

**BIOPHYSICAL ASSESSMENT (VERTEBRATE FAUNA
AND FLORA): AMMONIA PIPELINES + AMMONIA
TERMINAL (ARANDIS-FARM 58-WALVIS BAY
AREA'S)**

SPECIALIST CONTRIBUTION:

Prepared by:

Peter L Cunningham

Environment and Wildlife Consulting Namibia

**P. O. Box 417
Karasburg
Namibia**

**Mobile: +264 81-3004080
E-mail: pckkwrc@yahoo.co.uk**

Prepared for:

Ms Kelly Ochs

Environmental Compliance Consultancy

**Windhoek
Namibia**

**Mobile: +264 81-4082077
www.eccenvironmental.com
E-mail: kelly@eccenvironmental.com**

CONTENTS

Biophysical Assessment (Vertebrate fauna and Flora): Ammonia Pipeline + Ammonia Terminal (Arandis-Farm 58-Walvis Bay Areas)

1	Introduction	1
2	Methods	7
2.1	Literature Review	7
2.2	Field survey	7
3.	Results	8
3.1	Reptile Diversity	8
3.2	Amphibian Diversity	18
3.3	Mammal Diversity	23
3.4	Avian Diversity	30
3.5	Flora	41
3.5.1	Trees and Shrubs	41
3.5.2	Grass	49
3.5.3	Other Species	53
3.6	Important Other Species	55
4	Important Species	57
5	Important Areas	60
6	Envisaged Impacts	81
6.1	Introduction	81
6.2	Faunal Impact	81
6.3	Floral Impact	85
6.4	Impact Methods	88
6.5	Assessment: Construction, Operation & Decommissioning	90
6.6	Impacts: Construction, Operation & Decommissioning	92
7	Recommendations	96
8	References	98

1 Introduction

A literature review was conducted to determine the actual as well as potential vertebrate fauna and flora associated with the general area commonly referred to as the Southern Namib or Southern Desert (Giess 1971, Mendelsohn *et al.* 2002). This area is bordered inland by the Central Namib or Central Desert (Giess 1971, Mendelsohn *et al.* 2002). Climatically the coastal area is referred to as Cool Desert with a high occurrence of fog. The Namib Desert Biome makes up a large proportion (32%) of the land area of Namibia with parks in this biome making up 69% of the protected area network or 29.7% of the biome (Barnard 1998). This has increased since the establishment of the !Dorob National Park.

The annual average rainfall in the general area is <100mm with a coefficient of variation between 50-100% (humidity 50-100%) while the average maximum and minimum temperatures are between 22-30 and 8-12°C, respectively. The dominant soil types vary between leptosols (inland – stony and/or very shallow soils), gypsisols (behind coastal dunes – gypsum soils with a higher rate of evaporation compared to precipitation) and arenosols (coastal dunes – deep windblown sands) (Jarvis *et al.* 2022). The general area is regarded as “low” in overall (all terrestrial species) diversity while the overall terrestrial endemism on the other hand is “moderate to high” (Mendelsohn *et al.* 2002).

Two important coastal wetlands – i.e., Walvis Bay Wetlands and Sandwich Harbour – both Ramsar sites, occur in the general area. According to Curtis and Barnard (1998) the entire coast and the Walvis Bay lagoon as a coastal wetland, are viewed as sites with special ecological importance in Namibia. The coast immediately north of Walvis Bay is viewed as a biodiversity “Red Flag Area” due to important bird area; high density of waders along beach and Damara tern breeding area (SAIEA 2010).

The known distinctive values along the coastline are its biotic richness (arachnids, birds, and lichens) with the Walvis Bay lagoon’s importance being its biotic richness and migrant shorebirds as well as being the most important Ramsar site in Namibia. The Ramsar site covers 12,600 ha with regular counts of birds varying between 37,000 and well over 100,000 individuals, albeit mainly migratory species (Kolberg n.d.). The Walvis Bay wetland is considered the most important coastal wetland in southern Africa and one of the top 3 in Africa (Shaw *et al.* 2004). The Sandwich Harbour Ramsar site covers 16,500 ha and falls within the Namib-Naukluft Park and enjoys full protection (Kolberg n.d.). This area is a centre of concentration of migratory shorebirds, waders and flamingos regularly supporting over 142,000 and 50,000 birds during summer and winter, respectively (Kolberg n.d.).

The area is bordered by the Kuiseb River to the south (Walvis Bay area) and the Swakop and Khan Rivers to the north (Swakopmund area) with catchment areas of 15,500 km² and 30,100 km², respectively with common riparian species including Ana tree, Tamarix, Camelthorn, Salvadora, Fig, Euclea, !Nara and Mesquite (Jacobson *et al.* 1995).

The central coastal region, and the general Swakopmund/Walvis Bay area in particular, is regarded as “relatively low” in overall (all terrestrial species) diversity (Mendelsohn *et al.* 2002). Overall terrestrial endemism in the area on the other hand is “moderate to high” (Mendelsohn *et al.* 2002). The overall diversity and abundance of large herbivorous mammals (big game) is viewed as “low to medium” with 1-2 species while overall diversity of large carnivorous mammals (large predators) is determined at 4 species with brown hyena being the most important with “medium” densities expected in the area (Mendelsohn *et al.* 2002).

According to Maggs (1998) there are approximately 4344 higher plant species with the most species being within the grasses (422), composites (Asteraceae) (385), legumes (Fabaceae) (377) and figies (Mesembryanthemaceae) (177), recorded from Namibia. Total species richness depends on further collecting and taxonomic revisions. High species richness is

found in the Okavango, Otavi/Karsveld, Kaokoveld, southern Namib and Central Highland (Windhoek Mountains) areas. Endemic species – approximately 687 species in total – are mainly associated with the Kaokoveld (northwestern) and the succulent Karoo (southwestern) Namibia. The major threats to the floral diversity in Namibia are:

- 1). Conversion of the land to agriculture (with associated problems) and,
- 2). poorly considered development (Maggs 1998, Mendelsohn *et al.* 2002).

The vegetation in the Desert Biome is characterised by a dominance of therophytes which persist in the form of seeds during unfavourable conditions (Lovegrove 1999). According to Mendelsohn *et al.* (2002) the dominant vegetation structure in the Southern Desert is grassland and dwarf shrubland. These Namib grasslands – mainly annual species – are very sparse, but nevertheless still dominate the little vegetation that grows there. The average plant production is extremely low with 0-5% variation in green vegetation biomass (Mendelsohn *et al.* 2002). The overall plant diversity (all species) in the general Walvis Bay/Swakopmund area is estimated as <50 species (Mendelsohn *et al.* 2002). These estimates are limited to “higher” plants as information regarding “lower” plants is sparse. Burke (2003) estimates that over 400 species – 10% of the flora of Namibia – occur in the central Namib and although it has not been identified as a centre of endemism, it is dominated by endemics such as *Arthroerua leubnitziae*. 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 is viewed as “medium” – with between 1-15 endemics expected from the general area (Mendelsohn *et al.* 2002). Furthermore, Mendelsohn *et al.* (2002) views the grazing and browse as virtually non-existent in the general area. The tourism potential of this area is viewed as moderate (Mendelsohn *et al.* 2002).

No communal and freehold conservancies are in the general area with the closest communal conservancy being the #Gaingu Conservancy in the general Spitzkoppe area (Mendelsohn *et al.* 2002, MEFT/NACSO 2021).

It is estimated that at least 63 reptile, 7 amphibian, 55 mammal, 182 bird species (breeding residents), 55 species of larger trees and shrubs and up to 56 grasses are known to or expected to occur in the general/immediate area of which a high proportion are endemics (e.g., reptiles with 60.3%).

A rapid site assessment was conducted between 27 and 29 April 2024 to determine the vertebrate fauna (e.g., reptiles, amphibians, mammals, and birds); flora (trees >1m in height; grasses and other important flora) and assess route(s) according to their ecological importance (sensitivity) along sections of the various ammonia pipeline options roughly between Walvis Bay and Arandis. This survey was preceded by a review of the historical reports of the vertebrate fauna and flora known/expected to occur in the general area as conducted by various authors (e.g., Cunningham 2006, 2007, 2010, 2011, 2013, 2019, 2021, 2024, Griffin 2005a, Henschel *et al.* 2000, Henschel *et al.* 2011, Kavari 2007).

This rapid site assessment was conducted to confirm vertebrate fauna and flora species as well as zone the areas according to sensitive habitats along sections of the various ammonia pipeline options between Arandis-Farm 58-Walvis Bay areas as well as the and Ammonia terminal site just north of Walvis Bay (Figures 1a & b - 2a & b). **This report was updated during June 2025 to include changes to the final ammonia pipeline route (instead of hydrogen pipeline) selected in the i) Arandis and ii) Richthofen areas (Figures 1c & 1d).**

Figures 1a-d. The various hydrogen/ammonia pipeline routes between Arandis via Farm 58 to Walvis Bay considered during this study (Source: ECC).



Figure 1a: Black = Ammonia; Blue = water and Red/Green/Purple/Yellow = various hydrogen pipeline routes (prior to change made to a complete ammonia pipeline) between Arandis and Farm 58 in the Dune 7 area.



Figure 1b: Black = Swakop Route; Green = Dorob Route and Blue = Naukluft Route.



Figure 1c: The final pipeline route selection between Arandis and Walvis Bay.



Figure 1d (i): The Arandis pipeline section route change. The dark blue dashed line indicates the original route.



Figure 1d (ii): The Richthofen pipeline section route change. The dark green dashed line indicates the original route.

Figures 2a-b. The proposed Ammonia pipeline route between Farm 58 in the Dune 7 area and the Ammonia terminal area north of Walvis Bay including the Farm 58 layout (Source: ECC).



Figure 2a: Hot Ammonia route from Farm 58 to the Ammonia Terminal.

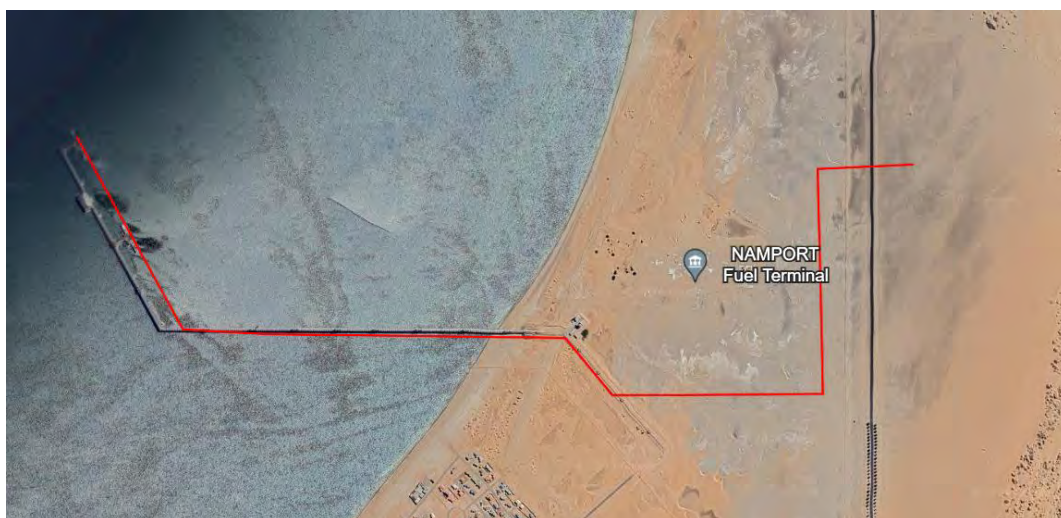


Figure 2b: Cold Ammonia route from Ammonia Terminal along pier into sea.

2 Methods

2.1 Literature Review

A comprehensive and intensive literature review (i.e., desktop study) regarding the vertebrate fauna (i.e., reptiles, amphibians, mammals, and birds) and flora (i.e., trees/shrubs >1m in height and grasses) including unique habitats that could potentially occur in the general area – i.e., Walvis Bay via Farm 58 to Arandis – was conducted using as many references as manageable. A list of the references consulted can be viewed in the Reference section (Page 98).

2.2 Field survey

According to the original ToR, fieldwork to determine the actual vertebrate fauna diversity would include the following:

- Small mammal trapping to determine small mammal diversity;
- Larger mammal observations – direct sightings, faeces, tracks, etc.;
- Reptile and amphibian transects (diurnal) to determine reptile and amphibian diversity; and
- Bird transects to determine avian diversity in the area.

Mammals:

Fieldwork consisted of:

- 1) Small mammal trapping,
- 2) Transects – vehicle and on foot – throughout the general area to determine the presence of larger mammals – e.g., direct sightings, faeces, carcasses, tracks, etc., and

1) *Small mammal trapping:*

- Collapsible aluminium Sherman small mammal traps baited with peanut butter and oats were set just prior to sunset.
- The traps were placed 10m to 20m apart depending on the habitats.
- Small mammals caught were identified *in situ*, photographed, measured (when applicable to facilitate identification) and released unharmed at the point of capture.
- Transect lengths and directions varied depending on terrain and perceived habitats.

2) *Larger mammal transects:*

- Transects to determine the presence of larger mammals was conducted throughout the area.
- Transect lengths and directions varied depending on terrain and perceived habitats.
- Direct observations of mammals encountered along these transects were made using 10 x 40 binoculars.
- All other signs of mammals were noted and identified to species level where possible. This included such signs as tracks, scats, carcasses and skulls and other signs – e.g., quills, hair/skins, dens/burrows, etc.
- All signs were photographed as evidence and/or to confirm by second opinions from other experts if required.
- Sightings were limited to diurnal observations only.

Reptiles and Amphibians:

- Transects to determine the presence of reptiles and amphibians was conducted throughout the area.
- Transects crisscrossed the entire area and were not conducted in rigid straight lines but focused on the habitats viewed as most suitable for reptiles and amphibians.

- Reptiles observed were either caught by hand or by using an active capture technique called 'reptile noosing' where an extendable fishing rod was fitted with a soft thread noose, positioned over the unsuspecting head of an individual and pulled tight. This technique does not result in the death or injury of the captured specimen.
- Reptiles caught were identified *in situ*, photographed and released unharmed at the point of capture.
- Sightings were limited to diurnal observations only.

Birds:

- Transects to determine the presence of birds was conducted throughout the area.
- Transect lengths and directions varied depending on terrain and perceived habitats.
- Direct observations of birds encountered along these transects were made using 10 x 40 binoculars.
- Bird calls were identified throughout and confirmed with direct observations.
- All other signs of birds were noted and identified to species level where possible. This included such signs as nests and scrapes, tracks, carcasses and other signs – e.g., feathers, regurgitated pellets, etc.
- All signs were photographed as evidence and/or to confirm by second opinions from other experts if required.
- Sightings were limited to diurnal observations only.

Flora:

- Flora assessment included a complete assessment of trees, shrubs [>1m in height]; grasses & herbs (and other species – e.g., bulbs, ferns, etc. – observed on site).
- Important species were photographed as evidence and/or to confirm by second opinions from other experts if required.

Habitats:

Furthermore, the various pipeline routes were zoned according to the sensitivity of the habitat(s) traversed (i.e., High = very sensitive; Medium = moderately sensitive; Low = least sensitive). Areas that could not be traversed due to lack of vehicle access was zoned using Google Earth maps.

Google Earth maps were also used to assess the changes to the final selected route (See Figure 1c) in the Arandis (See Figure 1d (i)) and Richthofen (See Figure 1d (ii)) areas.

3. Results

3.1 Reptile Diversity

Reptile diversity known and/or expected to occur in the general area – i.e., Arandis-Farm 58-Walvis Bay – is presented in Table 1.

Approximately 261 species of reptiles are known or expected to occur in Namibia thus supporting approximately 30% of the continent's 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 area is estimated at between 41-50 species and 21-24 species (Mendelsohn *et al.* 2002) or 30-40 and 9-12 species, respectively (Jarvis *et al.* 2022). Griffin (1998a) presents figures of between 21-30 and 7-8 for endemic lizards and snakes, respectively, from the general area. Griffin (1998a) puts the species richness distribution of endemics also between 3-4 species in the general area while the Namib-Naukluft Park has

an estimated 100 species in total and the neighbouring Skeleton Coast National Park has at least 77 species of reptiles. No data exists for the !Dorob National Park.

At least 63 species of reptiles are expected to occur in the general area with 38 species being endemic – i.e., 60.3% endemic. Two species expected to occur in the area (*Stigmochelys pardalis* and *Varanus albigularis*) are classified as vulnerable and protected game although both, especially *S. pardalis*, probably only occasionally passes through the general area as a vagrant and not expected to occur permanently in the area due to the overall arid conditions. *Pelomedusa subrufa* is only expected to occur in drainage lines in the area (e.g., Khan, Kuiseb, Swakop and Tumas Rivers and their tributaries) with suitable habitat – i.e., long lasting water holes. *Lycophidion capense* and *Lycophidion namibianum* only marginally occur in the Namib-Naukluft Park (Griffin 1998a) and potentially could occur in the general area. Three important coastal and dune and/or *Salsola* hummock associated species are *Bitis peringueyi* (Péringuey's Adder), *Typhlosaurus braini* (Brains's Blind Legless Skink) and *Pachydactylus rangei* (Web-footed gecko).

Afroedura africana africana and *Meroles micropholidotus* are classified as insufficiently known and rare (Griffin 2003) and are probably the reptiles of most concern in the general area. Another important species from the general area is *Pedioplanis husabensis* which although secure (Griffin 2003) is associated with the Husab Mountains and surrounding area only (Cunningham *et al.* 2012). Fifty-two species have some form of international conservation status (i.e., IUCN; SARDB and CITES) with *Varanus albigularis* the species of most concern and classified as vulnerable, peripheral, and protected game under Namibian legislation and listed as safe to vulnerable by the SARDB (2004). The IUCN (2025) classifies 49 species as least concern although some reptiles have not yet been assessed for the IUCN Red List.

The 63 species expected to occur in the general area consist of at least 19 snakes (2 thread snakes, 1 quill snouted and 16 typical snakes) of which 9 species (47.4%) are endemic, 1 tortoises, 1 terrapin, 19 lizards of which 11 species classified as endemic (57.9% endemic), 1 plated lizard, 1 monitor, 2 agamas, 1 chameleon and 17 geckos of which 15 species classified as endemic (i.e., 88.2% endemic).

Gecko's (17 species with 15 species being endemic) and lizards (19 species with 11 species being endemic) are the most important groups of reptiles expected from the general area followed by snakes (19 species with 9 species being endemic). Namibia with approximately 129 species of lizards (Lacertilia) has one of the continents richest lizard fauna (Griffin 1998a). Geckos expected and/or known to occur in the general area have the highest occurrence of endemics (88.2%) of all the reptiles in this area. Griffin (1998a) confirms the importance of the gecko fauna in Namibia.

The endemic *Afroedura africana africana* (African flat gecko), *Meroles micropholidotus* (small-scale desert lizard) and *Pedioplanis husabensis* (Husab sand lizard) are viewed as the most important reptiles potentially occurring in the area. *Pedioplanis husabensis* is very habitat specific and mainly occurs on "white/grey" geology in the Khan River area south of Arandis (Cunningham *et al.* 2012). *Leptotyphlops occidentalis* (western thread snake) and *Lycophidion namibianum* (Namibian wolf snake) are the snakes viewed as the most important in the area. Three important coastal and dune and/or *Salsola* hummock associated species are *Bitis peringueyi* (Péringuey's Adder), *Typhlosaurus braini* (Brains's Blind Legless Skink) and *Pachydactylus rangei* (Web-footed gecko).

The most important species is the endemic *Pedioplanis husabensis* (Husab sand lizard) which is a restricted range species (100% of the taxon's range within Namibia) occurring in the general area of the confluence of the Swakop and Khan Rivers. It is furthermore viewed as "threatened" by the 'uranium rush' (SAIEA 2010) with its total known range currently estimated at <5,000km² (Wassenaar and Mannheimer 2010) which would put it in the

Table 1. Reptile diversity expected to occur in the general Arandis-Farm 58-Walvis Bay areas – literature study – and species confirmed during the rapid site assessment (✓) and/or the author's previous records (✓¹⁻¹⁰) from the general area.

Species: Scientific name	Species: Common name	Species confirmed	Species confirmed: Previous studies	Namibian conservation and legal status	International Status		
					SARDB	IUCN	CITES
TURTLES AND TERRAPINS							
<i>Stigmochelys pardalis</i>	Leopard Tortoise			Vulnerable; Peripheral; Protected Game		LC	C2
<i>Pelomedusa galeata (subrufa)</i>	Marsh/Helmeted Terrapin			Secure		LC	C3
SNAKES							
Thread Snakes							
<i>Namibiana (Leptotyphlops) occidentalis</i>	Western Thread Snake			Endemic; Secure	P	LC	
<i>Namibiana (Leptotyphlops) labialis</i>	Damara Thread Snake			Endemic; Secure		LC	
Quill Snouted Snakes							
<i>Xenocalamus bicolour bicolor</i>	Bicoloured Quill-snouted Snake			Secure			
Typical Snakes							
<i>Boaedon (Lamprophis) fuliginosus</i>	Brown House Snake			Secure		LC	
<i>Lycophidion capense</i>	Cape Wolf Snake			Secure			
<i>Lycophidion namibianum</i>	Namibian Wolf Snake			Endemic; Secure		LC	
<i>Pseudaspis cana</i>	Mole Snake			Secure		LC	
<i>Pythonodipsas carinata</i>	Western Keeled Snake			Endemic; Secure			
<i>Dipsina multimaculata</i>	Dwarf Beaked Snake			Endemic; Secure		LC	
<i>Psammophis trigrammus</i>	Western Sand Snake		√ ¹	Endemic; Secure		LC	
<i>Psammophis notostictus</i>	Karoo Sand Snake			Secure		LC	
<i>Psammophis leightoni namibensis</i>	Namib Sand Snake		√ ^{1,2,3,4,9}	Secure		LC	
<i>Dasypeltis scabra</i>	Common/Rhombic Egg Eater			Secure		LC	
<i>Aspidelaps lubricus infuscatus</i>	Coral Snake			Secure			
<i>Aspidelaps scutatus</i>	Shield-nose Snake			Endemic; Secure		LC	
<i>Naya nigricincta</i>	Black-necked Spitting Cobra			Endemic; Secure	R		
<i>Bitis arietans</i>	Puff Adder		√ ⁸	Secure		LC	
<i>Bitis caudalis</i>	Horned Adder		√ ^{1,3,5,6,8}	Secure		LC	
<i>Bitis peringueyi</i>	Péringuey's Adder		√ ^{4,7}	Endemic; Secure		LC	
LIZARDS							
Skinks							

Species: Scientific name	Species: Common name	Species confirmed	Species confirmed: Previous studies	Namibian conservation and legal status	International Status		
					SARDB	IUCN	CITES
<i>Typhlosaurus braini</i>	Brains's Blind Legless Skink			Endemic; Secure			
<i>Typhlacontias brevipes</i>	FitzSimon's Burrowing Skink		√7,8,9	Endemic; Secure			
<i>Trachylepis acutilabris</i>	Wedge-snouted Skink		√3,11	Secure		LC	
<i>Trachylepis occidentalis</i>	Western Three-striped Skink			Secure		LC	
<i>Trachylepis hoeschi</i>	Hoesch's Skink		√1,5	Endemic; Secure		LC	
<i>Trachylepis striata wahlbergi</i>	Striped Skink			Secure		LC	
<i>Trachylepis sulcata</i>	Western Rock Skink		√1,9	Secure		LC	
<i>Trachylepis variegata variegata</i>	Variegated Skink		√6,8	Secure		LC	
Old World Lizards							
<i>Heliobolus lugubris</i>	Bushveld Lizard			Secure		LC	
<i>Meroles anchietae</i>	Shovel-snouted Lizard		√4	Secure		LC	
<i>Meroles cuneirostris</i>	Wedge-snouted Desert Lizard		√4	Endemic; Secure		LC	
<i>Meroles micropholidotus</i>	Small-scale Desert Lizard		√10	Endemic; Insufficiently known; Rare?		LC	
<i>Meroles reticulatus</i>	Reticulated Desert Lizard		√2,4,7,8,9,11	Endemic; Secure		LC	
<i>Meroles suborbitalis</i>	Spotted Desert Lizard		√3,5	Endemic; Secure		LC	
<i>Pedioplanis breviceps</i>	Short-headed Sand Lizard		√6	Endemic; Secure		LC	
<i>Pedioplanis namaquensis</i>	Namaqua Sand Lizard			Secure			
<i>Pedioplanis inornata</i>	Plain Sand Lizard		√2,6,10	Endemic; Secure		LC	
<i>Pedioplanis husabensis</i>	Husab Sand Lizard		√1,6	Endemic; Secure		LC	
<i>Pedioplanis undata</i>	Western Sand Lizard		√10	Endemic; Secure		LC	
Plated Lizards							
<i>Cordylus subtaeniatus</i>	Dwarf Plated Lizard			Endemic; Secure		LC	
Monitors							
<i>Varanus albigularis</i>	Rock or White-throated Monitor			Vulnerable; Peripheral; Protected Game	S to V	LC	C2
Agama							
<i>Agama planiceps</i>	Namibian Rock Agama		√5	Endemic; Secure		LC	
<i>Agama anchietae</i>	Western Rock Agama		√1,5	Endemic; Secure		LC	
Chameleons							
<i>Chamaeleo namaquensis</i>	Namaqua Chameleon		√1,2,4,6	Secure		LC	C2
Geckos							
<i>Afroedura africana africana</i>	African Flat Gecko			Endemic; Insufficiently known; Rare?		LC	

Species: Scientific name	Species: Common name	Species confirmed	Species confirmed: Previous studies	Namibian conservation and legal status	International Status		
					SARDB	IUCN	CITES
<i>Chondrodactylus angulifer namibensis</i>	Giant Ground Gecko		√ ^{1,3,4,6}	Endemic; Secure		LC	
<i>Narudasia festiva</i>	Festive Gecko			Endemic; Secure		LC	
<i>Pachydactylus bicolor</i>	Velvety Thick-toed Gecko		√ ^{3,4}	Endemic; Secure		LC	
<i>Pachydactylus kochii</i>	Kock's Thick-toed Gecko		√ ^{3,6}	Endemic; Secure			
<i>Pachydactylus turneri</i>	Turner's Thick-toed Gecko		√ ^{1,6}	Secure			
<i>Pachydactylus scherzi</i>	Schertz's Thick-toed Gecko			Endemic; Secure		LC	
<i>Pachydactylus punctatus</i>	Speckled Thick-toed Gecko		√ ^{3,6}	Secure		LC	
<i>Pachydactylus rugosus rugosus</i>	Rough Thick-toed Gecko			Endemic; Secure		LC	
<i>Pachydactylus weberi weneri</i>	Weber's Thick-toed Gecko			Endemic; Secure		LC	
<i>Pachydactylus rangei</i>	Web-footed gecko		√ ⁴	Endemic; Secure		LC	
<i>Ptenopus carpi</i>	Carp's Barking Gecko		√ ³	Endemic; Secure		LC	
<i>Ptenopus garrulus maculatus</i>	Common Barking Gecko		√ ^{1,3,4,6}	Endemic; Secure		LC	
<i>Ptenopus kochi</i>	Koch's Barking Gecko		√ ⁴	Endemic; Secure		LC	
<i>Phelsuma (Rhoptropus) afer</i>	Common Namib Day Gecko	√	√ ^{2,3,4,6,9,11}	Endemic; Secure			
<i>Phelsuma (Rhoptropus) boultoni</i>	Boulton's Namib Day Gecko		√ ^{4,5,6,10}	Endemic; Secure			
<i>Phelsuma (Rhoptropus) bradfieldi</i>	Bradfield's Namib Day Gecko		√ ^{1,9}	Endemic; Secure			

Namibian conservation and legal status according to the Nature Conservation Ordinance No 4 of 1975 (Griffin 2003)

Endemic – includes Southern African Status (Branch 1998)

SARDB (2004): S to V – Safe to Vulnerable; V – Vulnerable; P – Peripheral

IUCN (2025): LC – Least Concern [All other species not yet assessed]

CITES: CITES Appendix 2/3 species

√¹ – Cunningham (2007), √² – Cunningham (2010a); √³ – Cunningham (2010b); √⁴ – Cunningham (2011a); √⁵ – Cunningham (2011b); √⁶ – Cunningham (2013); √⁷ – Cunningham (2014); √⁸ – Cunningham (2019); √⁹ – Cunningham (2021); √¹⁰ – Cunningham (2023); √¹¹ – Cunningham (2024)

Source for literature review: Alexander and Marais (2007), Branch (1998), Branch (2008), Bonin *et al.* (2006), Boycott and Bourquin (2000), Broadley (1983), Buys and Buys (1983), Cunningham (2006), Cunningham (2007), Cunningham (2010a), Cunningham (2010b), Cunningham (2011a), Cunningham (2011b), Cunningham (2013), Cunningham (2014), Cunningham (2019), Cunningham (2021), Cunningham (2023), Cunningham (2024), Griffin (2003), Hebbard (n.d.), IUCN (2025), Marais (1992), SARDB (2004), Schleicher (2020), Tolley and Burger (2007)

“endangered” category according to the IUCN Red List Categories and Criteria although currently listed as least concern (IUCN 2025). Cunningham *et al.* (2012) showed that *P. husabensis* is an extreme habitat specialist, selecting not only marble substrates, but specifically marble surrounded by other bare rock types. Although white coloured geology occurs along the various pipeline routes, especially in the Husab area, no *P. husabensis* were encountered during the rapid site assessment.

As reptiles are generally understudied animals; occur at low densities in such marginal habitat, many more species are expected to occur in the general area than confirmed during the fieldwork. However, except for *Pedioplanis husabensis* associated with specific habitat and geology in the general area (i.e., Husab area), no reptiles are exclusively associated with the project areas.

During the rapid site assessment only 1 reptile species was confirmed from the various routes traversed (*Phelsuma (Rhoptropus) afer* (Figure 3) while a total of 34 species has been confirmed from the general area by Cunningham (2007, 2010a,b, 2011a,b, 2013, 2014, 2019, 2021, 2023, 2024) (See Table 1). The low number of species is probably due to the extreme barren coastal and Farm 58 areas and overall dry conditions between Arandis and Farm 58 (along the various proposed pipeline routes) as well as overall low densities in these marginal habitats (i.e., coastal salt pan habitat in the Ammonia Terminal area and sparsely vegetated gypsum/gravel plains in the Farm 58 area are low biodiversity areas).



Figure 3. *Phelsuma (Rhoptropus) afer* (common Namib day gecko) were common in rocky areas north and south of Goanikontes (i.e., Alternative Route: Purple – See Figure 1).

Other areas:

As reptiles are viewed as an important group in the desert areas of Namibia the following unpublished reports are included from the general area:

Other reptile related work in the general area includes Henschel *et al.* (2000) from Gobabeb, Griffin (2005) from Valencia, Cunningham (2006) from Trekkopje, Henschel *et al.* (2011) from Marenica and Kavari (2007) from Rössing Uranium Mine. Their findings are presented in the following tables:

According to Henschel *et al.* (2000) at least 20 species of lizards (12 geckos, 5 lizards and 3 skinks) have been recorded on the gravel plains at Gobabeb. Henschel *et al.* (2006) indicate an expected 53 reptile species from Gobabeb of which 17 species are associated with the gravel habitats (Table 2).

Table 2. Reptiles recorded on the gravel plains at Gobabeb.

Family and Scientific name	Common name
Gekkonidae	
<i>Chondrodactylus angulifer</i>	Giant Ground Gecko
<i>Pachydactylus kockii</i>	Koch's Thick-toed Gecko
<i>Pachydactylus turneri</i>	Turner's Thick-toed Gecko
<i>Pachydactylus scherzi</i>	Schertz's Thick-toed Gecko
<i>Pachydactylus rugosus</i>	Rough Thick-toed Gecko
<i>Pachydactylus rangei</i>	Palmato gecko
<i>Ptenopus carpi</i>	Banded Barking Gecko
<i>Ptenopus garrulus</i>	Common Barking Gecko
<i>Rhoptropus afer</i>	Common Namib Day Gecko
<i>Rhoptropus barnardi</i>	Lesser Namib Day Gecko
<i>Rhoptropus bradfieldi</i>	Bradfield's Namib Day Gecko
<i>Narudasia festiva</i>	Festive Gecko
Lacertidae	
<i>Meroles suborbitalis</i>	Spotted Desert Lizard
<i>Pedioplanis breviceps</i>	Short-headed Sand Lizard
<i>Pedioplanis lineoocellata</i>	Ocellated Sand Lizard
<i>Pedioplanis namaquensis</i>	Namaqua Sand Lizard
<i>Pedioplanis undata</i>	Western Sand Lizard
Scincidae	
<i>Trachylepis acutilabris</i>	Wedge-snouted Skink
<i>Trachylepis occidentalis</i>	Western Three-striped Skink
<i>Trachylepis spilogaster</i>	Namibian Tree Skink

Source: Henschel *et al.* (2000)

Table 3 indicates the reptile diversity known, reported and/or expected to occur (77 species) in the general Valencia Uranium area as presented by Griffin (2005a).

Table 3. Reptiles reported and/or expected to occur in the general Valencia area.

Species: Scientific name	Common name
Turtles and Tortoises and Terrapins	
<i>Geochelone pardalis</i>	Leopard tortoise
<i>Pelomedusa subrufa</i>	Marsh/Helmeted Terrapin
Snakes	
Worm Snakes	
<i>Leptotyphlops occidentalis</i>	Western Thread/Worm Snake
<i>Leptotyphlops labialis</i>	Damara Thread/Worm Snake
<i>Leptotyphlops scutifrons</i>	Peter's Thread/Worm Snake
Blind Snakes	
<i>Rhinotyphlops lalandei</i>	Delalande's Blind Snake
<i>Rhinotyphlops schinzi</i>	Beaked Blind Snake
Boas and Pythons	
<i>Python anchietae</i>	Namibian Dwarf Python
Typical Snakes	
<i>Lamprophis fuliginosus</i>	Brown House Snake
<i>Pseudaspis cana</i>	Mole Snake
<i>Psammophylax rhombeatus</i>	Spotted Skaapsteker
<i>Dipsina multimaculata</i>	Dwarf Beaked Snake
<i>Psammophis trigrammus</i>	Western Sand Snake

Species: Scientific name	Common name
<i>Psammophis notostictus</i>	Karoo Sand Snake
<i>Psammophis leightoni namibensis</i>	Namib Sand Snake
<i>Psammophis subtaeniatus</i>	Western Striped-bellied Sand Snake
<i>Psammophis leopardinus</i>	Leopard Whip Snake
<i>Dasypeltis scabra</i>	Common/Rhombic Egg Eater
<i>Philothamnus semivariegatus</i>	Spotted Bush Snake
<i>Telescopus beetzi</i>	Namaqua Tiger Snake
<i>Telescopus semiannulatus</i>	Southern Tiger Snake
<i>Telescopus sp. nov.</i>	Damara Tiger Snake
<i>Pythonodipsas carinata</i>	Western keeled Snake
<i>Prosymna frontalis</i>	Shouthwestern Shovel-snout
<i>Aspidelaps lubricus infuscatus</i>	Coral Snake
<i>Aspidelaps scutatus scutatus</i>	Shield-nose Snake
<i>Naja anchietae</i>	Angolan Cobra
<i>Naja nigricollis nigricincta</i>	Black-necked Spitting Cobra
<i>Naja woodi</i>	Black Spitting Cobra
<i>Naja nivea</i>	Cape Cobra
<i>Dendroaspis polylepis</i>	Black Mamba
<i>Bitis arietans</i>	Puff Adder
<i>Bitis caudalis</i>	Horned Adder
Lizards	
Worm Lizards	
<i>Zygaspis quadrifrons</i>	Kalahari Round-headed Worm Lizard
Skinks	
<i>Trachylepis acutilabris</i>	Wedge-snouted Skink
<i>Trachylepis occidentalis</i>	Western Three-striped Skink
<i>Trachylepis hoeschi</i>	Western Rock Skink
<i>Trachylepis spilogaster</i>	Namibian Tree Skink
<i>Trachylepis sulcata</i>	Western Rock Skink
<i>Trachylepis variegata variegata</i>	Variegated Skink
<i>Trachylepis wahlbergii</i>	Wahlberg's Striped Skink
Old World Lizards	
<i>Nucras intertexta</i>	Spotted Sandveld Lizard
<i>Heliobolus lugubris</i>	Bushveld Lizard
<i>Meroles knoxii</i>	Round-snouted Sand Lizard
<i>Meroles cuneirostris</i>	Wedge-snouted Desert Lizard
<i>Meroles suborbitalis</i>	Spotted Desert Lizard
<i>Pedioplanis breviceps</i>	Short-headed Sand Lizard
<i>Pedioplanis lineoocellata</i>	Ocellated Sand Lizard
<i>Pedioplanis namaquensis</i>	Namaqua Sand Lizard
<i>Pedioplanis gaerdesi</i>	Damara Sand Lizard
<i>Pedioplanis undata</i>	Western Sand Lizard
<i>Pedioplanis inornata</i>	Plain Sand Lizard
<i>Pedioplanis hasabensis</i>	Husab Sand Lizard
Plated Lizards	
<i>Cordylus subtaeniatus</i>	Dwarf Plated Lizard
<i>Gerrhosaurus nigrolineatus</i>	Black-lined Plated Lizard
<i>Gerrhosaurus validus</i>	Giant Plated Lizard
Monitors	
<i>Varanus albigularis</i>	Rock Monitor
Agamas	
<i>Agama anchietae</i>	Western Rock Agama
<i>Agama planiceps</i>	Namibian Rock Agama
Chameleons	
<i>Chamaeleo namaquensis</i>	Namaqua Chameleon
Geckos	
<i>Afroedura africana africana</i>	African Flat Gecko
<i>Chondrodactylus angulifer namibensis</i>	Giant Ground Gecko

Species: Scientific name	Common name
<i>Narudasia festiva</i>	Festive Gecko
<i>Pachydactylus bicolor</i>	Velvety Thick-toed Gecko
<i>Pachydactylus capensis</i>	Cape Thick-toed Gecko
<i>Pachydactylus fasciatus</i>	Damaraland Banded Thick-toed Gecko
<i>Pachydactylus kockii</i>	Koch's Thick-toed Gecko
<i>Pachydactylus punctatus</i>	Speckled Thick-toed Gecko
<i>Pachydactylus turneri</i>	Turner's Thick-toed Gecko
<i>Pachydactylus scherzi</i>	Schertz's Thick-toed Gecko
<i>Pachydactylus rugosus rugosus</i>	Rough Thick-toed Gecko
<i>Pachydactylus weberi</i>	Weber's Thick-toed Gecko
<i>Lygodactylus bradfieldi</i>	Namibian Dwarf Gecko
<i>Ptenopus garrulus maculatus</i>	Common Barking Gecko
<i>Rhoptropus afer</i>	Common Namib Day Gecko
<i>Rhoptropus barnardi</i>	Lesser Namib Day Gecko
<i>Rhoptropus bradfieldi</i>	Bradfield's Namib Day Gecko

Source: Griffin (2005)

A survey of the reptiles associated with the Trekkopje Uranium Mining area conducted by Cunningham (2006b) indicated the presence of 22 reptile species (8 snakes, 1 skink, 2 lizards, 2 agamas, 1 chameleon and 8 geckos) (Table 4).

Table 4. Reptiles recorded in the general Trekkopje Uranium Mining area.

Species: Scientific name	Species: Common name
Typical Snakes	
<i>Lamprophis fuliginosus</i>	Brown House Snake
<i>Lycophidion namibianum</i>	Namibian Wolf Snake
<i>Dipsina multimaculata</i>	Dwarf Beaked Snake
<i>Psammophis leightoni namibensis</i>	Namib Sand Snake
<i>Dasypeltis scabra</i>	Common Egg Eater
<i>Aspidelaps lubricus infuscatus</i>	Coral Snake
<i>Naya nigricincta</i>	Black-necked Spitting Cobra
<i>Bitis caudalis</i>	Horned Adder
Lizards	
Skinks	
<i>Trachylepis acutilabris</i>	Wedge-snouted Skink
Old World Lizards	
<i>Pedioplanis namaquensis</i>	Namaqua Sand Lizard
<i>Pedioplanis husabensis</i>	Husab Sand Lizard
Agamas	
<i>Agama aculeata</i>	Ground Agama
<i>Agama anchietae</i>	Anchieta's Agama
Chameleons	
<i>Chamaeleo namaquensis</i>	Namaqua Chameleon
Geckos	
<i>Chondrodactylus angulifer namibensis</i>	Giant Ground Gecko
<i>Lygodactylus bradfieldi</i>	Bradfield's Dwarf Gecko
<i>Pachydactylus bicolor</i>	Velvety Thick-toed Gecko
<i>Pachydactylus serval serval</i>	Western Spotted Thick-toed Gecko
<i>Ptenopus carpi</i>	Carp's Barking Gecko
<i>Rhoptropus afer</i>	Common Namib Day Gecko
<i>Rhoptropus boultoni</i>	Boulton's Namib Day Gecko
<i>Rhoptropus bradfieldi</i>	Bradfield's Namib Day Gecko

Source: Cunningham (2006b)

A survey of the reptiles associated with the Marenica Mining site in the Spitzkoppe area conducted by Henschel *et al.* (2011) indicated the presence of 19 reptile species (1 snake, 5 skinks, 6 lizards, 2 agamas, 1 chameleon and 4 geckos) (Table 5).

Table 5. Reptiles recorded in the general Marenica (Spitzkoppe) area.

Family and Scientific name	Common name
Typical Snakes	
<i>Psammophis leightoni namibensis</i>	Namib Sand Snake
Lizards	
Skinks	
<i>Trachylepis acutilabris</i>	Wedge-snouted Skink
<i>Trachylepis occidentalis</i>	Western Three-striped Skink
<i>Trachylepis hoeschi</i>	Western Rock Skink
<i>Trachylepis spilogaster</i>	Namibian Tree Skink
<i>Trachylepis variegata variegata</i>	Variegated Skink
Old World Lizards	
<i>Pedioplanis breviceps</i>	Short-headed Sand Lizard
<i>Pedioplanis inornata</i>	Plain Sand Lizard
<i>Pedioplanis namaquensis</i>	Namaqua Sand Lizard
Agamas	
<i>Agama anchietae</i>	Anchieta's Agama
<i>Agama planiceps</i>	Namibian Rock Agama
Chameleons	
<i>Chamaeleo namaquensis</i>	Namaqua Chameleon
Geckos	
<i>Chondrodactylus angulifer namibensis</i>	Giant Ground Gecko
<i>Pachydactylus bicolor</i>	Velvety Thick-toed Gecko
<i>Pachydactylus turneri</i>	Turner's Thick-toed Gecko
<i>Pachydactylus scherzi</i>	Schertz's Thick-toed Gecko
<i>Ptenopus garrulus maculatus</i>	Common Barking Gecko
<i>Rhoptropus boultoni</i>	Boulton's Namib Day Gecko
<i>Rhoptropus bradfieldi</i>	Bradfield's Namib Day Gecko

Source: Henschel *et al.* (2011)

A pilot study conducted by Kavari (2007) on the reptile diversity associated with the future expansion of the Rössing Uranium Mine indicated the presence of 6 reptile species (3 geckos, 1 lizard, 1 chameleon and 1 snake) (Table 6).

Table 6. Reptiles recorded in the general Rössing Uranium Mine area.

Family and Scientific name	Common name
Typical snakes	
<i>Psammophis notostictus</i>	Karoo Sand Snake
Geckkonidae	
<i>Trachylepis variegata variegata</i>	Variegated Skink
<i>Trachylepis hoeschi</i>	Western Rock Skink
<i>Ptenopus garrulus</i>	Common Barking Gecko
Lacertidae	
<i>Pedioplanis hasabensis</i>	Husab Sand Lizard
Chameleons	
<i>Chamaeleo namaquensis</i>	Namaqua Chameleon

Source: Kavari (2007)

Ammonia Terminal Impact (Coast)

The proposed development is in a barren saline pan area and consequently development impacts are not expected to be detrimental to reptiles as this is an extremely marginal environment for reptiles.

However, the Salsola dune hummock habitat, located on the eastern boundary of the proposed development area, are important for a variety of reptiles and should be avoided.

Farm 58 (Dune 7 area)

The proposed development is in a barren gypsum/sandy gravel plain area and although the diversity of reptiles in this habitat is low, developments are expected to be detrimental to reptile species associated with the affected area/habitat.

However, the rocky habitat with small sparsely vegetated ephemeral drainage lines, located on the north eastern/eastern boundary of the proposed development area, are important for a variety of reptiles and should be avoided.

Solar PV Plant impact

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

Pipeline impact

The impact of heavy machinery during excavation of a trench to bury the proposed ammonia pipelines is expected to be detrimental to reptiles associated with the affected areas/habitats.

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.

Access route impact

The impact of pipeline access routes 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., best practices speed limits to be followed), no off-road driving, limited nocturnal driving, etc.), speed humps and vehicle calming devices recommended to be incorporated to prevent speeding along the route. This should act as mitigation measure for important slow moving, especially nocturnal, reptiles.

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

3.2 Amphibian Diversity

Amphibian diversity known and/or expected to occur in the general area – i.e., Arandis-Farm 58-Walvis Bay – is presented in Table 7.

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 because 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. Desert areas are marginal habitat for amphibians.

The dry sandy coastal desert (Namib) and saline coastal areas are poor habitat for amphibians (Cunningham & Jankowitz 2010). Although the ephemeral Khan, Kuiseb and Swakop Rivers reach the sea in the Walvis Bay and Swakopmund areas, they seldom flow with temporary freshwater pools being rare close to the coast. The ephemeral Tumas River, located between the Kuiseb and Swakop Rivers, flows even more sporadically and is effectively blocked by the high dunes in the area (i.e., east of the dune belt area). Other water bodies in the area (except for leakages associated with various pipelines) are generally saline of nature and not suitable habitat for amphibians.

Overall, the saline coastal habitats are marginal for amphibians. According to Mendelsohn *et al.* (2002), the overall frog diversity in the general area is estimated at between 1-3 species or 1-4 species (Jarvis *et al.* 2022). Griffin (1998b) puts the species richness in the general area at 2 species while the Namib-Naukluft Park has an estimated 9 species in total and the neighbouring Skeleton Coast National Park has at least 10 species of amphibians. Henschel *et al.* (2006) includes 2 species from Gobabeb.

At least 7 species of amphibians can occur in suitable habitat in the general area (Du Preez and Carruthers 2009). The area is underrepresented, with 3 toads and 1 species each for rain, rubber, sand and platanna known and/or expected to occur in the area (i.e., potentially could be found in the area). Of these, 3 species are endemic (*Poyntonophrynus dombensis*, *Poyntonophrynus hoeschi* and *Phrynomantis annectens*) (Griffin 1998b) – i.e., high level (42.9%) of amphibians of conservation value from the general area. The IUCN (2025) classifies all the species as least concern.

The most important species are the 3 endemics although they are widespread throughout Namibia and not specifically associated with the Project areas. Overall suitable habitat for amphibians in the general area is viewed as the ephemeral Khan, Kuiseb, Swakop and Tumas Rivers and their various tributaries. Temporary pools after localised rainfall events could potentially serve as habitat for amphibians throughout the area. None of the unique/important amphibian species are exclusively associated with the proposed development area.

No amphibians were observed during the rapid site assessment. The area is extremely marginal with very little rainfall generally occurring in the area (<50mm annual average) and being highly variable (>100% coefficient of variation) and sporadic of nature (Mendelsohn *et al.* 2002). Although there was some surface water observed, most of these are saline and marginal amphibian habitat. However, there was evidence of temporary pools in drainage lines and rivers (Khan & Swakop Rivers) throughout the general area (Figures 4-6). Furthermore, no amphibians were observed at various other development sites throughout the general area (Cunningham 2007, 2010a,b, 2011a, 2013, 2014, 2019, 2021, 2023, 2024) although Cunningham (2011b) did confirm the endemic *Phrynomantis annectens* (marbled rubber frog) from the Khan River area.

Potentially important amphibian habitats occur in the ephemeral drainage lines and rivers throughout the area. These pools could provide temporary habitat under good rainfall years and consequently viewed as an important amphibian habitat (Figures 4-6).

Table 7. Amphibian diversity expected to occur in the general Arandis-Farm 58-Walvis Bay areas – literature study – and species confirmed during the fieldwork (√) and/or the author's previous records (√¹⁻¹⁰) from the general area.

Species: Scientific name	Species: Common name	Species confirmed	Species confirmed: Previous studies	Namibian conservation and legal status	International Status
Toads					
<i>Poyntonophrynus dombensis</i>	Dombe Toad			Endemic	LC
<i>Amietophrynus poweri</i>	Western Olive Toad				LC
<i>Poyntonophrynus hoeschi</i>	Hoesch's Pygmy Toad			Endemic	LC
Rain Frogs					
<i>Breviceps adspersus</i>	Common/Bushveld Rain Frog				LC
Rubber Frog					
<i>Phrynomantis annectens</i>	Marbled Rubber Frog		√ ⁴	Endemic	LC
Sand Frogs					
<i>Tomopterna tandyi</i>	Tandy's Sand Frog				LC
Platannas					
<i>Xenopus laevis</i>	Common Platanna				LC

Endemic – Griffin (1998b)

IUCN (2025): LC – Least Concern

√¹ – Cunningham (2010a); √² – Cunningham (2010b); √³ – Cunningham (2011a); √⁴ – Cunningham (2011b); √⁵ – Cunningham (2013); √⁶ – Cunningham (2014); √⁷ – Cunningham (2019); √⁸ – Cunningham (2021); √⁹ – Cunningham (2023); √¹⁰ – Cunningham (2024)

Source for literature review: Carruthers (2001), Channing (2001), Channing and Griffin (1993), Cunningham (2010a), Cunningham (2010b), Cunningham (2011a), Cunningham (2011b), Cunningham (2013), Cunningham (2014), Cunningham (2019), Cunningham (2021), Cunningham (2023), Cunningham (2024), Du Preez and Carruthers (2009), Griffin (1998b), IUCN (2025), Passmore and Carruthers (1995)



Figure 4. Pools in the Swakop River close to Swakopmund, albeit mostly saline, could serve as amphibian habitat, especially after flooding events.



Figure 5. Leakages along the existing water pipeline from Arandis-Swakopmund-Walvis Bay could serve as amphibian habitat.



Figure 6. Seeps in the Swakop River and its tributaries are potentially important amphibian habitat.

Ammonia Terminal Impact (Coast)

The proposed development is in a barren saline pan area and consequently development impacts are not expected to be detrimental to amphibians as this is an extremely marginal environment for amphibians.

Farm 58 (Dune 7 area)

The proposed development is in a barren gypsum/sandy gravel plain area and consequently development impacts are not expected to be detrimental to amphibians as this is an extremely marginal environment for amphibians.

Solar PV Plant impact

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

Pipeline impact

The impact of heavy machinery during excavation of a trench to bury the proposed ammonia pipelines is expected to be detrimental to amphibians associated with the affected areas/habitats.

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 amphibians – i.e., would not impede their movement, etc.

Access route impact

The impact of pipeline access routes is not expected to be detrimental to most amphibians as there are numerous existing tracks throughout the general area and the overall footprint is small. However, track discipline should be maintained (e.g., best practices speed limits to be followed), no off-road driving, limited nocturnal driving, etc.), speed humps and vehicle calming devices recommended to be incorporated to prevent speeding along the route. This

should act as mitigation measure for important slow moving, especially nocturnal, amphibians.

However, culverts may result in water accumulation and become artificial habitat for amphibians along these routes, resulting in potentially more mortalities. This could be negated by limiting nocturnal vehicle activity along this route and/or ensure adequate drainage and speedy runoff around culvert infrastructures.

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

3.3 Mammal Diversity

Mammal diversity known and/or expected to occur in the general area – i.e., Arandis-Farm 58-Walvis Bay – is presented in Table 8.

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*.

Overall terrestrial diversity and endemism – all species – is classified as “low” and “average” respectively in the western central part of Namibia (Mendelsohn *et al.* 2002). The overall diversity (1-2 species) and abundance of large herbivorous mammals is “low” in the general area with oryx and springbok having the highest density 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 brown hyena having the highest density of the larger species (Mendelsohn *et al.* 2002). The overall mammal diversity in the general area is estimated at between 16-30 species with 3-4 species being endemic to the area (Mendelsohn *et al.* 2002, Jarvis *et al.* 2022). Griffin (1998c) puts the species richness distribution of endemics also between 3-4 species in the general area while the Namib-Naukluft Park has an estimated 80 species in total and the neighbouring Skeleton Coast National Park has at least 87 species of mammals.

At least 55 species of mammals are known and/or expected to occur in the general area of which 11 species (20%) are classified as endemic (Table 8). The Namibian legislation classifies 5 species as vulnerable, 1 species as rare, 2 species as insufficiently known, 1 species as specially protected game, 5 species as protected game, 4 species as huntable game, 3 species as problem animals, 1 species as invasive alien, 1 species as a migrant and 1 species is not listed. According to the Carnivore Red List for Namibia 1 species is classified as endangered, 2 species as vulnerable and 1 species as near threatened (NCE, LCMAN, MEFT 2022). At least 34.5% (19 species) of the mammalian fauna that occur or are expected to occur in general area are represented by rodents of which 6 species (31.6%) are endemic. This is followed by bats with 13 species (23.6%) of which 1 species is listed as endemic and rare (7.7%) and carnivores with 11 species (20%) of which 1 species (9.1%) is endemic and 5 species listed as vulnerable (45.5%).

Seventeen species (30.9%) have international conservation status (some species more than 1 classification) of which 3 species classified as vulnerable and 2 species as near threatened by the IUCN (2025) while 1 species is classified as endangered, 2 species as vulnerable, 8 species as near threatened and 2 species as data deficient by the SARDB (2004) and 6 species as either CITES Appendix 1 (2 species) and 2 (4 species) species. 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. Although the brown and house rats are expected to occur in Walvis Bay and Swakopmund, they are commensally with humans and could occur in the general area – i.e., along settlements within the Kuiseb River and various mining sites – although they probably do not occur away from the coastal areas.

The most important species from the general area are the Namibian wing-gland bat (*Cistugo seabrai*) listed as endemic and rare; Littledale’s whistling rat (*Protomys littledalei namibensis*) – of which the subspecies “*namibensis*” is known to occur in the ephemeral river courses in the “Swakopmund area” Griffin (2003) – listed as endemic; brown hyena (*Parahyaena brunnea*) and leopard (*Parthera pardus*) listed as near threatened and vulnerable (population trends decreasing), respectively by the IUCN (2025).

Habitat alteration and overutilization are the two primary processes threatening most mammals (Griffin 1998c) with species probably underrepresented in the above-mentioned table for the general area being the bats and rodents, as these groups have not been well documented from the arid central western part of Namibia.

None of the unique/important mammal species are exclusively associated with the proposed development area.

During the rapid site assessment, a total of 7 species of mammals were confirmed from the various routes traversed while a total of 28 species has been confirmed from the general area by Cunningham (2010a,b, 2011a,b, 2013, 2014, 2019, 2021, 2023, 2024) (See Table 8). However, some of these species – e.g., cheetah, kudu, leopard, warthog, etc. – are species that are expected to occasionally pass through the area, depending on environmental conditions, and not thought to remain in the area throughout the year due to the overall marginal habitat for these species. Furthermore, only 9 large mammal species (oryx, springbok, steenbok, brown hyena, black-backed jackal, bat-eared fox, Cape fox, aardvark and porcupine) and 7 small mammal species of which 3 species were rodents caught in small mammal traps (suricate, dassie rat, ground squirrel, round-eared elephant-shrew, Namaqua rock mouse, four-striped grass mouse and Setzer’s hairy-footed gerbil) were observed at Marenica (Spitzkoppe area) by Henschel *et al.* (2011).

The low number of species is probably due to the extreme barren coastal and Farm 58 areas and overall dry conditions between Arandis and Farm 58 (along the various proposed pipeline routes) as well as overall low densities in these marginal habitats (i.e., coastal salt pan habitat in the Ammonia Terminal area and sparsely vegetated gypsum/gravel plains in the Farm 58 area are low biodiversity areas).

A capture success rate for small mammals using Sherman Small Mammal Traps of 8.06% of 3 species (*Proboscideus flavicaudatus* [round-eared elephant shrew], *Gerbillurus paeba* [hairy-footed gerbil] and *Rhabdomys pumilio* [Four-striped Grass Mouse]); 7.4% of 1 species (*Tatera leucogaster* [bushveld gerbil]); 7.1% of 2 species (*Gerbillurus vullinus* [brush-tailed hairy-footed gerbil] & *Elephantulus intufi* [bushveld elephant-shrew]) and 4.4% of 1 species (*Gerbillurus paeba*) were achieved in the neighbouring Ongolo/Tumas; Farm Geluk; Hope/Goreb and Tumas/Reptile areas, respectively (Cunningham 2013, 2021, 2023, 2024).

The low “capture success” rates of between 4.4-8.06% (Cunningham 2013, 2021, 2023, 2024) are indicative of the general marginal habitat, low rodent densities, and overall dry conditions. Rodents are typically “boom-and-bust” species with higher densities expected during the rainy season (when/if this occurs – i.e., not necessarily an annual occurrence) with an increase in grass cover and available food.

Table 8. Mammal diversity expected to occur in the general Arandis-Farm 58-Walvis Bay areas – literature study – and species confirmed during the fieldwork (✓) and/or the author's previous records (✓¹⁻¹⁰) from the general area.

Species: Scientific name	Species: Common name	Species confirmed	Species confirmed: Previous studies	Carnivore Red List (Namibia)	Namibian conservation and legal status	International Status		
						SARDB	IUCN	CITES
Elephant Shrews								
<i>Macroscelides proboscideus flavicaudatus</i>	Round-eared Elephant-shrew		√ ^{2,3,5}		Endemic; Secure			
<i>Elephantulus intufi</i>	Bushveld Elephant-shrew		√ ⁹		Secure	DD		
Aardvark								
<i>Orycteropus afer</i>	Aardvark		√ ^{8,9,10}		Secure; Protected Game			
Bats								
<i>Eidolon helvum</i>	African Straw-coloured Fruit Bat				Secure; Migrant			
<i>Rhinolophus darlingi</i>	Darling's Horseshoe Bat				Secure; Peripheral	NT	NT	
<i>Rhinolophus fumigatus</i>	Rüppell's Horseshoe Bat				Secure	NT		
<i>Taphozous mauritanus</i>	Mauritian Tomb Bat				Secure			
<i>Nycteris thebaica</i>	Egyptian Slit-faced Bat				Secure			
<i>Sauromys petrophilus</i>	Robert's Flat-headed Bat				Secure			
<i>Tadarida aegyptiaca</i>	Egyptian Free-tailed Bat				Secure			
<i>Miniopterus natalensis</i>	*Natal Long-fingered Bat				Secure	NT		
<i>Cistugo seabrai</i>	*Namibian Wing-gland Bat				Endemic; Rare	V		
<i>Eptesicus hottentotus</i>	Long-tailed Serotine Bat				Secure			
<i>Mimetillus thomasi</i>	Thomas's Flat-headed Bat				Not listed			
<i>Neoromicia zuluensis</i>	Zulu Serotine Bat				Secure			
<i>Pipistrellus rueppellii</i>	Rüppell's Pipistelle Bat				Insufficiently known; Peripheral			
Hares and Rabbits								
<i>Lepus capensis</i>	Cape Hare	√	√ ^{2,3,5,8,9,10}		Secure			
Porcupine								
<i>Hystrix africaeustralis</i>	Porcupine		√ ^{2,4,5,8}		Secure			
Squirrels								
<i>Xerus inaurus</i>	Southern Ground Squirrel				Secure			
<i>Xerus princeps</i>	Mountain Ground Squirrel		√ ¹⁰		Endemic	NT		
Rats and Mice								
<i>Petromys typicus</i>	Dassie Rat		√ ^{8,9}		Endemic; Secure	NT		

EIA: Vertebrate Fauna & Flora - Cunningham

Species: Scientific name	Species: Common name	Species confirmed	Species confirmed: Previous studies	Carnivore Red List (Namibia)	Namibian conservation and legal status	International Status		
						SARDB	IUCN	CITES
<i>Pedetes capensis</i>	Springhare							
<i>Rhabdomys pumilio</i>	Four-striped Grass Mouse		√ ^{2,3,5,6,7}		Secure			
<i>Mastomys coucha</i>	Southern Multimammate Mouse				Secure			
<i>Aethomys chrysophilus</i>	Red Veld Rat				Secure			
<i>Aethomys namaquensis</i>	Namaqua Rock Mouse		√ ³		Secure			
<i>Protomys littledalei namibensis</i>	Littledale's Whistling Rat		√ ⁸		Endemic	NT		
<i>Desmodillus auricularis</i>	Cape Short-tailed Gerbil				Secure			
<i>Gerbillurus paeba</i>	Hairy-footed Gerbil		√ ^{1,3,5,8}		Secure			
<i>Gerbillurus tytonis</i>	Dune Hairy-footed Gerbil		√ ^{3,6}		Endemic; Secure			
<i>Gerbillurus setzeri</i>	Setzer's Hairy-footed Gerbil				Endemic			
<i>Gerbillurus vallinus</i>	Brush-tailed Hairy-footed Gerbil		√ ⁹		Endemic; Secure			
<i>Tatera leucogaster</i>	Bushveld Gerbil		√ ¹⁰		Secure	DD		
<i>Petromyscus collinus</i>	Pygmy Rock Mouse		√ ⁴		Endemic; Secure			
<i>Mus musculus</i>	House Mouse				Invasive alien			
Primates								
<i>Papio ursinus</i>	Chacma Baboon	√	√ ⁴		Secure; Problem animal			C2
Carnivores								
<i>Parahyaena (Hyaena) brunnea</i>	Brown Hyena	√	√ ^{2,3,5,6,8,9,10}	NT	Insufficiently known; (Vulnerable?); Peripheral	NT	NT	
<i>Crocuta crocuta</i>	Spotted Hyena			V	Secure?; Peripheral	NT		
<i>Felis silvestris</i>	African Wild Cat		√ ^{3,5,7,8}		Vulnerable			C2
<i>Suricata suricatta marjoriae</i>	Suricate		√ ^{3,5,6}		Endemic; Secure			
<i>Otocyon megalotis</i>	Bat-eared Fox		√ ^{2,5}		Vulnerable(?); Peripheral; Protected Game			
<i>Vulpes chama</i>	Cape Fox		√ ^{3,7,8}		Vulnerable?			
<i>Canis mesomelas</i>	Black-backed Jackal	√	√ ^{1,2,3,4,5,6,7,8,9,10}		Secure; Problem animal			
<i>Ictonyx striatus</i>	Striped Polecat				Secure			
<i>Mellivora capensis</i>	Ratel				Secure; Protected Game			
<i>Acinonyx jubatus</i>	Cheetah		√ ⁵	E	Vulnerable; Protected Game	V	V	C1
<i>Caracal caracal</i>	Caracal				Secure; Problem animal			C2

Species: Scientific name	Species: Common name	Species confirmed	Species confirmed: Previous studies	Carnivore Red List (Namibia)	Namibian conservation and legal status	International Status		
						SARDB	IUCN	CITES
<i>Panthera pardus</i>	Leopard			V	Secure(?); Peripheral; Protected Game		V	C1
Pigs								
<i>Phacochoerus africanus</i>	Warthog				Secure; Huntatable game			
Zebra								
<i>Equus zebra hartmannae</i>	Hartmann's Mountain Zebra	√	√ ^{4,5,8,9}		Endemic; Secure; Specially Protected Game	E	V	C2
Antelopes								
<i>Oryx gazella</i>	Gemsbok	√	√ ^{2,3,4,5,7,8,9,10}		Secure; Huntatable game			
<i>Tragelaphus strepsiceros</i>	Kudu		√ ^{2,4}		Secure; Huntatable game			
<i>Sylvicapra grimmia</i>	Common Duiker				Secure			
<i>Antidorcas marsupialis</i>	Springbok	√	√ ^{2,3,4,5,7,8,9,10}		Secure; Huntatable game			
<i>Raphicerus campestris</i>	Steenbok		√ ^{4,5}		Secure; Protected Game			

SARDB (2004): NT – Near Threatened, V – Vulnerable, DD – Data Deficient

IUCN (2025): V – Vulnerable, NT – Near Threatened, All the other species are listed as: LC – Least Concern

CITES: CITES Appendix 1 or 2 species

Carnivore Red List: E – Endangered, V – Vulnerable, NT – Near Threatened

* - Monandjem *et al.* (2010): NT – Near Threatened

√¹ – Cunningham (2010a); √² – Cunningham (2010b); √³ – Cunningham (2011a); √⁴ – Cunningham (2011b); √⁵ – Cunningham (2013); √⁶ – Cunningham (2014); √⁷ – Cunningham (2019); √⁸ – Cunningham (2021); √⁹ – Cunningham (2023); √¹⁰ – Cunningham (2024)

Source for literature review: Cunningham (2010a), Cunningham (2010b), Cunningham (2011a), Cunningham (2011b), Cunningham (2013), Cunningham (2014), Cunningham (2019), Cunningham (2021), Cunningham (2023), Cunningham (2024), De Graaff (1981), Estes (1995), Frost (2014), Griffin and Coetzee (2005), IUCN (2025), Joubert and Mostert (1975), Monandjem *et al.* (2010), NCE, LCMAN, MEFT (2022), Skinner and Smithers (1990), Skinner and Chimimba (2005), Stander and Hannsen (2003) and Taylor (2000)

Of the 7 species observed and/or confirmed from the area during the rapid site assessment, Hartmann's mountain zebra (*Equus zebra hartmannae*), classified as "vulnerable" by the IUCN (2025) and the brown hyena (*Parahyaena [Hyaena] brunnea*), classified as "near threatened" by the IUCN (2025) are viewed as the most important (Figure 7).

Although the bats viewed as most important from the general area – Namibian wing-gland bat (*Cistugo seabrai*) and the Namib long-eared bat (*Laephotis namibensis*) – potentially occur in the area, no bats were observed during the fieldwork.

According to Griffin (1998c) habitat alteration and overutilization are the two primary processes threatening most mammals in Namibia. However, none of the mammal species expected and/or observed/confirmed during the rapid assessment are exclusively associated with the Project areas.



Figure 7. Hartmann's mountain zebra (*Equus zebra hartmannae*) – vulnerable (IUCN 2025) – tracks observed in the Husab Mine and Swakop River areas.

Ammonia Terminal impact (Coast)

The proposed development is in a barren saline pan area and consequently development impacts are not expected to be detrimental to mammals as this is an extremely marginal environment for mammals.

However, the Salsola dune hummock habitat, located on the eastern boundary of the proposed development area, are important for a variety of rodents (and carnivore foraging area – e.g., black-backed jackal, brown hyena) and should be avoided.

Farm 58 impact (Dune 7 area)

The proposed development is in a barren gypsum/sandy gravel plain area and although the diversity of mammals in this habitat is low, developments are expected to be detrimental to mammal species associated with the affected area/habitat.

However, the rocky habitat with small sparsely vegetated ephemeral drainage lines, located on the north eastern/eastern boundary of the proposed development area, are important for a variety of mammals and should be avoided.

Solar PV Plant impact

The impact of aboveground PV plant infrastructure is not expected to be detrimental to mammals – i.e., would not impede their movement, etc.

Pipeline impact

The impact of heavy machinery during excavation of a trench to bury the proposed ammonia pipelines is expected to be detrimental to mammals associated with the affected areas/habitats.

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.

Pipeline impact - Ungulates**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.). Zebra would experience similar difficulties as gemsbok while kudu, a typical jumping species, would not be affected.

The effect of aboveground pipeline infrastructure >80cm is expected to be detrimental to most ungulates – i.e. would impede their movement, etc.

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.

It would be recommended to bury the various pipelines to avoid affecting wildlife movement.

Access route impact

The impact of a pipeline 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 are recommended to be incorporated to prevent speeding along the route. This should act as mitigation measure for important slow moving, especially nocturnal, mammals.

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

3.4 Avian Diversity

Bird diversity known and/or expected to occur in the general area – i.e., Arandis-Farm 58-Walvis Bay – is presented in Table 9. This table excludes coastal marine birds although some may occasionally occur in the area (e.g., gulls and terns), migratory birds (e.g., Petrel, Albatross, Skua, 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.

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 in the general area is estimated at 111-170 species and 2-4 species being endemic (Mendelsohn *et al.* 2022). Simmons (1998a) suggests 4-6 endemic species and a “low to average” ranking for southern African endemics and “high” ranking for southern African red data birds expected from the general area.

Important bird areas in the general area include the Walvis Bay wetland – considered the most important coastal wetland in southern Africa and one of the top 3 in Africa (Bethune *et al.* 2007) and supports mainly Palaearctic migrants, often comprising up to 88% of the birds – e.g., up to 1% of the global Chestnut-banded Plover (approximately 2,000 individuals) are expected to occur in the Walvis Bay area (Whitelaw *et al.* 1978). Between 70,000 and 100,000 birds in winter and up to 250,000 in spring are supported by the wetland (Bethune *et al.* 2007). The Namib coast is especially important for 8 species and in terms of global populations it supports >90% of the world’s chestnut-banded plovers (*Charadrius pallidus*); 31% of Cape teal (*Anas capensis*); and 26% of African black oystercatchers (*Haematopus moquini*). In terms of African endemic races, it supports: >90% of the lack-necked grebe (*Podiceps nigricollis gurneyi*); and 33% of the white-fronted plover (*Charadrius m. Marginatus*); and in terms of southern African sub-continental populations, it supports 31% of pied avocet (*Recurvirostra avocetta*), 13.7% of greater flamingo (*Phoenicopterus roseus*) and 10.3% of lesser flamingo (*Phoenicopterus minor*) (Williams and Simmons 2008a). Furthermore, up to 200,000 Holarctic shorebirds are supported seasonally along the Namibian coast belonging largely to 12 annually occurring species, of which 5 species occur in numbers that form a significant proportion of the southern African flyway populations – e.g. curlew sandpiper (*Calidris ferruginea* 35%); sanderling (*C. alba* 32%); ruddy turnstone (*Arenaria interpres* 17.5%); grey plover (*Pluvialis squatarola* 7.8%) and red knot (*Calidris canutus* 1.6%) (Williams and Simmons 2008b). According to Simmons and Brown (2009) 28 wetland bird species are of special concern in Namibia.

The Walvis Bay and Sandwich Harbour wetlands are also classified as Ramsar sites (i.e., Namibia is signatory to the Ramsar Convention protecting important wetland sites) as well as globally Important Birding Area (IBA’s) (Simmons 1998a). The Ammonia Storage Plant falls within the IBA known as the 30 km beach (national IBA status) while other IBA’s in the general area include Walvis Bay (global IBA status), Sandwich Harbour (global IBA status), and the Mile 4 Saltworks (global IBA status) (Simmons 1998a), all along the coast.

Coastal areas and wetlands are immensely important as 8 and 34 bird species are classified as critically endangered, endangered, or vulnerable in each of the biomes (i.e., Coastal areas and Wetlands), respectively (Simmons 1998a).

A published summer bird count from the general area indicates 38 species (116,118 individuals) at Walvis Bay; 24 species (1,464 individuals) at the Walvis Bay sewerage ponds; 18 species (134 individuals) at the Swakop River mouth and 34 species (84,011 individuals) at Sandwich Harbour (Kolberg 2010). Of these, waders/shorebirds (~50,000), gulls/terns/skimbers (~30,000) and grebes (~10,000) were the most numerous at Walvis Bay indicating the importance of the general area for a variety of birds. The latest bird counts at the Walvis Bay lagoon (February 2020) and sewage works (June 2019) resulted in 137,142 (45 species) and 15,963 (21 species), respectively (Bridgeford 2019, 2020).

However, the most important bird known to occur (and breed) along the coast is the Damara tern (*Sternula balaenarum*) classified as near endemic and near threatened under Namibian legislation (Simmons *et al.* 2015) and least concern (population trend decreasing with 2,200-5,700 mature individuals due to increased recreation and construction pressure on breeding grounds) by the IUCN (2025). With 98% of the Damara tern breeding population being in Namibia (Braby 2010a, Braby 2010b; Braby 2011; Crawford and Simmons 1997); very low inter-colony dispersal rates with only 70 known colonies (Braby 2011); the importance of the general area cannot be stressed enough. Furthermore, the Caution Reef breeding colony (~13 to 120 nests since 1994) closer to Swakopmund is viewed as the third largest known breeding colony (Braby 2011). Disturbance and urbanisation, especially off-road vehicles, impact on breeding success and consequently pose the biggest threat to Damara terns along the Namibian coast (Braby *et al.* 2001, Braby 2011, Braby and Braby 2002). Although Damara tern potentially could breed on the salt pan (Ammonia Terminal area) and the sandy/gravel gypsum plains (Farm 58 area), this has not yet been recorded and neither are these areas the quiet undisturbed habitat the birds prefer.

Abovementioned indicates the importance of the general coastal areas although not specifically related to the Project area, although the Ammonia Terminal area and associated ammonia pipeline to Farm 58 area, east of the Dune 7, are within this important bird habitat.

According to the literature review, at least 182 species of terrestrial ["breeding residents"] birds occur and/or could occur in the general area at any time (Hockey *et al.* 2006, Maclean 1985, Tarboton 2001). Although many of the species mentioned in Table 9 do not occur permanently in the Project area they are included as potentially breeding/occurring along the coast – i.e., the 182 species is viewed as an overestimate for the actual area.

Furthermore, environmental conditions such as "berg winds" ("East weather" – local vernacular) often bring unexpected avian guests to the coastal areas although these are not resident all year (Pers obs). All the migrant species (Walvis Bay and surroundings is world renowned for its Palaearctic migrants) have been excluded here, although the Bay area serves as an important feeding ground for a variety of mainly aquatic species. The coastal area is also a thoroughfare area for aquatic species, especially the Palaearctic migrants as well as a known route followed by flamingo's moving between the coast and the Etosha Pans (SAIEA 2010).

Seven of the 14 Namibian endemic bird species (50% of all Namibian endemic species or 4% of the species expected to occur in the area) can or are likely to occur in the general area although Simmons *et al.* (2015) view Damara tern as near endemic. The most important endemic birds known/expected to occur in the general area are Gray's lark, dune lark and Herero chat. Gray's lark is one of the species with the most restricted range in Namibia (Simmons 1998a). Furthermore, Simmons *et al.* (2015) list 2 species as critically endangered (great crested grebe, Cape gannet), 7 species as endangered (Cape cormorant, bank cormorant, black stork, white-backed vulture, martial eagle, tawny eagle, Ludwig's bustard), 6 species as vulnerable (great white pelican, greater flamingo, lesser flamingo, secretarybird, lappet-faced vulture, Hartlaub's gull) and 8 species as near threatened (black-necked grebe, crowned cormorant, Verreaux's eagle, peregrine falcon, kori bustard, African black oystercatcher, chestnut-banded plover, Damara tern).

Table 9. Avian diversity expected to occur in the general Arandis-Farm 58-Walvis Bay areas – literature study – and species confirmed during the fieldwork (√) and/or the author's previous records (√¹⁻¹⁰) from the general area.

Species: Scientific name	Species: Common name	Species confirmed	Species confirmed: Previous studies	Namibian conservation and legal status	International Status	
					Southern Africa	IUCN
<i>Struthio camelus</i>	Common Ostrich	√	√ ^{2,3,4,5,7,8,9,10}			
<i>Podiceps cristatus</i>	Great Crested Grebe			CE		
<i>Tachybaptus ruficollis</i>	Little Grebe		√ ³			
<i>Podiceps nigricollis</i>	Black-necked Grebe		√ ³	NT		
<i>Pelecanus onocrotalus</i>	Great White Pelican		√ ^{1,3}	V		
<i>Pelecanus rufescens</i>	Pink-backed Pelican					
<i>Phalacrocorax lucidus</i>	White-breasted Cormorant		√ ^{3,6}			
<i>Morus capensis</i>	Cape Gannet		√ ³	CE, SP	Breeding endemic	E
<i>Phalacrocorax capensis</i>	Cape Cormorant		√ ^{6,10}	E	Breeding endemic	E
<i>Phalacrocorax neglectus</i>	Bank Cormorant			E, SP	Endemic	E
<i>Phalacrocorax africanus</i>	Reed Cormorant		√ ³			
<i>Microcarbo (Phalacrocorax) coronatus</i>	Crowned Cormorant			NT	Endemic	
<i>Anhinga melanogaster</i>	Darter					
<i>Ardea cinerea</i>	Grey Heron		√ ³			
<i>Ardea melanocephala</i>	Black-headed Heron		√ ³			
<i>Ardea purpurea</i>	Purple Heron					
<i>Egretta garzetta</i>	Little Egret					
<i>Egretta intermedia</i>	Yellow-billed Egret		√ ⁶			
<i>Egretta alba</i>	Great Egret					
<i>Egretta ardesiaca</i>	Black Egret					
<i>Bubulcus ibis</i>	Cattle Egret					
<i>Ardeola ralloides</i>	Squacco Heron					
<i>Ixobrychus minutas</i>	Little Bittern					
<i>Scopus umbretta</i>	Hamerkop					
<i>Ciconia nigra</i>	Black Stork			E		
<i>Phoenicopterus ruber</i>	Greater Flamingo		√ ⁶	V		
<i>Phoenicopterus minor</i>	Lesser Flamingo			V		NT

<i>Dendrocygna viduata</i>	Whitefaced Duck				
<i>Alopochen aegyptiacus</i>	Egyptian Goose				
<i>Anas capensis</i>	Cape Teal	$\sqrt{3}$			
<i>Anas hottentota</i>	Hottentot Teal				
<i>Anas erythrorhyncha</i>	Redbilled Teal	$\sqrt{3}$			
<i>Anas smithii</i>	Cape Shoveller				
<i>Netta erythrophthalma</i>	Southern Pochard				
<i>Sagittarius serpentarius</i>	Secretarybird		V		E
<i>Gyps africanus</i>	White-backed Vulture		E		CE
<i>Torgos tracheliotus</i>	Lappet-faced Vulture	$\sqrt{5,8,9,10}$	V		E
<i>Circaetus pectoralis</i>	Black-chested Snake-Eagle				
<i>Elanus caeruleus</i>	Black-shouldered Kite				
<i>Aquila verreauxii</i>	Verreaux's Eagle		NT		
<i>Aquila rapax</i>	Tawny Eagle		E		V
<i>Polemaetus bellicosus</i>	Martial Eagle	$\sqrt{5}$	E		E
<i>Buteo augur</i>	Augur Buzzard	$\sqrt{4}$			
<i>Melierax canorus</i>	Southern Pale Chanting Goshawk	$\sqrt{3,4,5,7,10}$		N-end	
<i>Falco peregrinus</i>	Peregrine Falcon		NT		
<i>Falco biarmicus</i>	Lanner Falcon	$\sqrt{4,7}$			
<i>Falco chicquera</i>	Red-necked Falcon				
<i>Falco rupicolus</i>	Rock Kestrel	$\sqrt{3,4,5,6,7,8,9,10}$			
<i>Falco rupicoloides</i>	Greater Kestrel	$\sqrt{8}$			
<i>Francolinus adspersus</i>	Red-billed Francolin				
<i>Trunix sylvatica</i>	Kurrichane Buttonquail				
<i>Porphyrio porphyrio</i>	African Purple Swamphen				
<i>Gallinula chloropus</i>	Common Moorhen				
<i>Fulica cristata</i>	Red-knobbed Coot	$\sqrt{3}$			
<i>Ardeotis kori</i>	Kori Bustard		NT		NT
<i>Neotis ludwigii</i>	Ludwig's Bustard	$\sqrt{5}$	E	N-end	E
<i>Eupodotis rueppellii</i>	Rüppell's Korhaan	$\sqrt{2,3,5,8,10}$	End	N-end	
<i>Eupodotis afra</i>	Black Korhaan				
<i>Actophilornis africanus</i>	African Jacana				
<i>Rostratula benghalensis</i>	Painted Snipe				
<i>Haematopus moquini</i>	African Black Oystercatcher	$\sqrt{10}$	NT	End	
<i>Charadrius marginatus</i>	White-fronted Plover	$\sqrt{6}$			
<i>Charadrius pallidus</i>	Chestnut-banded Plover	$\sqrt{3}$	NT		NT

<i>Charadrius pecuarius</i>	Kittlitz's Plover			
<i>Charadrius tricollaris</i>	Three-banded Plover	√ ³		
<i>Vanellus armatus</i>	Blacksmith Lapwing	√ ³		
<i>Recurvirostra avosetta</i>	Pied Avocet			
<i>Himantopus himantopus</i>	Black-winged Stilt	√ ³		
<i>Burhinus capensis</i>	Spotted Thick-knee			
<i>Cursorius rufus</i>	Burchell's Courser	√ ¹⁰		
<i>Rhinoptilus africanus</i>	Double-banded Courser	√ ³		
<i>Larus dominicanus</i>	Kelp Gull	√ ^{3,6,10}		
<i>Larus cirrocephalus</i>	Grey-headed Gull			
<i>Larus hartlaubii</i>	Hartlaub's Gull	√ ^{3,6,10}	V	End
<i>Thalasseus (Sterna) bergii</i>	Swift Tern	√ ^{3,6}		
<i>Sternula (Sterna) balaenarum</i>	Damara Tern		End; NT	Breeding endemic
<i>Chlidonias hybrida</i>	Whiskered Tern			
<i>Pterocles namaqua</i>	Namaqua Sandgrouse	√ ^{3,5,10}		N-end
<i>Pterocles bicinctus</i>	Double-banded Sandgrouse			N-end
<i>Columba guinea</i>	Speckled Pigeon	√ ^{3,4}		
<i>Columba livea</i>	Rock Dove	√ ⁶		
<i>Streptopelia capicola</i>	Cape Turtle Dove			
<i>Streptopelia senegalensis</i>	Laughing Dove	√ ⁴		
<i>Streptopelia capicola</i>	Cape Turtle-Dove			
<i>Oena capensis</i>	Namaqua Dove	√ ^{4,10}		
<i>Agapornis roseicollis</i>	Rosy-faced Lovebird	√	End	N-end
<i>Corythaixoides concolor</i>	Grey Go-away-bird	√	√ ^{7,10}	
<i>Tyto alba</i>	Barn Owl			
<i>Otus leucotis</i>	Southern White-faced Scops-Owl			
<i>Glaucidium perlatum</i>	Pearl-spotted Owlet			
<i>Bubo africanus</i>	Spotted Eagle Owl	√ ^{2,8}		
<i>Bubo lacteus</i>	Giant Eagle Owl			
<i>Caprimulgus tristigma</i>	Freckled Nightjar			
<i>Apus bradfieldi</i>	Bradfield's Swift	√ ^{4,5}		N-end
<i>Colius colius</i>	White-backed Mousebird			End
<i>Urocolius indicus</i>	Red-faced Mousebird			
<i>Ceryle rudis</i>	Pied Kingfisher	√ ³		
<i>Merops hirundineus</i>	Swallow-tailed Bee-eater	√ ⁴		
<i>Upupa epops</i>	Hoopoe	√ ⁴		

<i>Phoeniculus cyanomelas</i>	Scimitar-billed Woodhoopoe				
<i>Tockus monteiri</i>	Monteiro's Hornbill			End	
<i>Tockus nasutus</i>	African Grey Hornbill				
<i>Lybius leucomelas</i>	Pied Barbet				
<i>Dendropicos fuscescens</i>	Cardinal Woodpecker				
<i>Mirafra sabota</i>	Sabota Lark		√ ⁸		
<i>Mirafra curvirostris</i>	Long-billed Lark				
<i>Calendulauda erythrochlamys</i>	Dune Lark		√ ^{3,7}	End	End
<i>Chersomanes albofasciata</i>	Spike-heeled Lark				N-end
<i>Calandrella cinerea</i>	Red-capped Lark		√ ⁴		
<i>Alauda starki</i>	Stark's Lark		√ ⁵		End
<i>Ammomanopsis grayi</i>	Gray's Lark	√	√ ^{2,3,4,5,8,9,10}	End	N-end
<i>Certhilauda subcoronata</i>	Karoo Long-billed Lark				End
<i>Eremopterix verticalis</i>	Grey-backed Sparrowlark		√ ^{4,10}		N-end
<i>Hirundo fuligula</i>	Rock Martin		√ ^{2,3,4,5,7,8,10}		
<i>Riparia paludicola</i>	Brown-throated Martin				
<i>Dicrurus adsimilis</i>	Fork-tailed Drongo				
<i>Corvus capensis</i>	Cape Crow		√ ^{2,3,5,9}		
<i>Corvus albus</i>	Pied Crow		√ ^{3,6,8,9}		
<i>Parus cinerascens</i>	Ashy Tit				N-end
<i>Anthoscopus minutes</i>	Cape Penduline Tit				N-end
<i>Turdoides bicolor</i>	Pied Babbler				
<i>Pycnonotus nigricans</i>	African Red-eyed Bulbul	√	√ ^{3,4}		N-end
<i>Monticola brevipes</i>	Short-toed Rock Thrush				
<i>Namibornis herero</i>	Herero Chat			End	N-end
<i>Oenanthe monticola</i>	Mountain Wheatear		√ ^{4,9}		N-end
<i>Cercomela familiaris</i>	Familiar Chat	√	√ ⁴		
<i>Cercomela tracterac</i>	Tracterac Chat	√	√ ^{2,3,4,5,7,8,9,10}		N-end
<i>Cercomela schlegelii</i>	Karoo Chat				N-end
<i>Myrmecocichla formicivora</i>	Ant-eating Chat				End
<i>Erythropygia paena</i>	Kalahari Robin				
<i>Parisoma subcaeruleum</i>	Chestnut-vented Tit-Babbler		√ ³		N-end
<i>Parisoma layardi</i>	Layard's Tit-Babbler				End
<i>Zosterops pallidus</i>	Orange River White-eye				End
<i>Sylvietta rufescens</i>	Long-billed Crombec				
<i>Eremomela icteropygialis</i>	Yellow-bellied Eremomela				
<i>Eremomela gregalis</i>	Karoo Eremomela				

<i>Acrocephalus baeticatus</i>	African Reed-Warbler		√ ³	
<i>Acrocephalus gracilirostris</i>	Lesser Swamp-Warbler			
<i>Cisticola aridulus</i>	Desert Cisticola			
<i>Cisticola subruficapilla</i>	Grey-backed Cisticola			N-end
<i>Cisticola juncidis</i>	Zitting Cisticola			
<i>Prinia flavicans</i>	Black-chested Prinia		√ ^{3,4,5,7}	
<i>Melaenornis mariquensis</i>	Marico Flycatcher			N-end
<i>Bradornis infuscatus</i>	Chat Flycatcher		√ ¹⁰	N-end
<i>Muscicapa striata</i>	Spotted Flycatcher			
<i>Batis pririt</i>	Pirit Batis		√ ⁹	N-end
<i>Motacilla capensis</i>	Cape Wagtail	√	√ ³	
<i>Anthus navaeseelandiae</i>	Richard's Pipit			
<i>Anthus similes</i>	Long-billed Pipit			
<i>Anthus vaalensis</i>	Buffy Pipit			
<i>Tchagra australis</i>	Brown-crowned Tchagra			
<i>Lanius collaris</i>	Common Fiscal		√ ^{4,5,7}	
<i>Laniarius atrococcineus</i>	Crimson-breasted Shrike			N-end
<i>Nilaus afer</i>	Brubru			
<i>Telophorus zeylonus</i>	Bokmakierie		√ ^{3,4,10}	N-end
<i>Creatophora cinerea</i>	Wattled Starling		√ ³	
<i>Lamprotornis nitens</i>	Cape Glossy Starling		√ ³	
<i>Onychognathus nabouroup</i>	Pale-winged Starling		√ ^{3,4,9}	N-end
<i>Chalcomitra senegalensis</i>	Scarlet-chested Sunbird			
<i>Nectarinia mariquensis</i>	Marico Sunbird			
<i>Nectarinia fusca</i>	Dusky Sunbird	√	√ ^{3,4,5,7,10}	N-end
<i>Passer domesticus</i>	House Sparrow	√	√ ^{3,7}	
<i>Passer motitensis</i>	Great Sparrow		√ ^{2,3}	N-end
<i>Passer melanurus</i>	Cape Sparrow		√ ^{4,7,8,9,10}	N-end
<i>Passer griseus</i>	Southern Grey-headed Sparrow		√ ³	
<i>Sporopipes squamifrons</i>	Scaly-feathered Finch		√ ³	N-end
<i>Plocepasser mahali</i>	White-browed Sparrow-Weaver		√ ¹⁰	
<i>Philetairus socius</i>	Sociable Weaver			End
<i>Ploceus velatus</i>	Southern Masked Weaver	√	√ ^{3,4,7,10}	
<i>Quelea quelea</i>	Red-billed Quelea			
<i>Euplectes orix</i>	Southern Red Bishop			
<i>Estrilda erythronotos</i>	Black-faced Waxbill			

<i>Estrilda astrild</i>	Common Waxbill	$\sqrt{3,7}$	
<i>Amadina erythrocephala</i>	Red-headed Finch		N-end
<i>Vidua regia</i>	Shaft-tailed Whydah		
<i>Serinus alario</i>	Black-headed Canary		
<i>Serinus flaviventris</i>	Yellow Canary		N-end
<i>Crithagra atrogularis</i>	Black-throated Canary	$\sqrt{3}$	
<i>Serinus albogularis</i>	White-throated Canary	$\sqrt{4}$	N-end
<i>Emberiza capensis</i>	Cape Bunting	$\sqrt{4}$	N-end
<i>Emberiza tahapisi</i>	Cinnamon-breasted Bunting		
<i>Emberiza impetuanii</i>	Lark-like Bunting	$\sqrt{3,4,9,10}$	N-end

End – Endemic; CE – Critically Endangered; E – Endangered; V – Vulnerable; SP – Specially Protected (Simmons *et al.* 2015)

End – Endemic; N-End – Near Endemic [Southern African status]: (Hockey *et al.* 2006)

CE – Critically Endangered; E – Endangered; V – Vulnerable; NT – Near Threatened (IUCN 2025)

$\sqrt{1}$ – Cunningham (2010a); $\sqrt{2}$ – Cunningham (2010b); $\sqrt{3}$ – Cunningham (2011a); $\sqrt{4}$ – Cunningham (2011b); $\sqrt{5}$ – Cunningham (2013); $\sqrt{6}$ – Cunningham (2014); $\sqrt{7}$ – Cunningham (2019); $\sqrt{8}$ – Cunningham (2021); $\sqrt{9}$ – Cunningham (2023); $\sqrt{10}$ – Cunningham (2024)

Source for literature review: Brown *et al.* (1998), Cunningham (2010a), Cunningham (2010b), Cunningham (2011a), Cunningham (2011b), Cunningham (2013), Cunningham (2014), Cunningham (2019), Cunningham (2021), Cunningham (2023), Cunningham (2024), Hockey *et al.* (2006), IUCN (2025), Komen (n.d.), Little and Crowe (2011), Maclean (1985) Peacock (2015), Peacock (2016), Simmons *et al.* (2015), Tarboton (2001)

Other important species known to occur in the general area but not included in Table 9 are maccoa duck (NT), Eurasian curlew (NT), Caspian tern (V) and black harrier (E) although these species are however not expected to occur permanently in the general area, but probably only pass over on their way to the coast.

The IUCN (2025) classifies 1 species as critically endangered (white-backed vulture), 7 species as endangered (Cape gannet, Cape cormorant, bank cormorant, lappet-faced vulture, martial eagle, secretarybird, Ludwig's bustard), 1 species as vulnerable (tawny eagle) and 3 species as near threatened (lesser flamingo, kori bustard, chestnut-banded plover).

According to the southern African status for birds 34 species are classified as near endemic and 12 species as endemic, of which 3 species are viewed as breeding endemics (Hockey *et al.* 2006).

A total of 11 species of birds were observed and/or confirmed (e.g., evidence thereof found) during the rapid assessment while a total of 84 species has been confirmed from the general area by Cunningham (2010a,b, 2011a,b, 2013, 2014, 2019, 2021, 2023, 2024) (Figures 8-9; See Table 9).

Lappet-faced vulture nests were confirmed from the general – See Cunningham (2021, 2024). According to the IUCN (2025) there are an estimated 6,500 mature lappet-faced vulture individuals left worldwide (populations decreasing) while Simmons *et al.* (2015) estimate 500 pairs from Namibia. All vulture numbers are declining drastically across their various natural range, making all nesting sites important as breeding areas in Namibia. As their nests are used over many years, and with only one egg laid between April and August (peak in May-July) any disturbance around nesting trees during this period could have catastrophic impacts over time for the species. The IUCN (2025) indicates that the known threats to lappet-faced vulture include transportation services (roads), human intrusions/disturbances (work related) and natural system modifications (ecosystem modifications). All nesting sites should be avoided with no activities allowed closer than 500m (preferably a greater distance – i.e., 1-1.5km) from the nests.

However, none of the bird species expected and/or observed/confirmed during the rapid assessment are exclusively associated with the Project areas.



Figure 8. The endemic Rüppell's korhaan (*Eupodotis rueppellii*) observed in the Husab Mine area.



Figure 9. Ostrich faeces indicate their presence in the general area.

Ammonia Terminal impact (Coast)

The proposed development is in a barren saline pan area and consequently development impacts are not expected to be detrimental to birds as this is an extremely marginal environment for birds.

However, the *Salsola* dune hummock habitat, located on the eastern boundary of the proposed development area, are important for a variety of birds and should be avoided.

Furthermore, the entire coastline is classified as an IBA (Important Birding Area) known as the 30 km beach (national IBA status) as well as a known bird flyway, especially for Palearctic migrant species and birds moving between the various important coastal foraging sites. Although the actual saline pan development area is not viewed as an important bird foraging site, the infrastructures may potentially affect the flight paths of certain birds, especially nocturnal migratory species, and should take cognisance of this and ensure that it is visible.

Farm 58 impact (Dune 7 area)

The proposed development is in a barren gypsum/sandy gravel plain area and although the diversity of birds in this habitat is low, developments are expected to be detrimental to bird species associated with the affected area/habitat.

However, the rocky habitat with small sparsely vegetated ephemeral drainage lines, located on the north eastern/eastern boundary of the proposed development area, are important for a variety of birds and should be avoided.

Solar PV Plant impact

The impact of aboveground PV plant infrastructure is not expected to be detrimental to birds – i.e., would not impede their movement, etc. Other problems such as “reflective surfaces” and “mirror collisions”, etc. are not applicable – i.e., does not pose the same avifaunal impact as CSP (Concentrated Solar Power) (Jenkins et al. 2017, Smit n.d.). However, the collision mortality impacts of birds with PV panels may be underestimated (Jenkins et al. 2017) and ongoing long-term monitoring is viewed as imperative to determine local bird mortalities.

Pipeline impact

The impact of heavy machinery during excavation of a trench to bury the proposed ammonia pipelines is expected to be detrimental to birds associated with the affected areas/habitats.

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

Pipeline impact - Birds

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.

Crossing Points

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

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.

Access route impact

The impact of a pipeline 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 are recommended to be incorporated to prevent speeding along the route. This should act as mitigation measure for important slow moving, especially nocturnal, mammals.

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

3.5 Flora

3.5.1 Tree and Shrub Diversity

It is estimated that at least 55 species of larger trees and shrubs (>1m in height) occur in the general area (Mannheimer and Curtis 2018) (Table 10).

The various developments fall within 3 vegetation types – i.e., Southern Namib (Ammonia Terminal area; ammonia pipeline to Farm 58), Central Namib and the Semi-desert and Savannah Transition Zone (Escarpment area) (various ammonia pipeline routes) (Giess 1971).

Southern Namib

According to Giess (1971) the Southern Namib stretches from the Swakop River southwards until Lüderitz. *Stipagrostis sabulicola* (tough dune grass) occurs with *Trianthema hereroensis* on the dunes while the inter-dune flats (streets) are covered with *Stipagrostis gonatostachys* after rains. The eastern inland sections – pro-Namib – are dominated by *Stipagrostis obtusa* and *S. ciliata* after rains while the plains closer towards the coast are dominated by *Mesembryanthemum cryptanthum* (Giess 1971). A common plant in the area is *Triathema hereroensis* which is known to be able to absorb fog-water through its leaves (Seely 2010).

Central Namib

The plains along the Central Namib are usually bare, although clumps of vygie *Mesembryanthemum cryptanthum* and grasses such as *Sporobolus nebulosus*, *Stipagrostis namibensis*, *S. hermannii*, *S. hirtigluma* subsp. *hirtigluma*, etc. appear in clumps after localised rains Giess (1971).

Semi-desert and Savannah Transition Zone (Escarpment area)

The general landscape is characterised by *Acacia senegal*, *Cyphostemma currorii*, *C. bainesii*, various *Commiphora* – e.g., *C. glaucescens*, *C. virgata*, *C. dinteri*, etc. – *Euphorbia guerichiana*, *Boscia foetida* and *B. albitrunca* while the grass cover consists largely of *Stipagrostis* species – e.g., *S. uniplumis* Giess (1971).

Of the 55 larger trees and shrubs species known and/or expected to occur in the general area (Mannheimer and Curtis 2018), 8 species are classified as endemics (14.6%), 3 species as near endemic (5.5%), 20 species are protected under the Forest Act No. 12 of 2001 (36.4%), 3 species are protected under the Nature Conservation Ordinance No. 4 of 1975 (5.5%) while 5 species are classified as CITES Appendix 2 (9.1%) species. The IUCN (2025) classifies 1 species as vulnerable (*Aloidendron (Aloe dichotoma) dichotomum*) and 1 species as near threatened (*Gossypium anomalum*). *Arthraerua leubnitziae* is endemic to the fog zone in the central Namib region (Burke 2003).

The most important species expected to occur in the area are *Acanthosicyos horridus* (protected; near endemic) which could be considered one of Namibia's most characteristic plants (Seely 2010) and remains an important commodity to the local Topnaar people (Burke 2003), *Capparis hereroensis* (endemic), *Aloidendron (Aloe dichotoma) dichotomum* (Protected F; NC; C2; N-end and classified as vulnerable by the IUCN 2025), *Gossypium anomalum* (classified as near threatened by the IUCN 2025) and the iconic *Welwitschia mirabilis* (Protected F; NC; C2) viewed as a Namib flagship species.

Table 10. Tree and shrub diversity (>1m in height) expected to occur in the general Arandis-Farm 58-Walvis Bay areas according to Mannheimer and Curtis (2018) and confirmed during the current study (✓) for the various sites – i.e., Ammonia Terminal (coastal site) area, Ammonia pipeline route (coastal), Farm 58 (Dune 7 area), Water pipeline and the various ammonia pipeline routes (i.e., alternatives) (Between Farm 58 and Arandis).

Species: Scientific name	Species confirmed								Namibian conservation and legal status	International status: IUCN (2025)
	Ammonia Terminal area	Ammonia Pipeline between Ammonia Terminal and Farm 58)	Farm 58 area	Water Pipeline	Ammonia Pipeline (between Farm 58 and Arandis)					
					Alternative: Red	Alternative: Green	Alternative: Purple	Alternative: Yellow		
<i>Acacia erioloba</i>					✓	✓	✓		Protected F	LC
<i>Acacia mellifera</i>										LC
<i>Acacia reficiens</i>				✓	✓	✓	✓	✓		LC
<i>Acacia tortilis</i>										LC
<i>Acanthosicyos horridus</i>						✓			Protected F; N-end End; Protected F	
<i>Adenia pechuelii</i>										LC
<i>Adenolobus garipensis</i>										LC
<i>Adenolobus pechuelii</i>				✓	✓					LC
<i>Aloidendron (Aloe dichotoma) dichotomum</i>									Protected F; NC; C2; N-end End	V
<i>Arthroa leubnitziae</i>			✓	✓	✓	✓	✓	✓		
<i>Boscia albitrunca</i>									Protected F	LC
<i>Boscia foetida</i>				✓				✓		LC
<i>Cadaba aphylla</i>										LC
<i>Capparis hereroensis</i>									End	
<i>Combretum imberbe</i>									Protected F	LC
<i>Commiphora dinteri</i>									End; Protected F	LC
<i>Commiphora glandulosa</i>										LC
<i>Commiphora glaucescens</i>									N-end	LC
<i>Commiphora saxicola</i>					✓	✓	✓	✓	End; Protected F	
<i>Commiphora tenuipetiolata</i>										LC

<i>Commiphora virgata</i>									End; Protected F	
<i>Cordia sinensis</i>										LC
<i>Elephantorrhiza suffruticosa</i>										LC
<i>Euclea pseudebenus</i>				√		√		√	Protected F	LC
<i>Euphorbia damarana</i>									End; C2	
<i>Euphorbia guerichiana</i>									C2	LC
<i>Euphorbia virosa</i>				√					C2	
<i>Faidherbia albida</i>						√			Protected F	LC
<i>Ficus cordata</i>									Protected F	LC
<i>Ficus sycomorus</i>									Protected F	LC
<i>Grewia tenax</i>										LC
<i>Gossypium anomalum</i>										NT
<i>Gymnosporia senegalensis</i>										
<i>Hoodia gordonii</i>									NC	
<i>Hyphaena petersiana</i>									Protected F	
<i>Laggera decurrens</i>										
<i>Lycium cinereum</i>										
<i>Lycium hirsutum</i>										
<i>Lycium tetrandrum</i>				√						
<i>Maerua juncea</i>										
<i>Maerua schinzii</i>									Protected F	LC
<i>Moringa ovalifolia</i>									Protected F	LC
<i>Parkinsonia africana</i>			√	√		√				LC
<i>Pechuel-Loeschea leubnitziae</i>										
<i>Phaeoptilum spinosum</i>							√	√		LC
<i>Salvadora persica</i>			√				√	√		
<i>Searsia marlothii</i>										LC
<i>Salsola</i> spp.	√	√	√	√	√	√	√	√		
<i>Salvadora persica</i>										LC
<i>Tamarix usneoides</i>			√	√		√	√		Protected F	
<i>Welwitschia mirabilis</i>							√		Protected F; NC; C2	
<i>Ziziphus mucronata</i>									Protected F	LC
<i>Zygophyllum clavatum</i>										
<i>Zygophyllum stapfii</i>			√	√	√	√	√	√	End	

End; N-end: Endemic and Near-endemic (Craven 1999, Mannheimer and Curtis 2018).

Protected (F): Forest Act No. 12 of 2001.

NC: Nature Conservation Ordinance No. 4 of 1975.

C2: CITES Appendix 2 species.

IUCN (2025): V = Vulnerable; NT = Near Threatened; LC = Least Concern, all other species not yet been assessed by the IUCN Red List.

[Although African species of Acacia have undergone a name change and grouped into two distinct genera – i.e., Vachellia and Senegalia – which are clearly separated based on several morphological, anatomical & biochemical attributes (e.g., Vachellia has capitate inflorescences (round, head-like flowers) and spinescent stipules (thorns) while Senegalia has spicate inflorescences (flowers in spikes) and the stipules are non-spinescent), the International Code of Nomenclature for algae, fungi, and plants is not prescriptive and I stick to Acacia throughout]

During the rapid assessment, a total of 18 species of larger trees/shrubs were identified throughout the various proposed Project development areas and a total of 50 species when including “other” smaller plants <1m in height (e.g., *Aloe* spp., herbs, etc.) – See Table 11. The Ammonia Terminal site and the Ammonia pipeline route had only 1 species (i.e., *Salsola* spp. on patches of dune hummocks), followed by the Farm 58 area with 3 species while the previously surveyed Hydrogen pipeline routes had at least 18 species of larger trees/shrubs present (50 species when including “other” plant species – e.g., *Aloe asperifolia*, *Galenia africana*, etc.) (See Table 12).

Of the 18 species, 3 species are classified as endemic (*Arthraerua leubnitziae*, *Commiphora saxicola*, *Zygophyllum stapfii*); 7 species are protected by the Forest Act No. 12 of 2001 (*Acacia erioloba*, *Acanthosicyos horridus*, *Commiphora saxicola*, *Euclea pseudebenus*, *Faidherbia albida*, *Tamarix usneoides*, *Welwitschia mirabilis*), 1 species protected under the Nature Conservation Ordinance No. 4 of 1975 (*Welwitschia mirabilis*) and 2 species listed as CITES Appendix 2 (*Euphorbia virosa*, *Welwitschia mirabilis*) from the Project area (See Tables 9 & 11; Figures 10-17).

The most important species confirmed from the various proposed Project sites are viewed as *Acanthosicyos horridus* (!Nara: Protected F, N-end), *Aloe asperifolia* (Protected NC), *Commiphora saxicola* (rock corkwood: end) as well as the unique *Welwitschia mirabilis* (welwitschia: Protected F, NC, C2). Other important species are the larger *Acacia erioloba* (camel thorn) specimens used by the endangered lappet-faced vultures as nesting sites (See Figures 10-11, 13, 16).

However, none of the important larger tree/shrub species is exclusively associated with the Project area.



Figure 10. Only a few *Acanthosicyos horridus* (!Nara) – protected F, N-end – individuals were observed in the Swakop River/Husab Mine area



Figure 11. *Aloe asperifolia* (kraal aloe) – protected NC – are common on dolerite ridges in the Goanikontes area.



Figure 12. *Arthroa leubnitziae* (pencil bush) – endemic – is common closer to the coast and dominant in the gravel plain areas.



Figure 13. *Commiphora saxicola* (rock corkwood) – endemic, protected F – observed on rocky ridges in the Khan and Swakop River areas.



Figure 14. *Euclea pseudebenus* (false ebony) – protected F – found in the larger ephemeral drainage lines throughout the area.



Figure 15. *Faidherbia albida* (ana tree) – protected NC – associated with the larger ephemeral Khan and Swakop Rivers.



Figure 16. *Welwitschia mirabilis* (welwitschia) – protected F; NC; C2 – are common in ephemeral drainage lines adjacent the Swakop River and Welwitschia Plains area further north.



Figure 17. *Zygophyllum stapffii* (dollar bush) – endemic – is common throughout the barren sandy areas.

3.5.2 Grass Diversity

It is estimated that up to 56 grasses – 28 to 39 species – (Müller 1984 [28 spp.], Müller 2007 [41 spp.], Van Oudshoorn 2012 [39 spp.]) occur in the general Project area.

Southern Namib

Stipagrostis sabulicola (tough dune grass) occurs on the dunes while the inter-dune flats (streets) are covered with *Stipagrostis gonatostachys* after rains. The eastern inland sections – pro-Namib – are dominated by *Stipagrostis obtusa* and *S. ciliata* after rains (Giess 1971).

Central Namib

The plains along the Central Namib are usually bare, although grasses such as *Sporobolus nebulosus*, *Stipagrostis namibensis*, *S. hermannii*, *S. hirtigluma* subsp. *hirtigluma*, etc. appear in clumps after localised rains Giess (1971).

Semi-desert and Savannah Transition Zone (Escarpment area)

The general landscape is characterised by grasses which consists largely of *Stipagrostis* species – e.g., *S. uniplumis* Giess (1971).

Table 11 indicates the grasses known and/or expected to occur in the general area and are derived from ¹Müller (1984), ²Müller (2007) and ³Van Oudtshoorn (2012).

According to various authors, a total of 56 species of grass potentially occurs in the general area (Table 11) although between 28 and 41 species are indicated by Müller (1984, 2007) specifically from Namibia. Three endemic grasses are expected to occur in the general area and include *Eragrostis omahekensis*, *Pennisetum foermeranum* and *Stipagrostis damarensis* with *S. damarensis* only occurring in the central and northern Namib in dry river courses (Burke 2005, Müller 2007). However, none are exclusively associated with the proposed development areas.

Table 11. Grass diversity expected to occur expected to occur in the general Arandis-Farm 58-Walvis Bay areas according to ¹Müller (1984), ²Müller (2007) and ³Van Oudtshoorn (2012) and confirmed during the current study (✓) for the various sites – i.e., Ammonia Terminal (coastal site) area, Ammonia pipeline route (coastal), Farm 58 (Dune 7 area), Water pipeline and the various pipeline routes (i.e., alternatives) (Between Farm 58 and Arandis).

Species: Scientific name	Species confirmed								Namibian conservation and legal status	Ecological Status	Grazing Value
	Ammonia Terminal area	Ammonia Pipeline (between Ammonia Terminal and Farm 58)	Farm 58 area	Water Pipeline	Ammonia Pipelines (between Farm 58 & Arandis)						
					Alternative: Red	Alternative: Green	Alternative: Purple	Alternative : Yellow			
^{2,3} <i>Anthephora pubescens</i>										Decreaser	High
² <i>Anthephora schinzii</i>										?	Low
³ <i>Aristida adscensionis</i>										Increaser 2	Low
^{2,3} <i>Brachiaria deflexa</i>										?	High
^{1,2} <i>Bachiaria glomerata</i>										Increaser 2	Average
^{2,3} <i>Cenchrus ciliaris</i>										Decreaser	High
^{1,2,3} <i>Centropodia glauca</i>										Decreaser	High
^{1,2,3} <i>Chloris virgata</i>										Increaser 2	Average
³ <i>Cladoraphis spinosa</i>										Increaser 1	Average
^{1,2,3} <i>Cynodon dactylon</i>										Increaser 2	High
^{1,2,3} <i>Dactyloctenium aegyptium</i>										Increaser 2	Average
^{1,2,3} <i>Enneapogon cenchroides</i>										Increaser 2	Low
^{1,2,3} <i>Enneapogon desvauxii</i>										Intermediate	Average
^{1,2,3} <i>Enneapogon scaber</i>										?	Low
^{1,3} <i>Enneapogon scoparius</i>										Increaser 2	Low
^{1,2} <i>Entoplocamia aristulata</i>										Intermediate	Low
^{1,2} <i>Eragrostis annulata</i>										Increaser 2	Low
³ <i>Eragrostis cilianensis</i>										Increaser 2	Low
^{1,2,3} <i>Eragrostis echinochloidea</i>										Increaser 2	Average
³ <i>Eragrostis lehmanniana</i>										Increaser 2	Average
^{1,2,3} <i>Eragrostis nindensis</i>										Increaser 2	Average
¹ <i>Eragrostis omahekensis</i>									End	?	Low

^{1,2} <i>Eragrostis porosa</i>					Intermediate	Low
³ <i>Eragrostis rotifer</i>					Intermediate	Low
^{2,3} <i>Eragrostis superba</i>					Increaser 2	Average
^{2,3} <i>Fingerhuthia africana</i>					Decreaser	Average
³ <i>Melinis repens</i>					Increaser 2	Low
³ <i>Microchloa caffra</i>					Increaser 2	Low
^{1,2} <i>Odyssea paucinervis</i>			√		?	Low
³ <i>Oropetium capense</i>					Increaser 2	Low
^{2,3} <i>Panicum repens</i>					Decreaser	High
² <i>Pennisetum foermeranum</i>				End	Decreaser	High
³ <i>Phragmites australis</i>	√		√		Decreaser	Low
³ <i>Poa annua</i>				Alien	?	Low
^{1,2} <i>Pogonarthria fleckii</i>					Increaser 2	Low
³ <i>Polypogon monspeliensis</i>				Alien	?	Average
³ <i>Setaria megaphylla</i>					Decreaser	High
^{1,2,3} <i>Schmidtia kalahariensis</i>					Increaser 2	Low
^{1,2,3} <i>Schmidtia pappophoroides</i>					Decreaser	High
^{1,2} <i>Setaria appendiculata</i>					Decreaser	High
^{1,2,3} <i>Setaria verticillate</i>					Increaser 2	Average
³ <i>Sporobolus festivus</i>					Increaser 2	Low
^{1,2,3} <i>Stipagrostis ciliata</i>			√		Decreaser	High
² <i>Stipagrostis damarensis</i>			√	End	?	Average
² <i>Stipagrostis dinteri</i>					?	High
² <i>Stipagrostis giessii</i>					?	High
^{1,2,3} <i>Stipagrostis hirtigluma</i>					Increaser 2	Low
^{1,2} <i>Stipagrostis hochstetteriana</i>					Decreaser	Average
^{1,2,3} <i>Stipagrostis namaquensis</i>					?	Average
^{1,2,3} <i>Stipagrostis obtusa</i>					Decreaser	High
^{1,2,3} <i>Stipagrostis uniplumis</i>			√		Increaser 2	Average
^{2,3} <i>Tragus berteronianus</i>					Increaser 2	Low
² <i>Triraphis purpurea</i>					?	Low
² <i>Triraphis ramosissima</i>					?	Average
^{1,2,3} <i>Tricholaena monachne</i>					Increaser 2	Average
² <i>Urochloa panicoides</i>					?	Low

End = Endemic (Müller 1984, 2007; *Burke 2003)

? = Undetermined in literature

Δ = Dominant species

During the rapid assessment, no grass species were observed in the Ammonia Terminal, Ammonia pipeline and Farm 58 areas, while only 2 were observed along the water pipeline route and 4 species were observed along the various pipeline options, respectively (See Table 11, Figure 18). The general area was very dry, accounting for the low number and abundance of grasses observed throughout.

The presence of plants is however dependent on environmental conditions, especially rainfall, implying that many more species, especially bulbs, herbs, grasses, etc., are expected to occur throughout the area than presented in Tables 10-11. Vegetation should be collected over various seasons, especially after localised rainfall events, to obtain the full potential spectrum occurring in an area. Species indicated in Tables 10-11 should be viewed as a “snapshot” in time as encountered during the rapid site assessment.

However, none of the important grass species is exclusively associated with the Project area.



Figure 18. *Stipagrostis damarensis* (Damara Bushman-grass) – endemic – associated with some ephemeral drainage lines in the area.

Ammonia Terminal impact (Coast)

The proposed development is in a barren saline pan area and consequently development impacts are not expected to be detrimental to flora as this is an extremely marginal environment for flora.

However, the Salsola dune hummock habitat, located on the eastern boundary of the proposed development area, are important for a variety of vertebrate fauna and should be avoided.

Farm 58 impact (Dune 7 area)

The proposed development is in a barren gypsum/sandy gravel plain area and although the diversity in this habitat is low, developments are expected to be detrimental to flora species associated with the affected area/habitat.

However, the rocky habitat with small sparsely vegetated ephemeral drainage lines, located on the north eastern/eastern boundary of the proposed development area, are important for a variety of vertebrate fauna and should be avoided.

Solar PV Plant impact

The impact of aboveground PV plant infrastructure is not expected to be detrimental to larger trees, shrubs and grasses.

Pipeline impact

The impact of heavy machinery during excavation of a trench to bury the proposed ammonia pipelines is expected to be detrimental to flora associated with the affected areas/habitats.

The pipeline route should avoid having to excavate protected tree/shrub species, especially in sensitive habitats like the Khan and Swakop Rivers and rocky terrain.

Access route impact

Creating new pipeline access routes is expected to be detrimental to flora associated with the affected area/habitat. This would affect a relatively small area over a short/limited period of time.

The pipeline access route should avoid having to excavate protected tree/shrub species, especially in sensitive habitats like the Khan and Swakop Rivers and rocky terrain.

Protected tree/shrub species, e.g., Aloe asperifolia, Commiphora saxicola, etc., known to occur throughout the development area, should be excavated and relocated to suitable habitat in the same general area.

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

3.5.3 Other species

Other species observed throughout the proposed development area included the following herbs, etc. (Table 12). This list is not comprehensive – i.e., many more species are known and/or expected to occur in the area, but not necessarily within the Project area and/or rain dependant.

A total of 32 species of “other” plants were confirmed throughout the Project area. This includes species confirmed by Cunningham (2024) from the general area.

Table 12. Other species (e.g., Aloes, bulbs, herbs, etc.) confirmed during the current study (✓) for the various sites – i.e., Ammonia Terminal (coastal site) area, Ammonia pipeline route (coastal), Farm 58 (Dune 7 area), Water pipeline and the various pipeline routes (i.e., alternatives) (Between Farm 58 and Arandis) – and compared to Cunningham (2024).

EIA: Vertebrate Fauna & Flora - Cunningham

Species	Species confirmed									Status	
	Ammonia Terminal area	Ammonia Pipeline	Farm 58 area	Water Pipeline	Hydrogen Pipelines				Cunningham (2024)		
					Alternative: Red	Alternative: Green	Alternative: Purple	Alternative: Yellow	Farm 58 area	Various Pipeline routes	
Acanthopsis disperma										√	NC
Aloe asperifolia				√	√		√				
Asparagus spp.										√	
Cleome suffruticosa						√			√	√	
Citrullus lanatus							√				
Codon royerii									√	√	
Cucumis africanus										√	
Cyperus spp.					√	√	√		√		
Euphorbia phylloclada				√							
Galenia africana				√	√	√	√				
Gomphocarpus filiformis				√	√	√	√				
Heliotropium lineare				√	√						
Indogophera auricoma				√							
Jamesbrittenia maxii					√	√	√				
Kleinia longiflora							√			√	
Kissenia capensis										√	
Monechma cleomoides					√					√	
Mesembryanthemum barklii									√		N-end
Pelargonium spp.							√				
Petalidium variabile						√			√	√	
Sarcocolon spp.							√				
Carcostemma viminalis					√						
Sesamum triphyllum										√	
Sesbania sesban										√	
Sesuvium sesuvioides										√	
Tephrosia dregeana										√	
Tetragonia ruduplicata				√		√					
Tribulus terrestris					√				√		
Tribulus zeyheri						√			√		
Tripteris spp.				√	√						
Trichodesma africanum										√	
Zygophyllum simplex				√	√				√		

Invasive alien species

Two invasive alien species were observed throughout the Project and included *Nicotiana glauca* (wild tobacco) and *Prosopis* spp. (mesquite spp.) mainly associated with the Khan and Swakop Rivers as well as leakages along the existing water pipeline route (Figures 19-20). These species should be eradicated when located in the various proposed development areas.



Figure 19. *Nicotiana glauca* (wild tobacco) – invasive alien species – observed in the area.



Figure 20. *Prosopis* spp. (mesquite spp.) – invasive alien species – in the Swakop River.

3.6 Important other species

Aloes

Aloes are protected throughout Namibia (See Nature Conservation Ordinance No. 4 of 1975) and although the coastal western areas are not favourable habitat for most aloes, at least 4 species potentially occur in the proposed Project area – *Aloidendron* (*Aloe dichotoma*) *dichotomum*, *Aloe asperifolia*, *A. hereroensis* and *A. namibensis* (Rothmann 2004). One species of *Aloe* was observed during the fieldwork (*Aloe asperifolia*) (See Figure 11).

Amaryllis

There are an estimated 260 members of the Amaryllidaceae family in southern Africa with several taxa in urgent need of conservation (especially associated habitats). In the Desert Biome in Namibia there are an estimated 13 species of which 2 species potentially occur in the general area (*Ammocharis deserticola*, *Crinum giessii*) (Duncan *et al.* 2020). No *Amaryllis* species were observed during the fieldwork.

Commiphora

Many endemic *Commiphora* species are found throughout Namibia with Steyn (2003) indicating that *Commiphora namaensis* and *C. oblancoolata* (not included in the Table 10) 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 (Nott and Curtis 2006). One species of *Commiphora* was observed during the fieldwork (*Commiphora saxicola*) (See Figure 13).

Euphorbias

At least 47 species of *Euphorbia* occur throughout Namibia of which 4 species are listed as rare, 1 endangered, 1 vulnerable and 1 near threatened (Möller and Becker 2019). *Euphorbia* species known/expected to occur in the general area include at least 4 species (*Euphorbia lignosa*, *E. gariepina*, *E. mauritanica*, *E. giessii*) (not included in the Table 10) potentially also occurring in the general area. Two species of *Euphorbia* were observed during the fieldwork (*Euphorbia phylloclada*, *E. virosa*) (See Tables 10 & 12).

Ferns

At least 64 species of ferns, of which 13 species being endemic, occur throughout Namibia. Ferns in the general area include at least 3 indigenous species (*Cheilanthes inaequalis*, *C. dinteri* and *Ophioglossum polyphyllum*) (Crouch *et al.* 2011). Although the project areas are marginal habitat for ferns, the general area is under collected with more species probably occurring than presented above. No ferns were observed during the fieldwork.

Hoodia

At least 10 species of *Hoodia* occur throughout Namibia with species protected by the Nature Conservation Ordinance no 4 of 1975. *Hoodia* species known/expected to occur in the general area include 3 species (*Hoodia currorii*, *H. gordonii*, *H. pedicelatta*) (Anon n.d.). No *Hoodia* species were observed during the fieldwork.

Lithops

Lithop species – all protected (See Nature Conservation Ordinance No. 4 of 1975) – are also known to occur in the general area and are often difficult to observe, especially during the dry season when their aboveground structures wither. Species expected to occur in the general area are *Lithops ruschiorum* var. *ruschiorum*, *L. gracilidelineata* subsp. *gracilidelineata* var. *gracilidelineata* and *L. g.* subsp. *gracilidelineata* var. *waldroniae* (Cole and Cole 2005, Earle and Round n.d.). No *Lithops* species were observed during the fieldwork.

Lichens

The overall diversity of lichens is poorly known from Namibia, especially the coastal areas and statistics on endemism is even sparser (Craven 1998). 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 BIOTO surveys in the early/mid 2000's was new to science (i.e. new species), is a case in point. More than 120 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 from the Namibian coast (Schulze and Rambold 2007). Many lichens look similar and are highly variable in appearance and notoriously difficult to identify unless with the use of a microscope (e.g., crustose lichens) or certain chemical tests. Off road driving is the biggest threat to these lichens which are often rare and unique to Namibia. Lichens are important as the endemic

Damara tern often uses these fields as a breeding ground (Craven and Marais 1986) and may even reveal life-saving antibiotics in future (Seely 2010).

Lichen diversity and abundance decreases from the sandy/gravel plains just south of the Swakop River to the sandy/gypsum plains north of the Kuiseb River east of the dune belt. The closest lichen hotspots include a Crustose lichen zone east of the dune belt area while extensive patches of fruticose and foliose lichens occur in the Mile 8 and Wlotzkasbaken areas between Swakopmund and Henties Bay – i.e., far to the north and west of the proposed development areas.

Only 1 lichen species (unidentified) was observed during the rapid assessment mainly on quartz pebbles in the rocky sections of the Farm 58 area and on dolerite ridges in the Goanikontes area (Figure 21).



Figure 21. Unidentified (*Caloplaca* spp.) lichen species observed on rocky substrate in the Goanikontes area.

Other species with commercial potential that could occur in the general area include *Acanthosicyos horridus* (Inara) (See Figure 10), classified as near endemic, often forming dense impenetrable patches, in the Kuiseb River Delta area, which has medicinal, cosmetic and nutritional value (Mendelsohn *et al.* 2002, Jarvis *et al.* 2022). Furthermore, Southern Africa is an important centre of diversity for the melon family (*Cucurbitaceae*) and they have an excellent potential for development to supplement or replace cereal production in arid regions (Kolberg 1998).

4 Important species

Reptiles

Of the 63 species of reptiles expected to occur in the general area, of which a high percentage are viewed as endemic (60.3%), a total of 34 species have been confirmed from the general Project area by the author.

The endemic *Afroedura africana africana* (African flat gecko), *Meroles micropholidotus* (small-scale desert lizard) and *Pedioplanis husabensis* (Husab sand lizard) are viewed as the

most important reptiles potentially occurring in the area. *Pedioplanis husabensis* is very habitat specific and mainly occurs on “white/grey” geology in the Khan River area south of Arandis (Cunningham *et al.* 2012). *Leptotyphlops occidentalis* (western thread snake) and *Lycophidion namibianum* (Namibian wolf snake) are the snakes viewed as the most important in the area. Three important coastal and dune and/or *Salsola* hummock associated species are *Bitis peringueyi* (Péringuey’s Adder), *Typhlosaurus braini* (Brains’s Blind Legless Skink) and *Pachydactylus rangei* (Web-footed gecko).

Sedentary species – e.g., most species including all geckos – will be adversely affected by the proposed project developments, however none of the reptiles (except for *P. husabensis* favouring specific geology and habitat throughout the general area) observed and/or confirmed from the area are exclusively associated with the proposed Project areas.

Amphibians

Amphibians are not viewed as important throughout the project area although the ephemeral Khan, Swakop and Tumas Rivers and their tributaries as well as rock pools might occasionally serve as temporary habitat. The endemic *Poyntonophrynus dombensis*, *Poyntonophrynus hoeschi* and *Phrynomantis annectens* are viewed as the most important although they are not exclusively associated with the proposed development areas.

Overall suitable habitat for amphibians in the general area is viewed as the ephemeral Khan, Kuiseb, Swakop and Tumas Rivers and their various tributaries. Temporary pools after localised rainfall events could potentially serve as habitat for amphibians throughout the area. Open surface water in the general area is usually saline while the sandy coastal saline pan areas are marginal habitat for amphibians. None of the unique/important amphibian species are exclusively associated with the proposed development areas and are not expected to be detrimentally affected by proposed developments.

Mammals

At least 55 species of mammals are known and/or expected to occur in the general area of which 11 species (20%) are classified as endemic. The most important species from the general area are the Namibian wing-gland bat (*Cistugo seabrai*) listed as endemic and rare; Littledale’s whistling rat (*Protomys littledalei namibensis*) – of which the subspecies “*namibensis*” is known to occur in the ephemeral river courses in the “Swakopmund area” Griffin (2003) – listed as endemic; brown hyena (*Parahyaena brunnea*) and leopard (*Parthera pardus*) listed as near threatened and vulnerable (population trends decreasing), respectively by the IUCN (2025). Hartmann’s mountain zebra (*Equus zebra hartmannae*), classified as vulnerable by the IUCN (2025), are associated with the rocky inland areas, moving between grazing areas and water points/seeps in the Khan and Swakop Rivers, and viewed as important.

Habitat alteration and overutilization are the two primary processes threatening most mammals (Griffin 1998c) with species probably underrepresented in the above-mentioned table for the general area being the bats and rodents, as these groups have not been well documented from the arid central western part of Namibia.

Sedentary species – e.g., rodents – will be adversely affected by the proposed project developments; however, none are exclusively associated with the proposed development areas. Larger mammal species are more mobile and often vacate areas frequented by humans. Aboveground pipeline infrastructures will act as a barrier to non-jumping ungulates.

Birds

At least 182 species of terrestrial [“breeding residents”] birds occur and/or could occur in the general area at any time. Seven of the 14 Namibian endemic bird species (50% of all Namibian endemic species or 4% of the species expected to occur in the area) can or are likely to occur in the general area. The most important endemic birds known/expected to

occur in the general area are Gray's lark, dune lark and Herero chat. Gray's lark is one of the species with the most restricted range in Namibia (Simmons 1998a). Furthermore, Simmons *et al.* (2015) list 2 species as critically endangered (great crested grebe, Cape gannet), 7 species as endangered (Cape cormorant, bank cormorant, black stork, white-backed vulture, martial eagle, tawny eagle, Ludwig's bustard), 6 species as vulnerable (great white pelican, greater flamingo, lesser flamingo, secretarybird, lappet-faced vulture, Hartlaub's gull) and 8 species as near threatened (black-necked grebe, crowned cormorant, Verreaux's eagle, peregrine falcon, kori bustard, African black oystercatcher, chestnut-banded plover, Damara tern). Other important species known to occur in the general area are maccoa duck (NT), Eurasian curlew (NT), Caspian tern (V) and black harrier (E) although these species are however not expected to occur permanently in the general area, but probably only pass over on their way to the coast. The IUCN (2025) classifies 1 species as critically endangered (white-backed vulture), 7 species as endangered (Cape gannet, Cape cormorant, bank cormorant, lappet-faced vulture, martial eagle, secretarybird, Ludwig's bustard), 1 species as vulnerable (tawny eagle) and 3 species as near threatened (lesser flamingo, kori bustard, chestnut-banded plover).

Bird species most likely to be adversely affected by the proposed project developments are the ground nesting species associated with gravel plains such as the endemic Gray's lark and Rüppell's korhaan as well as larger raptors, especially the disturbance at breeding sites (i.e., lappet-faced vulture nesting sites mainly isolated with bigger *Acacia erioloba* trees). Aboveground pipeline infrastructures will act as a barrier to ostrich.

Flora

The most important species confirmed from the various proposed Project sites are viewed as *Acanthosicyos horridus* (!Nara: Protected F, N-end), *Aloe asperifolia* (Protected NC), *Aloe namibensis* (Protected NC), *Aloidendron (Aloe dichotoma) dichotomum* (quiver tree: Protected F, NC, C2, N-end and classified as vulnerable by the IUCN 2025), *Commiphora saxicola* (rock corkwood: end) as well as the unique *Welwitschia mirabilis* (welwitschia: Protected F, NC, C2). Other important species are the larger *Acacia erioloba* (camel thorn) specimens used by the endangered lappet-faced vultures as nesting sites.

Important plant species known and/or expected from the general Project area and included in the Red Data Book for Namibia include at least 7 species of which 1 species is listed as near threatened (*Adenia pechuelii*) and 6 species as endemic (Table 13) (Loots 2005). All the species included in Table 13 are viewed as important.

Table 13. Important species – i.e. Red Data spp. – known to occur in the general Project area according to Loots (2004).

Species: Scientific name	Conservation status
<i>Adenia pechuelii</i>	Endemic, NT
<i>Aloe namibensis</i>	Endemic, NC, C2, LC
<i>Chamaeigigas intrepidus</i>	Endemic, LC
<i>Euphorbia monteiri</i> subsp. <i>monteiri</i>	Endemic, C2, LC
<i>Lithops gracilidelineata</i> subsp. <i>gracilidelineata</i>	NC, LC
<i>Lithops ruschiorum</i>	Endemic, NC, LC
<i>Nicotiana africana</i>	Endemic, LC

Endemic (Loots 2005)

NC – Nature Conservation Ordinance No. 4 of 1975

Rare; NT – Near Threatened; LC – Least Concern (Loots 2005)

C2 – CITES Appendix 2 spp.

5. Important areas

The MEFT (2013) views the following strategies regarding habitat units in the Namib Naukluft Park as important:

1. Because of the large open systems involved, and the intention to create linkages with adjacent ecosystems (e.g., coastal, and marine to west and escarpment belt to east), ecosystem management should be minimal, and a largely hands-off approach should be adopted, but 'hands-on' in terms of forging strategic partnerships for open landscape conservation and to prevent and/or minimizing damage to important habitats and species in the NNP;
- 2) Should it become necessary to apply active management, interventions should aim to manage the arid ecosystems for long-term diversity, health, productivity and climate change resilience and adaptation, by ensuring connectivity, preventing overuse of all components, including water, fauna and flora, landscapes, etc.;
- 3) Allow and promote variability in management and "patchiness" in ecosystem expression in response to variable climatic conditions and ecosystem functioning;
- 4) Build up a good monitoring record of ecological and bio-climatic information, including the diversity and abundance of various species in different taxa, including the less studied lower plants, invertebrates, etc.;
- 5) Monitor the health of populations of species high on the food chain (e.g., key predators and scavengers), flagship and keystone species and other strategic key indicator species (including indicator species for early warning of climate change impacts) – if these species prosper it follows that the base of the food chain is likely to be diverse and in good condition;
- 6) Monitor key habitats such as Important Bird Areas and Important Plant Areas;
- 7) Monitor human impacts on landscapes, ecosystems, habitats, and species with particular attention to fragile and high value components of the system, and human activities known to have significant impacts;
- 8) Participatory and outsourced approaches for monitoring should be used, fully involving relevant stakeholders; and
- 9) No poisons or pesticides (or other toxic chemicals) may be used in the park unless when approved by the Director responsible for Park Management.

The Project area has habitats viewed as sensitive/high environmental value – i.e., ephemeral river courses, inselbergs, and inland rocky hills – within the Namib Naukluft Park (MEFT 2013).

Sensitive areas

The areas of most concern, presented from most to least importance, would be:

i) Ephemeral drainage lines – i.e., Khan, Swakop & Tumas Rivers (and associated tributaries)

The various larger well vegetated ephemeral drainage lines throughout the project area (i.e., Khan, Swakop & Tumas Rivers) which drains the general area westwards towards the coast. These, well vegetated drainage lines, are virtual lifelines for most vertebrate fauna, especially ungulates, small mammals and birds that forage along these vegetated areas. The drainage lines often pass alongside broken rocky terrain which serves as habitat to a wide variety of reptiles – e.g., Namib day geckos. The bigger trees – e.g., mainly *Acacia erioloba* (camel thorn), *Euclea pseudobenus* (wild ebony), *Faidherbia albida* (ana tree), *Tamarix usneoides* (tamarisk) and *Ziziphus mucronata* (buffalo thorn) – also found along the drainage lines (especially the Khan and Swakop Rivers) serve as habitat for a variety of species (e.g., lappet-faced vulture nesting/roosting sites as well as other larger raptors and bark/cavity roosting bats, rodents, etc.) (Figures 22-23).

The Swakop River (706km²) is listed as a biodiversity “Red Flag” area with important features the linear oasis, riparian woodland, aquifer recharge, rich wildlife, and bird flight paths (SAIEA 2010).



Figure 22. The Swakop River riparian habitat is a linear oasis in an otherwise marginal environment and serves as habitat to a variety of vertebrate fauna.



Figure 23. The Tumas River with *Salsola* hummocks is an important habitat in a barren area.

ii) Light coloured “white and grey” geology – Husab/Rössing/ Witpoortberg areas

The endemic and restricted range species, *Pedioplanis husabensis* (Husab sand lizard), occurs on “light coloured” geology (marble/granite ridges) in the general area, especially in the Husab/Rössing/Witpoortberg areas – i.e., especially along the green/yellow pipeline

alternative routes (Figure 24). The Husab/Witpoortberg area (60km²) is listed as a biodiversity “Red Flag” area with the inselbergs having high biodiversity – e.g., many *Lithops* spp. and important *Adenia pechuelii* (elephant’s foot). The MEFT (2013) views inland rocky hills as less sensitive than inselbergs, but nonetheless important for biodiversity and refugia for plants and animals, particularly during dry periods.



Figure 24. Typical “white” geology favoured by the endemic and range restricted *Pedioplanis husabensis* (Husab sand lizard) in the vicinity of the Husab Mountains. Images for this lizard species can be viewed in Cunningham (2010a, 2013, Cunningham *et al.* 2012).

iii) *Welwitschia mirabilis* Flats

These barren plains north of the Swakop River in the Husab Mine area, support moderate-high densities of *Welwitschia mirabilis* (welwitschia) – protected F; NC; C2 – especially along small drainage lines (Figure 25). The Welwitschia Flats (138km²) is listed as a biodiversity “Red Flag” area with the various ridges and plains in this area supporting very high plant abundance and diversity compared to surrounding areas and high productivity probably due to ‘fog trap’ between the Khan and Swakop River valleys (SAIEA 2010). According to the MEFT Namib Naukluft Management Plan, the central Namib gravel plains with inselbergs that support plains wildlife such as oryx, springbok and ostrich, are viewed as notable and important features with ephemeral river courses one of the most important habitats (MEFT 2013).



Figure 25. *Welwitschia mirabilis* (welwitschia) – protected F; NC; C2 – are important in the barren plain area known as *Welwitschia* Flats north of the Swakop River (i.e., Husab Mine area).

iv) 30km Coast between Walvis Bay and Swakopmund

This coastal strip is an Important Bird Area (IBA) (90km²) and is listed as a biodiversity “**Red Flag**” area with a high density of waders along the beach areas as well as breeding sites for Damara tern (*Sternula balaenarum*) (Figure 26). Although Damara tern potentially could breed on the salt pan (Ammonia Terminal site) and the sandy/gravel gypsum plains (Farm 58 area), this has not yet been recorded and neither are these areas the quiet undisturbed habitat the birds prefer (i.e., not expected to breed in the Project area).



Figure 26. The barren salt pan area at the proposed Ammonia Terminal site. Although this is typical Damara tern (*Sternula balaenarum*) breeding habitat, this specific area is disturbed by its proximity to Walvis Bay and various anthropomorphic activities.

v) Lappet-faced vulture nesting sites

Lappet-faced vultures are known to breed throughout the general area (See Cunningham 2021, 2024) and although not confirmed along the various pipeline alternative routes, nevertheless remain important should such nesting sites be encountered. Nesting trees are viewed as important as the vultures are classified as endangered by the IUCN (2025) with population trends decreasing throughout their range. With an estimated of only 6,500 mature individuals, human intrusion, and disturbances; utility and service lines and ecosystem modifications are viewed as threats (Birdlife International 2023). The IUCN (2025) indicates that the known threats to lappet-faced vulture include transportation services (roads), human intrusions/disturbances (work related) and natural system modifications (ecosystem modifications). Furthermore, nesting sites are re-used and disturbances around these nesting sites should be avoided, especially between May-July during peak breeding season, as lapped-faced vultures are known to abandon their nests when disturbed. All nesting sites should be avoided with no activities allowed closer than 500m (preferably a greater distance – i.e., 1-1.5km) from the nests.

Other important areas in the general vicinity include:

- Inland gravel plains (813km²; Biodiversity “Yellow Flag” area): Lichens, invertebrates and biodiversity associated with Tumas drainage area. Tumas ‘mouth’ (reedbed and ephemeral spring on eastern edge of dunes), hummocks and ephemeral wetland;
- Broken hills linked to Swakop River valley (520km²; Biodiversity “Yellow Flag” area): Wilderness area, scenic beauty, lappet-faced vulture breeding area, large cave with abundant bats;
- The amalgamated Swakop-Khan confluence (Haigamchab), Goanikontes, Rössing Mountain (439km²; Biodiversity “Yellow Flag” area): Haimgamchab – huge, very old *Acacia erioloba*, permanent spring (supports furthest west occurrence of baboons), reedbeds. Swakop River canyon upstream of Goanikontes with marble ridges, rich patches of special plants (*Aloe dichotoma*, *Anacampseros* and *Lithops ruschiorum*), Rössing cave (concentrated bat population); and
- Mountains surrounding Rössing, including Rössing Dome (42km²; Biodiversity “Yellow Flag” area): High density of *Lithops ruschiorum* and *Adenia pechuelli*, lizard *Pedioplanis husabensis*, only known distribution of possibly extinct spider *Moggridgea eremicola* (SAIEA 2010).

The important (sensitive) areas at each proposed development sites are indicated below:

Coastal Development (Ammonia Terminal site & Ammonia pipeline route)

Important areas include a patch of *Salsolea* spp. dune hummocks immediately east of the proposed Ammonia Terminal site located on a barren salt pan. These vegetated hummocks have a high diversity of vertebrate (and invertebrate) fauna and serve as foraging area for carnivores (e.g., black-backed jackal, brown hyena, etc.) and ungulates (e.g., gemsbok, springbok, etc.). Another vegetated patch occurs immediately west (at the base) of the Dune 7 area in the vicinity of the proposed Ammonia pipeline route. These areas should be avoided (Figures 27-28).



Figure 27. The *Salsola* spp. dune hummocks on the eastern boundary of the Ammonia Terminal site and immediately west of the Dune 7 area are important habitats.

Alternative routes are recommended (See Figure 28):

Rather than the straight line and shortest route as depicted in Figure 28, venturing to the south would avoid all the important *Salsola* spp. dune hummock habitats as well as most of the fluctuating and very mobile dune system. These proposed alternative routes would follow already disturbed areas (i.e., roads; township periphery and railway line) and/or saline pan systems and have the least impact on the biodiversity/ecology of the area.

The existing TransNamib access road could also be used to construct/maintain/service this alternative pipeline route.

Furthermore, maintenance would be less affected as this proposed alternative pipeline route would be out of the main dune fields and constant windblown sand issues.

Dune morphology is complex and often not stable but can change depending on wind direction and speed, etc. The Namib Sand Sea is viewed as Namibia's most iconic landscape feature and a World Heritage site (Jarvis *et al.* 2022). The Namib sand dunes are not only characteristic of the Namibian coastal areas and although they differ in shape most Namib dunes are comprised of grains of quartz and some heavy minerals. Sand typically slopes steeply upwards at approximately 14° from the dune base and often vegetated along the lower sections of the dune slope (plinth). The slip face is the area of cascading sand near the dune crest (32-34°) usually representing <1% of the dune surface area although supporting most life on a dune (Seely 2010).

Dunes take on various shapes in the Namib Desert although those located closer to the coast are known as traverse dunes with their long axis lying perpendicularly to the dominant southerly winds with their slip faces orientated northwards. The most mobile dunes are the barchan dunes – i.e., dunes crossing the Kuiseb River area closer to the coast and behind and in the vicinity of the Walvis Bay sewage works and bird sanctuary.

In the Ammonia Pipeline route area, there are a combination of smaller barchan dunes and the larger traverse dunes. The barchan dunes are devoid of vegetation while the lower

sections of the traverse dunes may be vegetated, especially *Salsola* spp. Placing the pipeline route to the south of the mobile dune sections is recommended as this would follow existing disturbed areas and require less overall maintenance compared to the route through this mobile dune section proposed (See Figure 28).



Figure 28. Important *Salsola* spp. dune hummock habitats (See dashed white oblongs) (©Google Earth). The alternative 2 x routes are indicated by the black dotted line (1st option) which would follow existing disturbed areas (road; township periphery & railway line) or the orange dotted line (2nd option) and would avoid the important *Salsola* spp. dune hummock areas as well as most of the mobile dune fields.

Dune 7 Development (Farm 58 site)

Important areas include rocky ridges and small vegetated ephemeral drainage lines in the northern/northeastern parts of the site which is located on a gypsum/sandy gravel plain. These sparsely vegetated, albeit small ephemeral drainage lines, and rocky ridges have a high diversity of vertebrate (and invertebrate) fauna and serve as foraging area for carnivores (e.g., black-backed jackal, brown hyena, etc.) and ungulates (e.g., gemsbok, springbok, etc.). Unique reptiles such as *Meroles reticulatus* and *Phelsuma (Rhoptropus) afer* are associated with these habitats as well as species preying on them (e.g., various snake species). These areas should be avoided (Figures 29-30). Potential bird mortalities associated with the Solar PV Plant panels, albeit not expected, should be monitored.



Figure 29. Important areas include rocky ridges and small vegetated ephemeral drainage lines in the Farm 58 area.

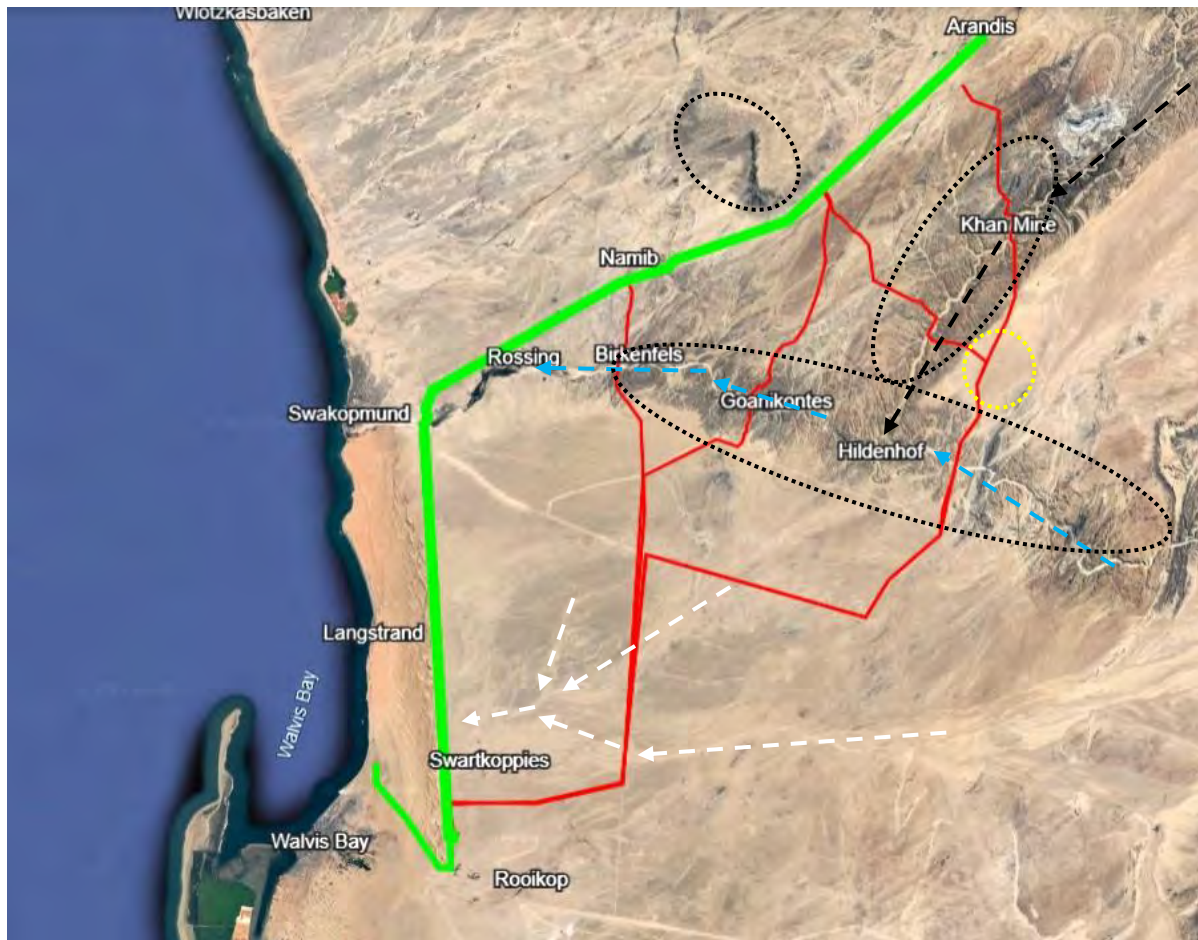


Figure 30. Important areas include low rocky ridges and small vegetated ephemeral drainage lines in the Farm 58 area (See dashed white oblong) (©Google Earth).

Various Pipeline Development Routes

Important areas include the larger well vegetated ephemeral Tumas, Kuiseb and Swakop Rivers, Welwitschia Flats, inselbergs, rocky ridges/outcrops/hills (especially with white geology favoured by the unique and range restricted *Pedioplanis husabensis*) and vegetated ephemeral drainage lines throughout the area. These areas have a high diversity of species, especially unique and/or protected species, and should be avoided and/or developed with

utmost sensitivity and care – i.e., adapting and altering the pipeline route to accommodate these important areas/species (Figures 31a & b).





Figures 31a & b. Important areas include the larger well vegetated ephemeral Khan River (black dashed arrows); Tumas River (white dashed arrows) and Swakop River (blue dashed arrows); Welwitschia Flats (yellow dotted circle), larger inselbergs, rocky ridges/outcrops/hills (black dotted oblongs) and other smaller vegetated ephemeral drainage lines throughout the area.

Top (31a): Various pipeline alternatives are indicated in red, while the existing water pipeline route is indicated in bold green and the proposed Ammonia pipeline in green. **Bottom (31b):** Alternative Ammonia pipeline routes (Swakop Route (left); Dorob Route (centre) and Naukluft Route (right) (©Google Earth).

A. Four Pipeline Routes (Alternatives: Red, Green, Purple & Yellow) between the Farm 58 and Arandis were assessed (See Figure 32a). The best route, from a biodiversity/ecology perspective, would be the Red Route (Alternative: Red) followed by the Purple Route (Alternative: Purple) and then the Green and Yellow Routes (Alternatives: Green & Yellow), respectively. The Green and Yellow routes would affect undisturbed and pristine areas and are viewed as the least acceptable routes to pursue.

Ranking these routes from least impact to most impact:

RED – PURPLE – GREEN – YELLOW



B. Three alternative Pipeline Routes (Alternatives: Black [Swakop], Green [Dorob] & blue [Naukluft]) were assessed (See Figure 32b). The best route, from a biodiversity/ecology perspective, would be the Black Route (Swakop Route) followed by the Blue Route (Naukluft Route) and then the Green Route (Dorob Route), respectively. Large parts of the Green and Blue Routes would affect undisturbed and pristine areas and are viewed as the least acceptable routes to pursue.

Ranking these alternative routes from least impact to most impact:

BLACK – BLUE – GREEN



Figures 32b: Alternative pipeline routes (Swakop Route (black); Dorob Route (green) and Naukluft Route (blue) (©ECC).

Ranking all the routes from least impact to most impact:

BLACK – RED – PURPLE – BLUE – GREEN – YELLOW

However, following the NamWater water pipeline route (Figure 32a) or the Swakop pipeline route (Figure 32b) would be the best options as they follow an existing development corridor with associated access routes in an already disturbed area = least impact on the biodiversity/ecology (See Blue line in Figure 32a & Black line in Figure 32b).

Option 1

NAMWATER PIPELINE ROUTE (Figure 32a) or **SWAKOP ROUTE** (Figure 32b)

The following recommendations should result in the least impact from a biodiversity/ecological perspective along this route.

1. Arandis area: The pipeline should remain to the south of the B2 tarmac highway;
2. Follow the existing NamWater pipeline the entire way to the Farm 58 area.

Table 14 indicates the zoning of the recommended NamWater Pipeline Route according to areas of importance (i.e., biodiversity/ecology) from Arandis to the Farm 58 area. The distance is approximately 80km of which 1.3km (i.e., 1.7% of the route) is viewed as “high” sensitivity while 78.7km (98.3%) is viewed as “low” sensitivity (Table 14).

Table 14. Areas of importance, with protected species potentially affected, along the NAMWATER PIPELINE ROUTE between Arandis and Farm 58 [Direction: Arandis – Swakopmund – Farm 58]

Hotspot areas	Distance (km)	Area	Important species	Common names	Status	Aliens	Other important features	Importance ranking
1	0 to 53.4	Arandis-Swakop	<i>A. asperifolia</i>	Kraal aloe	NC			Low
	53.4 to 54.1	Swakop	<i>T. usneoides</i>	Tamarisk	F		Swakop River	High
	54.1 to 78.0	Tumas River						Low
2	78.0 to 78.3	Tumas River					Tumas River	High
	73.8 to 75.5	Tumas River	<i>A. leubnitziae</i>	Pencil bush	End			Low
3	75.5 to 75.8	Tumas River	<i>A. leubnitziae</i>	Pencil bush	End		Tumas River	High
	75.8 to 80.0	Farm 58						Low

Distance: ±80km**Importance ranking:** High, and Low**Status:** End = Endemic spp.**F:** Forest Act No. 12 of 2001**NC:** Nature Conservation Ordinance No 4 of 1975

Should following the existing NamWater water pipeline route and/or the Swakop pipeline routes not be feasible then I would recommend following the Red Route (Alternative: Red) in Figure 32a. This Route is expected to have the least impact on biodiversity/ecology as it follows the NamPower 220kV line for most of the way – i.e., already impacted with an existing access route within an existing development corridor (i.e., not affect any pristine habitats).

Option 2

RED ROUTE

The following recommendations should result in the least impact from a biodiversity/ecological perspective along this route.

1. Farm 58 area: The pipeline should remain to the east of the tarmac highway; follow an existing gravel track to the 220kV transmission line running immediately to the north/northeast of Farm 58 to the Kuiseb Substation area;
2. Follow the 220kV transmission line from the Kuiseb Substation via the Walmund Substation area to the Swakop River (Birkenfels area);
3. Follow either the gravel road to the B2 highway and all the way along the B2 highway to Arandis or the 220kV or 66kV transmission lines from the Birkenfels area (Swakop River) to the Lithops Substation area and then the tarmac access route from the Lithops Substation to the B2 highway and the entire way to Arandis – i.e., remain to the south of the B2 tarmac highway.

Table 15 indicates the zoning of the recommended RED ROUTE according to areas of importance (i.e., biodiversity/ecology) from Farm 58 to the Arandis area. The distance is approximately 83.5km (following the 220kV transmission line) of which 11.3km (i.e., 13.2% of the route) is viewed as “high” sensitivity; 10.1km (12.1%) is viewed as “medium” sensitivity while 62.1km (74.4%) is viewed as “low” sensitivity (Table 15).

Table 15. Areas of importance, with protected species potentially affected, along the RED ROUTE between Farm 58 and Arandis via the 220kV transmission line [Direction: Farm 58 – Kuiseb SS – Walmund SS – Birkenfels – Lithops SS - Arandis]

Hotspot areas	Distance (km)	Area	Important species	Common names	Status	Aliens	Other important features	Importance ranking
1	0 to 8.5	Farm 58	<i>A. leubnitziae</i>	Pencil bush	End			Low
	8.5 to 8.7	Kuiseb SS	<i>A. leubnitziae</i>	Pencil bush	End		Rocky hill + lichens	High
								Low
2	8.7 to 12	Kuiseb SS						Low
	12 to 13.5	Kuiseb SS						Low
	13.5 to 13.8	Kuiseb SS	<i>A. leubnitziae</i>	Pencil bush	End		Tumas River	High
3	13.8 to 19.5	Kuiseb SS	<i>A. leubnitziae</i>	Pencil bush	End			Low
	19.5 to 19.7	Walmund SS	<i>Zygophyllum stapfii</i>	Dollar bush	End		Drainage line	High
	19.7 to 28.0	Walmund SS	<i>A. leubnitziae</i>	Pencil bush	End			Low
4	28.0 to 36.9	Walmund SS	<i>A. leubnitziae</i>	Pencil bush	End			Low
	36.9 to 37.2	Walmund					Drainage line	High
	37.2 to 38.9	Swakop River						Low
5	38.9 to 48.9	Swakop River	<i>Acacia erioloba</i>	Camelthorn	F	<i>Prosopis</i> spp.	Swakop River + hills/mountains	High
6	48.9 to 59.0	Lithops SS					Drainage line + rocky area	Medium
	59.0 to 68.0	Lithops SS	<i>Aloe asperifolia</i>	Kraal aloe	NC			Low
	60.0 to 71.5	Lithops SS	<i>Commiphora saxicola</i>	Rock corkwood	End; F			Low
7	71.5 to 75.5	B2	<i>Aloe asperifolia</i>	Kraal aloe	NC			Low
	75.5 to 75.8	B2	<i>Commiphora saxicola</i>	Rock corkwood	End; F		Dolerite ridges	High
	75.8 to 83.5	Arandis						Low

Distance: ±83.5km**Importance ranking:** High, Medium, and Low**Status:** End = Endemic spp.**F:** Forest Act No. 12 of 2001**NC:** Nature Conservation Ordinance No 4 of 1975

Options 3-5 are included below but are expected to have a higher impact on the biodiversity/ecology than Options 1 and 2 and/or affect pristine habitats (e.g. Options 4 & 5).

Option 3

PURPLE ROUTE

The following recommendations should result in the least impact from a biodiversity/ecological perspective along this route.

1. The pipeline should remain to the east of the gravel road (D1991) – i.e., Goanikontes road.

Table 16 indicates the zoning of the recommended PURPLE ROUTE according to areas of importance (i.e., biodiversity/ecology) from the B2/D1991 T/Off via Goanikontes to the 220kV transmission line T/Off. The distance is approximately 29.8km (following the D1991 gravel road) of which 7.2km (i.e., 24.2% of the route) is viewed as “high” sensitivity; 4.3km (14.4%) is viewed as “medium” sensitivity while 18.3km (61.4%) is viewed as “low” sensitivity (Table 16).

Option 4

BLUE ROUTE

The following recommendations should result in the least impact from a biodiversity/ecological perspective along this route.

1. Farm 58 area: The pipeline should remain to the east of the tarmac highway; follow an existing gravel track to the 220kV transmission line running immediately to the north/northeast of Farm 58 to the Kuiseb Substation area;
2. Follow the 220kV transmission line from the Kuiseb Substation via the Walmund Substation area to the Swakop River (Birkenfels area);
3. Follow either the gravel road to the B2 highway and all the way along the B2 highway to Arandis or the 220kV or 66kV transmission lines from the Birkenfels area (Swakop River) to the Lithops Substation area and then the tarmac access route from the Lithops Substation to the B2 highway and the entire way to Arandis – i.e., remain to the south of the B2 tarmac highway.

Table 17 indicates the zoning of the recommended GREEN ROUTE according to areas of importance (i.e., biodiversity/ecology) from the 220kV T/Off (Walmund Substation area) along the C28 and then along the Husab Mine/Giant Welwitchia gravel road to the Husab Mine area. From the Husab Mine T/Off Google Earth was used to assess the route due to lack of access. The distance is approximately 60km (following the D1991 gravel road) of which 15.5km (i.e., 25.8% of the route) is viewed as “high” sensitivity; 3.1km (5.2%) is viewed as “medium” sensitivity while 41.4km (69%) is viewed as “low” sensitivity (Table 17).

Option 5

GREEN ROUTE(S) x 2 (Route a = Figure 32a & Route b = Figure 32b)

The following recommendations should result in the least impact from a biodiversity/ecological perspective along this route.

1. The pipeline should remain to the north of the C28 and west of the Husab Mine/Giant Welwitchia gravel road (Figure 32a);
2. The pipeline should avoid crossing the unspoilt area between Farm 58 and the C28 and rather follow the 220kV transmission lines (Figure 32b);
3. Pipeline follow the existing pipeline route.

Table 17a indicates the zoning of the recommended GREEN ROUTE (Figure 32a) according to areas of importance (i.e., biodiversity/ecology) from the 220kV T/Off (Walmund Substation area) along the C28 and then along the Husab Mine/Giant Welwitchia gravel road to the

Husab Mine area. From the Husab Mine T/Off Google Earth was used to assess the route due to lack of access. The distance is approximately 60km (following the D1991 gravel road) of which 15.5km (i.e., 25.8% of the route) is viewed as “high” sensitivity; 3.1km (5.2%) is viewed as “medium” sensitivity while 41.4km (69%) is viewed as “low” sensitivity (Table 17a).

Table 17b indicates the zoning of the recommended GREEN ROUTE (Figure 32b) according to areas of importance (i.e., biodiversity/ecology) from the Farm 58 area to the B2 highway and onwards to the Arandis area using Google Earth to assess the route due to lack of access. The distance is approximately 73km of which 55km (i.e., 75.3% of the route) is viewed as “high” sensitivity while 18km (24.7%) is viewed as “low” sensitivity (Table 17b).

Option 6

YELLOW ROUTE

The following recommendations should result in the least impact from a biodiversity/ecological perspective along this route.

1. The pipeline should follow existing tracks to the B2.

Table 18 indicates the zoning of the recommended YELLOW ROUTE according to areas of importance (i.e., biodiversity/ecology) from the Husab Mine/Giant Welwitchia T/Off to the B2 tarmac road. Due to lack of access this section was assessed using Google Earth. The distance is approximately 18.1km (following drainage lines) of which 7.3km (i.e., 40.3% of the route) is viewed as “high” sensitivity and 10.8km (59.7%) is viewed as “low” sensitivity (Table 18).

Table 16. Areas of importance, with protected species potentially affected, along the PURPLE ROUTE between the B2/D1991 T/Off via Goanikontes to the 220kV transmission line T/Off [Direction: B2/D1991 T/Off – Goanikontes – 220kV T/Off]

Hotspot areas	Distance (km)	Area	Important species	Common names	Status	Aliens	Other important features	Importance ranking
	0 to 13.8	B2	<i>A. asperifolia</i> <i>A. leubnitziae</i> Sarcocaulon spp.	Kraal aloe Pencil bush Bushman candle	NC End NC		White geology	Low
1	13.8 to 21.0	Swakop River	<i>Tamarix usneoides</i>	Pencil bush Wild tamarisk	End F		Swakop River + hills	High
2	21.0 to 25.3	Swakop River					Moon landscape area	Medium
	25.3 to 29.8	220kV line						Low

Distance: ±29.8km

Importance ranking: High, Medium, and Low

Status: End = Endemic spp.

F: Forest Act No. 12 of 2001

NC: Nature Conservation Ordinance No 4 of 1975

Table 17a. Areas of importance, with protected species potentially affected, along the GREEN ROUTE a (Figure 32a) from the 220kV T/Off (Walmund Substation area) along the C28 and then along the Husab Mine/Giant Welwitschia gravel road to the Husab Mine area [Direction: Walmund SS – Husab Mine T/Off]

Hotspot areas	Distance (km)	Area	Important species	Common names	Status	Aliens	Other important features	Importance ranking
	0 to 28.7	Walmund SS	<i>A. leubnitziae</i> <i>Acacia erioloba</i>	Pencil bush Camel thorn	End F			Low
1	28.7 to 35.8	Swakop River	<i>Euclea pseudobenus</i> <i>Tamarix usneoides</i> <i>Welwitschia mirabilis</i>	Wild ebony Wild tamarisk Welwitschia	F F F, C2, N-end		Swakop River + hills	High
2	35.8 to 36.7	Welwitschia Flats	<i>Welwitschia mirabilis</i>	Welwitschia	F, C2, N-end		White geology	Medium
	36.7 to 42.4	Husab Mine						Low
3	42.4 to 50.6	Khan River					Khan River + hills	High
4	50.6 to 52.8	Khan River					Rocky area	Medium
	52.8 to 56.8	B2						Low

5	56.8 to 57.0	B2	Dolerite ridge	High
	57.0 to 60.0	B2		Low

Distance: ±60.0km

Importance ranking: High, Medium, and Low

Status: End = Endemic spp.

F: Forest Act No. 12 of 2001

C2: CITES Appendix 2 species

NC: Nature Conservation Ordinance No 4 of 1975

Table 17b. Areas of importance, with protected species potentially affected, along the GREEN ROUTE b (Figure 32b) from the Farm 58 area to the B2 area [Direction: Farm 58 to B2]

Hotspot areas	Distance (km)	Area	Important species	Common names	Status	Aliens	Other important features	Importance ranking
1	0 to 55.0	Farm 58-B2					Swakop & Tumas Rivers + unspoilt plains	High
	55.0 to 73.0	B2-Arandis					Rocky areas	Low

Distance: ±73.0km

Importance ranking: High and Low

Status:

F:

C2:

NC:

[Google Maps assessment of route only]

Table 18. Areas of importance, with protected species potentially affected, along the YELLOW ROUTE from the Husab Mine/Giant Welwitchia T/Off to the B2 tarmac road [Direction: Husab Mine T/Off – B2]

Hotspot areas	Distance (km)	Area	Important species	Common names	Status	Aliens	Other important features	Importance ranking
1	0 to 9.3	Husab Mine						Low
	9.3 to 16.6	Khan River					Khan River + hills + white geology	High
	16.6 to 18.1	B2						Low

Distance: ±18.1km

Importance ranking: High, and Low

Status:

F:

NC:

Final Route & Changes

The final route selection – See Figure 1c – with changes suggested in the Arandis (See Figure 1d (i)) and Richthofen (See Figure 1d (ii)) areas due to potential conflict with other linear infrastructures, is not expected to negatively impact on the vertebrate fauna and flora if proposed mitigations are incorporated.

Arandis Section (Figure 33)

Important habitats along the alternative route proposed include:

- Dolerite ridges (black geology); and
- Rocky areas.

The dolerite ridges and rocky habitats are known to support populations of *Aloe asperifolia* (kraal aloe) – protected NC – and *Commiphora saxicola* (rock corkwood) – endemic, protected F – in the general Arandis area.



Figure 33: The Arandis pipeline section with proposed route change. Important habitats along this route include dolerite ridges (black arrows) and rocky areas (black dotted oblongs). The dark blue dashed line indicates the original pipeline route.

Richthofen Section (Figure 34)

Important habitats along the alternative route proposed include:

- Swakop River;
- Dolerite ridges (black geology); and
- Rocky areas.

The Swakop River habitat is known to support bigger trees (e.g., mainly *Acacia erioloba* (camel thorn), *Euclea pseudobenus* (wild ebony), *Faidherbia albida* (ana tree), *Tamarix usneoides* (tamarisk) and *Ziziphus mucronata* (buffalo thorn) and open surface water and bird habitat associated with the sand mining dams in the general Richthofen area.

The rocky habitats are known to support populations of *Aloe asperifolia* (kraal aloe) – protected NC – and *Commiphora saxicola* (rock corkwood) – endemic, protected F – in the general Richthofen area.



Figure 34: The Richthofen pipeline section with proposed route change. Important habitats along this route include the Swakop River with open surface water and bird habitat (blue dotted oblong); dolerite ridges (black arrows) and rocky areas (white dotted oblongs). The dark green dashed line indicates the original pipeline route.

6 Envisaged impacts

6.1 Introduction

All developments change or are destructive to the local fauna to some or other degree. Assessing potential impacts is occasionally obvious, but more often difficult to predict accurately. Such predictions may change depending on the scope of the development – i.e., development, once initiated, and may have a different effect on the fauna as originally predicted. Thus, continuing monitoring of such impacts during the development phase(s) is imperative.

6.2 Faunal impact

Faunal impact with the proposed Ammonia Pipeline Project developments would be localised. The following table indicates the potential/envisaged impacts expected regarding faunal loss (which is obviously closely linked to habitat destruction):

Description	Faunal disturbance will vary depending on the scale/intensity of the development operation and associated and inevitable infrastructure.
Extent	1. Ammonia Terminal infrastructure(s) - Localised disruption/destruction of the habitat and thus consequently fauna associated directly with the actual sites. This, however, would be relatively small area(s) with localised implications. 2. Ammonia Pipeline route - Localised disruption/destruction of the habitat and thus consequently fauna associated directly with the actual route. This, however, would be relatively small area(s) with localised implications. 3. Pipeline Access Route(s) - Localised disruption/destruction of the habitat

	and thus consequently fauna associated directly with the actual route(s). This, however, would be a relatively small area with localised implications.
Duration	1. Ammonia Terminal infrastructure(s) - The duration of the impact is expected to be permanent at the site. 2. Ammonia Pipeline route - The duration of the impact is expected to be permanent along the route. This, however, would be relatively small area(s) with localised implications. 3. Access route(s) - The duration of the impact is expected to be permanent along the route(s). This, however, would be relatively small area(s) with localised implications.
Intensity	1. Ammonia Terminal infrastructure(s) - The actual development site would be permanently altered. This, however, would be a relatively small area with localised implications. 2. Ammonia Pipeline route - The actual construction site(s) associated with the various infrastructures would be permanently altered. This, however, would be relatively small areas with localised implications. 3. Access route(s) - The actual sites where construction of the route(s) would be located would be permanently altered. This, however, would be relatively small area(s) with localised implications. The areas adjacent the various development site(s) and other associated infrastructure should not be significantly affected. This, however, would depend on control over the contractors during the road building, construction phase(s) & production phase(s), but should be limited to localised implications. Areas not directly affected by the development and associated infrastructure, although within the immediate area, would be affected minimally. This would include dust, noise, light & other associated disturbances in the area, but be limited to the construction periods.
Mitigation	General 1. Limit the development to actual sites to be developed and avoid affecting adjacent areas, especially the <i>Salsoia</i> spp. dune hummocks; well vegetated Khan/Swakop/Tumas Rivers; ephemeral drainage lines; rocky outcrops (especially white geology areas); dolerite ridges; Welwitschia Flats, etc. throughout the entire area. 2. Avoid development & associated infrastructure in sensitive areas – e.g., <i>Salsoia</i> spp. dune hummocks; well vegetated Khan/Swakop/Tumas Rivers; ephemeral drainage lines; rocky outcrops (especially white geology areas), small drainage lines with <i>Welwitschia mirabilis</i> plants; lapped-faced vulture nesting sites; rocky outcrops; etc. – in the proposed development area (See Sections 4 & 5; Figures 28, 30-34). This would minimise the negative effect on the local environment especially unique features serving as habitat to various vertebrate fauna species. 3. Remove (e.g., capture) unique and sensitive fauna, especially sedentary and slow-moving reptiles (e.g., Namaqua chameleon, etc.) before commencing with the development activities and/or species serendipitously located during this period and relocate to a less sensitive/disturbed sites in the immediate area. 4. Prevent and discourage the setting of snares (poaching), illegal collecting of veld foods, indiscriminate killing of perceived dangerous species (e.g., snakes, etc.) and collecting of wood (e.g., Khan/Swakop River areas) as this would diminish and negatively affect the local fauna – especially during the development phase(s).

5. Attempt to avoid the destruction of bigger trees during the development phase(s) – especially with the development of access & pipeline routes – as these serve as habitat for a myriad of fauna.

6. Rehabilitation of the disturbed areas – i.e., initial development access route “scars” and associated tracks as well as associated development infrastructures. Preferably workers should be transported in/out to the construction sites daily to avoid excess damage to the local environment (e.g., pollution, wood collection, poaching, etc.). Such rehabilitation would not only confirm the company’s environmental integrity but also show true local commitment to the environment.

7. Prevent domestic pets – e.g., cats & dogs – accompanying the workers during the construction phase as cats decimate the local fauna and interbreed & transmit diseases to the indigenous African wild cat found in the area (especially pipeline areas). Dogs often cause problems when bonding on hunting expeditions thus negatively affecting the local fauna. The indiscriminate and wanton killing of the local fauna by such pets should be avoided at all costs.

8. Initiate a suitable waste removal system (i.e., remove to Arandis/Swakopmund/Walvis Bay and not store on site) as this often attracts wildlife – e.g., baboons, black-backed jackal, crows, gulls, etc. – which may result in human-wildlife conflict issues.

9. Educate/inform contractors and staff on protected species (See Tables 1-9) to avoid and the consequences of illegal collection of such species.

10. Investigate the idea of employing an Environmental Officer during the construction phase(s) to ensure compliance and minimise the overall impact on the fauna and the environment.

Ammonia Terminal site

11. Avoid disturbance of *Salsolea* spp. dune hummock area to the east of the saline pan).

Ammonia Pipeline route

12. Avoid disturbance of *Salsolea* spp. dune hummock sites west of the large Dune 7 system (See Figure 28).

13. Follow the alternative pipeline routes recommended to avoid sensitive areas and the mobile dune delt areas (See Figure 28).

14. Bury the pipeline (especially at drainage lines used as wildlife foraging corridors) or else it could become a barrier to most non-jumping wild ungulates (e.g., Hartmann’s mountain zebra, oryx, springbok) and ostrich.

15. Do not leave the pipeline trench open overnight and/or have escape routes at either end to allow for trapped fauna to escape.

16. Place wildlife crossing points at drainage lines, which are used as thoroughfares, with such areas being at least 100m in width (i.e., covered for 100m or placed below ground) should the pipeline have to be constructed above ground.

17. The recommended Swakop route (BLUE – Figure 32a) and the alternative route (Alternative RED) – See Figures 31-32 – would have the least impact on biodiversity/ecology and avoid pristine areas but rather follow existing tracks along existing development corridors (e.g., NamWater pipeline; 66/220Kv transmission line(s), etc.). The final selected pipeline route (See Figure 1c), including changes in the Arandis and Richthofen

	areas, are not expected to negatively affect biodiversity/ecology if important habitats are avoided (Figures 33-34). Farm 58 area 18. Avoid disturbance of rocky ridges & small vegetated ephemeral drainage lines on northern/northeastern boundary (See Figure 30). Access routes 19. These track(s) should avoid the <i>Sal/sola</i> spp. dune hummocks; well vegetated Khan/Swakop/Tumas Rivers; ephemeral drainage lines; rocky outcrops (especially white geology areas), small drainage lines with <i>Welwitschia mirabilis</i> plants; lapped-faced vulture nesting sites; rocky outcrops; dolerite ridges, etc. This would minimise the effect on localised potentially sensitive habitats in the area. 20. Avoid driving randomly through the area (i.e., enforce “track discipline”), but rather stick to permanently placed roads/tracks – especially during the construction phase. This would minimise the effect on localised potentially sensitive habitats in the area. 21. Stick to speed limits of maximum 30km/h as this would result in fewer faunal road mortalities. Speed humps could also be used to ensure the speed limit. Lower speeds would also minimise dust pollution. 22. Implement erosion control. – i.e., avoid constructing tracks up steep gradients; incorporate erosion furrows (runoff sites) and humps along tracks to channel water off the tracks to minimise erosion problems; cross drainage lines at right angles, etc. The area(s) towards & adjacent the drainage line(s) are easily eroded, and further development may exacerbate this problem. Avoid construction within 100m of the main drainage line(s) to minimise erosion problems as well as preserving the riparian associated fauna.
Frequency of occurrence	Expected to be a “once off” issue affecting the selected site(s). Further developments & associated infrastructure developments in future throughout the area would however increase the frequency of occurrence.
Probability	Definite (100%) negative impact on fauna is expected in the actual development areas. This, however, would be much localised and cover only a small area(s) and should avoid sensitive areas. Highly Probable (75%) negative impact on fauna is expected in the general areas especially during the construction and development phase(s) because of noise, increased activities, etc. Probable (50%) negative impact on fauna is expected from the infrastructure (roads/tracks/buildings, etc.). Precautionary principle (e.g., avoid unique habitat features as well as adhering to the proposed mitigating measures would minimise this) would decrease the significance of these potential impacts.
Significance	Before mitigation: High After mitigation: Medium to Low
Status of the impact	Negative Localised unique habitats (e.g., <i>Sal/sola</i> spp. dune hummocks; well vegetated Khan/Swakop/Tumas Rivers; ephemeral drainage lines; rocky outcrops (especially white geology areas), small drainage lines with <i>Welwitschia</i>

	<i>mirabilis</i> plants; lapped-faced vulture nesting sites; rocky outcrops; dolerite ridges, etc.) with associated fauna would bear the brunt of this proposed development, but be limited in extent and only permanent at the actual mining site(s) and access routes and infrastructure sites.
Legal requirements	Fauna related: Nature Conservation Ordinance No. 4 of 1975, CITES, IUCN and SARDB Habitat – Flora related: Forest Act No. 12 of 2001, Nature Conservation Ordinance No. 4 of 1975, CITES
Degree of confidence in predictions	As an ecologist I am sure of the above-mentioned predictions made and would suggest that the mitigation measures be implemented to minimise potentially negative aspects regarding the local fauna in the area.

6.3 Floral impact

Floral impact with the proposed Ammonia Pipeline Project developments would be localised. The following table indicates the potential/envisaged impacts expected regarding floral loss (which is obviously closely linked to habitat destruction):

Description	Floral disturbance will vary depending on the scale/intensity of the development operation and associated and inevitable infrastructure.
Extent	1. Ammonia Terminal infrastructure(s) - Localised disruption/destruction of the habitat and thus consequently flora associated directly with the actual sites. This, however, would be relatively small area(s) with localised implications. 2. Ammonia Pipeline route - Localised disruption/destruction of the habitat and thus consequently flora associated directly with the actual route. This, however, would be relatively small area(s) with localised implications. 3. Pipeline Access Route(s) - Localised disruption/destruction of the habitat and thus consequently flora associated directly with the actual route(s). This, however, would be a relatively small area with localised implications.
Duration	1. Ammonia Terminal infrastructure(s) - The duration of the impact is expected to be permanent at the site. 2. Ammonia Pipeline route - The duration of the impact is expected to be permanent along the route. This, however, would be relatively small area(s) with localised implications. 3. Access route(s) - The duration of the impact is expected to be permanent along the route(s). This, however, would be relatively small area(s) with localised implications.
Intensity	1. Ammonia Terminal infrastructure(s) - The actual development site would be permanently altered. This, however, would be a relatively small area with localised implications. 2. Ammonia Pipeline route - The actual construction site(s) associated with the various infrastructures would be permanently altered. This, however, would be relatively small areas with localised implications. 3. Access route(s) - The actual sites where construction of the route(s) would be located would be permanently altered. This, however, would be relatively small area(s) with localised implications. The areas adjacent the various development site(s) and other associated infrastructure should not be significantly affected. This, however, would depend on control over the contractors during the road building, construction phase(s) & production phase(s), but should be limited to localised implications. Areas not directly affected by the development and associated infrastructure, although within the immediate area, would be affected minimally. This would include dust, noise, light & other associated disturbances in the area, but be

	limited to the construction periods.
Mitigation	General 1. Limit the development to actual sites to be developed and avoid affecting adjacent areas, especially the <i>Salsola</i> spp. dune hummocks; well vegetated Khan/Swakop/Tumas Rivers; ephemeral drainage lines; rocky outcrops (especially white geology areas); dolerite ridges; Welwitschia Flats, etc. throughout the entire area. 2. Avoid development & associated infrastructure in sensitive areas – e.g., <i>Salsola</i> spp. dune hummocks; well vegetated Khan/Swakop/Tumas Rivers; ephemeral drainage lines; rocky outcrops (especially white geology areas), small drainage lines with <i>Welwitschia mirabilis</i> plants; rocky outcrops; dolerite ridges, etc. – in the proposed development area (See Sections 4 & 5; Figures 28, 30-34). This would minimise the negative effect on the local environment especially unique features serving as habitat to various vertebrate fauna/flora species. 3. Identify protected and unique species (i.e., <i>Aloe</i> spp., <i>Commiphora saxicola</i> (rock corkwood), <i>Lithops</i> spp., <i>Welwitschia mirabilis</i> (welwitschia), etc.). Other important species are the larger <i>Acacia erioloba</i> (camel thorn) specimens used by the endangered lappet-faced vultures as nesting sites before the commencement of development activities in areas where these occur and avoid. 4. Prevent and discourage the collecting of firewood (e.g., Khan/Swakop Rivers) as dead wood has an important ecological role. Such collecting of firewood, especially for economic reasons, often leads to abuses – e.g., chopping down of live and/or protected tree species such as <i>Acacia erioloba</i>, etc. which is a good quality wood. 5. Avoid the removal and damage of bigger trees (especially protected species (i.e., <i>Acacia erioloba</i> (camel thorn), <i>Faidherbia albida</i> (ana tree), etc. – during developments – including the development of access routes – as these serve as habitat for a myriad of fauna. 6. Implement a policy of “no tolerance” towards the existing invasive alien plant species (e.g., <i>Nicotiana glauca</i>, <i>Prosopis</i> spp. – heavy infestations observed in the Khan/Swakop River areas) in the general area. This should include the removal and destruction of these species throughout the proposed development areas. Such activity would be beneficial to the overall ecology of the area, especially the Khan/Swakop River areas where most of these aliens currently occur. 7. Rehabilitation of the disturbed areas – i.e., initial development access route “scars” and associated tracks, as well as temporary accommodation sites. Preferably workers should be transported in/out to the construction sites daily to avoid excess damage to the local environment (e.g., wood collection, poaching, etc.). Such rehabilitation would not only confirm the various development companies’ environmental integrity but also show true local commitment to the environment. 8. Limit development – i.e., keep to the bare minimum – in the drainage lines or within 100m of these drainage lines to preserve the associated riparian flora (and associated fauna).

9. Educate/inform contractors on protected species to avoid and the consequences of damaging such species. Liaise with MEFT to provide this service.

10. Investigate the idea of employing a qualified environmental officer (EO) during the construction phase to ensure appropriate conduct by contractor(s).

11. Avoid the use of herbicides for plant/weed control throughout the areas.

12. Employ an ecologist for advice on the best pipeline route(s)/sites, etc. prior to construction – i.e., assist with the final alignment.

Ammonia Terminal site

13. Avoid disturbance of *Salsoia* spp. dune hummock area to the east of the saline pan) (See Figure 28).

Ammonia Pipeline route

14. Avoid disturbance of *Salsoia* spp. dune hummock sites west of the large Dune 7 system (See Figure 28).

15. Follow the alternative pipeline routes recommended to avoid sensitive areas and the mobile dune delt areas (See Figure 28).

16. Use the excavated soil to fill the trench when burying the pipeline and not disturb other areas.

17. Eradicate all invasive alien plants expected to benefit from leaks during maintenance activities once the pipeline is operational (especially if following the NamWater pipeline route).

18. The recommended Swakop route (BLUE – Figure 32a) and the alternative route (Alternative RED) – See Figures 31-32 – would have the least impact on biodiversity/ecology and avoid pristine areas but rather follow existing tracks along existing development corridors (e.g., NamWater pipeline; 66/220Kv transmission line(s), etc.). The final selected pipeline route (See Figure 1c), including changes in the Arandis and Richthofen areas, are not expected to negatively affect biodiversity/ecology if important habitats are avoided (Figures 33-34).

Farm 58 area

19. Avoid disturbance of rocky ridges & small vegetated ephemeral drainage lines on northern/northeastern boundary (See Figure 30).

Access routes

20. These track(s) should avoid the *Salsoia* spp. dune hummocks; well vegetated Khan/Swakop/Tumas Rivers; ephemeral drainage lines; rocky outcrops (especially white geology areas); dolerite ridges; small drainage lines with *Welwitschia mirabilis* plants; lapped-faced vulture nesting sites; rocky outcrops; etc. This would minimise the effect on localised potentially sensitive habitats/flora in the area.

21. Avoid driving randomly through the area (i.e., enforce “track discipline”), but rather stick to permanently placed roads/tracks – especially during the construction phase. This would minimise the effect on localised potentially sensitive habitats/flora in the area.

22. Stick to speed limits of maximum 30km/h as this would result in less dust pollution potentially affecting flora. Speed humps could also be used to ensure the speed limit.

23. Implement erosion control. – i.e., avoid constructing tracks up steep

	gradients; incorporate erosion furrows (runoff sites) and humps along tracks to channel water off the tracks to minimise erosion problems; cross drainage lines at right angles, etc. The area(s) towards & adjacent the drainage line(s) are easily eroded, and further development may exacerbate this problem. Avoid construction within 100m of the main drainage line(s) to minimise erosion problems as well as preserving the riparian associated flora.
Frequency of occurrence	Expected to be a “once off” issue affecting the selected site(s).
Probability	Definite (100%) negative impact on flora is expected in the actual development areas. This, however, would be much localised and cover only a small area(s) and should avoid sensitive areas. Highly Probable (75%) negative impact on flora is expected in the general areas especially during the construction and development phase(s) because of dust, increased activities, etc. Probable (50%) negative impact on flora is expected from the infrastructure (roads/tracks/buildings, etc.). Precautionary principle (e.g., avoid unique habitat features as well as adhering to the proposed mitigating measures would minimise this) would decrease the significance of these potential impacts.
Significance	Before mitigation: High After mitigation: Medium to Low
Status of the impact	Negative Localised unique habitats with associated flora would bear the brunt of this proposed development but be limited in extent and only permanent at the actual development sites and access routes.
Legal requirements	Flora related: Forest Act No. 12 of 2001, Nature Conservation Ordinance No. 4 of 1975, CITES, IUCN Habitat – Flora related: Forest Act No. 12 of 2001, Nature Conservation Ordinance No. 4 of 1975, CITES
Degree of confidence in predictions	As an ecologist I am sure of the above-mentioned predictions made and would suggest that the mitigation measures be implemented to minimise potentially negative aspects regarding the local fauna in the area.

6.4 Impacts – Methods

The construction and operation of the proposed new ammonia pipelines between Arandis and Walvis Bay (via Farm 58 – Dune 7 area) as well as the Ammonia Terminal (Walvis Bay) would result in various impacts on the vertebrate fauna and flora and can be placed into three categories:

Direct Impacts: These are directly as a result of the construction of the proposed pipelines and associated developments and include general habitat destruction and the destruction of species of conservation concern.

Indirect Impacts: These are not directly associated with the proposed developments but potentially affect species of conservation concern recorded within the general area and include impacts as a result of changes in the hydrology, etc. and affect species rather on a population level.

Cumulative Impacts: These are impacts that the proposed developments will have from a broad area perspective by considering land-use and transformation of natural habitat in areas surrounding the site (i.e., considering past, present and anticipated changes to biodiversity).

Mitigation measures are not always straightforward and/or easy to implement, but should be based on the following steps as mitigation hierarchy:

Step 1: Avoid/prevent loss to biodiversity and ecosystem services: The project location, layout and phasing should avoid negative impacts on biodiversity. Areas of high biodiversity should be identified prior to development activities to avoid negative impacts;

Step 2: Minimise impacts on biodiversity and ecosystem services: The project location, layout, and phasing should minimise the negative impacts on biodiversity;

Step 3: Rehabilitation – concurrently, progressively and on cessation of the activity: Rehabilitation should attempt to return the affected area(s) to pre-development natural state; and

Step 4: Offset significant residual negative impacts on biodiversity or ecosystem services: This refers to the compensation for the remaining and unavoidable negative impacts on biodiversity.

Assessment Criteria

The environmental impacts are assessed with and without mitigation measures and the results are presented in impact tables summarising the assessment. Mitigation and management actions are recommended to enhance positive impacts and minimising negative impacts.

The following risk assessment was used to determine the significance of impacts.

Significance = (Magnitude + Duration + Scale) x Probability

The maximum potential value for significance of an impact is 100 points. Environmental impacts are rated as high, medium, or low significance on the following basis:

High environmental significance = 60-100 points

Medium environmental significance = 30-59 points

Low environmental significance = 0-29 points

Magnitude (M)

[Description & Numerical value]

Very high = 10

High = 8

Moderate = 6

Low = 4

Minor = 2

Duration (D)

[Description & Numerical value]

Permanent = 5
 Long-term (ceases at end of operation) = 4
 Medium-term = 3
 Short-term = 2
 Immediate = 1

Scale (S)**[Description & Numerical value]**

International = 5
 National = 4
 Regional = 3
 Local = 2
 Site = 1
 None = 0

Probability (P)**[Description & Numerical value]**

Definite (or unknown) = 5
 High = 4
 Medium = 3
 Low = 2
 Improbable = 1
 None = 0

The following criteria against which these activities are assessed are presented below.

Nature of the Impact

This is an appraisal of the type of effect the project would have on the environment. This description includes what would be affected and how and whether the impact is expected to be positive or negative.

Scale of the Impact

A description of whether the impact will be local, limited to the study area and its immediate surroundings, regional, national or international scale.

Duration of the Impact

This provides an indication of whether the lifespan of the impact would be immediate, short term (0-5 years), medium term (6-15 years), long term (cesses at end of operational phase) or permanent.

Probability of Occurrence

This describes the probability of the impact occurring. This is rated as none, improbable (low likelihood), low, medium, high and definite.

Significance

This describes the degree of significance for the predicted impact based on the available information and level of knowledge and expertise – i.e., High, Medium and Low.

6.5 Assessment: Construction, Operational and Decommissioning Phases

The proposed new ammonia pipelines between Arandis and Walvis Bay (via Farm 58 – Dune 7 area) as well as the Ammonia Terminal (Walvis Bay) would include the construction of the following:

- Ammonia Terminal Plant (Walvis Bay);
- Ammonia pipeline (Walvis Bay to Arandis area); and
- Pipeline access route(s).

The impacts that the construction and operation of the proposed new ammonia pipeline project may have on the vertebrate fauna and flora recorded throughout the general area were based on a comprehensive literature review and rapid site assessment.

Possible impacts and their sources that this development is likely to have on the biodiversity and ecology (vertebrate fauna and flora) are provided for the construction phase (Table 19), operational phase (Table 20) and decommissioning phase (Table 21).

Table 19. Impacts expected to occur during the Construction Phase.

Impact - Description	Impact - Source	Affected Area
Destruction of vertebrate fauna, especially protected spp. + pipeline trench act as pitfall trap	Ground clearing for ammonia terminal; Farm 58 developments & pipeline routes and access route(s)	Project area
Destruction of vegetation, especially protected tree/shrub spp.	Ground clearing for ammonia terminal; Farm 58 developments & pipeline routes and access route(s)	Project area
Destruction of sensitive habitats	Ground clearing for ammonia terminal; Farm 58 developments & pipeline routes and access route(s)	Project area
Soil erosion issues	Mechanised clearing activities especially adjacent rivers and drainage lines	Pipeline route
Introduction & spread of invasive alien plant spp.	Ground clearing activities & habitat change	Pipeline route

Table 20. Impacts expected to occur during the Operational Phase.

Impact - Description	Impact - Source	Affected Area
Pipeline act as barrier to non-jumping ungulates & ostrich	Pipeline barrier	Pipeline route
Soil erosion issues	Access/maintenance route(s)	Pipeline route
Introduction & spread of invasive alien plant spp.	Access/maintenance route(s)	Pipeline route

Table 21. Impacts expected to occur during the Decommissioning Phase.

Impact - Description	Impact - Source	Affected Area
Destruction of vertebrate fauna, especially protected spp.	Vehicle movement	Project area
Soil erosion issues	Vehicle movement	Project area
Introduction & spread of invasive alien plant spp.	Vehicle movement	Project area

6.6 Impacts: Construction, Operational and Decommissioning Phases

The following impact tables describe the impacts that are expected to occur during the Construction, Operational and Decommissioning Phases:

CONSTRUCTION PHASE:

1. Destruction of vertebrate fauna, especially protected species + pipeline pitfall trap

	Scale	Duration	Magnitude	Probability of occurrence	Significance	Confidence
Without Mitigations	Local (2)	Short term (2)	High (8)	Definite (5)	High (60)	High
With Mitigations	Site (1)	Immediate (1)	Low (4)	Low (2)	Low (12)	High

Description of Impact: The land clearing activities by mechanical methods, at the various development areas would result in numerous protected species being eradicated and/or dispersed (See Tables 1-4). Vertebrate fauna (e.g., especially sedentary, slow moving and ground nesting species; various cavity dwellers such as bats, various reptiles, etc.; various avifauna using vegetation in affected areas for perching/roosting/breeding, etc.) associated with the area, especially the old/large tree specimens associated with the Khan & Swakop Rivers, would be killed and/or displaced.

Mitigation Measures:

- Remove important slow-moving species such as Namaqua chameleon, etc. prior to construction activities as well as when serendipitously encountered throughout the proposed development areas;
- Bury pipeline;
- Should pipeline be above ground then raised wildlife crossing points should be 100m in width and located at natural movement corridors (i.e., drainage lines);
- Do not leave the pipeline trench open overnights as this will act as a giant pitfall trap;
- Maintain and enforce track discipline along the access route(s);
- Avoid affecting *Salsola* spp. dune hummocks at the Ammonia Terminal; ammonia (Dune 7 area and Tumas River area) pipeline route;
- Avoid white geology hills/ridges as these support localised populations of the endemic Husab sand lizard (Arandis, Swakop River, Husab areas);
- Avoid dolerite ridge habitats – e.g., various day gecko spp., etc. (Arandis & Swakop River areas);

- Avoid trees with raptor nests (especially lappet-faced vulture as these bird numbers is declining dramatically throughout their range and are classified as endangered by the IUCN 2025);
- See Figure 28 for alternative ammonia pipeline route;
- See Figure 30 for areas to avoid in the Farm 58 area; and
- See Figures 1c; 31-32 & Section 5 for best pipeline route (i.e., 1st Option = NamWater pipeline or Swakop pipeline option; if not feasible then Option Red Route).

2. Destruction of vegetation, especially protected tree/shrub species

	Scale	Duration	Magnitude	Probability of occurrence	Significance	Confidence
Without Mitigations	Local (2)	Permanent (5)	Very high (10)	Definite (5)	High (85)	Definite
With Mitigations	Site (1)	Long term (4)	Low (4)	High (4)	Medium (36)	High

Description of Impact: The land clearing activities by mechanical methods, at the various development areas would result in numerous protected tree species, being eradicated (See Table 6). Vertebrate fauna (e.g., cavity dwellers such as bats, gallago, hornbills, parrots, various reptiles, etc. including various raptors e.g. eagles, vultures using such trees as perching/roosting/breeding) associated with these trees, especially the old/large specimens, would be killed and/or displaced.

Mitigation Measures:

- Remove and relocate important species – e.g., *Aloe asperifolia*, *Commiphora saxicola*, *Lithops* spp., *Sarcocaulon* spp., etc.;
- Bury pipeline;
- Avoid affecting *Salsola* spp. dune hummocks at the Ammonia Terminal; ammonia (Dune 7 area and Tumas River area) pipeline route;
- Avoid white geology hills/ridges – e.g., *Commiphora* spp. (Arandis, Swakop River, Husab areas);
- Avoid dolerite ridge habitats – e.g., *Aloe asperifolia*, *Commiphora saxicola*, etc. (Arandis & Swakop River areas);
- Avoid the destruction of *Welwitschia* dominated areas (e.g., ephemeral drainage lines & *Welwitschia* Flats areas);
- Avoid the destruction of large trees – e.g., *Acacia erioloba*, etc. used by raptors & vultures, etc.;
- See Figure 28 for alternative ammonia pipeline route;
- See Figure 30 for areas to avoid in the Farm 58 area; and
- See Figures 1c; 31-34 & Section 5 for best pipeline route (i.e., 1st Option = NamWater pipeline or Swakop pipeline option; if not feasible then Option Red Route).

3. Destruction of sensitive habitats

	Scale	Duration	Magnitude	Probability of occurrence	Significance	Confidence
Without Mitigations	Local (2)	Permanent (5)	Very high (10)	Definite (5)	High (85)	Definite
With Mitigations	Site (1)	Long term (4)	Low (4)	High (4)	Low (36)	High

Description of Impact: The land clearing activities by mechanical methods at the various development areas would result in some sensitive habitats being destroyed and/or detrimentally affected (See Section 5). Vertebrate fauna & flora associated with these sensitive habitats, would be killed and/or displaced.

Mitigation Measures:

- Avoid development and associated infrastructure in sensitive areas – e.g., *Salsola* spp. dune hummocks; white geology in the immediate area (See Section 5). This would minimise the negative effect on the local environment especially unique features serving as habitat to various vertebrate fauna and flora species;

- Avoid trees with raptor nests (especially lappet-faced vulture as these bird numbers is declining dramatically throughout their range and are classified as endangered by the IUCN 2025, respectively);
- Avoid white geology hills/ridges – e.g., *Commiphora* spp & endemic Husab sand lizard (Arandis, Swakop River, Husab areas);
- Avoid dolerite ridge habitats – e.g., *Aloe asperifolia*, *Commiphora saxicola*, etc. (Arandis & Swakop River areas);
- Avoid the destruction of *Welwitschia* dominated areas (e.g., ephemeral drainage lines & *Welwitschia* Flats areas);
- See Figure 28 for alternative ammonia pipeline route;
- See Figure 30 for areas to avoid in the Farm 58 area; and
- See Figures 1c; 31-32 & Section 5 for best pipeline route (i.e., 1st Option = NamWater pipeline or Swakop pipeline option; if not feasible then Option Red Route).

4. Soil erosion issues

	Scale	Duration	Magnitude	Probability of occurrence	Significance	Confidence
Without Mitigations	Site (1)	Long term (4)	Moderate (6)	High (4)	Medium (44)	High
With Mitigations	Site (1)	Short term (2)	Minor (2)	Low (2)	Low (10)	High

Description of Impact: The land clearing activities by mechanical methods especially adjacent the ephemeral drainage lines and larger rivers – e.g., Khan & Swakop Rivers – could result in erosion issues.

Mitigation Measures:

- Avoid mechanical activities adjacent/through the Khan & Swakop Rivers;
- Where new tracks must be made off the main routes, the routes should be selected causing minimal damage to the environment – e.g., use the same tracks; cross drainage lines at right angles; avoid placing tracks within drainage lines; avoid collateral damage (i.e. select routes that do not require the unnecessary removal of trees/shrubs, especially protected species);
- Rehabilitate all new tracks created; and
- Ensure & implement erosion control measures along pipeline access/maintenance route(s);

5. Invasion and spread of invasive alien plant species

	Scale	Duration	Magnitude	Probability of occurrence	Significance	Confidence
Without Mitigations	Site (1)	Long term (4)	Moderate (6)	High (4)	Medium (44)	High
With Mitigations	No (0)	Immediate (1)	Minor (2)	Low (2)	Low (6)	High

Description of Impact: Soil disturbances by mechanical methods, at the various development areas would favour invasive alien plant species becoming established. Invasive alien plant species, already present in the area (See Section 3.5.3), would flourish in the disturbed areas and could also inadvertently be transported into the area as seed on the various vehicles accessing the sites and access route.

Mitigation Measures:

- Limit land clearing activities to the actual pipeline route and infrastructures area to prevent random soil disturbances favouring invasive alien plant species;
- Remove and destroy all invasive alien plants encountered in the project area (See Section 3.5.3 & Figures 19-20); and
- Ensure that vehicles accessing the route are free of vegetation, especially if contractors are used which also use their vehicles in urban areas.

OPERATIONAL PHASE:

6. Pipeline acts as barrier to non-jumping ungulate species & ostrich

	Scale	Duration	Magnitude	Probability of occurrence	Significance	Confidence
Without Mitigations	Regional (3)	Long term (4)	Very high (10)	Definite (5)	High (90)	High
With Mitigations	Site (1)	Short term (2)	Minor (2)	Definite (5)	Low (25)	High

Description of Impact: Above ground pipeline infrastructures would act as a physical barrier to non-jumping ungulates (e.g., gemsbok, Hartmann's Mountain zebra, springbok) & ostrich and affect their local/regional movement and foraging patterns.

Mitigation Measures:

- Bury pipeline (especially at drainage lines used as wildlife foraging corridors);
- Should pipeline be above ground then raised wildlife crossing points should be 100m in width and located at natural movement corridors (i.e., drainage lines);
- Do not leave the pipeline trench open overnights as this will act as a giant pitfall trap;
- Ensure that escape routes are sloped at each end of the trench to ensure that species falling into trench can escape;
- Avoid affecting *Salsola* spp. dune hummocks at the Ammonia Terminal; ammonia (Dune 7 area and Tumas River area) pipeline route;
- See Figure 28 for alternative ammonia pipeline route;
- See Figure 30 for areas to avoid in the Farm 58 area; and
- See Figures 1c; 31-32 & Section 5 for best pipeline route (i.e., 1st Option = NamWater pipeline or Swakop pipeline option; if not feasible then Option Red Route).

7. Soil erosion issues

	Scale	Duration	Magnitude	Probability of occurrence	Significance	Confidence
Without Mitigations	Site (1)	Long term (4)	High (8)	Definite (5)	High (65)	High
With Mitigations	Site (1)	Short term (2)	Moderate (6)	Medium (3)	Low (27)	High

Description of Impact: Typical maintenance operations would result in continued erosion issues if not continuously maintained. The focus areas should be adjacent to the Khan & Swakop Rivers.

Mitigation Measures:

- Implement and maintain erosion control measures where applicable along the access route – i.e., use the same tracks; cross drainage lines at right angles;
- Rehabilitate eroded areas annually – i.e., after the rainy season and/or flooding events (during winter months); and
- Maintain track discipline – i.e., no offroad driving; speed control; use the same track, etc.

8. Introduction & spread of invasive alien plant spp.

	Scale	Duration	Magnitude	Probability of occurrence	Significance	Confidence
Without Mitigations	Site (1)	Long term (4)	Moderate (6)	High (4)	Medium (44)	High
With Mitigations	Site (1)	Short term (2)	Minor (2)	Low (2)	Low (10)	High

Description of Impact: Invasive alien plant species would become established on disturbed areas and could also inadvertently continuously be transported into the area as seed on the various vehicles accessing the pipeline route.

Mitigation Measures:

- Remove and destroy all invasive alien plants encountered along the pipeline route; and

- Ensure that vehicles accessing the project area are free of vegetation, especially if contractors are used which also use their vehicles in urban areas.

DECOMMISSIONING PHASE:

9. Destruction of vertebrate fauna, especially protected spp.

	Scale	Duration	Magnitude	Probability of occurrence	Significance	Confidence
Without Mitigations	Site (1)	Medium term (3)	Low (4)	High (4)	Medium (32)	High
With Mitigations	None (0)	Short term (2)	Minor (2)	High (4)	Low (16)	High

Description of Impact: Typical rehabilitation operations, including heavy vehicle movement along the various access routes to remove pipelines, would result in some destruction of vertebrate fauna (i.e., especially slow-moving species).

Mitigation Measures:

- Avoid sensitive areas;
- Avoid nocturnal vehicle movement; and
- Maintain and enforce track discipline – i.e., no offroad driving; speed control; use the same track, etc.

10. Soil erosion issues

	Scale	Duration	Magnitude	Probability of occurrence	Significance	Confidence
Without Mitigations	Regional (3)	Long term (4)	High (8)	High (4)	High (60)	High
With Mitigations	Site (1)	Short term (2)	Low (4)	Low (2)	Low (14)	High

Description of Impact: Typical rehabilitation operations, including heavy vehicle movement along the various access routes to remove pipelines, would result in some erosion issues if not continuously maintained.

Mitigation Measures:

- Rehabilitate eroded areas annually – i.e., after the rainy season & flooding events (during winter months); and
- Maintain and enforce track discipline – i.e., no offroad driving; speed control; use the same track, etc.

11. Introduction & spread of invasive alien plant spp.

	Scale	Duration	Magnitude	Probability of occurrence	Significance	Confidence
Without Mitigations	Site (1)	Short term (2)	Low (4)	High (4)	Low (28)	High
With Mitigations	None (0)	Immediate (1)	Minor (2)	Low (2)	Low (6)	High

Description of Impact: Invasive alien plant species would become established on disturbed areas and could also inadvertently continuously be transported into the area as seed on the various vehicles accessing the pipeline route.

Mitigation Measures:

- Remove and destroy all invasive alien plants encountered along the pipeline route; and
- Ensure that vehicles accessing the project area are free of vegetation, especially if contractors are used which also use their vehicles in urban areas.

7 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 Ammonia Pipeline Project development would be sedentary species – e.g., most species including all geckos – will be adversely affected by the proposed project developments, however none of the reptiles (except for *P. husabensis* favouring specific geology and habitat throughout the general area) observed and/or confirmed from the area are exclusively associated with the proposed Project areas. The endemic *Poyntonophrynus dombensis*, *Poyntonophrynus hoeschi* and *Phrynomantis annectens* are viewed as the most important amphibians although they are not exclusively associated with the proposed development areas. The most important mammal species from the general area are the Namibian wing-gland bat (*Cistugo seabrai*) listed as endemic and rare; Littledale's whistling rat (*Protomys littledalei namibensis*) – of which the subspecies “*namibensis*” is known to occur in the ephemeral river courses in the “Swakopmund area” Griffin (2003) – listed as endemic; brown hyena (*Parahyaena brunnea*) and leopard (*Parthera pardus*) listed as near threatened and vulnerable (population trends decreasing), respectively by the IUCN (2025). Hartmann's mountain zebra (*Equus zebra hartmannae*), classified as vulnerable by the IUCN (2025), are associated with the rocky inland areas, moving between grazing areas and water points/seeps in the Khan and Swakop Rivers, and viewed as important. The most important endemic birds known/expected to occur in the general area are Gray's lark, dune lark and Herero chat. Gray's lark is one of the species with the most restricted range in Namibia (Simmons 1998a). Furthermore, Simmons *et al.* (2015) list 2 species as critically endangered (great crested grebe, Cape gannet), 7 species as endangered (Cape cormorant, bank cormorant, black stork, white-backed vulture, martial eagle, tawny eagle, Ludwig's bustard), 6 species as vulnerable (great white pelican, greater flamingo, lesser flamingo, secretarybird, lappet-faced vulture, Hartlaub's gull) and 8 species as near threatened (black-necked grebe, crowned cormorant, Verreaux's eagle, peregrine falcon, kori bustard, African black oystercatcher, chestnut-banded plover, Damara tern). Other important species known to occur in the general area are maccoa duck (NT), Eurasian curlew (NT), Caspian tern (V) and black harrier (E) although these species are however not expected to occur permanently in the general area, but probably only pass over on their way to the coast. The IUCN (2025) classifies 1 species as critically endangered (white-backed vulture), 7 species as endangered (Cape gannet, Cape cormorant, bank cormorant, lappet-faced vulture, martial eagle, secretarybird, Ludwig's bustard), 1 species as vulnerable (tawny eagle) and 3 species as near threatened (lesser flamingo, kori bustard, chestnut-banded plover).

Flora species most likely to be adversely affected by pipeline developments would be the various protected species – See Sections 3.5, 3.6 & 4 – although these species are not specifically associated with the development sites.

Important areas in the general vicinity are viewed as the ephemeral drainage lines and bigger rivers (e.g., Tumas, Khan & Swakop); areas of light-coloured geology (hills & ridges); dolerite ridge habitats; Welwitschia Flats, 30km coastline between Swakopmund and Walvis Bay & lappet-faced vulture nesting sites – See Section 5 & Figures 28, 30-34.

See Figure 28 for alternative ammonia pipeline routes.

See Figure 30 for areas to avoid in the Farm 58 area.

See Figures 1c; 31-34 & Section 5 for best pipeline route (i.e., 1st Option = NamWater pipeline or Swakop pipeline option; if not feasible then Option Red Route).

It is not expected that the ammonia pipeline developments (including changes in the layout of the pipeline route in the Arandis and Richthofen areas) will adversely affect any unique

vertebrate fauna and flora in the Project areas, especially if the proposed recommendations (mitigation measures) are incorporated – See Sections 4-6.

8 References

Alexander, G. and Marais, J. 2007. A guide to the reptiles of southern Africa. Struik Publishers, Cape Town, RSA.

Anon n.d. Hoodia in Namibia. NBRI/MEFT, Windhoek.

Bethune, S., Shaw, D. and Roberts, K.S. 2007. Wetlands of Namibia. John Meinert Printing, Windhoek.

BirdLife International (2023) Species factsheet: *Torgos tracheliotos*. Downloaded from <http://datazone.birdlife.org/species/factsheet/lappet-faced-vulture-torgos-tracheliotos> on 25/06/2023.

Bonin, F., Devaux, B. & Dupré, A. 2006. Turtles of the world. John Hopkins University Press, Baltimore, USA.

Boycott, R.C. and Bourquin, O. 2000. The Southern African Tortoise Book. O Bourquin, Hilton, RSA.

Braby, J. 2010a. New migration records for the Damara Tern *Sterna balaenarum*. *Ornithological Observations* 1: 38-41.

Braby, J. 2010b. The Damara Tern: What we know and what we don't. Unpublished Report, NACOMA, Swakopmund, Namibia.

Braby, J. 2011. The biology and conservation of the Damara Tern in Namibia. PhD thesis, University of Cape Town, RSA.

Braby, R., Shapira, A. and Simmons, R.E. 2001. Successful conservation measures and new breeding records for Damara terns *Sterna balaenarum* in Namibia. *Marine Ornithology* 29(2): 81-84.

Braby, J. and Braby, N. 2002. Report on daily observations at the breeding colony of Damara terns *Sterna balaenarum* south of Swakopmund in the gravel plains surrounding the horses' grave yards during the 2001/2 season. Unpublished report, MET, Swakopmund.

Braby, J., Braby, R.J., Braby, N. and Simmons, R.E. 2009. Protecting Damara Terns *Sterna balaenarum* from recreational disturbance in the Namib Desert increases breeding density and overall success. *Ostrich* 80(2): 71-75.

Branch, B. 1998. Field guide to snakes and other reptiles of southern Africa. Struik Publishers, Cape Town, RSA.

Branch, B. 2008. Tortoises, terrapins and turtles of Africa. Struik Publishers, Cape Town, RSA.

Bridgeford, P. 2019. African waterbird census – Walvis Bay sewage ponds, 21 July 2019. Unpublished report, Walvis Bay.

Bridgeford, P. 2020. African waterbird census – Walvis Bay Ramsar site, 15-16 February 2020. Unpublished report, Walvis Bay.

Broadley, D.G. 1983. Fitzsimons' Snakes of southern Africa. Jonathan Ball and AD. Donker Publishers, Parklands, RSA.

Brown, C.J., Jarvis, A., Robertson, T. and Simmons, R. 1998. Bird diversity. In: Barnard, P. (ed.). Biological diversity in Namibia: a country study. Windhoek: Namibian National Biodiversity Task Force.

Burke, A. 2003. Wild flowers of the Central Namib. Namibia Scientific Society, Windhoek.

Burke, A. 2005. Wild flowers of the northern Namib. Namibia Scientific Society, Windhoek.

Buys, P.J. and Buys, P.J.C. 1983. Snakes of Namibia. Gamsberg Macmillan Publishers, Windhoek, Namibia.

Carruthers, V.C. 2001. Frogs and frogging in southern Africa. Struik Publishers, Cape Town, RSA.

Channing, A. 2001. Amphibians of Central and Southern Africa. Protea Bookhouse, Pretoria, RSA.

Channing, A. and Griffin, M. 1993. An annotated checklist of the frogs of Namibia. *Madoqua* 18(2): 101-116.

Cole, D.T. and Cole, N.A. 2005. Lithops Flowering Stones. Cactus and Co. Libri

Craven, P. 1998. Lichen diversity in Namibia. In: Barnard, P. (ed.). Biological diversity in Namibia: a country study. Windhoek: Namibian National Biodiversity Task Force.

Craven, P. (ed.). 1999. A checklist of Namibian plant species. Southern African Botanical Diversity Network Report No. 7, SABONET, Windhoek.

Craven, P. and Marais, C. 1986. Namib Flora. Gamsberg Macmillan Publishers, Windhoek.

Crawford, R.J.M. and Simmons, R.E. 1997. Damara Tern *Sterna balaenarum*. In: Harrison, J., Allan, D.G., Underhill, L.G., Herremans, M., Tree, A.J., Brown, C.J. (Eds). The atlas of southern African birds. Vol 1: Non-passerines. Johannesburg: BirdLife South Africa pp 480–481.

Crouch, N.R., Klopper, R.R., Burrows, J.E. and Burrows, S. M. 2011. Ferns of southern Africa – a comprehensive guide. Struik Nature, Cape Town, RSA.

Cunningham, P.L. 2006. A guide to the tortoises of Namibia. Polytechnic of Namibia, Windhoek, Namibia.

Cunningham, P.L. 2007. Reptiles associated with the Valencia Mine area. Unpublished Report, Digby Wells Environmental Consultants, Johannesburg, RSA.

Cunningham, P.L. 2010a. Vertebrate fauna and flora observed at Farm 37, Walvis Bay, Wind Energy Facility. Unpublished Report, Risk Based Solutions, Windhoek.

Cunningham, P.L. 2010b. Vertebrate fauna and flora associated with the uranium EPL 3496 – Inca & TRS areas. Unpublished Report, Softchem, Johannesburg.

Cunningham, P.L. 2011a. Biophysical assessment (Vertebrate fauna & Flora) associated with the Kuiseb Delta and Dune Belt area. Unpublished report, University Central Consultancy Bureau; University of Namibia; Windhoek.

Cunningham, P.L. 2011b. Vertebrate fauna and flora associated with the Khan River EPL 3602. Unpublished Report, Risk Based Solutions, Windhoek, Namibia.

Cunningham, P.L. 2013. Vertebrate fauna associated with Reptile Uranium's EPL's Ongolo and Tumas. Unpublished Report, Softchem, Johannesburg, RSA.

Cunningham, P.L. 2014. Biophysical assessment (Vertebrate fauna & Flora): Desert Rose development. Unpublished report, Aurecon, Windhoek.

Cunningham, P.L. 2019. Biophysical assessment – Kuiseb Delta new scheme project developments. Unpublished Report, Urban Green, Windhoek, Namibia.

Cunningham, P.L. 2021. Vertebrate fauna associated with Reptile Mineral Resources and Exploration EPL's 3496/3497, Tumas Project Area. Unpublished Report, Deep Yellow, Perth, Australia.

Cunningham, P.L. 2023. Vertebrate fauna and flora associated with the Hope & Goreb Project area (EPL5796). Unpublished Report, EnviroNam, Windhoek, Namibia.

Cunningham, P.L. 2024. Vertebrate fauna and flora associated with the Green Hydrogen Project (Farm 58, Walvis Bay, and Farm Geluk 116, Usakos). Unpublished report, Environam, Windhoek, Namibia.

Cunningham, P.L. and Jankowitz, W. 2010. A review of fauna and flora associated with coastal and inland saline flats from Namibia with special reference to the Etosha Pan. *Sabkha Ecosystems Volume III: Africa and Southern Europe*. DOI: 10.1007/978-90-481-9673-9_2. Springer Science & Business Media.

Cunningham, P.L., Wassenaar, T. and Henschel, J. 2012. Notes on some aspects of the ecology of the Husab Sand Lizard, *Pedioplanis husabensis*, from Namibia. *African Herp News* 56: 1-11.

Cunningham, P.L., Marais, A. and Van Zyl, N. 2015. Above-ground pipelines as wildlife barriers in the Namib Desert. *Roan News – Special edition on water 2015*: 50-54.

De Graaff, G. 1981. The rodents of southern Africa. Buterworths, RSA.

Du Preez, L. and Carruthers, V. 2009. A complete guide to the frogs of southern Africa. Struik Publishers, Cape Town, RSA.

Duncan, G., Jeppe, B. and Voigt, L. 2020. Field guide to the Amaryllis Family of Southern Africa and surrounding territories. Gally Press, Mpumalanga, RSA.

Earle, R. and Round, J. n.d. Lithops of Namibia. www.lithopsfoundation.com

Estes, R.D. 1995. The behaviour guide to African mammals. Russel Friedman Books, Halfway House, RSA.

Frost, W. 2014. The antelope of Africa. Jacana Media (Pty) Ltd, Auckland Park, South Africa.

Griffin, M. 1998a. Reptile diversity. In: Barnard, P. (ed.). Biological diversity in Namibia: a country study. Windhoek: Namibian National Biodiversity Task Force.

Griffin, M. 1998b. Amphibian diversity. In: Barnard, P. (ed.). Biological diversity in Namibia: a country study. Windhoek: Namibian National Biodiversity Task Force.

Griffin, M. 1998c. Mammal diversity. In: Barnard, P. (ed.). Biological diversity in Namibia: a country study. Windhoek: Namibian National Biodiversity Task Force.

Griffin, M. 2003. Annotated checklist and provisional national conservation status of Namibian reptiles. Ministry of Environment and Tourism, Windhoek.

Griffin, M. and Coetzee, C.G. 2005. Annotated checklist and provisional national conservation status of Namibian mammals. Ministry of Environment and Tourism, Windhoek, Namibia.

Hebbard, S. n.d. A close-up view of the Namib and some of its fascinating reptiles. ST Promotions, Swakopmund, Namibia.

Henschel, J.R., Pallett, J., Berry, C., Griffin, M., Hachfeld, B., Makuti, O. and Seely, M.K. 2006. Checklist of the flora and vertebrates of Gobabeb. *Journal Namibia Scientific Society* 54: 31-56.

Henschel, J., van der Waal, C. and Wassenaar, T. 2011. Baseline study of vertebrates at Marenica EPL 3287. Unpublished Report, African Wilderness Restoration, Windhoek.

Hockey, P.A.R., Dean, W.R.J. and Ryan, P.G. 2006. Roberts Birds of Southern Africa VII Edition. John Voelcker Bird Book Fund.

IUCN, 2025. IUCN red list of threatened animals, IUCN, Gland, Switzerland.

Jacobson, P.J., Jacobson, K.M., and Seely, M.K. 1995. Ephemeral rivers and their catchments: sustaining people and development in western Namibia. Desert Research Foundation of Namibia, Windhoek.

Jarvis, A., Mendelsohn, J., Mendelsohn, M., and Robertson, T. 2022. Atlas of Namibia: Its land, water and life. Namibia Nature Foundation, Windhoek.

Jenkins, A.R., Ralston-Paton, S. and Smit-Robinson, H.A. 2017. Birds and solar energy. Guidelines for assessing and monitoring the impact of solar power generating facilities on birds in southern Africa. Birdlife Soth Africa, Johannesburg.

Joubert, E. and Mostert, P.M.K. 1975. Distribution patterns and status of some mammals in South West Africa. *Madoqua* 9(1): 5-44.

Kolberg, H. n.d. Preliminary Inventory of Namibia's Wetlands. Directorate Scientific Services, Ministry of Environment and Tourism, Windhoek, Namibia.

Kolberg, H. 1998. Genetic diversity of wild plants. In: Barnard, P. (ed.). Biological diversity in Namibia: a country study. Windhoek: Namibian National Biodiversity Task Force.

Kolberg, H. 2010. Summary of the summer 2010 wetland bird counts in Namibia. *Lanioturdus* 43(4): 13.

Komen, L. n.d. The Owls of Namibia – Identification and General Information. NARREC, Windhoek, Namibia.

Little, R., and Crowe, T. 2011. Gamebirds of southern Africa. Struik, Cape Town, RSA.

Loots, S. 2005. Red data book of Namibian plants. Southern African Botanical Diversity Network Report No. 38. SABONET, Pretoria and Windhoek.

- Lovegrove, B. 1999. The living deserts of southern Africa. Fernwood Press, Vlaeberg, RSA.
- Macleay, G.L. 1985. Robert's birds of southern Africa. John Voelcker Bird Book Fund.
- Mannheimer, C.A. and Curtis, B. A. (eds) 2018. Le Roux and Müller's field guide to the trees and shrubs of Namibia. 2nd edition, Namibia Publishing House, Windhoek.
- Marais, J. 1992. A complete guide to the snakes of southern Africa. Southern Book Publishers, Witwatersrand University Press, Johannesburg, RSA.
- MEFT 2013. Management Plan – Namib Naukluft Park – September 2013. Ministry of Environment, Forestry and Tourism, Windhoek, Namibia.
- MEFT/NACSO 2021. The state of community conservation in Namibia (Annual Report 2020). MEFT/NACSO, Windhoek.
- Mendelsohn, J., Jarvis, A., Roberts, A. and Robertson, T. 2002. Atlas of Namibia. A portrait of the land and its people. David Philip Publishers, Cape Town, RSA.
- Möller, A. and Becker, R. 2019. Field guide to the succulent Euphorbias of Southern Africa. Briza Publications, Pretoria.
- Monadjem, A., Taylor, P.J., F.P.D. Cotterill and M.C. Schoeman. 2010. Bats of southern and central Africa. Wits University press, Johannesburg, RSA.
- Müller, M.A.N. 1984. Grasses of South West Africa/Namibia. John Meinert Publishers (Pty) Ltd, Windhoek, Namibia.
- Müller, M.A.N. 2007. Grasses of Namibia. John Meinert Publishers (Pty) Ltd, Windhoek, Namibia.
- NCE, LCMAN, MEFT (eds) 2022. Conservation status and red list of the terrestrial carnivores of Namibia. MEFT, LCMAN, NCE, Windhoek.
- Passmore, N.I. and Carruthers, V.C. 1995. South African Frogs - A complete guide. Southern Book Publishers, Witwatersrand University Press, Johannesburg, RSA.
- Peacock, F. 2015. The definitive guide to southern Africa's little brown jobs. CTP Book Printers, Cape Town, South Africa.
- Peacock, F. 2016. The definitive guide to southern Africa's shorebirds. CTP Book Printers, Cape Town, South Africa.
- Rothmann, S. 2004. Aloes, aristocrats of Namibian flora. ST promotions, Swakopmund.
- SAIEA (Southern African Institute for Environmental Assessment), 2010. Strategic Environmental Assessment for the central Namib Uranium Rush. Ministry of Mines and Energy, Windhoek, Namibia.
- SARDB, 2004. CBSG Southern Africa. In: Griffin, M. 2005. Annotated checklist and provisional national conservation status of Namibian mammals. Ministry of Environment and Tourism, Windhoek.
- Schleicher, A. 2020. Reptiles of Namibia. Kuiseb Publishers, Windhoek.
- Seely, M. 2010. The Namib. Natural history of an ancient desert. DRFN, Windhoek.

Schultz, M. and Rambold, G. 2007. Diversity shifts and ecology of soil lichens in central Namibia. Talk, Ecological Society of Germany, Austria and Switzerland (GfÖ), 37th Annual Meeting, Marburg: 12/9/2007 to 15/9/2007.

Schultz, M., Zedda, L. and Rambold, G. 2009. New records of lichen taxa from Namibia and South Africa. *Bibliotheca Lichenologica* 99: 315-354.

Simmons, R.E. 1998a. Important Bird Areas (IBA's) in Namibia. In: Barnard, P. (ed.). Biological diversity in Namibia: a country study. Windhoek: Namibian National Biodiversity Task Force.

Simmons, R.E. 1998b. Areas of high species endemism. In: Barnard, P. (ed.). Biological diversity in Namibia: a country study. Windhoek: Namibian National Biodiversity Task Force.

Simmons R.E., Brown, C.J. and Kemper, J. 2015. Birds to watch in Namibia: red, rare and endemic species. Ministry of Environment and Tourism and Namibia Nature Foundation, Windhoek, Namibia.

Skinner, J.D. and Smithers, R.H.N. 1990. The mammals of the southern African subregion. University of Pretoria, RSA.

Skinner, J.D. and Chimimba, C.T. 2005. The mammals of the southern African subregion. Cambridge University Press, Cape Town, RSA.

Smit, H.A. n.d. Guidelines to minimise the impact on birds of solar facilities and associated infrastructure in South Africa. http://www.birdlife.org.za/images/stories/conservation/birds_and_wind_energy/solar_power.pdf

Stander, P. and Hanssen, L. 2003. Namibia large carnivore atlas. Unpublished Report, Ministry of Environment and Tourism, Windhoek, Namibia.

Tarboton, W. 2001. A guide to the nests and eggs of southern African birds. Struik Publishers, Cape Town, RSA.

Taylor, P.J. 2000. Bats of southern Africa. University of Natal Press, RSA.

Tolley, K. and Burger, M. 2007. Chameleons of southern Africa. Struik Nature, Cape Town, RSA.

Van Oudtshoorn, F. 2012. Guide to grasses of Southern Africa. Briza Publications, Pretoria, South Africa.

Wassenaar, T.D., and Mannheimer, C.M. 2010. Biodiversity impact assessment of the proposed Husab Mine of Swakop Uranium (Pty) Ltd. Unpublished Report, Metago Environmental Engineers, Johannesburg, South Africa.

Whitelaw, D.A., Underhill, L.G., Cooper, J. and Clining, C.F. 1978. Waders (Charadrii) and other birds on the Namib Coast: counts and conservation priorities. *Madoqua* 2(2): 137-150.

Williams, A.J. and Simmons, R.E. 2008a. The importance of wetlands along Namibia's desert coast for African waterbirds. Proceedings of the Namib Coastal Marine Bird Action Plan, 1 April 2008, Swakopmund.

Williams, A.J. and Simmons, R.E. 2008b. Africa's Namib desert coast supports >200 000 Holacrtic shorebirds. Proceedings of the Namib Coastal Marine Bird Action Plan, 1 April 2008, Swakopmund.

Wirth, V. 2010. Lichens of the Namib Desert. Klaus Hess Verlag, Göttingen-Windhoek.