (Brown *et al.* 1998, Maclean 1985). Fourteen species of birds are endemic or near endemic to Namibia with the majority of Namibian endemics occurring in the savannas (30%) of which ten species occur in a north-south belt of dry savannah in central Namibia (Brown *et al.* 1998).

Bird diversity and endemism is viewed as "high" in the general Karibib area with 171-200 species, of which 8 species being endemic (Mendelsohn *et al.* 2000). Simmons (1998a) suggests 7-9 endemic species and a "high" ranking for southern African endemics and "average" ranking for red data birds expected from the general area. Although the Karibib area is not classified as an Important Birding Area (IBA) in Namibia (Simmons 1998a) the closest such sites are located to the west at the coast – i.e. Walvis Bay, Sandwich and Mile 4 Saltworks – while the closest inland IBA's are Brandberg and Naukluft.

According to the literature at least 217 bird species [mainly terrestrial "breeding residents"] occur and/or could occur in the general Karibib area at any time (Hockey *et al.* 2006, Maclean 1985, Tarboton 2001). Twelve of the 14 Namibian endemics are expected to occur in the general area (85.7% of all Namibian endemic species or 5.6% of all the species expected to occur in the area). Eight species are classified as endangered (violet wood-hoopoe, Ludwig's bustard, white-backed vulture, black harrier, tawny eagle, booted eagle, martial eagle, black stork), 2 species as vulnerable (lappet-faced vulture, secretarybird) and 5 species as near threatened (Rűppel's parrot, kori bustard, Verreaux's eagle, peregrine falcon, marabou stork) (Simmons *et al.* 2015). Fifty seven species have a southern African conservation rating with 8 species classified as endemic (14% of southern African endemics or 3.7% of all the birds expected) and 49 species classified as near endemic (86% of southern African endemics or 22.7% of all the birds expected) (Hockey *et al.* 2006). The IUCN (2021) classifies 1 species as critically endangered (white-backed vulture), 5 species as endangered (Ludwig's bustard, lack harrier, lappet-faced vulture, martial eagle, secretarybird), 1 species as vulnerable (tawny eagle) and 1 species as near threatened (kori bustard).

Cunningham (2021) confirmed 75 species during summer and winter observations from the area while a total of at least 115 species are confirmed from the general area if one includes

Table 4. Avian diversity expected (literature study) and confirmed by Cunningham (2021) ($\surd^{S}$ = summer 2021 and $\surd^{W}$ = winter 2021) including author's confirmed records (and farm manager sightings - √#) from other studies conducted from the general area (See: Cunningham 2011, 2013, 2017).

Species: Scientific name	Species: Common name	Cunningham, Twin Hills (2021)	Navachab Gold (2011)	Helikon Lithium (2013)	Helikon/ Rubicon Lithium (2017)	Namibian conservation and legal status	International status	
							Southern African status	IUCN
Struthio camelus	Common Ostrich		√					
Scleroptila levaillantoides	Orange River Francolin						Near endemic	
Pternistis hartlaubi	Hartlaub's Spurfowl					Endemic	Near endemic	
Pternistis adspersus	Red-billed Spurfowl	$\surd^{S}$	√				Near endemic	
Pternistis swainsonii	Swainson's Spurfowl							
Coturnix coturnix	Common Quail	$\surd^{S,W}$						
Coturnix delegorguei	Harlequin Quail							
Numida meleagris	Helmeted Guineafowl	$\surd^{S,W}$	√	√	√			
Turnix sylvaticus	Kurrichane Buttonquail							
Indicator minor	Lesser Honeyguide							
Campethera abingoni	Golden-tailed Woodpecker							
Dendropicos fuscescens	Cardinal Woodpecker							
Dendropicos namaquus	Bearded Woodpecker							
Tricholaema leucomelas	Acacia Pied Barbet		√		√		Near endemic	
Tockus monteiri	Monteiro's Hornbill	$\surd^{S,W}$	√	√	√	Endemic		
Tockus damarensis	Damara Hornbill	$\surd^{W}$				Endemic	Near endemic	
Tockus leucomelas	Southern yellow-billed Hornbill	$\surd^{W}$	√		√		Near endemic	
Tockus nasutus	African Grey Hornbill	$\surd^{W}$	√					
Upupa africana	African Hoopoe	$\surd^{S}$	√		√			
Phoeniculus purpureus	Green Wood-Hoopoe							
Phoeniculus damarensis	Violet Wood-Hoopoe					E; Endemic		
Rhinopomastus cyanomelas	Common Scimitarbill	$\surd^{S,W}$	√	√	√			
Coracias caudatus	Lilac-breasted Roller	$\surd^{S}$	√					
Coracias naevius	Purple Roller	$\surd^{S}$	√					
Merops hirundineus	Swallow-tailed Bee-eater	$\surd^{S}$	√		√			

Merops apiaster	European Bee-eater							
Colius colius	White-backed Mousebird	√S					Endemic	
Urocolius indicus	Red-faced Mousebird		√					
Clamator jacobinus	Jacobin Cuckoo	√S						
Clamator glandarius	Great Spotted Cuckoo							
Cuculus clamosus	Black Cuckoo							
Cuculus gularis	African Cuckoo							
Chrysococcyx klaas	Klaas's Cuckoo							
Chrysococcyz caprius	Diderick Cuckoo		√					
Poicephalus rueppellii	Rüppell's Parrot					NT; Endemic	Near endemic	
Agapornis roseicollis	Rosy-faced Lovebird			√	√	Endemic	Near endemic	
Cypsiurus parvus	African Palm Swift		√					
Tachymarptis melba	Alpine Swift	√S	√					
Apus bradfieldi	Bradfield's Swift		√				Near endemic	
Apus affinis	Little Swift		√					
Apus caffer	White-rumped Swift							
Corythaixoides concolor	Grey Go-away Bird	√S,W	√					
Tyto alba	Barn Owl							
Otus senegalensis	African Scops Owl							
Ptilopsis granti	Southern White-faced Scops Owl							
Bubo africanus	Spotted Eagle Owl	√S		√				
Bubo lacteus	Verreaux's Eagle-Owl							
Glaucidium perlatum	Pearl-spotted Owlet							
Caprimulgus pectoralis	Fiery-necked Nightjar							
Caprimulgus tristigma	Freckled Nightjar	√S	√					
Caprimulgus rufigena	Rufous-cheeked Nightjar							
Caprimulgus europaeus	European Nightjar							
Columba livia	Rock Dove							
Columba guinea	Speckled Pigeon		√	√				
Streptopelia capicola	Cape Turtle Dove	√S	√	√	√			
Streptopelia senegalensis	Laughing Dove	√S	√					
Oena capensis	Namaqua Dove	√S,W	√		√			
Neotis ludwigii	Ludwig's Bustard		√			E	Near endemic	E
Ardeotis kori	Kori Bustard	√S,W	√			NT		NT
Lophotis ruficrista	Red-crested Korhaan	√S,W	√		√		Near endemic	
Afrotis afraoides	Northern Black Korhaan	√S,W					Endemic	

Eupodotis rueppellii	Rüppell's Korhaan		√			Endemic	Near endemic	
Pterocles namaqua	Namaqua Sandgrouse		√	√	√		Near endemic	
Pterocles bicinctus	Double-banded Sandgrouse	√W			√		Near endemic	
Burhinus capensis	Spotted Thick-knee							
Charadrius tricollaris	Three-banded Plover		√					
Vanellus armatus	Blacksmith Lapwing	√S,W						
Vanellus coronatus	Crowned Lapwing	√S,W						
Rhinoptilus africanus	Double-banded Courser	√W						
Rhinoptilus chalcopterus	Bronze-winged Courser							
Cursorius rufus	Burchell's Courser	√S					Near endemic	
Cursorius temminckii	Temminck's Courser	√S	√					
Elanus caeruleus	Black-shouldered Kite							
Milvus migrans	Black Kite	√S	√					
Gyps africanus	White-backed Vulture	√W;√#	√			E		CE
Aegypius tracheliotos	Lappet-faced Vulture	√W;√#	√			V		E
Circaetus pectoralis	Black-chested Snake-Eagle	√S	√		√			
Circaetus cinereus	Brown Snake-Eagle							
Melierax canorus	Southern Pale Chanting Goshawk	√S,W			√		Near endemic	
Melierax gabar	Gabar Goshawk							
Accipiter badius	Shikra		√					
Accipiter minullus	Little Sparrowhawk							
Accipter ovampensis	Owambo Sparrowhawk							
Buteo vulpinus	Steppe Buzzard		√					
Buteo augur	Augur Buzzard							
Buteo rufofuscus	Jackal Buzzard							
Aquila nipalensis	Steppe Eagle							
Circus maurus	Black Harrier					E		E
Aquila rapax	Tawny Eagle		√			E		V
Aquila verreauxii	Verreaux's Eagle		√		√	NT		
Aquila spilogaster	African Hawk-Eagle							
Aquila pennatus	Booted Eagle					E		
Polemaetus bellicosus	Martial Eagle					E		E
Sagittarius serpentarius	Secretarybird	√#				V		E
Polihierax semitorquatus	Pygmy Falcon				√			
Falco rupicolus	Rock Kestrel		√	√	√			
Falco rupicoloides	Greater Kestrel							

Falco chicquera	Red-necked Falcon					
Falco biarmicus	Lanner Falcon		√			
Falco peregrinus	Peregrine Falcon				NT	
Egretta garzetta	Little Egret	√W				
Egretta intermedia	Yellow-billed Egret					
Ardea cinerea	Grey Heron					
Ardea melanocephala	Black-headed Heron					
Bubulcus ibis	Cattle Egret					
Scopus umbretta	Hamerkop					
Ciconia nigra	Black Strork				E	
Ciconia abdimii	Abdim's Stork					
Leptoptilos crumeniferus	Marabou Stork				NT	
Dicrurus adsimilis	Fork-tailed Drongo	√S,W	√	√		
Terpsiphone viridis	African Paradise-Flycatcher					
Nilaus afer	Brubru					
Dryoscopus cubla	Black-backed Puffback					
Tchagra australis	Brown-crowned Tchagra					
Laniarius atrococcineus	Crimson-breasted Shrike	√S,W		√		Near endemic
Telophorus zeylonus	Bokmakierie					Near endemic
Prionops plumatus	White-crested Helmet-Shrike					
Lanioturdus torquatus	White-tailed Shrike	√S,W	√	√	Endemic	Near endemic
Batis pririt	Pririt Batis	√W	√	√		Near endemic
Corvus capensis	Cape Crow					
Corvus albus	Pied Crow					
Lanius collurio	Red-backed Shrike		√			
Lanius minor	Lesser Grey Shrike	√S	√			
Lanius collaris	Common Fiscal	√S,W	√	√		
Eurocephalus anguitimens	Southern White-crowned Shrike					Near endemic
Anthoscopus minutes	Cape Penduline Tit					Near endemic
Parus carpi	Carp's Tit				Endemic	Near endemic
Parus cinerascens	Ashy Tit			√		Endemic
Riparia paludicola	Brown-throated Martin	√S				
Hirundo rustica	Barn Swallow		√			
Hirundo dimidiata	Pearl-breasted Swallow					
Hirundo cucullata	Greater Striped Swallow					
Hirundo spilodera	South African Cliff-Swallow					

Hirundo fuligula	Rock Martin	√S	√	√	√		
Delichon urbicum	Common House Martin						
Pycnonotus nigricans	African Red-eyed Bulbul	√S,W	√	√	√		Near endemic
Achaetps pycnopygius	Rockrunner		√			Endemic	Near endemic
Sylvietta rufescens	Long-billed Crombec	√W	√				
Eremomela icteropygialis	Yellow-bellied Eremomela						
Eremomela gregalis	Karoo Eremomela						
Eremomela usticollis	Burnt-necked Eremomela						
Acrocephalus baeticatus	African Reed Warbler						
Turdoides bicolor	Southern Pied Babbler						Endemic
Parisoma layardi	Layard's Tit-Babbler						Endemic
Parisoma subcaeruleum	Chestnut-vented Tit-Babbler	√S,W	√				Near endemic
Zosterops pallidus	Orange River White-eye						
Cisticola subruficapilla	Grey-backed Cisticola						Near endemic
Cisticola jaridulus	Desert Cisticola		√				
Prinia flavicans	Black-chested Prinia	√S,W	√	√	√		
Malcorus pectoralis	Rufous-eared Warbler						
Camaroptera brevicaudata	Grey-backed Camaroptera						
Calamonastes fasciolatus	Barren Wren-Warbler						
Mirafra passerina	Monotonous Lark						
Mirafra fasciolata	Eastern Clapper Lark	√S					Near endemic
Mirafra sabota	Sabota Lark	√W	√	√			
Calendulauda africanoides	Fawn-coloured Lark	√S					Near endemic
Pinarocorys nigricans	Dusky Lark						
Ammomanopsis grayi	Gray's Lark					Endemic	
Chersomanes albofasciata	Spike-heeled Lark				√		Near endemic
Certhilauda subcoronata	Karoo Long-billed Lark						Near endemic
Eremopterix leucotis	Chestnut-backed Sparrowlark						
Eremopterix verticalis	Grey-backed Sparrowlark				√		Near endemic
Calandrella cinerea	Red-capped Lark		√				
Alauda starki	Stark's Lark		√				Near endemic
Monticola brevipes	Short-toed Rock Thrush		√				
Psophocichla litsitsirupa	Groundscraper Thrush						
Bradornis infuscatus	Chat Flycatcher	√S,W					Near endemic
Melaenornis mariquensis	Marico Flycatcher	√S,W	√	√	√		Near endemic
Muscicapa striata	Spotted Flycatcher						

Cercotrichas leucophrys	White-browed Scrub-Robin						
Cercotrichas paena	Kalahari Scrub-Robin	√S,W	√		√		
Namibornis herero	Herero Chat					Endemic	Near endemic
Oenanthe monticola	Mountain Wheatear	√W	√	√	√		Near endemic
Oenanthe pileata	Capped Wheatear	√S,W	√		√		
Cercomela schlegelii	Karoo Chat						Near endemic
Cercomela tractrac	Tractrac Chat	√S	√		√		Near endemic
Cercomela familiaris	Familiar Chat	√W	√				
Myrmecocichla formicivora	Ant-eating Chat		√		√		Endemic
Onychognathus nabouroup	Pale-winged Starling	√S,W	√	√	√		Near endemic
Lamprotornis nitens	Cape Glossy Starling	√S,W	√		√		
Lamprotornis australis	Burchell's Starling						
Cinnyricinclus leucogaster	Violet-backed Starling		√				
Creatophora cinerea	Wattled Starling		√				
Chalcomitra senegalensis	Scarlet-chested Sunbird		√				
Nectarinia fusca	Dusky Sunbird	√S	√	√	√		Near endemic
Cinnyris mariquensis	Marico Sunbird						
Bualornis niger	Red-billed Buffalo-Weaver		√		√		
Sporopipes squamifrons	Scaly-feathered Finch	√W					Near endemic
Plocepasser mahali	White-browed Sparrow-Weaver	√S,W	√	√	√		
Philetairus socius	Sociable Weaver	√S					Endemic
Ploceus intermedius	Lesser Masked-Weaver	√W					
Ploceus velatus	Southern Masked-Weaver	√S	√	√	√		
Ploceus rubiginosus	Chestnut Weaver	√S,W	√		√		
Quelea quelea	Red-billed Quelea	√W					
Amadina erythrocephala	Red-headed Finch	√W					Near endemic
Estrilda erythronotos	Black-faced Waxbill		√				
Estrilda astrild	Common Waxbill						
Granatina granatina	Violet-eared Waxbill	√S,W	√				
Pytilia melba	Green-winged Pytilia						
Vidua paradisaea	Long-tailed Paradise-Whydah						
Vidua regia	Shaft-tailed Whydah		√		√		
Passer domesticus	House Sparrow		√				
Passer motitensis	Great Sparrow	√S					Near endemic
Passer melanurus	Cape Sparrow						Near endemic
Passer griseus	Southern Grey-headed Sparrow						

Motacilla capensis	Cape Wagtail		√			
Anthus cinnamomeus	African Pipit					
Anthus vaalensis	Buffy Pipit					
Anthus similes	Long-billed Pipit					
Serinus alario	Black-headed Canary					Endemic
Crithagra atrogulariis	Black-throated Canary					
Serinus flaviventris	Yellow Canary	√S,W	√			Near endemic
Serinus albogularis	White-throated Canary	√W	√	√		Near endemic
Emberiza impetuani	Lark-like Bunting	√S,W	√		√	Near endemic
Emberiza tahapisi	Cinnamon-breasted Bunting					
Emberiza capensis	Cape Bunting		√			Near endemic
Emberiza flaviventris	Golden-breasted Bunting					

This table excludes migratory birds (e.g. Petrel, Albatross, Skua, etc.), aquatic species (e.g. ducks, etc.) and species breeding extralimital (e.g. stints, sandpipers, etc.) and rather focuses on birds that are breeding residents or can be found in the area during any time of the year. This would imply that many more birds (e.g. Palaearctic migrants) could occur in the area depending on "favourable" environmental conditions.
Namibian status: E – Endangered, V- Vulnerable, NT – Near Threatened (Simmons *et al.* 2015)
Southern African status: Hockey *et al.* (2006)
IUCN (2021): CE – Critically Endangered, E – Endangered, V- Vulnerable, NT – Near Threatened. All other species not listed are viewed as "Least Concern" by IUCN (2021)

Source for literature review: Brown *et al.* (1998), Cunningham (2011), Cunningham (2013), Cunningham (2017), Cunningham (2021), Hockey *et al.* (2006), IUCN (2021), Komen (n.d.), Little and Crowe (2011), Maclean (1985), Peacock (2015), Simmons *et al.* (2015), Tarboton (2001)

species identified by Cunningham (2011, 2013 and 2017) – See Table 4. The most important species confirmed by Cunningham (2021) are Monteiro's hornbill (endemic), Damara hornbill (endemic), kori bustard (NT), white-backed vulture (CE), lappet-faced vulture (E) and secretarybird (V).

The most important bird species from the general area are those classified as endemic to Namibia of which the Damara hornbill and Herero chat are viewed as the most important due to the overall lack of knowledge of these species. Although also viewed as important, Rüppels korhaan is migratory throughout its range while the rockrunner inhabits inaccessible terrain and is widespread throughout mountainous areas in Namibia. Other species of concern are those classified as endangered (violet wood-hoopoe, Ludwig's bustard, black harrier, tawny eagle, booted eagle, martial eagle, black stork) and near threatened (Rűppel's parrot, Verreaux's eagle, peregrine falcon, marabou stork) (Simmons *et al.* 2015) and those species classified by the IUCN (2021) as critically endangered (white-backed vulture), endangered (Ludwig's bustard, lack harrier, lappet-faced vulture, martial secretarybird), vulnerable (tawny eagle) and near threatened (kori bustard). Although white-backed vulture, lappet-faced vulture and secretarybird are not known to breed in the area (Eddie Nederlof *pers.com.*), such nesting sites, should these be established and/or located in future, are viewed as extremely important and should be avoided at all costs.

Infrastructure impact

Plant site/waste rock dumps/ tailings storage facility (TSF)/open pits

The impact during construction, are expected to be detrimental to birds, especially species favouring large trees (e.g. various raptors); cavity nesting species (e.g. hornbills, barbets, etc. – also associated with large trees); and ground nesting species associated with the affected area/habitat.

The impact of aboveground plant site infrastructure is not expected to be detrimental to birds – i.e. would not impede their movement, etc. However, the lighting and artificial habitat is expected to attract certain birds to the area (e.g. chats, crows, owls, smaller raptors, etc.).

The impact of the waste rock dumps is not expected to be detrimental to birds – i.e. would not impede their movement, etc. However, the artificial habitat is expected to attract certain birds to the area (e.g. chats, crows, owls, smaller raptors, etc.). Furthermore, WRD 2 would cover parts of the northern tributaries of the Okawayo River and should be avoided.

The impact of the TSF is not expected to be detrimental to birds – i.e. would not impede their movement, etc. However, the artificial habitat is expected to attract certain birds to the area (e.g. crows, smaller raptors, various aquatic species, etc.).

The impacts of the open pit(s) are expected to be detrimental to ostrich associated with the affected area/habitat and/or could act as pitfall traps. However, ostrich known/expected to occur in the area would avoid the active mining areas and/or be deterred by the waste rock dump sites around the pits while the smaller birds would probably use the pit(s) as part of their habitat and/or rather be attracted to the rocky waste dumps as more suitable habitat. Filling up of the pits after mining and/or sloping the pits would negate the pitfall problem.

The impacts of the mining activities are expected to be detrimental to birds associated with the affected area/habitat although larger birds known/expected to occur in the area would avoid the active mining areas. All vehicle activities (including long hauling) should abide by the speed limits to avoid road mortalities. Furthermore, most birds are very adaptable to disturbances, range over vast areas, and are attracted to areas with grazing after localised rainfall events (i.e. mostly avoid disturbed areas). However, raptor breeding trees (especially vulture species) should be avoided, especially during the breeding season, as they might abandon nests when regularly disturbed.

Pipeline impact

The impact of heavy machinery during the excavation of a trench to bury the proposed water pipeline is expected to be detrimental to birds, especially ground nesting species (e.g. bustard and korhaan species, etc.), associated with the affected area/habitat. This would affect a relatively small area over a short/limited period of time.

However, an open trench could act as a giant pitfall trap for ostrich and should not be left open overnight and/or have regular exists along its route, especially at the two ends of the trench.

Height

A detailed study on the effects of an aboveground pipeline infrastructure on avifauna was conducted by Cunningham et al. (2015) on a 40km section from the Swakopmund Base Station to the Langer Heinrich Mine junction. Heights; crossing points and species affected were assessed. It was determined that ostrich did not cross the pipeline at all and viewed it as an effective barrier. Other birds were not adversely affected by the pipeline infrastructure. Aboveground pipeline(s) act as a barrier to ostrich (Cunningham et al. 2015).

Crossing Points

Ostrich activity is correlated to the availability of vegetation, especially vegetated drainage lines.

Raised – earth covered – crossing points, 30m in width were not used by ostrich while buried sections did not impede movements at all (Cunningham et al. 2015).

The effect of aboveground pipeline infrastructure is expected to be detrimental to ostrich – i.e. would impede their movement, etc.

To prevent the pipeline serving as a barrier to ostrich, it would be recommended to bury the pipeline along the entire route.

Transmission line impact (66kV)

The impact of heavy machinery during the construction, and especially the excavation of holes to plant pylons for the proposed transmission line are expected to be detrimental to birds, especially ground nesting species associated with the affected area/habitat. This would affect a relatively small area over a short/limited period of time.

However, open holes could act as pitfall traps for ostrich and should not be left open overnight and/or covered.

None of the unique/important species are exclusively associated with the proposed development area although the effect of aboveground transmission line infrastructure is expected to be detrimental to certain birds – e.g. "pylon sensitive species". Existing transmission line infrastructure, include 33kV (e.g. Karibib Air force Base) overhead lines in the general area.

Although it is currently not known what type of construction configuration is envisaged, it would probably be 66kV – i.e. 1) 66kV wooden H-Pole structure or 2) 66kV guyed steel monopole. Problems with 66kV lines include bird streamers although this is dependent on the presence of large bird species. Furthermore, horizontally configured designs experience more problems with bird streamers than vertically configured designs probably due to birds perching/roosting closer to the conductors increasing the probability of flashovers (Van Rooyen 2003).

Birds expected to be negatively affected (i.e. collision and/or electrocution) by the transmission line developments include:

- *Birds flying at pylon height – e.g. bustards, swifts, sandgrouse, ravens, raptors and aquatic and marine species.*
- *Birds with nocturnal transients – e.g. Palaearctic migrants and wetland birds (i.e. coastal area).*
- *Birds following certain geological and/or landscape features (e.g. rivers; mountain ranges, etc.) whilst foraging and/or migrating – e.g. aquatic/marine species and raptors.*
- *Birds attracted to the area during rainfall events – e.g. bustards – and temporary water sources in ephemeral rivers/drainage lines – e.g. aquatic/marine species.*

Pylon sensitive species

Pylon sensitive bird species (See Scott and Scott n.d.) known/expected to occur in the general area include:

- *Black stork;*
- *Booted eagle;*
- *Kori bustard;*
- *Lappet-faced vulture;*
- *Ludwig's bustard;*
- *Marabou stork;*
- *Martial eagle;*
- *Peregrine falcon;*
- *Tawny eagle;*
- *Verreaux's eagle; and*
- *White-backed vulture.*

Other potential transmission line issues related to birds would be species that typically nest on such structures.

Nest induced faulting caused by birds (See Scott and Scott n.d.) includes:

- *Cape crow;*
- *Pied crow;*
- *Sociable weaver;*
- *Red-billed Buffalo-weaver;*
- *Eagles – large; and*
- *Vultures.*

Factors influencing collision risk

The following factors influence the collision risk for birds (See: Van Rooyen 2003):

- *Voltage levels – i.e. correlation between physical size of bird and collision risk;*
- *Body size and flight behaviour – i.e. birds with a heavy body size and small wing surface are more prone to collisions;*
- *Flight height and habitat use – i.e. short distance, low altitude, frequency of overhead structures;*
- *Age (i.e. young birds more prone to collisions);*
- *Resident versus migratory birds (i.e. movement into unfamiliar terrain increases collisions);*
- *Weather (i.e. inclement weather increases collisions);*
- *Time of day (i.e. nocturnal movement increases collisions);*
- *Land use (i.e. cultivated areas attract birds); and*
- *Topography (i.e. mountains/rivers/shorelines act as corridors).*

As many of the "pylon sensitive" bird species occur in the general area, it is recommended that BFD's (Bird Flight Diverters – e.g. coils, flappers, etc.) are installed along the

transmission line route from where it turns east along the tarmac Karibib-Omaruru road towards the mine area to minimise/prevent mortalities.

Access route impact
The impact of an access route is not expected to be detrimental to most birds as there are numerous existing tracks throughout the general area and the overall footprint is small. However, track discipline should be maintained (e.g. minimise speed (e.g. 40km/h), no off-road driving, limited nocturnal driving, etc.), speed humps and vehicle calming devices should be incorporated along the route. This should act as mitigation measure for important, especially nocturnal, birds.

A tarmac access route would result in less dust pollution and make installing the speed humps and vehicle calming devices, etc. easier than a gravel route. However, a tarmac access route would attract certain birds (e.g. crows, smaller raptors, owls, etc.) to it for foraging purposes resulting in potentially more mortalities. This could be negated by limiting nocturnal vehicle activity along this route.

Furthermore, none of the unique/important species are exclusively associated with the proposed development area.

Okawayo River diversion
The impact during construction, are expected to be detrimental to avifauna associated with the affected area/habitat.

Species using the riparian vegetation habitat and/or the river system as a thoroughfare would be negatively affected although the proposed diversion would become vegetated over time and eventually serve the same purpose.

The Twin Hills project area has been heavily impacted due to current/past mining and farming activities (e.g. marble quarrying) and none of the unique birds are expected to be exclusively associated with this area.

3.5 Tree and Shrub Diversity

It is estimated that at least 74-101 species of larger trees and shrubs (>1m) (Coats Palgrave 1983 [85sp.], Curtis and Mannheimer 2005 [101sp.], Mannheimer and Curtis 2009 [91], Mannheimer and Curtis 2018 [101], Van Wyk and Van Wyk 1997 [62sp. and 12sp. endemic]) occur in the general Karibib area.

The trees and shrubs known, and/or expected to occur in the general area (derived from Mannheimer and Curtis 2018) is presented in Table 5 below. Species indicated are know from the quarter-degree square distribution principle used and don't necessarily occur throughout the entire area. Some species indicated to possibly occur in the area according to Coats Palgrave (1983) and Van Wyk and Van Wyk (1997) are excluded here.

Eight species of trees and shrubs (7.9%) expected to occur in the general Karibib area are classified as endemic, 4 species as near endemic (4%), 21 species (20.8%) are protected by the Forest Act No 12. of 2001, 5 species (5%) are protected under the Nature Conservation Ordinance No. 4 of 1975 while 6 species (5.9%) are classified as CITES Appendix 2 species. All the trees with some kind of conservation and/or protected status are viewed as important in the general Karibib area. The most important species are viewed as *Commiphora dinteri*, *Commiphora saxicola*, *Commiphora virgata*, *Cyphostemma bainesii*, *Cyphostemma currorii* and *Erythrina decora* (See Table 5).

Table 5. Tree and shrub diversity expected (literature study) and confirmed (Cunningham 2021) including author's confirmed records from other studies conducted from the general area (See: Cunningham 2013, 2017). The trees and shrubs known, and/or expected to occur in the general area (derived from Mannheimer and Curtis 2018).

Species Expected: Scientific name	Cunningham, Twin Hills (2021)			Helikon Lithium (2013)	Helikon/ Rubicon Lithium (2017)	Namibian conservation and legal status
	Plains	Hills	Rivers			
Acacia erioloba	√	√	√	√	√	Protected (F#)
Acacia erubescens	√	√			√	
Acacia hebeclada				√	√	
Acacia hereroensis						
Acacia karroo					√	
Acacia mellifera	√	√	√	√	√	
Acacia reficiens	√	√	√	√	√	
Acacia senegal					√	
Acacia tortilis	√		√	√	√	
Adenia pechuelii						End
Adenolobus garipensis		√			√	
Adenolobus pechuelii						
Albizia anthelmintica	√	√	√	√	√	Protected (F#)
Aloe dichotoma						Protected (F#), NC, C2, N-end
Aloe litoralis	√				√	NC, C2
Azima tetracantha		√	√	√	√	
Boscia albitrunca	√	√	√		√	Protected (F#)
Boscia foetida	√	√	√	√	√	
Cadaba aphylla						
Caesalpinia rubra						
Catophractes alexandri	√	√		√	√	
Combretum apiculatum		√			√	
Combretum hereroense						
Combretum imberbe			√			Protected (F#)
Commiphora africana	√					
Commiphora dinteri						Protected (F#), End
Commiphora glandulosa		√			√	
Commiphora glaucescens		√			√	N-end

Commiphora pyracanthoides						
Commiphora saxicola						Protected (F#), End
Commiphora tenuipetiolata		√			√	
Commiphora virgata		√				Protected (F#), End
Cordia sinensis						
Croton gratissimus		√				
Cyphostemma bainesii						Protected (F#), End, NC
Cyphostemma currorii	√	√				Protected (F#), NC
Dichrostachys cinerea	√	√	√	√	√	
Diospyros lycioides			√		√	
Dombeya rotundifolia		√			√	
Ehretia alba			√		√	
Erythrina decora						Protected (F#), End
Elephantorrhiza suffruticosa		√			√	
Euclea pseudebenus			√	√	√	Protected (F#)
Euclea undulata					√	
Euphorbia avasmontana		√				C2
Euphorbia damarana						End, C2
Euphorbia guerichiana		√			√	C2
Euphorbia virosa						C2
Faidherbia albida	√		√	√	√	Protected (F#)
Flueggea virosa		√				
Ficus cordata		√			√	Protected (F#)
Ficus ilicina						
Ficus sycomorus						Protected (F#)
Gossypium anomalum						
Gossypium triphyllum						
Grewia avellana						
Grewia bicolor	√				√	
Grewia flava	√	√	√	√	√	
Grewia flavescens		√	√		√	
Grewia tenax						
Grewia villosa		√	√			
Gymnosporia senegalensis		√	√			
Ipomoea adeniodes	√					
Laggera decurrens	√					
Lycium bosciifolium	√	√	√		√	
Lycium cinereum						
Lycium eenii	√		√	√	√	

Maerua juncea						
Maerua parvifolia						
Maerua schinzii		√			√	Protected (F#)
Manuleopsis dinteri						End
Montinia caryophyllacea	√				√	
Moringa ovalifolia		√				Protected (F#), NC, N-end
Mundulea sericea		√			√	
Obetia carruthersiana						N-end
Olea europaea						
Ozoroa crassinervia						
Parkinsonia africana	√			√	√	
Pechuel-Loeschea leubnitziae	√		√		√	
Phaeoptilum spinosum	√					
Rotheca myricoides						
Rhigozum trichotomum	√				√	
Salsola spp.						
Salvadora persica			√			
Searsia ciliata						
Searsia lancea						Protected (F#)
Searsia marlothii		√	√		√	
Searsia pyroides						
Steganotaenia araliacea						
Sterculia africana		√			√	Protected (F#)
Strophanthus amboensis						
Tamarix usneoides						Protected (F#)
Tarchonanthus camphoratus						
Tetradenia riparia						
Tinnea rhodesiana						
Terminalia pruniodes	√	√				
Vangueria cyanescens						
Vangueria infausta						
Vernonia cinerascens						
Ximenia americana	√	√	√	√	√	
Ziziphus mucronata	√		√	√	√	Protected (F#)

Endemic and Near-endemic – (Mannheimer and Curtis 2018)
F# – Forest Act No. 12 of 2001
NC – Nature Conservation Ordinance No. 4 of 1975
C2 – CITES Appendix 2 species

Source for literature review: Coats Palgrave (1983), Cunningham (2013), Cunningham (2017), Cunningham (2021), Curtis and Mannheimer (2005), Loots (2005), Mannheimer and Curtis (2009), Mannheimer and Curtis (2018), Rothmann (2004), Steyn (2003), Van Wyk and Van Wyk (1997)

Although between 74 and 101 larger species of trees and shrubs are known and/or expected to occur in the general area only 28, 36 and 25 species were identified in the following habitats – plains, hills and rivers – throughout the proposed development area, respectively (Although not included in Table 5, 4 more species – i.e. *Kleinia longiflora*, *Leucosphaera bainesii*, *Monechma gentisifolium* and *Petalidium* spp. were observed in the plain areas and 3 more species – i.e. *Leucosphaera bainesii*, *Monechma gentisifolium* and *Petalidium* spp. were observed in the hill areas). A total of 58 species of larger trees and shrubs were identified throughout the area (See Table 5 including the above 4 mentioned shrub species) (Cunningham 2021).

A total of at least 62 species are confirmed from the general area if one includes species identified by Cunningham (2013, 2017) as well as the 4 shrub species indicated above – See Table 5.

The most important protected species (including endemic/near endemic, etc.) are viewed as:

Plains

- *Acacia erioloba*, *Albizia anthelmintica*, *Aloe litoralis*, *Boscia albitrunca*, *Cyphostemma currorii*, *Faidherbia albida* and *Ziziphus mucronata*

Hills

- *Acacia erioloba*, *Albizia anthelmintica*, *Boscia albitrunca*, *Commiphora glaucescens*, *Commiphora virgata*, *Cyphostemma currorii*, *Euphorbia guerichiana*, *Euphorbia avasmontana*, *Ficus cordata*, *Maerua schinzii*, *Moringa ovalifolia* and *Sterculia africana*

Rivers

- *Acacia erioloba*, *Albizia anthelmintica*, *Boscia albitrunca*, *Combretum imberbe*, *Euclea pseudebenus*, *Faidherbia albida* and *Ziziphus mucronata*

According to Cunningham (2021) tree/shrub densities vary between 10.8±0.69 (SE) and 16.2±0.91 (SE) which can be converted to 1,080 and 1,620 trees/shrubs per hectare indicating that the area is relatively open although there are patches of dense *Acacia erubescens* and *A. reficiens* in places, indicating the first signs of bush thickening, and should be monitored (Bester 1996, Cunningham 1998).

The protected and/or unique species identified by Cunningham (2021) throughout the proposed Twin Hills mining development areas occur widespread throughout Namibia and not limited to the Twin Hills project area. However, unique habitats such as ephemeral drainage lines have larger specimens which often serve as habitat for a variety of species – e.g. raptor breeding sites, bark and cavity dwelling species (bats, birds and reptiles), etc. – and stabilise river banks while hills have a higher diversity of species including unique species – e.g. *Commiphora* spp.*, Ficus cordata*, *Moringa ovalifolia*, etc. However, many species (e.g. *A. litoralis*, *Cyphostemma currorii*, etc.) are relatively easily to transplant/relocate and could be relocated to other similar habitat should mining activities be necessary in the areas they occur in.

Infrastructure impact

Plant site/waste rock dumps/ tailings storage facility (TSF)/open pits

The impact during construction, are expected to be detrimental to larger trees/shrubs associated with the affected area/habitat.

The impact of aboveground plant site infrastructure is expected to be detrimental to larger trees/shrubs as this would involve land clearing and infrastructure building activities.

The impact of the waste rock dumps is expected to be detrimental to larger trees/shrubs as this would involve covering the areas with rock and other excavated material. Furthermore, WRD 2 would cover parts of the northern tributaries of the Okawayo River and should be avoided.

The impact of the TSF is expected to be detrimental to larger trees/shrubs as this would involve covering the areas with rock and other excavated material.

The impacts of the open pit(s) are expected to be detrimental to larger trees/shrubs as this would involve the excavation and removal of all flora on site.

The impacts of the mining activities are expected to be detrimental to larger trees/shrubs along various roads/tracks and other development areas – i.e. removal/destruction in/along certain areas and/or dust pollution and other contaminants. All vehicle activities (including long hauling) should abide by the speed limits to minimise dust pollution. However, larger trees/shrubs not in the immediate vicinity of proposed development areas will not be adversely affected.

Pipeline impact
The impact of heavy machinery during excavation of a trench to bury the proposed water pipeline is expected to be detrimental to larger trees/shrubs associated with the affected area/habitat. This would affect a relatively small area over a short/limited period of time.

The impact of above/below ground pipeline infrastructure is not expected to be detrimental to larger trees/shrubs, although associated cleared areas would initially benefit annuals and pioneer species while water leakages would benefit species in the immediate vicinity.

Transmission line impact (66kV)
The impact of heavy machinery during construction, and especially the excavation of holes to plant pylons for the proposed transmission line are expected to be detrimental to larger trees/shrubs associated with the affected area/habitat. This would affect a relatively small area over a short/limited period of time.

The impact of aboveground transmission line infrastructure is not expected to be detrimental to larger trees/shrubs unless these grow beneath the transmission line and would have to be pruned and/or removed to gain access under the line and/or pose flashover problems.

Access route impact
The impact of an access route is not expected to be detrimental to larger trees/shrubs as there are numerous existing tracks throughout the general area and the overall footprint is small. However, track discipline should be maintained (e.g. minimise speed (e.g. 40km/h), no off-road driving, limited nocturnal driving, etc.), speed humps and vehicle calming devices should be incorporated along the route. This should act as mitigation measure to minimise dust pollution and/or the destruction of flora during offroad driving.

A tarmac access route would result in less dust pollution and make installing the speed humps and vehicle calming devices, etc. easier than a gravel route.

Furthermore, none of the unique/important species are exclusively associated with the proposed development area.

Okawayo River diversion
The impact during construction, are expected to be detrimental to larger trees/shrubs associated with the affected area/habitat.

The riparian vegetation habitat would be negatively affected although the proposed diversion would become vegetated over time and eventually serve the same purpose.

The Twin Hills project area has been heavily impacted due to current/past mining (e.g. marble quarrying) and farming activities and none of the unique larger trees/shrubs are expected to be exclusively associated with this area.

3.6 Grass Diversity

It is estimated that at least 52-72 grasses (Müller 2007 [72sp.], Van Oudshoorn 2012 [52sp.]) – approximate total of 80 species – occur in the general Karibib area. The grasses known and/or expected to occur in the general area ([1]Müller 2007 and [2]Van Oudtshoorn 2012) is presented in Table 6 below.

Of the approximately 80 grasses that are expected in the general area, 1 species is viewed as endemic (*Eragrostis omahekensis*) (Table 7).

Although between 52 and 72 grasses are known and/or expected to occur in the general area only 19, 16 and 12 species were identified in the following habitats – plains, hills and rivers – throughout the proposed development area during summer and winter (combined), respectively. A total of 30 species of grasses were identified throughout the area (Cunningham 2021). A total of at least 32 species are confirmed from the general area if one includes species identified by Cunningham (2013, 2017) – See Table 6.

Infrastructure impact
Plant site/waste rock dumps/ tailings storage facility (TSF)/open pits
The impact during construction, are expected to be detrimental to grasses associated with the affected area/habitat.

The impact of aboveground plant site infrastructure is expected to be detrimental to grasses as this would involve land clearing and infrastructure building activities.

The impact of the waste rock dumps is expected to be detrimental to grasses as this would involve covering the areas with rock and other excavated material. Furthermore, WRD 2 would cover parts of the northern tributaries of the Okawayo River and should be avoided.

The impact of the TSF is expected to be detrimental to rasses as this would involve covering the areas with rock and other excavated material.

The impacts of the open pit(s) are expected to be detrimental to grasses as this would involve the excavation and removal of all flora on site.

The impacts of the mining activities are expected to be detrimental to grasses along various roads/tracks and other development areas – i.e. removal/destruction in/along certain areas and/or dust pollution and other contaminants. All vehicle activities (including long hauling) should abide by the speed limits to minimise dust pollution. However, grasses not in the immediate vicinity of proposed development areas will not be adversely affected.

Pipeline impact
The impact of heavy machinery during excavation of a trench to bury the proposed water pipeline is expected to be detrimental to grasses associated with the affected area/habitat. This would affect a relatively small area over a short/limited period of time.

The impact of above/below ground pipeline infrastructure is not expected to be detrimental to grasses, although associated cleared areas would initially benefit annuals and pioneer species while water leakages would benefit species in the immediate vicinity.

Table 6. Grass diversity expected (literature study) and confirmed (Cunningham 2021) ($\surd^S$ = summer 2021 and $\surd^W$ = winter 2021) including author's confirmed records from other studies conducted from the general area (See: Cunningham 2013, 2017). The grasses known, and/or expected to occur in the general area (derived from [1]Müller 2007 and [2]Van Oudtshoorn 1999).

Species: Scientific name	Cunningham (2021)			Helikon Lithium (2013)	Helikon/ Rubicon Lithium (2013)	Ecological Status *	Grazing Value *
	Plains	Hills	Rivers				
[1,2]*Andropogon chinensis*						Increaser 1	Average
[2]*Andropogon eucomus*						Increaser 2	Low
[1]*Anthephora argentea*						Decreaser	High
[1,2]*Anthephora pubescens*		$\surd^{S,W}$			$\surd$	Decreaser	High
[1]*Anthephora schinzii*	$\surd^S$	$\surd^S$			$\surd$	Increaser 2	Low
[1,2]*Aristida adscensionis*	$\surd^W$	$\surd^W$	$\surd^W$		$\surd$	Increaser 2	Low
[1,2]*Aristida congesta*	$\surd^W$					Increaser 2	Low
[1]*Aristida effusa*						Increaser 2	Low
[1,2]*Aristida meridionalis*						Increaser 2	Low
[1]*Aristida rhiniochloa*						Increaser 2	Low
[1,2]*Bachiaria deflexa*						Increaser 2	Average
[1]*Brachiaria malacodes*						?	Low
[1]*Brachiaria glomerata*						Decreaser	Average
[1,2]*Brachiaria nigropedata*						Decreaser	High
[1,2]*Cenchrus ciliaris*	$\surd^{S,W}$	$\surd^S$	$\surd^S$	$\surd$	$\surd$	Decreaser	High
[1,2]*Centropodia glauca*						Decreaser	High
[1,2]*Chloris virgata*		$\surd^S$				Increaser 2	Average
[2]*Cladoraphis spinosa*						Increaser 1	Low
[1,2]*Cynodon dactylon*						Increaser 2	High
[1,2]*Dactyloctenium aegyptium*						Increaser 2	Low
[1]*Danthoniopsis ramosa*						?	High
[1,2]*Dichanthium annulatum*						Decreaser	High
[2]*Diplachne fusca*						Decreaser	High
[1]*Echinochloa colona*						?	Low
[2]*Elionurus muticus*						Increaser 2	Low
[1,2]*Enneapogon cenchroides*	$\surd^W$	$\surd^W$	$\surd^{S,W}$	$\surd$	$\surd$	Increaser 2	Low
[1,2]*Enneapogon desvauxii*	$\surd^W$	$\surd^W$		$\surd$	$\surd$	Intermediate	Average
[1,2]*Enneapogon scaber*						?	Low

[1,2]*Enneapogon scoparius*						Increaser 2	Low
[1]*Entoplocamia aristulata*	√W				√	Intermediate	Low
[1,2]*Eragrostis annulata*						Increaser 2	Low
[1]*Eragrostis cylindriflora*	√S,W		√S	√	√	?	Low
[2]*Eragrostis biflora*			√W			Increaser 2	Low
[2]*Eragrostis cilianensis*						Increaser 2	Low
[1,2]*Eragrostis echinochloidea*	√W				√	Increaser 2	Average
[1]*Eragrostis homomalla*						?	Low
[2]*Eragrostis lehmanniana*						Increaser 2	Average
[1,2]*Eragrostis nindensis*	√S	√S,W		√	√	Increaser 2	Average
[1]*Eragrostis omahekensis* [E]						?	Low
[1]*Eragrostis porosa*	√S,W	√W			√	Intermediate	Low
[1]*Eragrostis rigidior*			√S			Increaser 2	Average
[1,2]*Eragrostis rotifer*	√S				√	Intermediate	Low
[1]*Eragrostis scopelophila*						?	High
[1,2]*Eragrostis superba*					√	Increaser 2	Average
[1,2]*Eragrostis trichophora*	√W				√	Increaser 2	Average
[1,2]*Eragrostis viscosa*						Increaser 2	Low
[1,2]*Fingerhuthia africana*		√S,W		√		Decreaser	Average
[1,2]*Heteropogon contortus*						Increaser 2	Average
[1,2]*Hyparrhenia hirta*						Increaser 1	Average
[1]*Leptochloa fusca*						?	Average
[1,2]*Microchloa caffra*						Increaser 2	Low
[1]*Monelytrum luederitzianum*						?	Average
[1,2]*Melinis repens*	√W	√W	√W	√	√	Increaser 2	Low
[1]*Odyssea paucinervis*						?	Average
[1,2]*Oropetium capense*						?	Low
[1,2]*Panicum coloratum*						Decreaser	High
[1,2]*Panicum maximum*		√W				Decreaser	High
[2]*Panicum repens*		√S	√S			Decreaser	High
[1]*Pogonarthria fleckii*					√	Increaser 2	Low
[2]*Polypogon monspeliensis*						?	Average
[1,2]*Schmidtia kalahariensis*	√W				√	Increaser 2	Low
[1,2]*Schmidtia pappophoroides*						Decreaser	High
[1]*Setaria appendiculata*						?	Average
[1,2]*Setaria verticillata*			√W		√	Increaser 2	Average
[1]*Sorghum bicolour*						?	Average

[1,2]*Sporobolus festivus*		√[W]				Increaser 2	Low
[1,2]*Stipagrostis ciliata*	√[S]					Decreaser	High
[1]*Stipagrostis giessii*						?	Average
[1,2]*Stipagrostis hirtigluma*						Increaser 2	Low
[1]*Stipagrostis hochstetteriana*	√[S,W]		√[S]		√	Decreaser	Average
[1,2]*Stipagrostis namaquensis*			√[S]		√	?	Average
[1,2]*Stipagrostis obtusa*						Decreaser	High
[1,2]*Stipagrostis uniplumis*	√[S]	√[W]	√[W]	√	√	Increaser 2	Average
[1,2]*Tricholaena monachne*						Increaser 2	Average
[1]*Triraphis purpurea*						?	Low
[1]*Triraphis ramosissima*		√[W]		√	√	?	Average
[1,2]*Tragus berteronianus*	√[S]					Increaser 2	Low
[1]*Tragus racemosus*						Increaser 2	Low
[1]*Urochloa brachyura*						?	Average
[1]*Urochloa panicoides*						?	Low

Endemic – (Müller 2007)
? – not classified in literature, but often similar to other species within the genus

Source for literature review: Müller (2007), Van Oudtshoorn (2012)

Transmission line impact (66kV)
The impact of heavy machinery during construction, and especially the excavation of holes to plant pylons for the proposed transmission line are expected to be detrimental to grasses associated with the affected area/habitat. This would affect a relatively small area over a short/limited period of time.

The impact of aboveground transmission line infrastructure is not expected to be detrimental to grasses.

Access route impact
The impact of an access route is not expected to be detrimental to grasses as there are numerous existing tracks throughout the general area and the overall footprint is small. However, track discipline should be maintained (e.g. minimise speed (e.g. 40km/h), no off-road driving, limited nocturnal driving, etc.), speed humps and vehicle calming devices should be incorporated along the route. This should act as mitigation measure to minimise dust pollution and/or the destruction of flora during offroad driving.

A tarmac access route would result in less dust pollution and make installing the speed humps and vehicle calming devices, etc. easier than a gravel route.

Furthermore, none of the unique/important species are exclusively associated with the proposed development area.

Okawayo River diversion
The impact during construction, are expected to be detrimental to grasses associated with the affected area/habitat.

The riparian vegetation habitat would be negatively affected although the proposed diversion would become vegetated over time and eventually serve the same purpose.

The Twin Hills project area has been heavily impacted due to current/past mining (e.g. marble quarrying) and farming activities and none of the unique grasses are expected to be exclusively associated with this area.

3.7 Other Species

Other species confirmed by Cunningham (2021) throughout the proposed development area included the following herbs, etc. (Table 7). However, this list is not comprehensive – i.e. many more species are known and/or expected to occur in the area.

The most important species are viewed as the endemic species (*Barleria lanceoloata* and *Lantana dinteri*) and near endemic species (*Emilia marlothina* and *Oxsalis purpurascens*) (Mannheimer 2012).

Table 7. Other species – bulbs, herbs, etc. – confirmed in various habitats (P – Plains; H – Hills; R - Rivers) during summer and winter observations throughout the Twin Hills project area (Cunningham 2021).

	Habitat		
Species	**Summer**	**Winter**	**Status**
Abutilon fruticosum	H	R	
Ammocharis coranica	R		
Aptosimum arenarium	P		
Aptosimum lineare	H		

Asparagus spp.	P, H		
Barleria lanceolata	H		End
Barleria lancifolia	H, R	H,R	
Barleria rigida	H		
Blepharis obmitrata	P	R	
Boophone disticha	P		
Citrullus lanatus	P	P	
Cleome elegantissima	H		
Cleome gynandra	P		
Cleome suffruticosa	P, H		
Commelina bendhalensis	H		
Corallocarpus welwitschii	P		
Crotalaria argyraea	P	P	
Cryptolepis decidua	H		
Cucumis meeusei	P		
Cyperus fulgens	R		
Cyperus schinzii	H		
Cyphostemma congestum	P		
Dactyliandra welwitschii		P,R	N-end
Dicoma tomentosa		P	
Dicoma spp.		R	
Dipcadi crispum	P		
Dipcadi glaucum	P		
Emilia marlothiana	H		N-end
Eriospermum rautanenii	P		
Euphorbia glanduligera		P	
Ferraria glutinosa	P		
Geigeria pectidia	P	P	
Gisekia africana	P		
Gossypium anomalum	R	P	
Harpagophytum procumbens	P		
Heliotropium lineare	P		
Hermania modesta		P	
Hermbstaedtia argenteiformis		R	
Hermbstaedtia odorata	P, R	P	
Hibiscus calyphyllus	P		
Hibiscus elliottiae	P, H	P	
Hibiscus palmatus	P		
Ingigophera alternans	P		
Indogophera cryptantha		R	
Indogophera pechuelii		H,R	
Ipomoea obscura	P		
Jamesbrittenia tenella		R	N-end
Jamesbrittenia spp.	H		
Kohautia caespitosa	P		
Lantana dinteri	H		End
Ledebouria undulata	P		

Leonotis ocymifolia		R	
Leucas pechuelii		P,R	
Leucasphaera bainesii	P,H,R	P,H,R	
Limeum aethiopicum	P		
Mollugo cerviana	P		
Momordica humilis	P		
Monechma divaricatum		R	
Monechma genistifolium	P	P	
Myrothamnus flabellifolius	H	H	
Nerine laticoma	P		
Oxalis purpurascens	H		N-end
Pergularia daemia		P,R	
Petalidium spp.	P,H,R	P,H,R	
Phyllanthus maderaspatensis	P	P,R	
Pseudogaltonia clavata	P, R		
Senna italica		P	
Sesamum triphyllum		R	
Sesbania sesban	P	P	
Solanum multiglandulosum	P	R	
Sesamum triphylum	R		
Talinum caffrum	P		
Tapinanthus oleifolius	P		
Tribulocarpus dimorphanthus	P	P	
Tribulus terrestris	P, R, H		

Fewer herbs (including bulbs, etc.) were oserved during the winter observations and can be ascribed to most of the herbs, etc. being annuals with above ground structures having died and withered. More herbs, etc. were observed in rivers during the winter observations as this habitat retains moisture for longer and the riparian vegetation provide shade and protection against herbivores.

Invasive alien species

Invasive alien species confirmed by Cunningham (2021) were associated with and/or spread from various farming activities – e.g. kraal, farmstead, etc. – and include:

- *Cryptostegia grandiflora* (rubber vine)
- *Datura ferox* (thorn apple spp.)
- *Datura innoxia* (thorn apple spp.)
- *Eucalyptus* spp. (Australian gum spp.)
- *Flaveria bidentis* (smelter's bush)
- *Leucaena leucocephala* (giant wattle)
- *Opuntia* spp. (prickly pear spp.)
- *Prosopis* spp. (mesquite spp.)

Some of these above mentioned species have already started invading the area, especially along the drainage lines, close to the farmstead (e.g. *Opuntia* and *Prosopis* spp.) and should be eradicated where/when encountered. Furthermore, mine related soil disturbances could favour some of the invasive alien species (e.g. *Datura* spp. increase in disturbed areas) and/or increase their range throughout the area.

3.8 Important Species

Reptiles
The high percentage of endemic reptile species (45.3%) associated with the rocky escarpment region of central western Namibia underscores the importance of this area without formal state protection. The most important species expected to occur in the general area (See Table 1) are viewed as the tortoises (*Stigmochelys pardalis* and *Psammobates oculiferus*); pythons (*Python anchietae* and *P. natalensis*); Namibian wolf snake (*Lycophidion namibianum*); monitor lizard (*Varanus albigularis*) and some of the endemic and little known gecko species – e.g. *Pachydactylus* species. Tortoises, snakes and monitor lizards are routinely killed for food or as perceived threats. Other important species are those viewed as "rare" – i.e. *Rhinotyphlops lalandei*, *Mehelya vernayi* and *Afroedura africana* – although very little is known about these species.

Amphibians
Of the 7 species of amphibians that potentially could occur in the general area, 2 species are endemic (*Poyntonophrynus hoeschi* and *Phrynomantis annectens*) (Griffin 1998b) and 1 species is classified as "near threatened" (*Pyxicephalus adspersus*) (Du Preez and Carruthers 2009) – i.e. high level (42.9%) of amphibians of conservation value from the general area (See Table 2). With the exception of these important species and due to the fact that there is little open permanent surface water in the area, amphibians are not viewed as very important in the general area.

Mammals
Of the 87 species of mammals known and/or expected to occur in the general Karibib area, 10 species (11.5%) are classified as endemic. At least 31% (27 species) of the mammalian fauna that occur or are expected to occur in the general Karibib area are represented by rodents of which 5 species (18.5%) are endemic. This is followed by bats 27.6% (24 species) of which 1 species is classified as "rare". These are the mammal group's least studied in Namibia. Species of greatest concern in the general area are those viewed as rare in Namibia – i.e. Namibian wing-gland bat and Southern African hedgehog – and species classified as vulnerable (cheetah, leopard, Hartmann's mountain zebra, giraffe) and near threatened (African straw-coloured fruit bat, Commerson's roundleaf bat, striped leaf-nosed bat, brown hyena) by the IUCN (2021) (See Table 3). Another important and unique species, although not observed, but known to occur in the general area, is the endemic Kaokoland slender or black mongoose (See: Cowley and Cunningham 2004, Warren *et al.* 2009).

Birds
At least 217 bird species [mainly terrestrial "breeding residents"] occur and/or could occur in the general Karibib area at any time and include 12 of the 14 Namibian endemics (85.7% of all Namibian endemic species or 5.6% of all the species expected to occur in the area). The most important bird species from the general area are those classified as endemic to Namibia of which the Damara hornbill and Herero chat are viewed as the most important due to the overall lack of knowledge of these species. Although also viewed as important, Rüppels korhaan is migratory throughout its range while the rockrunner inhabits inaccessible terrain and is widespread throughout mountainous areas in Namibia. Other species of concern are those classified as endangered (violet wood-hoopoe, Ludwig's bustard, black harrier, tawny eagle, booted eagle, martial eagle, black stork) and near threatened (Rűppel's parrot, Verreaux's eagle, peregrine falcon, marabou stork) (Simmons *et al.* 2015) and those species classified by the IUCN (2021) as critically endangered (white-backed vulture), endangered (Ludwig's bustard, lack harrier, lappet-faced vulture, martial eagle, secretarybird), vulnerable (tawny eagle) and near threatened (kori bustard) (See Table 4). Although white-backed vulture, lappet-faced vulture and secretarybird are not known to breed in the area (Eddie Nederlof *pers.com.*), such nesting sites, should these be

established and/or located in future, are viewed as extremely important and should be avoided at all costs.

Flora

Trees/shrubs and Grasses

At least 91 to 101 larger species of trees and shrubs are known and/or expected to occur in the general area of which 8 species (7.9%) expected to occur in the general Karibib area are classified as endemic, 4 species as near endemic (4%), 21 species (20.8%) are protected by the Forest Act No 12. of 2001, 5 species (5%) are protected under the Nature Conservation Ordinance No. 4 of 1975 while 6 species (5.9%) are classified as CITES Appendix 2 species. Although all the trees with some kind of conservation and/or protected status (including endemic/near endemic species) are viewed as important in the general Karibib area, the most important species are viewed as *Commiphora dinteri*, *Commiphora saxicola*, *Commiphora virgata*, *Cyphostemma bainesii*, *Cyphostemma currorii* and *Erythrina decora* (See Table 5). The endemic grass – *Eragrostis omahekensis* – is viewed as the most important species potentially occurring in the general area.

Important plant species known and/or expected from the general Karibib area and included in the Red Data Book for Namibia include at least 16 species of which 1 species is listed as rare (*Diclis tenuissima*), 1 species as vulnerable (*Lithops werneri*) and 1 species as near threatened (*Adenia pechuelii*) (Table 8) (Loots 2005). All the species included in Table 9 are viewed as important.

Table 8. Important species – i.e. Red Data spp. – known to occur in the general Karibib area according to Loots (2004).

Species: Scientific name	Conservation status
Adenia pechuelii	Endemic, NT
Aloe dinteri	Endemic, NC, C2, LC
Aloe namibensis	Endemic, NC, C2, LC
Australluma peschii	Endemic, LC
Chamaegigas intrepidus	Endemic, LC
Crassula capitella subsp. *nodulosa*	LC
Cyphostemma bainesii	Endemic, LC
Diclis tenuissima	Endemic, Rare
Dombeya rotundifolia var. *velutina*	Endemic, LC
Euphorbia monteiroi subsp. *brandbergensis*	Endemic, C2, LC
Lithops gracilidelineata subsp. *gracilidelineata*	NC, LC
Lithops ruschiorum	Endemic, NC, LC
Lithops werneri	Endemic, NC, V
Namacodon schinzianum	Endemic, LC
Nicotiana africana	Endemic, LC
Trema orientalis	LC

Endemic (Loots 2005)
NC – Nature Conservation Ordinance No. 4 of 1975
Rare; V – Vulnerable; NT – Near Threatened; LC – Least Concern (Loots 2005)
C2 – CITES Appendix 2 spp.

Other

Aloes

Aloes are protected throughout Namibia with 3 other aloe species not included in Table 5, but which potentially occur in the general area, and also viewed as important are *Aloe asperifolia*, *A. hereroensis* and *A. zebrina* (Rothmann 2004).

Commiphora

Many endemic Commiphora species are found throughout Namibia with Steyn (2003) indicating that *Commiphora crenato-serrata* (not included in the Table 5) potentially also

occurring in the general area. *Commiphora* species have economic potential (i.e. resin properties used in the perfume industry – e.g. *C. wildii*) making them an important species (Knott and Curtis 2006).

Lithops
Lithops species – all protected (See Nature Conservation Ordinance No. 4 of 1975) – are also known to occur in the general area and often difficult to observe, especially during the dry season when their aboveground structures wither. The closest species are currently only known to occur west of Usakos and include *Lithops gracilidelineata* var. *gracilidelineata* and *L. werneri* (Cole and Cole 2005, Earle and Round n.d.).

Ferns
At least 64 species of ferns, of which 13 species being endemic, occur throughout Namibia. Ferns in the general Karibib area include at least 15 indigenous species (*Actiniopteris radiata*, *Asplenium cordatum*, *Cheilanthes dinteri*, *C. eckloniana*, *C. marlothii*, *C. parviloba*, *Marselia aegyptiaca*, *M. ephippiocarpa*, *M. farinosa*, *M. macrocarpa*, *M. nubica*, *M. unicornis*, *M. vera*, *Ophioglossum polyphyllum* and *Pellaea calomelanos*) (Crouch *et al.* 2011). The general area is undercollected with more species probably occurring in the general area than presented above.

Lichens
The overall diversity of lichens is poorly known from Namibia, especially the coastal areas and statistics on endemicity is even sparser (Craven 1998). More than 100 species are expected to occur in the Namib Desert with the majority being uniquely related to the coastal fog belt (Wirth 2010). Lichen diversity is related to air humidity and generally decreases inland form the Namibian coast (Schults and Rambold 2007). Off road driving is the biggest threat to these lichens which are often rare and unique to Namibia. To indicate how poorly known lichens are from Namibia, the recent publication by Schultz *et al.* (2009) indicating that 37 of the 39 lichen species collected during BIOTA surveys in the early/mid 2000's were new to science (i.e. new species), is a case in point. Lichens are known to occur on rocky terrain in the mountainous terrain in the general area.

Other species with commercial potential that could occur in the general Karibib area include *Harpagophytum procumbens* (Devil's claw) – harvested for medicinal purposes and often over-exploited – and *Citrullus lanatus* (Tsamma melon) which potentially has a huge economic benefit (Mendelsohn *et al.* 2002).

3.9 Important Areas

The most important areas in the Twin Hills project area are:

1. Limestone/marble hills

Rocky areas generally have high biodiversity and consequently viewed as important habitat for all vertebrate fauna and flora in the general Karibib area. Protected species associated with and confirmed from the hills in the Twin Hills project area include unique species such as *Commiphora glaucescens*, *Commiphora virgata*, *Cyphostemma currorii*, *Euphorbia avasmontana*, *Ficus cordata*, *Moringa ovalifolia* and *Sterculia africana* (See Table 5).

2. Ephemeral drainage lines

The various ephemeral drainage lines are important habitat to larger trees, especially *Acacia erioloba*, *Euclea pseudebenus*, *Faidherbia albida* and *Ziziphus mucronata* (See Table 5). The most important drainage line is the Okawayo River bisecting the Twin Hills project area (See Figures 1 and 2).

3. Ephemeral dams and pans

The various ephemeral ground dams, albeit artificial, and pans are important habitat, mainly for amphibians, although the larger trees associated with such features serve as habitat to a variety of vertebrate fauna.

4. Bird flyways

Although very little is known regarding bird flight paths in Namibia, especially species moving/migrating at night, most birds seem to follow the shortest routes between selected habitats – e.g. dams, estuaries, bays, etc. However, unpredictable rainfall events may lure species into areas not normally frequented and storms (e.g. berg winds) may also force birds into areas not regularly visited. Planning for all eventualities is therefore not always possible.

Avifauna is expected to be potentially affected by the 66kV overhead transmission line. Although, none of the unique/important bird species are exclusively associated with the proposed development area, the effect of aboveground transmission line infrastructure(s) is expected to be detrimental to certain birds – e.g. "pylon sensitive" species. Species potentially affected by the proposed overhead transmission line once operational and at greatest risk would be those larger species flying at pylon height (e.g. bustards, eagles, vultures); nocturnal travellers (e.g. flamingos and Palaearctic species) and species potentially visiting the area for roosting/foraging, etc. (e.g. bustards).

Although very little is known regarding the actual flight paths used by the birds frequenting the general area, Figures 3 and 4 indicate potential flight paths and documented bird mortalities caused by transmission lines in Namibia.

As vultures are known to breed in the general area; are viewed as an a known "pylon sensitive" species (See Scot and Scot n.d.); species of conservation concern (critically endangered – IUCN 2021); located between known bird mortality "hotspot" areas and known to be negatively affected by transmission lines, anti-perching devices should be placed on pylons and anti-collision mechanisms – BFD's (bird flight diverters) such as coils, flappers, etc. – should be attached to the transmission line from the tarmac road (Karibib-Omaruru) to the plant site. Other important species that would also benefit from BFD's, and known to frequent the area after localised rainfall events, are kori and Lüdwig's bustards.

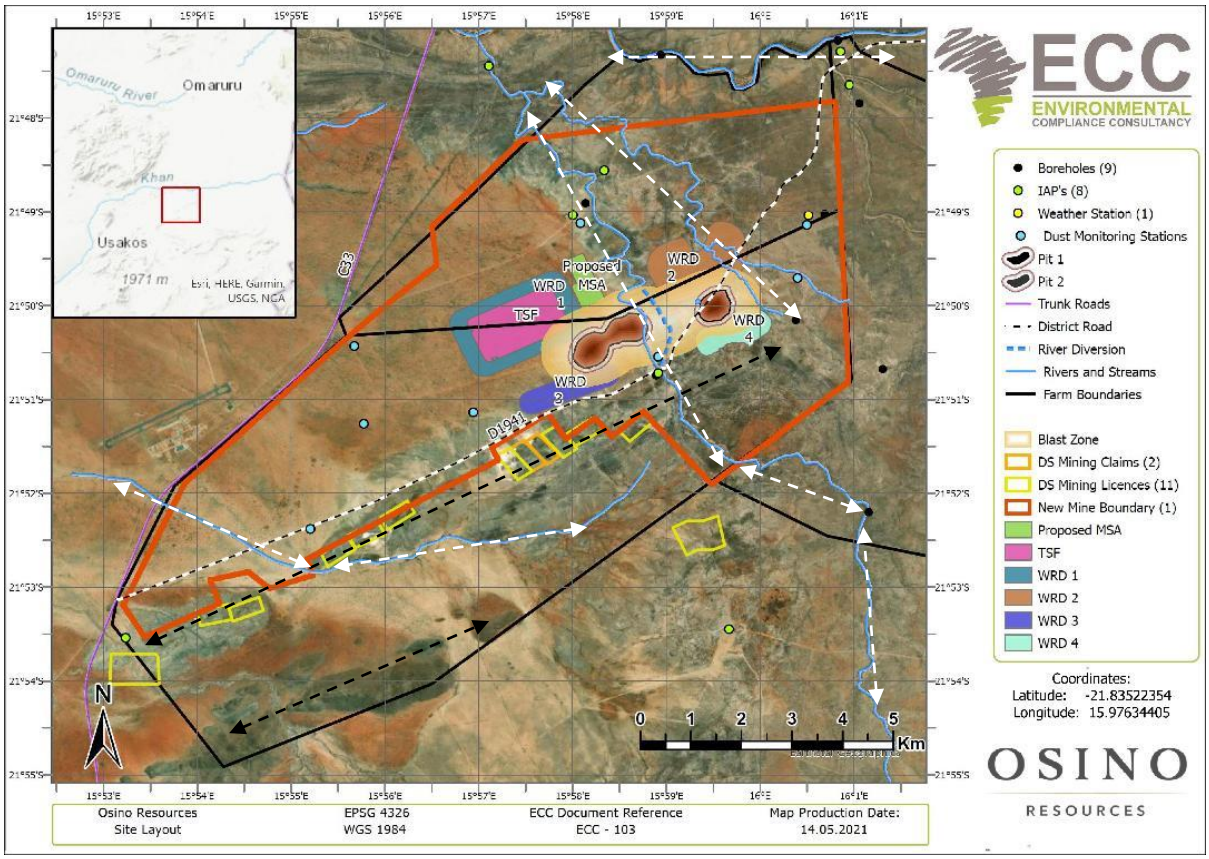

Figure 3. Expected bird flight paths along ephemeral drainage lines (white dashed arrows) and between mountainous areas (black dashed arrows) in the general area.

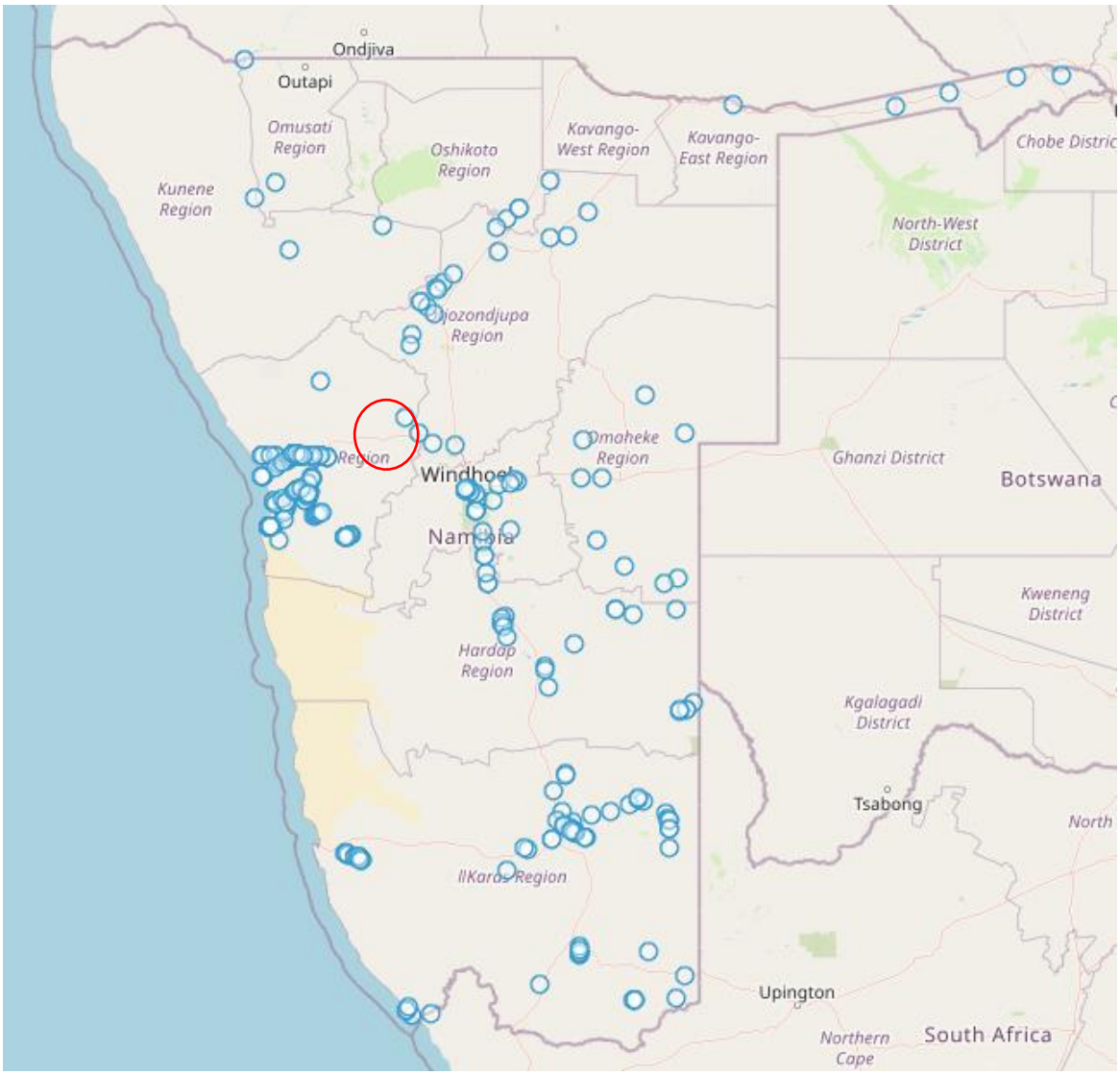

Figure 4. Known bird mortalities caused by power lines throughout Namibia (March 2021) are indicated by blue circles. The general Karibib area – indicated by a red circle – although not currently a known "hotspot" BIRD collision risk area, is located between such sites to the west and east, and new transmission line(s) undoudtedly would increase bird collisions risks, etc. (Source: www.the-eis.com).

4 Conclusion

As all development have potential negative environmental consequences, identifying the most important faunal species including high risk habitats beforehand, coupled with environmentally acceptable mitigating factors, lessens the overall impact of such development.

Vertebrate fauna species most likely to be adversely affected by the proposed mining/prospecting in the Twin Hills project areas would be sedentary species (i.e. species with limited mobility) such as unique reptiles (i.e. tortoises *Stigmochelys pardalis* and *Psammobates oculiferus*; pythons – *P. anchietae* and *P. natalensis*; Namibian wolf snake (*Lycophidion namibianum*) – *Varanus albigularis*; some of the endemic and little known gecko species – e.g. *Pachydactylus* species and species viewed as "rare" – i.e. *Rhinotyphlops lalandei*, *Mehelya vernayi* and *Afroedura africana* – although very little is known about these species). Amphibians are not viewed as important in the area and mammals are more mobile and although important species are known to occur and/or pass through the area (see elsewhere in this report) none are expected to be specifically

associated and/or expected to be negatively affected by the developments. Although general disturbances could affect bird species of concern – i.e. species classified as endangered (violet wood-hoopoe, Ludwig's bustard, white-backed vulture, black harrier, tawny eagle, booted eagle, martial eagle, black stork), vulnerable (lappet-faced vulture, secretarybird) and near threatened (Rűppel's parrot, kori bustard, Verreaux's eagle, peregrine falcon, marabou stork) – birds are also mobile and not limited to the area.

Flora species most likely to be adversely affected by mining/prospecting would be the various protected species although these species are not specifically associated with the development sites.

Important areas in the general vicinity are viewed as hills (limestone/marble hills), ephemeral drainage lines, ground dams and pans and bird flight paths.

WRD 2 would cover parts of the northern tributaries of the Okawayo River and should be avoided.

The proposed water pipeline should not be placed aboveground as this would act as a barrier to ungulates and ostrich and should be buried.

Bird flight diverters (BDF's) should be attached to the proposed 66kV transmission line from the tarmac road to the mine plant area to minimise/prevent avifauna mortalities.

Although the proposed Okawayo River diversion would affect vertebrate fauna and flora directly associated with the loss of habitat and thoroughfare, the diversion would eventually be vegetated again and serve the same purpose. This proposed diversion (See Figure 2) is viewed as the best option compared to other alternatives discussed in Cunningham (2021).

It is not expected that mining/prospecting developments will adversely affect any unique vertebrate fauna and flora in the Twin Hills project areas, especially if the proposed recommendations (mitigation measures) are incorporated – See this report under each section and Cunningham (2021).

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