APPENDIX E: TERRESTRIAL BIODIVERSITY ASSESSMENT, POTGIETER CONSULTANCY CC 2022

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TERRESTRIAL BIODIVERSITY
BASELINE DESCRIPTION AND IMPACT ASSESSMENT

HDF Energy, Renewstable® Swakopmund

Prepared for:
SLR Environmental Consulting

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PROJECT	**Terrestrial biodiversity: HDF Energy Renewstable® Swakopmund**
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Biography of practitioner

Henriette Potgieter has an M.Sc in Environmental Sciences from the Northwest University in South Africa and is a member of EAPAN. She has been a practitioner in Namibia since 2015. Her fields of specialisation are

a) biodiversity baseline studies and biodiversity impact assessments, and

c) environmental strategy, environmental management plans, and scoping studies for tourism.

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ABBREVIATIONS

CITES	Convention on International Trade in Endangered Species
EAPAN	Environmental Assessment Professionals of Namibia
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
FA	Forest Act 12 of 2001
IUCN	International Union for Conservation of Nature and
MEFT	Ministry of Environment, Forestry and Tourism
NCO	Nature Conservation Ordinance 4 of 1975
QDS	Quarter Degree Square
RAMSAR	The Ramsar Convention on Wetlands

1 INTRODUCTION

1.1 Background

HDF Energy proposes to develop a hydrogen to power plant in Swakopmund, using their trademarked Renewstable® technology. Electricity will be generated by PV arrays and delivered to the grid. A portion of the generated energy will be transformed into Hydrogen (H2) and stored on site in hydrogen storage tanks and fed into high-capacity fuel cells for night-time delivery.

A desalination plant will be built 6km from the main site to produce water which will be further purified on site to ultra-pure water for use in their process and for cleaning solar panels. The water will be transported to the power plant via a 315 mm pipeline within a servitude of 50 m running next to an existing road.

SLR (South Africa) was commissioned by Renewstable® Swakopmund to do an Environmental and Social Impact Assessment (ESIA) as part of an application for environmental clearance in terms of the Environmental Management Act, 7 of 2007. Potgieter Consultancy CC was contracted by SLR to conduct a terrestrial biodiversity study for the EIA.

This report presents a baseline description of the habitat and biodiversity on and around the project site, followed by an impact assessment with suggested management and/or mitigation measures.

1.2 Terms of reference

1. Site visit.
2. Baseline description of terrestrial biodiversity: mammals, reptiles, amphibians, plants, and invertebrates.
3. Biodiversity impact assessment.

1.3 Assumptions and limitations

The duration of the site visit was too short for systematic surveys, and information on the taxa for the species lists was based largely on existing literature. It is possible that some factors that could affect the persistence of species and/or composition of populations may have been overlooked during the short site visit.

The species list for invertebrates (including conservation status and endemicity) was compiled by Dr John Irish (APPENDIX I), an invertebrate specialist in Namibia. The discussion of invertebrates was done by this author.

1.4 Methodology

1.4.1 Sources used

Species lists were compiled from specialised literature on the various taxa.

- **Plants**: (Mannheimer & Curtis, 2009) (Mannheimer, et al., 2008)
- **Mammals**: (Griffin, 2003) (Skinner & Smithers, 1990)

- **Reptiles**: (Alexander & Marais, 2007) (Branch, 1998) (Griffin, 2003) (Marais, 2004)
- **Amphibians**: (Du Preez & Carruthers, 2009) (Griffin, 2003)
- **Invertebrates**: (Irish, 2022) The bibliography used by Irish is given in APPENDIX I.

The IUCN Red List (IUCN, 2022) was consulted for the international conservation status of all species, accessed on 21/02/2022.
The Catalogue of Life: 2020 Annual Checklist was consulted for the taxonomy of mammals and reptiles.

Datasets that were perused for records for the site:

- The National Herbarium of Namibia is thanked for the use of information from the specimen database: Botanical Research and Herbarium Management System (BRAHMS), National Botanical Research Institute.
- Curtis & Mannheimer, 2022: http://treeatlas.biodiversity.org.na/
- Irish, 2022. Namibia Biodiversity Database.
- The Global Biodiversity Information Facility, data portal: www.gbif.org/datasets/resource

1.4.2 Site visit

The site was visited from 11th to 13th January 2022 to examine the nature of the habitats within and adjacent to the project area, and also to look at any ecological factors that might affect the presence of the relevant taxa.

Visible signs of the presence of vertebrate species were recorded, such as spoor, dung, nests, holes/burrows and pathways. Information for the species lists (Appendix I-IV) was extrapolated from literature on similar areas, taking into account the habitat-specificity of the taxa involved. Plant species were identified on site as far as possible, and notes were made of the vegetation structure and the potential role that vegetation could play in sustaining animal taxa.

The project site and surrounding landscape were traversed in a vehicle where tracks or roads existed, and on foot in an attempt to observe as many ecological features as possible in situ. The site for the desalination plant was investigated on foot.

Visibility and accessibility were clear and unhindered.

1.4.3 Habitat categorisation

Potential habitat types were initially identified by inspecting the project site and the surrounding landscape on Google Earth Pro, and then reviewed during the site visit.

Habitats were categorised in terms of their functionality for fauna, as well as the plant communities observed and/or likely to occur. The descriptions of habitat types are based mainly on topography, substrate, and vegetation structure.

1.4.4 Impact Assessment

Following the site visit, a biodiversity baseline report was drawn up, contained in section 2 of this document. This is followed by an assessment of the potential impacts that the project might have on the biodiversity of the project site and its surrounding areas.

1.5 Study area

The study area for data searches (Purple outline in Figure 1) extends approximately 5 km from the borders of the project site (white outline) and it excludes the beach and marine environment. The study area was chosen to include as comprehensive a range of taxa as possible, while excluding ecosystems that have no representation in the project area, such as the Swakop River.

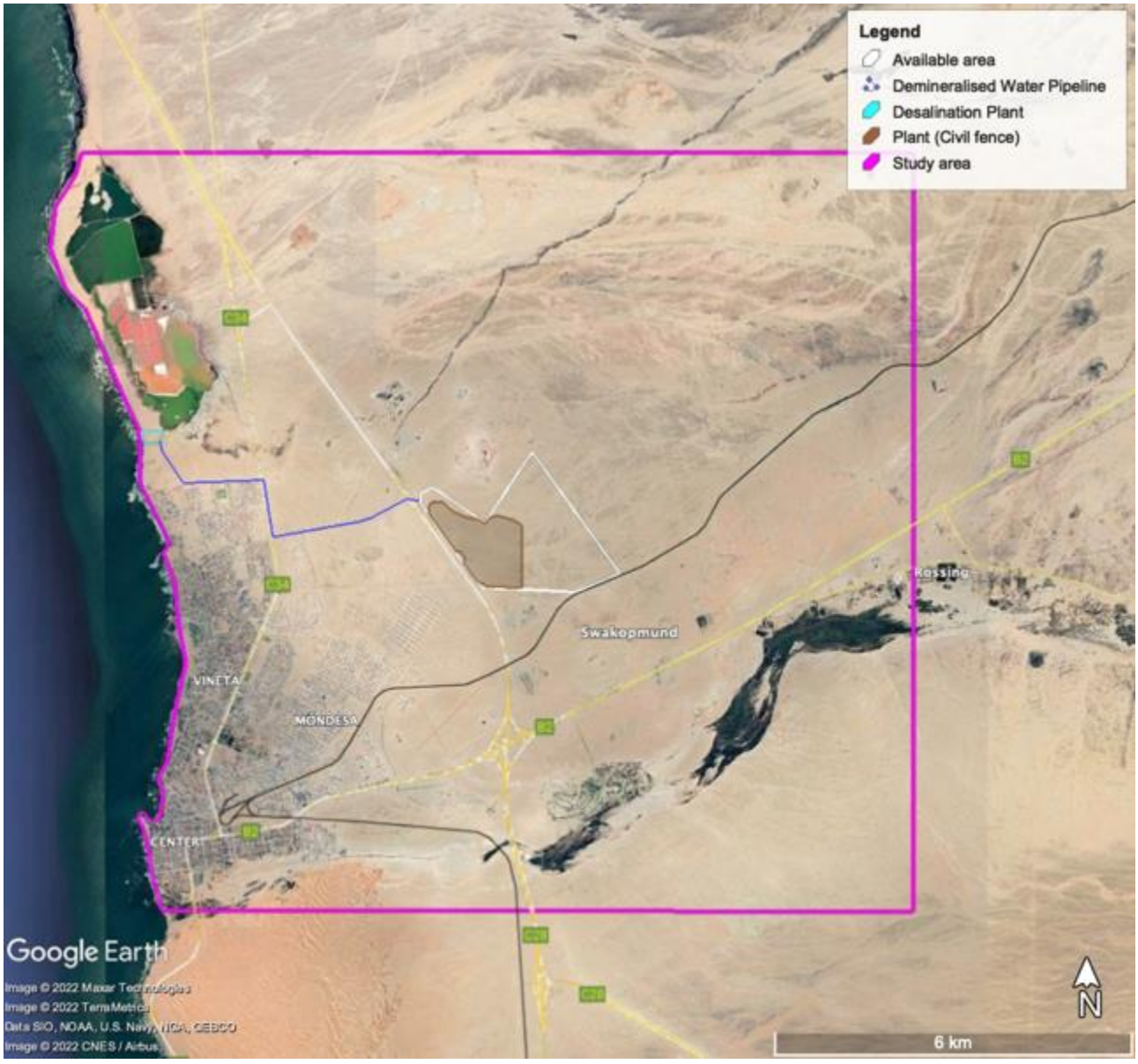

Figure 1. The study area for this report.

1.6 Legal framework

This section outlines the laws, policies and conventions that are relevant to the protection of biodiversity in the project area and its surrounding landscape. It is by no means an

exhaustive legal investigation and serves merely to highlight the issues specific to the project site that are addressed in this report.

The protection of biodiversity and ecosystems is entrenched in the Namibian Constitution and Article 95 (l) commits the state to the "maintenance of ecosystems, essential ecological processes and biological diversity of Namibia and utilization of living natural resources on a sustainable basis for the benefit of all Namibians".

The Nature Conservation Ordinance 4 of 1975 and its amendments (Nature Conservation General Amendment Act, 1990 and Nature Conservation Amendment Act, 1996) regulate the declaration of protected areas, as well as the protection status of individual species as Protected or Specially Protected.

Plant species are declared Protected in terms of the Forest Act 12 of 2001 and the Forest Regulations of 2015.

Namibia is a signatory to several international conventions and agreements that bind Namibia to sustainable development and the conservation of biodiversity, and other conventions may be relevant to this development. They include:

- United Nations Convention on Biological Diversity
- United Nations Convention on Climate Change
- Ramsar Convention on Wetlands
- International Union for the Conservation of Nature (IUCN) – categorises the extinction threat for any given taxon, used in the species lists in the appendices to this report
- Convention on International Trade in Endangered Species (CITES) – regulates the trade in endangered species
- Convention to combat Desertification
- Climate Change Policy (draft)

The Water Resources Management Act 24 of 2003 provides a framework for managing water resources and is relevant since the desalination plant will abstract seawater and discharge effluent back to the ocean.

The National Policy on Human-wildlife Conflict Management (2009) is germane because of the proximity of the Dorob National Park and Important Bird Areas.

1.7 Project description [1]

HDF Energy's "Renewstable Swakopmund" Project is designed to combine solar Photovoltaic (PV) power with hydrogen production to generate consistent, stable, dispatchable clean renewable power to the national grid. HDF Energy plans to build and operate an 85 MW solar power plant and long-term Hydrogen energy storage and it commits to delivering 30MW during daylight hours and 6MW during the night, which will meet the energy needs of Swakopmund.

[1] Email received from Theo Wicks, 5 July 2022

The construction phase of the proposed project will be for a period of up to 20 – 24 months and will create about 300 direct jobs with an estimated wage bill of N$67 million. The project estimates that a further 1,350 indirect and induced jobs will be created over the construction period.

The operations phase is expected to last 25 years, on a 24-hour, 7 days a week basis. It will run with an estimated workforce of 45 people, of whom approximately 70% will be unskilled, doing tasks such as the cleaning of the PV panels.

Once the solar PV facility reaches the end of its life, the facility will be decommissioned or continue to operate following the issuance of a new Power Purchase Agreement by NamPower. If decommissioned, all components will be removed, and where possible all materials will be recycled, otherwise they will be disposed of in accordance with local regulations and international best practice.

The main physical project components are:

- An eighty-five (85) MW solar PV power plant with tracker configuration;
- A Reverse Osmosis (RO) desalination plant and demineralization plant;
- A hydrogen chain consisting of electrolysers, hydrogen storage, hydrogen fuel cells and a battery energy storage facility;
- A Battery Energy Storage System and energy management system;
- An overhead electrical transmission line;
- Water pipeline between the desalination plant and the power plant; and
- A hydrogen refuelling station.

1.7.1 Solar PV plant

The main equipment used to convert the solar energy to electricity are:

- Photovoltaic modules, which convert the solar radiation into direct current;
- The single-axis tracker, which supports and orients the PV modules to minimize the angle of incidence between the incoming sun rays and the PV modules surface during the day;
- The string combiner boxes, which consolidate the output of the strings of photovoltaic modules before reaching the inverter;
- Central inverters, which convert DC from solar field to AC; and
- Power Transformers, which raise the voltage level from low to medium.

1.7.2 Desalination Plant

A new desalination facility, using seawater reverse osmosis technology, is proposed at the Townlands site near Mile 4 near to the Swakopmund Salt Works. The Plant is designed to produce 200 m3/day of desalinated and demineralised water to be used in the hydrogen chain, for cleaning PV panels and for general water supply to the facility.

Power for the desalination plant will be provided via an onsite solar PV facility.

1.7.3 Hydrogen Chain

Hydrogen is produced through a process of electrolysis which, using renewable energy, separates desalinated/demineralised water into hydrogen molecules and oxygen molecules. Hydrogen is then stored in a series of horizontal storage tanks with a combined capacity to store ~ 4 600 m3 of hydrogen.

Produced oxygen will either be vented to the atmosphere or stored if a beneficial use is determined.

Stored hydrogen is then used in four (4) hydrogen fuel cells to generate electricity.

1.7.4 Battery Energy Storage System

Battery Energy Storage System (BESS) is used to accommodate or compensate the intermittency of PV system, to provide stable power and support the ramp up and ramp down of the system. BESS is used for small power supply duration compared to hydrogen storage.

The total capacity of BESS considered is 93 MWh for a Power of 31 MW. This total capacity is separated in 25 modules.

1.7.5 Energy Management System

The Energy Management System (EMS) is the software that will compute the solar irradiance forecast in advance and optimize the use of both the hydrogen and battery storages in order to deliver the maximum amount of power to the grid and minimize the energy losses

1.7.6 Electrical Transmission

The evacuation of electricity from the Renewstable® Swakopmund facility will be via:

- The existing Tamariskia servitude to tie into the existing Tamariskia substation
- To the south to a proposed Sekelduin substation; or
- A loop in – loop out system tying into the nearby existing transmission line and utilising existing infrastructure.

1.7.7 Hydrogen refueling station

As part of the project concept, HDF Energy has proposed the inclusion of a small-scale hydrogen refueling station.

The refuelling station will be supplying hydrogen at 350 barg for up to maximum three (3) buses per day.

1.7.8 Associated infrastructure

Development of infrastructure associated with the various project components such as buildings, access roads, internal potable and effluent supply, internal electrical reticulation

1.7.9 Life of project

It is anticipated that a Power Purchase Agreement (PPA) will be signed for a period of up to 25-years. Beyond this duration, the proposed project may continue to operate subject to further approvals or be decommissioned

2 RECEIVING ENVIRONMENT

2.1 Landscape description

On a global scale, the study area falls in the Afrotropical Region for all vertebrate taxa (Proches & Ramdhani, 2012) and on the regional scale, in the Namib Desert biome. The dominant landscape is Central-western Plains with a Central Desert vegetation type, dominated by sparse shrubs and grasses (Mendelssohn, et al., 2002) (ACACIA, 2011).

Climatically the study area may be classified as a Cold Arid Desert (Kottek, et al., 2006), hyper-arid with a rainfall that is not only very low (annual median is less than 50 mm) but also extremely variable: more than 100%, which is the highest rank of variation coefficient (Mendelssohn, et al., 2002).

Swakopmund's climate is tempered by the cold Benguela Current that flows from the Antarctic north along the Namibian coast. Features such as low temperatures, low solar radiation, strong winds, high humidity, and frequent fog (more than 146 days per year) are due to the influence of the Benguela Current and contribute to unique adaptations (Mendelssohn, et al., 2002).

A thick coastal fog occurs frequently along the Central Namib coast and up to 50 km inland. It is a significant source of moisture and supports exceptional ecological systems. Many animals and plants are highly adapted to utilise the fog for their water needs. A long evolutionary history and the presence of diverse ecological niches contribute to a high biodiversity with unique assemblages of fauna and flora and high endemism rates. This hyper-arid ecosystem is extremely susceptible to disturbance and recovery rates are low.

An important feature of the project site is its location in the Dorob National Park. The Park is a recognised Important Bird Area and contains several wetlands protected by the Ramsar Convention. Apart from its international importance for birds, the Dorob also contains extensive lichen fields and high rates of endemism for many taxa.

2.2 Habitat classification

It is often more practical to address environmental on the level of habitats rather than species. On the species level there are several challenges for the environmental manager: Invertebrates are immeasurable in number, microscopic in size and in Namibia, most species and even some higher taxa are probably undescribed. The taxonomy and distribution of our reptiles have not been updated in two decades, and across all taxa there are many areas in the country with patchy species specific records.

An advantage to assessing and conserving habitats is that we can maintain ecological processes which would benefit all the constituent species, whether they are known or unknown.

When assigning habitat categories, the following physical characteristics are considered: topography, substrate, vegetation structure and floristics. The opportunities for food and shelter they present to animals, both vertebrates and invertebrates, are also taken into account. This results in a broad categorisation of macrohabitats within which several microhabitats may be discernible. In deciding whether to group them as one single habitat or to treat them as several distinct habitat types a practical approach is followed. If a

different set of environmental management measures are required for a specific area/ecosystem, it is considered a separate habitat.

Habitats were assigned a sensitivity rating of Highly Sensitive, Sensitive or Least Sensitive. Ratings were based on properties of the habitat itself:

- nationally or regionally scarce habitats
- size of habitat, in the context of the total availability of comparable habitats in Namibia and/or the region.
- exceptionally high diversity and/or abundance of species
- high level of endemism
- species of conservation concern are supported
- key ecological processes
- contributes disproportionately to ecological function (nutrient and energy flows)
- provides critical resources
- restorability after disturbance

2.3 Habitat description

The topography of the study area consists of a gently sloping coastal plain in a landscape devoid of structural features. The substrate is gravel and deep, sandy soils, with mixed sand and rock on the shore at the site of the desalination plant. Ill-defined washes drain across the study area towards the ocean, and surface water is limited to man-made structures at the Swakopmund Salt Works and the municipal sewerage plant. The Swakop River valley is located south of the study area and its riparian habitat is too far away to significantly affect assemblages on the site except for the highly mobile avifauna, a taxon excluded from this report.

The Central Namib gravel plains habitat is known to have high levels of range-restricted endemism (Mendelssohn, et al., 2002). Invertebrates, burrowing reptiles, and small mammals are the animal taxa most likely to be supported by the coastal gravel plain.

The Brown Hyaena and Black-backed Jackal are two carnivore species that travel across the study area to feed at the landfill and on the beach. They are also attracted to the evaporation pans of the Mile 4 Salt Works with its high abundance of marine birds.

The coastal plains, including the study area, is a highly disturbed habitat of the Central Namib. Development and expansion of Swakopmund town is the major cause of impacts in the study area. Other existing activities in the area that have impacts on biodiversity include the landfill, salt works, guano harvesting and oyster farming (Figure 2).

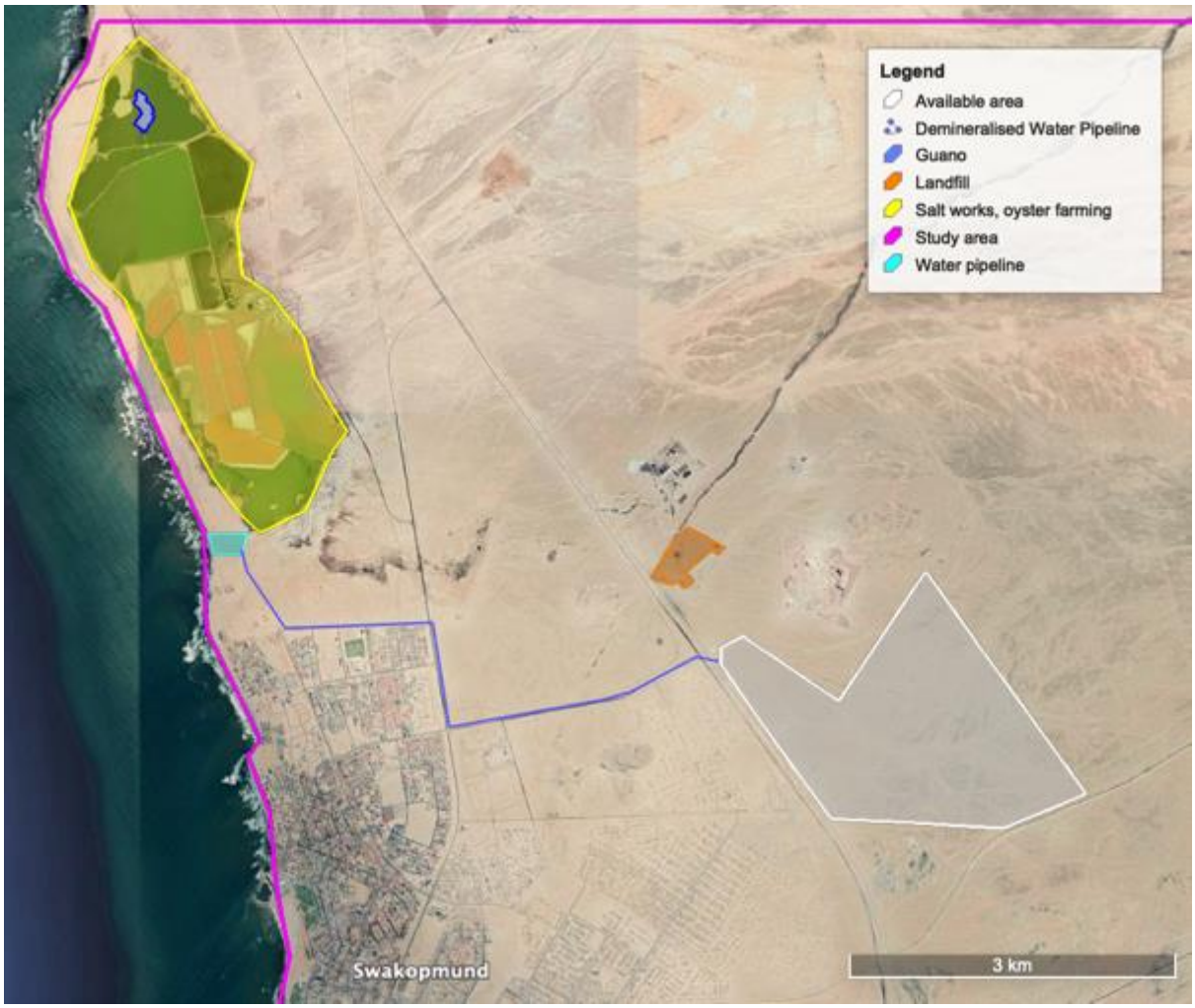

Figure 2. Some of the existing activities that impact biodiversity.

There are abundant vehicle tracks and general human activities (dog walking, people walking) on both the sites of the power plant and the desalination plant (Figure 4). Rubbish from the landfill covered the power plant site, being blown by the wind and getting stuck on every rock, shrub and stick of vegetation (Figure 3).

Figure 3. Rubbish on the site of the power plant.

Figure 4. Wheel, human and dog tracks on the desalination site.

In assigning a sensitivity rating, several aspects were considered. The coastal gravel plains habitat is a common type in the Central Namib region, and the site is highly disturbed. On the other hand, the cumulative impact of development along the Central Namib coastline needs to be considered; the plains are a valuable corridor to brown hyaenas; and it is unlikely that restoration will be possible to any meaningful extent. The gravel plains habitat is considered Sensitive, but with careful planning and adherence to the Environmental Management Plan, this may go down to Least Sensitive.

The project sites (power plant, pipeline, and desalination plant) are located on the coastal gravel plain, within which two microhabitat types were identified: low gradient hills (Figure 5) and drainages (Figure 6) on the site of the PV plant. The gravel plain at the desalination site has a deep, sandy substrate with some loose gravel (Figure 7, Figure 8).

Figure 5. Low gradient hills.

Figure 6. A drainage running from the low hills.

Figure 7. Desalination site: Loose gravel in the foreground and deep sand on the ocean side.

Figure 8. Substrate of loose gravel at the desalination site.

The pipeline will run in the reserves along an existing road across a gravel plain that has been severely modified and anthropogenically disturbed. It is not considered a discrete habitat that offers distinct resources to living organisms. Linear developments present a significant barrier to the movement of animals, but this development proposes an underground pipeline. It is foreseen that impacts are likely to take place mainly during the construction phase.

Lichens occur on the low hills, making this a microhabitat of high conservation and biodiversity value (Figure 9, Figure 10). Lichens are an important ecological indicator that can be used to monitor environmental impacts and they play a crucial role in soil conservation and the nutrient cycle in hyper-arid ecosystems. Lichens provide food for beetles and ungulates, shelter for invertebrate taxa, and nesting cover for the vulnerable, endemic Damara Tern. Most of the currently planned development will take place outside the hill microhabitat.

Figure 9. A low hill on top of which lichens occur.

Figure 10. A rocky outcrop with lichens

Vegetation is sparse or absent on the low hills, but there are rocky outcrops where nutrients get trapped, providing sustenance for detritivores and invertebrates, and for the vertebrates (mainly reptiles) that feed on them. The combination of lichens and rocky outcrops gives the low hills some trophic value and contributes to the rating of this habitat as Sensitive (Figure 11).

Figure 11. Lichens on a rocky outcrop.

Several poorly defined drainages are embedded in the gravel plains habitat and drain stormwater from the low hills, through a large, shallow drainage (Figure 15) and southwest- and westwards to the ocean (Figure 12). Vegetation is mainly confined to these drainages where plains adapted fauna use the vegetation for food and shelter. Soil and organic material get trapped against the plants, sustaining detritivores and invertebrates (Figure 13). The substrate in the drainages is sandier than the surrounding plains and offers shelter to burrowing invertebrates, reptiles, and small mammals (Figure 14).

Figure 12. Shallow drainage lines meandering across the plain in the west of the site.

Figure 13. Sparse vegetation in a drainage line.

Figure 14. Substrate in a drainage line.

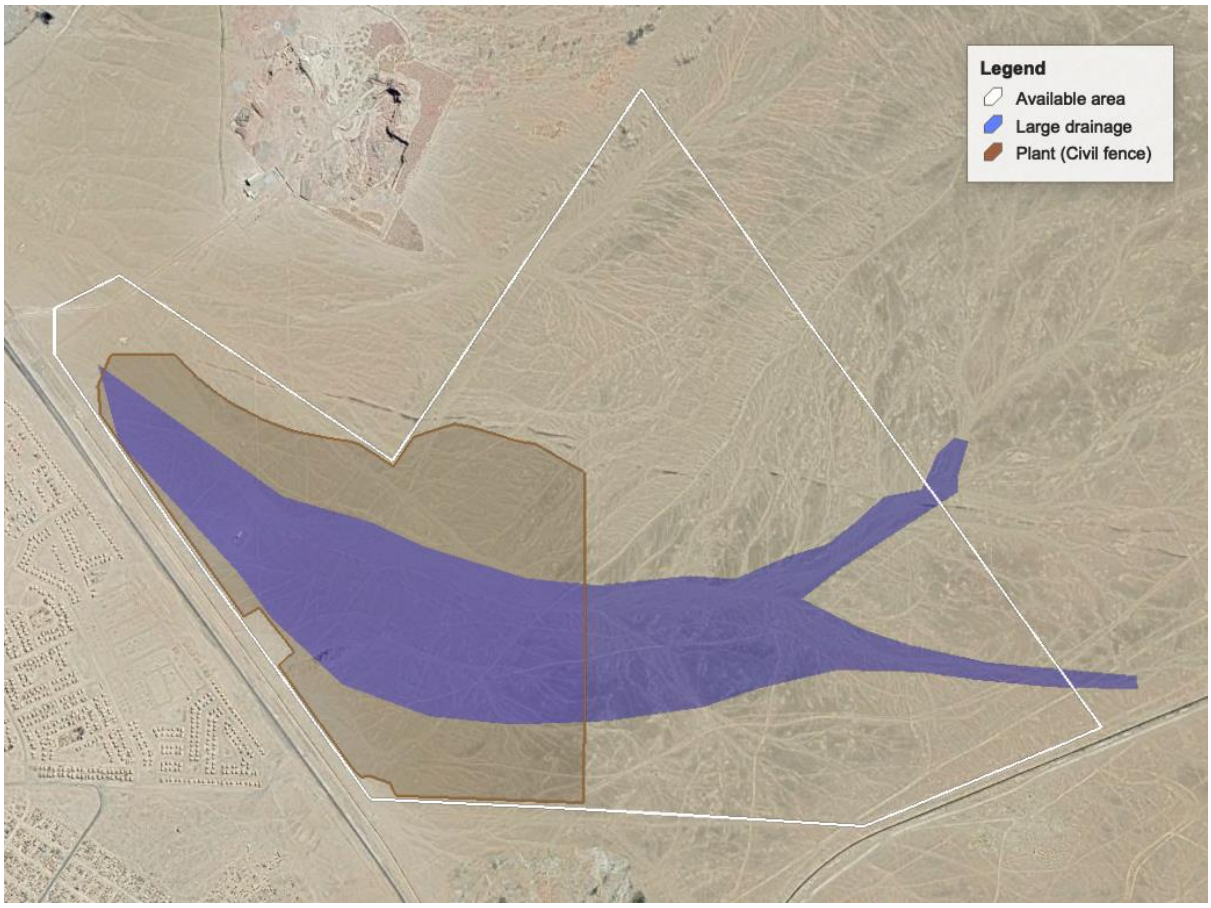

Figure 15. A large, but shallow and ill-defined drainage (blue).

Drainages present a high ecological value for most taxa in arid zones. They play a large role in supporting diversity by providing resources and movement corridors to organisms and serving as important pockets of high diversity in a surrounding landscape that contains relatively fewer resources. Like rivers, larger drainages (Figure 15) and washes often play a role as refugia for all taxa in times of environmental stress, and they play a large role in supporting diversity by serving as source areas for re-colonisation after disturbances. Usually this would result in a rating of Highly Sensitive but in this case, there are factors that decrease the sensitivity: previous human disturbance; the small size of the drainages; and the low density and diversity of vegetation they support.

2.4 Species

The taxa that were investigated are listed in the appendices. Taxa are listed on species level for mammals, reptiles and plants. Invertebrates are listed at species level where it is known, and at higher taxonomic levels (genera or families) where not enough is known to classify them to species level.

Taxa that appear in the data sets perused for this report were examined for their compatibility with the habitat types in the project area and were included in the lists only if they:

- are expected to occur or have been previously recorded in the study area, AND
- are compatible with the habitats in the study area, excluding the shore, marine habitats and the Swakop River.

The conservation status of taxa was used as indicator of their relative significance for applying conservation, management and mitigation measures in this project, with the caveat that all organisms are worthy of protection. The continued survival of taxa of concern is particularly threatened by development because it would increase the already existing environmental pressures. In deciding whether a taxon is of concern, three elements were considered: range-restricted or endemic distribution, IUCN status, and Namibian legal status.

A taxon is considered endemic if 75% or more of their distribution range falls in Namibia. The Central Namib has high rates of endemism, particularly for reptiles, scorpions and plants (Mendelssohn, et al., 2002), leading to unique assemblages of taxa.

The International Union for the Conservation of Nature (IUCN) publishes a regularly updated "Red List" that gives the level of extinction threat for any given taxon. There are four categories of threatened status: Endangered, Critically Endangered, Vulnerable and Data Deficient. Any taxon defined as threatened would be of concern in the impact assessment in this report.

Namibian legal status refers to protection afforded species according to the Nature Conservation Ordinance 4 of 1975 (NCO) and its amendments, and the Forest Act 12 of 2001 (FA) and its regulations.

2.4.1 Mammals

A total of 23 mammal species are known to occur in the study area (APPENDIX II), six of which are endemic to Namibia: Angola hairy Bat, Namib long-eared Bat, Namib round-eared elephant Shrew, Setzer's hairy-footed Gerbil, Brush-Tailed hairy-footed Gerbil, Pygmy rock Mouse.

All the mammals have had their conservation status assessed for the IUCN Red List. The Brown Hyaena has been classified as Near Threatened. Brown hyaenas from two different clans are known to cross the site of the power plant, scavenging for food on the coast, at the landfill, and at the salt works with its abundance of birds. The proposed project could potentially cut off the access routes of the hyaenas, disrupting their foraging behaviour and adversely affecting the populations in the area. The Brown Hyaena is a species of serious concern for this project, especially in view of the cumulative effect of developments along the coast.

2.4.2 Reptiles

The study area supports 25 known reptiles, 18 of which are endemic (APPENDIX III). This amounts to the extremely high rate of 72%. Of the occurring species, 22 have been assessed by the IUCN and are considered of Least Concern. The Namaqua Chameleon is listed on CITES Appendix 2.

The national and international assessment of reptiles in Namibia is almost 20 years old and it is likely that the situation, specifically regarding threatened species, has changed significantly.

2.4.3 Amphibians

There are no frog species with distribution ranges that overlap with the study area.

2.4.4 Terrestrial vegetation

Vegetation in the study area is sparse, consisting of small shrubs and grasses that are adapted to the harsh saline environment, poor soils and hyper-aridity. A contributing factor to the general lack of plants on the two project sites is the ongoing, decades-long disturbance by vehicles, urban sprawl, and salt works.

The plant species list (APPENDIX IV) was compiled using data obtained from the National Herbarium of Namibia for the quarter degree square (QDS) 2214DA, listing 129 plant species. Of those, 19 are endemic and 7 are protected by either the Forest Act (FA) or the Nature Conservation Ordinance (NCO). The QDS includes the Swakop River and many other microhabitats that are not present on the project sites, and it is expected that only a small percentage of these 129 species actually occurs here.

Salsola spp are present on the project sites. Other shrubs and sub-shrubs that were observed include *Psilocaulon kuntzei,* and three endemic species *Arthraerua leubnitziae*, *Blepharus grossa* and *Tetraena stapffii*. The near-endemic and legally protected (by both FA and NCO) *Welwitschia mirabilis* was not observed.

The potential impacts of the project on terrestrial vegetation are not deemed to play a significant role in deciding project acceptability, with the exception of lichens (Section 2.4.5).

2.4.5 Lichens

The study area falls outside the range of any of the major lichen fields of the Central Namib, but several different lichens were observed in the low rolling hills habitat of the power plant site. They are distributed mainly on the crests and sides of the hills, and are absent from the washes and plains.

Lichens play an important ecological role in the Central Namib and their presence on the hills was the main contributing factor to assigning that habitat a Sensitive rating. Lichens are highly sensitive to disturbance and notoriously slow to recover.

Lichens form biological soil crusts, stabilising the fragile sandy soils, retaining moisture, reducing wind and water erosion, fixing atmospheric nitrogen, and contributing to soil organic matter and nutrient richness. They provide shelter for the nests of the near-threatened endemic Damara Tern and food for invertebrates.

Anthropogenic disturbance of lichens is predominantly mechanical and may be caused by off-road driving, construction, mining activities, and powerline or pipeline maintenance. Increased dust deposition due to human activities reduces the ability of lichens to absorb moisture from fog. These frequent disturbances may have a negative effect on the cover, species composition and physiological functioning of a biological soil crust.

The project as currently planned does not impact the low rolling hills where the lichens occur, but substrate disruption is seldom confined to the planned footprint of any development, and it has been observed that vehicles and earthmoving equipment affect a wide area surrounding any development. Care should be taken to prevent substrate disruption by staying on designated roads and keeping foot and vehicle traffic away from the lichen hills.

2.4.6 Invertebrates

Dr John Irish was contracted to provide a species list with conservation status for the invertebrate taxa that are likely to occur in the study area. His species list, methodology and bibliography are given in APPENDIX I.

Invertebrates are listed at species level where it is known, and at higher taxonomic levels (genera, families, and even orders) where not enough is known to classify them to species level. The taxa were analysed and discarded from the list if they are not compatible with the habitats on the project sites, e.g. the Swakop River does not have an equivalent riparian ecosystem on or near the project site.

A total of 265 invertebrate taxa are likely to occur in the study area, a conservative number seeing as Namibian invertebrates are vastly under-studied and -recorded. Of these, 189 were identified to species level and 84 are endemic species, amounting to 44% of likely occurring species. Only ten species have been evaluated by the IUCN and classified as Least Concern.

3 IMPACT ASSESSMENT

ISSUE 1: DESTRUCTION OF HABITAT AND ORGANISMS

Description of impact

Source of impact during construction:
Construction and use of roads by vehicles and machinery.
Clearing of land; laydown areas; water tanks; building of infrastructure.
Excavation of earth by heavy machinery.
Water pipeline and power line construction and maintenance.
Accommodation for construction staff.
Human activities and vehicle movements.
Removing and laying down of soil during the pipeline construction.

Source of impact during operations:
Use of roads by vehicles and machinery.
Footprint of the PV array, electrolysis system, hydrogen storage cylinders.
Human activities and vehicle movements.
Vertical structures (e.g. buildings, pylons, PV array) and barriers (e.g. water pipeline, excavated ponds at desalination plant) cause habitat fragmentation.

Impact pathway and receptors:
Death of animals that are struck by earthmoving equipment, vehicles, and machinery.
Brown hyaena is particularly vulnerable to roadkill.
Death of animals due to poaching.
Noise disturbs animals and causes increase in stress.
Mammal and reptile burrows, burrow habitats and feeding habitats are destroyed, affecting the viability of the populations of these taxa.
Parts of territories and home ranges are destroyed.
Increased dust levels (during construction) may have a negative effect on the health and growth rate of lichens.
Disturbance and destruction of lichens by traversing.
Large footprint of the project results in destruction of plants, disturbance and compaction of soil, and alteration of drainage channels. Loss of plants and disturbance of soil cause a decline in habitat quality.
Fragmentation of habitat, leading to the loss of migration corridors for various taxa, in turn resulting in the loss of individual organisms and potentially populations. This is a cumulative impact.

Impact Assessment

The relatively low sensitivity of the habitats (Section 2.3), low abundance, low species richness, and low endemicity rates of the taxa covered in this report contribute to a low significance rating of the impact. There are two notable exceptions: brown hyaenas and invertebrates. The brown hyaena is near-threatened, and 44% of invertebrate species occurring here are endemic/near-endemic to Namibia.

Issue: Destruction of habitat and organisms		
Phases: Construction, operation, decommissioning		
Criteria	Without Mitigation	With Mitigation
Intensity	M	L
Duration	M	M
Extent	L	L
Consequence	L	L
Probability	M	M
Significance	L	VL
Nature of cumulative impacts	Development on the coastline of Dorob National Park: expansion of Swakopmund town, sand mining, salt mining, tourism, desalination plants, upriver mines causing downriver impacts, off-road driving. Habitat	

	fragmentation must be addressed for the Dorob National Park, if not at a regional level.
Degree to which impact can be reversed	Low. It is unlikely that habitat degradation and fragmentation on this scale can be reversed, but the pipeline and both project sites are in highly disturbed habitat.
Degree to which impact may cause irreplaceable loss of resources	Impact will cause irreplaceable loss of organisms, but not of populations. The loss needs to be measured in the context of the relatively low conservation concern of the taxa covered in this report (except invertebrates and brown hyaena that are of high conservation concern.
Degree to which impact can be mitigated	High. It is important to implement the restoration plan from the planning and construction phase.
Residual impacts	None
Mitigated outcome	Few deaths. No increased risk of extinction.

Mitigation actions

Keep the overall development footprint as small as possible.
The extent and location of the two construction sites should be fenced, and all construction activities should take place within the fence (not applicable to pipeline). Adherence should be strictly enforced.
Mitigation actions specifically for the water pipeline include:

- Route for trench should follow existing roads.
- Excavated and laid-down soil should be levelled.
- Dig the trench as close as possible to the road reserve, in an already disturbed area.

All roads and tracks should be planned to minimise fragmentation or disturbance of habitats.
Anti-erosion measures should be taken where roads and tracks cross a wash or drainage.
Carefully plan the placement of stockpiling construction material to avoid sensitive areas.
Limit construction activities to daytime hours to reduce noise and light.
Educate construction and permanent staff as to their environmental obligations. All contractors should be held responsible for transgressions, and significant penalties should be levied to ensure compliance.
Position temporary construction infrastructure (e.g. accommodation) in areas that will definitely be disturbed during operations.
Erect linear structures (power lines, water pipelines) as close as possible to existing roads and tracks.
No sewerage overflow or French drain may be placed within 100 m of a large drainage.
Identify nests, dens, burrows and other breeding locations, demarcate them, and avoid these sites. If avoidance is not possible, relocate the organisms if feasible.
Reptiles and amphibians that are exposed during ground clearing should be captured for translocation by a qualified expert.
No collection of plants should be allowed. No fires should be allowed.
Avoid damage to lichens by staying on designated roads and restricting foot and vehicle traffic to the project site (brown polygon in Figure 1).

Monitoring

A comprehensive restoration plan should be drawn up by an expert BEFORE construction commences, at least at conceptual level, and should make provision for monitoring and adaptive management as the project continues. Some rehabilitation actions should be implemented during operations in order to be effective, e.g. removal and storage of topsoil; location of waste dumps; road and pipeline locations.

ISSUE 2: DISTURBANCE OF ANIMALS AND INTERFERENCE WITH THEIR BEHAVIOUR

Description of impact

Source of impact:

Increase in human and vehicle presence and movement resulting from operational activities.
Infrastructure and roads form obstacles to the directional movement of animals.
Loud noise caused by vehicles and machinery.

Impact pathway and receptors:

Larger mammals and birds are the taxa most likely to be affected.
The loss of movement corridors and interference with the feeding habits of the brown hyaena is of grave concern.
The loss of migration corridors causes stress and an increased risk of death to various taxa.
Animals are disturbed while going about their daily activities, such as feeding and breeding.
Noise disturbs the normal behaviour of animals, specifically mammals.

Impact Assessment

Low animal densities limit the intensity of the impact. Strict enforcement of mitigation measures will lower the significance.

Issue: Disturbance of animals and interference with their behaviour		
Phases: Construction, operation, decommissioning		
Criteria	Without Mitigation	With Mitigation
Intensity	M	L
Duration	M	L
Extent	L	L
Consequence	M	L
Probability	H	L
Significance	M	VL
Nature of cumulative impacts	Development on the coastline of Dorob National Park: expansion of Swakopmund town, sand mining, salt mining, tourism, desalination plants, upriver mines causing downriver impacts, off-road driving. Habitat fragmentation must be addressed for the Dorob National Park, if not at a regional level.	
Degree to which impact can be reversed	Low.	
Degree to which impact may cause irreplaceable loss of resources	Low.	
Degree to which impact can be mitigated	High.	
Residual impacts	None.	
Mitigated outcome	Ensure that movement corridors are available.	

Mitigation actions

The extent of the operation should be clearly demarcated on site layout plans, and on the ground it should be either fenced in or marked with clear signposts.
Areas surrounding the PV and related installations that are not part of the demarcated development should be considered no-go zones. No employees, visitors, vehicles, or machinery should be allowed in such zones.
No off-road driving or driving next to established roads/tracks should be allowed.
Limit activities to day-time hours to reduce noise.
No fires should be allowed.
Train all staff and contractors how to interact with wildlife in a sensitive and situation-appropriate manner.
A specialist on brown hyaneas should be consulted for input on the restoration/rehabilitation plan. The plan should make provision for adequate corridors for hyaenas and smaller mammals to migrate.

ISSUE 3: LIGHT POLLUTION

Description of impact

Source of impact:
Light sources that are visible outdoors, e.g. at the perimeters of the two plants, along roads, and in office/accommodation areas.

Impact pathway and receptors:
Invertebrates that are attracted to the light provide an unnatural food source for taxa such as bats and geckos. These insectivores are attracted to the food and then face conditions where they are more likely to die from causes such as collisions and predation.
Invertebrates die every night from exhaustion or predation, potentially disrupting their population numbers and causing disturbances in ecological processes.

Impact Assessment

A high percentage (44) of invertebrate species in the study area are Namibian endemics or near-endemics and this impact are likely to affect them most.
Not much is known about the effect of light on populations and ecosystems - precautionary principle is applied here.

Issue: Light pollution		
Phases: Construction and operation		
Criteria	Without Mitigation	With Mitigation
Intensity	M	L
Duration	M	M
Extent	L	L
Consequence	M	L
Probability	H	M
Significance	M	VL
Nature of cumulative impacts	None.	
Degree to which impact can be reversed	Medium. Implementing mitigation measures will reverse some effects. Possibly ecosystem level disturbance but localised.	
Degree to which impact may cause irreplaceable loss of resources	Low.	
Degree to which impact can be mitigated	High.	
Residual impacts	None.	
Mitigated outcome	Fewer deaths.	

Mitigation actions

Not much is known about the effect of light on populations and ecosystems and the precautionary principle is applied here.
Install motion detectors to limit light use to the minimum possible.
Outdoor lights should be directed downwards and not up into the sky.
Use yellow or amber outdoor lights because invertebrates don't detect yellow light as well as white.
Install insect screens in doors and windows located in buildings that are used after sunset.

4 CONCLUSIONS

Three impacts were identified and all three can be mitigated to very low significance.

The historical and ongoing disturbance in the study area and specifically on the two project sites makes it unlikely that any functional, range-restricted ecosystem or assemblage of species will be impacted significantly by the proposed development, with the caveat that an EMP is drawn up before construction starts and that adherence to its recommendations is strictly enforced.

The proposed water pipeline will be constructed along an existing road. If construction and maintenance activities keep strictly within the boundaries of the already disturbed road verges, the pipeline may possibly have no significant long term negative impact on biodiversity in the area.

The Brown Hyaena is an individual species of concern and should be addressed on a regional scale. Planning movement corridors and safe passage along the entire coastline should be done with current and future developments in mind by regional and local authorities. It is a concern that cannot be effectively addressed in this report or by this project. Nevertheless, the EMP for this project should include provision for the safe daily movement of brown hyaenas.

A high proportion of invertebrates occurring in the area are Namibian endemics or near-endemics, making them a taxon of conservation concern. The disturbed state of the project sites makes it unlikely that invertebrate populations will be at increased risk of extinction.

Another taxon of concern is lichens. They were observed only on the crests and slopes of the low hills habitat. It is possible that disturbance may be avoided by applying management measures.

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APPENDIX I. Invertebrate species list

Dr John Irish provided the following list of invertebrates. It includes species, genera and families that are known or expected to occur in the study area.

- **Endem** = Endemism: X = Namibian endemic or near-endemic species (> 75% distribution range in Namibia). A = alien species.
- **IUCN** = conservation status on IUCN Red List version 2021-03, accessed 15 January 2022: CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near-Threatened; DD = Data Deficient; LC = Least Concern; blank = Not Evaluated.
- **Legal** = Legal status in Namibia: a) Nature Conservation Ordinance, no. 4 of 1975 (NCO): PG = Protected Game, SP = Specially Protected Game, HG = Huntable Game, b) CITES: C1, C2 = Appendix 1 or 2.

						CONSERVATION STATUS		
PHYLUM	CLASS	ORDER	FAMILY	SPECIES	COMMON NAME	ENDEM	IUCN	NAMIBIA
Arthropoda	Arachnida	Araneomorphae	Agelenidae	*Tegenaria domestica*	funnel-web spiders			
			Ammoxenidae		termite-eating spiders			
			Araneidae	*Argiope australis*	spiders			
			Eresidae	*Seothyra fasciata*	buckspoor spider			
			Gnaphosidae	*Asemesthes* sp.	spiders			
				Camillina cordifera	spiders			
				Zelotes scrutatus	spiders			
			Lycosidae		wolf spiders			
			Oonopidae		goblin spiders			
			Philodromidae		spiders			
			Pholcidae		spiders			
			Prodidomidae		spiders			
			Salticidae		jumping spiders			
			Segestriidae		spiders			
			Sicariidae	*Hexophthalma hahni*	six-eyed crab spiders			

						CONSERVATION STATUS		
PHYLUM	CLASS	ORDER	FAMILY	SPECIES	COMMON NAME	ENDEM	IUCN	NAMIBIA
			Sparassidae		huntsman spiders			
				Carparachne aureoflava	spiders	X		
				Leucorchestris arenicola	spiders	X		
			Tetragnathidae		spiders			
			Theridiidae	*Latrodectus geometricus*	button spider			
			Thomisidae		crab spiders			
			Zodariidae	*Psammoduon deserticola*	spiders	X		
		Ixodida			ticks			
		Mesostigmata			mites			
		Pseudoscorpiones			false scorpions			
		Scorpiones	Buthidae	*Parabuthus namibensis*	scorpions	X		
				Parabuthus stridulus	scorpions	X		
				Parabuthus villosus	scorpions	X		
			Scorpionidae	*Opistophthalmus carinatus*	scorpions			
				Opistophthalmus coetzeei	scorpions	X		
				Opistophthalmus opinatus	scorpions	X		
				Opistophthalmus penrithorum	scorpions	X		
		Solifugae	Daesiidae	*Biton striatus*	hunting spiders			
				Blossia falcifera	hunting spiders			
			Gylippidae	*Trichotoma brunnea*	hunting spiders	X		
			Hexisopodidae	*Hexisopus moiseli*	hunting spiders	X		
			Melanoblossidae		hunting spiders			
			Solpugidae	*Solpugista bicolor*	hunting spiders	X		
				Zeria lawrencei	hunting spiders			
				Zeria monteiri	hunting spiders			
	Chilopoda	Scolopendromorpha	Scolopendridae		centipedes			

						CONSERVATION STATUS		
PHYLUM	CLASS	ORDER	FAMILY	SPECIES	COMMON NAME	ENDEM	IUCN	NAMIBIA
				Cormocephalus oligoporus	centipedes			
	Diplopoda	Spirostreptida	Spirostreptidae	*Doratogonus rugifrons*	millipedes		LC	
	Entognatha	Collembola			springtails			
	Insecta	Blattodea	Blaberidae	*Gyna caffrorum*	cockroaches			
			Blattidae		cockroaches			
			Ectobiidae	*Namablatta bitaeniata*	cockroaches			
		Coleoptera	Anthicidae	*Anthelephila* sp.	ant beetles			
			Brachyceridae	*Ocladius serripes*	weevils	X		
			Brentidae	*Episus contractus*	weevils			
			Buprestidae	*Acmaeodera affabilis*	jewel beetles			
				Acmaeodera amoenula	jewel beetles			
				Acmaeodera grata	jewel beetles			
				Acmaeodera signifera	jewel beetles			
			Carabidae	*Eurymorpha cyanipes*	tiger beetles	X		
				Graphipterus ancora	ground beetles			
				Graphipterus cordiger	ground beetles			
				Graphipterus michaelseni	ground beetles	X		
			Cerambycidae	*Anthracocentrus capensis*	longhorned beetles			
			Chrysomelidae		leaf beetles			
			Curculionidae		weevils			
				Hyomora sp.	weevils			
				Neocleonus sannio	weevils			
			Dermestidae		museum beetles	X		
			Meloidae	*Hycleus svakopensis*	blister beetles	X		
			Melyridae		beetles			
			Oedemeridae	*Apterosessinia* sp.	beetles	X		

						CONSERVATION STATUS		
PHYLUM	CLASS	ORDER	FAMILY	SPECIES	COMMON NAME	ENDEM	IUCN	NAMIBIA
			Ptinidae	*Damarus magnus*	spider beetles	X		
				Damarus singularis	spider beetles	X		
			Scarabaeidae	*Cheironitis indicus*	dung beetles		DD	
				Heliocopris pirmal	dung beetles			
				Onitis mniszechi	dung beetles	X	DD	
				Onthophagus semiflavus	dung beetles	X		
				Pachnoda sinuata	fruit chafers			
				Pachylomera femoralis	dung beetles			
				Scarabaeolus rubripennis	dung beetles	X		
			Staphylinidae	*Bledius* sp.	rove beetles	X		
			Tenebrionidae	*Carchares* sp.	toktokkies	X		
				Cardiosis amabilis	toktokkies	X		
				Cauricara brunnipes	toktokkies	X		
				Cauricara eburnea	toktokkies	X		
				Epiphysa arenicola	toktokkies	X		
				Eurychora sp.	toktokkies			
				Geophanus sp.	toktokkies			
				Gonocephalum sp.	toktokkies			
				Gonopus angusticostis	toktokkies	X		
				Gonopus hirtipes	toktokkies			
				Gonopus tibialis	toktokkies			
				Gyrosis devexa	toktokkies	X		
				Gyrosis orbicularis	toktokkies	X		
				Gyrosis ornatipennis	toktokkies	X		
				Herpiscius damarinus	toktokkies			
				Metriopus depressus	toktokkies	X		

						CONSERVATION STATUS		
PHYLUM	CLASS	ORDER	FAMILY	SPECIES	COMMON NAME	ENDEM	IUCN	NAMIBIA
				Occidentophosis damarina	toktokkies	X		
				Occidentophosis parentalis	toktokkies	X		
				Ocnodes gibberosulus	toktokkies	X		
				Onychosis gracilipes	toktokkies	X		
				Onymacris marginipennis	toktokkies	X		
				Onymacris rugatipennis	toktokkies	X		
				Onymacris unguicularis	toktokkies	X		
				Pachynotelus machadoi	toktokkies			
				Pachyphaleria capensis	toktokkies			
				Physadesmia globosa	toktokkies	X		
				Physosterna cribripes	toktokkies	X		
				Protocalosis balti	toktokkies	X		
				Rhammatodes aequalipennis	toktokkies			
				Stenocara sp.	toktokkies			
				Stips dohrni	toktokkies			
				Tarsocnodes ephialtes	toktokkies			
				Tarsosis damarensis	toktokkies	X		
				Tarsosis stena	toktokkies			
				Zophosis dorsata	toktokkies	X		
				Zophosis kochi	toktokkies	X		
				Zophosis mniszechi	toktokkies	X		
		Diptera	Anthomyiidae	*Fucellia capensis*	flies			
			Asilidae	*Euscelidia procula*	assassin flies			
				Laphyctis orichalcea	assassin flies	X		
				Neolophonotus albus	assassin flies	X		
				Stichopogon punctus	assassin flies			

						CONSERVATION STATUS		
PHYLUM	CLASS	ORDER	FAMILY	SPECIES	COMMON NAME	ENDEM	IUCN	NAMIBIA
				Stiphrolamyra diaxantha	assassin flies	X		
			Bombyliidae	*Anthrax kaokoensis*	bee flies	X		
				Exhyalanthrax sp.	bee flies			
				Exoprosopa cervina	bee flies			
				Exoprosopa heros	bee flies			
				Villa sp.	bee flies			
			Calliphoridae	*Chrysomya albiceps*	bluebottles			
				Lucilia sericata	bluebottles			
				Rhinia apicalis	bluebottles			
			Chloropidae	*Elachiptera lyrica*	flies			
			Dolichopodidae	*Hydrophorus praecox*	long-legged flies			
				Thinophilus munroi	long-legged flies			
			Milichiidae	*Milichiella lacteipennis*	flies			
			Muscidae	*Musca conducens*	flies			
				Muscina stabulans	flies			
			Mydidae	*Namibimydas gaerdesi*	mydas flies	X		
			Sarcophagidae	*Wohlfahrtia pachytyli*	fles flies			
			Syrphidae	*Eristalinus* sp.	hover flies	X		
				Ischiodon aegyptius	hover flies			
			Tabanidae	*Bartolomeudiasiella kuhnelti*	horse flies	X		
			Tachinidae	*Periscepsia carbonaria*	flies			
			Tephritidae	*Campiglossa ignobilis*	fruit flies			
				Dacus bistrigulatus	fruit flies			
				Neoceratitis minima	fruit flies			
				Tanaica hyalipennis	fruit flies			
			Therevidae		stiletto flies			

						CONSERVATION STATUS		
PHYLUM	CLASS	ORDER	FAMILY	SPECIES	COMMON NAME	ENDEM	IUCN	NAMIBIA
		Hemiptera	Alydidae		broad-headed bugs			
			Berytidae		stilt bugs			
			Cydnidae		burrowing bugs			
			Lygaeidae	*Spilostethus pandurus*	seed bugs			
			Miridae		plant bugs			
			Reduviidae		asassin bugs			
		Hymenoptera	Apidae	*Amegilla velutina*	bees			
				Apis mellifera	honey bee			
				Braunsapis albipennis	bees			
				Braunsapis otavica	bees			
				Ceratina citrinifrons	bees			
				Epeolus sp.	bees			
				Thyreus delumbatus	bees			
			Bethylidae		wasps			
			Bradynobaenidae		wasps			
			Colletidae	*Colletes microdontus*	plaster bees			
				Colletes rufotibialis	plaster bees			
				Hylaeus sp.	plaster bees			
				Scrapter pyretus	plaster bees	X		
			Crabronidae	*Bembix albata*	wasps	X		
				Bembix capensis	wasps			
				Bembix ochracea	wasps			
				Bembix olivata	wasps			
				Cerceris curvitarsis	wasps			
				Cerceris spinicaudata	wasps			
				Diodontus saegeri	wasps	X		

						CONSERVATION STATUS		
PHYLUM	CLASS	ORDER	FAMILY	SPECIES	COMMON NAME	ENDEM	IUCN	NAMIBIA
				Kohlia cephalotes	wasps			
				Miscophus deserticolus	wasps	X		
				Miscophus ichneumonoides	wasps			
				Miscophus krunki	wasps	X		
				Miscophus sabulosus	wasps	X		
				Namiscophus namaquensis	wasps	X		
				Palarus maculatus	wasps			
				Philanthus triangulum	wasps			
				Tachysphex albocinctus	wasps			
				Tachysphex pentheri	wasps			
				Tachysphex schoenlandi	wasps			
				Tachysphex scopa	wasps			
				Tachysphex tenuicornis	wasps	X		
				Tachysphex thysanomerus	wasps	X		
			Formicidae	*Camponotus callmorphus*	ants	X		
				Camponotus fulvopilosus	ants			
				Camponotus maculatus	sugar ant			
				Lepisiota sp.	ants			
				Lepisiota validiuscula	ants			
				Linepithema humile	Argentine ant	A		
				Messor sp.	harvester ants			
				Monomorium alamarum	ants	X		
				Ocymyrmex monardi	ants			
				Ocymyrmex robustior	ants	X		
				Ocymyrmex turneri	ants	X		
				Ocymyrmex zekhem	ants	X		

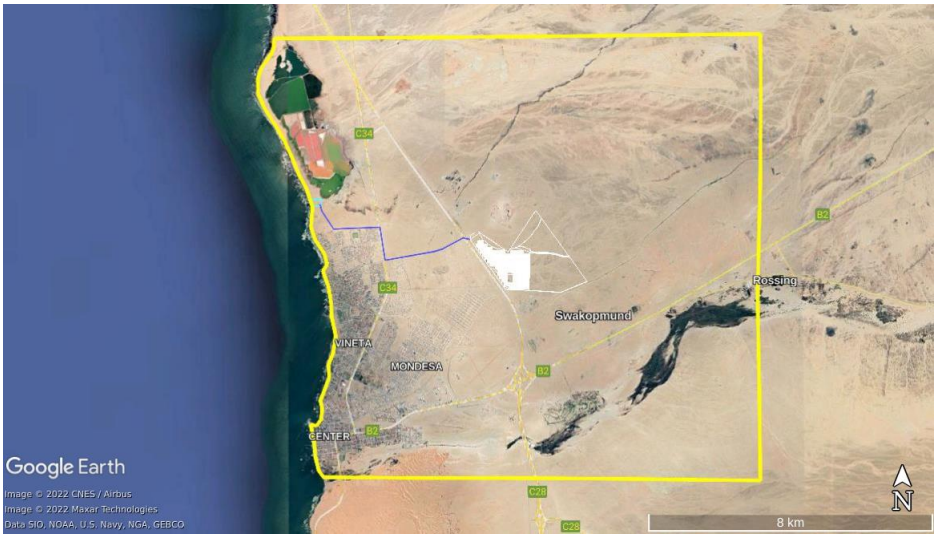
						CONSERVATION STATUS		
PHYLUM	CLASS	ORDER	FAMILY	SPECIES	COMMON NAME	ENDEM	IUCN	NAMIBIA
				Paltothyreus tarsatus	ants			
				Pheidole tenuinodis	ants			
				Tetramorium rufescens	ants			
				Tetramorium sericeiventre	ants			
			Halictidae	*Cellariella* sp.	sweat bees			
				Ceylalictus sp.	sweat bees			
				Halictus sp.	sweat bees			
				Lasioglossum sp.	sweat bees	X		
				Nomia sp.	sweat bees			
				Nomioides sp.	sweat bees			
				Patellapis sp.	sweat bees	X		
				Pseudapis cinerea	sweat bees			
			Megachilidae	*Afranthidium* sp.	leafcutter bees			
				Fidelia paradoxa	leafcutter bees			
				Heriades sp.	leafcutter bees			
				Megachile sinuata	leafcutter bees			
			Melittidae	*Capicola micheneri*	bees	X		
				Melitta arrogans	bees			
			Mutillidae		velvet ants			
				Dasylabris sp.	velvet ants			
			Plumariidae		wasps			
			Pompilidae		spider wasps			
			Scoliidae	*Campsomeriella caelebs*	wasps			
			Sphecidae	*Ammophila bechuana*	wasps			
				Podalonia canescens	wasps			
				Prionyx indus	wasps			

						CONSERVATION STATUS		
PHYLUM	CLASS	ORDER	FAMILY	SPECIES	COMMON NAME	ENDEM	IUCN	NAMIBIA
				Prionyx kirbii	wasps			
			Vespidae	*Allepipona erythrura*	wasps	X		
				Quartinia minima	wasps	X		
				Quartinia tuberculiventris	wasps	X		
				Quartinia tuberculiventroides	wasps	X		
		Isoptera	Hodotermitidae	*Hodotermes mossambicus*	termites			
			Rhinotermitidae	*Psammotermes allocerus*	termites			
		Lepidoptera	Crambidae	*Spoladea recurvalis*	grass moths			
			Erebidae	*Utetheisa pulchella*	moths			
			Lycaenidae	*Azanus jesous*	topaz blue (butterfly)		LC	
				Cacyreus sp.				
				Chilades trochylus	grass jewel		LC	
				Lampides boeticus	lucerne blue		LC	
			Nymphalidae	*Hypolimnas misippus*	diadem		LC	
				Melanitis leda	evening brown		LC	
				Vanessa cardui	painted lady		LC	
			Papilionidae	*Papilio demodocus*	citrus swallowtail			
			Pieridae	*Catopsilia florella*	African migrant		LC	
				Eurema brigitta	broad-bordered grass yellow		LC	
			Sphingidae	*Hyles livornica*	hawk moths			
		Mantodea			mantids			
		Neuroptera	Myrmeleontidae	*Palparellus flavofasciatus*	antlions	X		
		Odonata	Libellulidae	*Crocothemis erythraea*	dragonflies		LC	
		Orthoptera	Acrididae	*Anacridium moestum*	grasshoppers			
				Schistocerca gregaria	grasshoppers			

						CONSERVATION STATUS		
PHYLUM	CLASS	ORDER	FAMILY	SPECIES	COMMON NAME	ENDEM	IUCN	NAMIBIA
			Lathiceridae	*Crypsicerus cubicus*	grasshoppers	X		
			Lithidiidae		grasshoppers			
			Mogoplistidae		pygmy crickets			
			Schizodactylidae	*Comicus* sp.	feathertoed crickets			
			Stenopelmatidae	*Maxentius* sp.	crickets			
			Tettigoniidae		katydids			
		Phthiraptera			lice			
		Psocoptera			booklice			
		Siphonaptera			fleas			
		Thysanoptera	Phlaeothripidae	*Haplothrips clarisetis*	thrips			
		Thysanura	Lepismatidae	*Ctenolepisma penrithae*	fishmoths	X		
Mollusca	Gastropoda	Pulmonata	Pupillidae	*Pupoides* sp.	snail			
			Sculptariidae	*Sculptaria corona*	snail	X		
				Sculptaria damarensis	snail	X		
				Sculptaria leschkei	snail	X		
				Sculptaria pyramidata	snail	X		
				Sculptaria sculpturata	snail	X		
Platyhelminthes	Cestoda				tapeworm			

Literature review methodology used by Dr Irish

Namibian biodiversity literature records are known to be geographically patchy. It is therefore customary to extend the area to be covered by data searches with a broad margin around the study site. This ensures more comprehensive data coverage. In the current case a rectangle extending about 5 km outwards from the outer borders of the proposed infrastructure developments was used for coordinate-based datasets. This relatively small study area is necessitated by the known high east-west and north-south faunal turnover rates in the Central Namib, particularly for invertebrates, that limit the extent to which study areas can be expanded while still remaining relatively homogeneous. The area was further clipped to the coastline in the west to exclude the marine environment. For quarter-degree square (QDS) based datasets, only square SE 2214Da was used. Locality-based datasets were accessed using all place names within the data coverage area as they appear on official 1:50000 map no. 2214Da. Data hits in all cases included taxa associated with the marine and coastal environment, or the Lower Swakop River riparian environment, respectively. Since neither of the latter habitats have counterparts in the area proposed to be developed, all recorded taxa were carefully vetted, and discarded for the purposes of this study if they were considered to be habitat-incompatible with the core study area.



Overview of data coverage area (yellow polygon). Satellite image courtesy Google Earth and their sources.

The utilised data sources were:

- The Namibia Biodiversity Database (NBD 2022), a coordinate-based collation that included 162108 literature records of Namibian biodiversity at the time of access.
- The Global Biodiversity Information Facility (GBIF 2022), that included 1675765 international museum records for Namibia at the time of access, unfortunately suffering from inadequate geo-referencing. GBIF data was accessed both by coordinates and by placenames, and results were carefully vetted for geographical plausibility.
- National Museum of Namibia (NMN) collection databases, including an indeterminate number of records. Not publicly available.
- Two coordinate-based global online datasets of ant distribution: Antweb version 8.40.1, dated 2020, and GABI (Guénard *et al.* 2017).

- A private collection of 210 Gb of pdf-based publications concerned with Namibian biodiversity, that was subjected to a placename-based text search. Details of utilised sources appear in the Bibliography below.

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APPENDIX II. Mammal species list

A list of the mammal species that are expected to occur in the study area.
ENDEM: An X indicates endemic species (> 75% of total population confined to Namibia).
IUCN: CR: Critically Endangered, EN: Endangered, VU: Vulnerable, NT: Near threatened, LC: Least Concern, LR: Lower Risk, NE: Not Evaluated, DD: Data Deficient.
NAM: Namibian legal protection. NCO: PG = Protected Game, SP = Specially Protected Game, HG = Huntable Game. CITES: C1, C2 = Appendix 1 or 2.

ORDER	FAMILY	SPECIES	COMMON NAME	CONSERVATION STATUS		
				END	IUCN	NAM
Artiodactyla	Bovidae	*Antidorcas marsupialis*	*Springbok*		LC	HG
Carnivora	Canidae	*Canis mesomelas*	*Black-Backed Jackal*		LC	
Carnivora	Herpestidae	*Suricata suricatta*	*Suricate*		LC	
Carnivora	Hyaenidae	*Hyaena brunnea*	*Brown Hyaena*		NT	
Carnivora	Mustelidae	*Ictonyx striatus*	*Striped Polecat*		LC	
Chiroptera	Vespertilionidae	*Cistugo seabrai*	*Angola hairy Bat*	X	LC	
Chiroptera	Vespertilionidae	*Laephotis namibensis*	*Namib long-eared Bat*	X	LC	
Lagomorpha	Leporidae	*Lepus capensis*	*Cape Hare*		LC	
Macroscelidea	Macroscelididae	*Macroscelides flavicaudatus*	*Namib round-eared Elephant Shrew*	X	LC	
Rodentia	Muridae	*Desmodillus auricularis*	*Short-tailed Gerbil*		LC	
Rodentia	Muridae	*Gerbillurus paeba*	*Hairy-footed Gerbil*		LC	
Rodentia	Muridae	*Gerbillurus setzeri*	*Setzer's hairy-footed Gerbil*	X	LC	
Rodentia	Muridae	*Gerbillurus vallinus*	*Brush-tailed hairy-footed Gerbil*	X	LC	
Rodentia	Muridae	*Mastomys natalensis*	*Multimammate Mouse*		LC	
Rodentia	Muridae	*Micaelamys namaquensis*	*Namaqua Rock Mouse*		LC	
Rodentia	Muridae	*Mus indutus*	*Desert Pygmy Mouse*		LC	
Rodentia	Muridae	*Parotomys littledalei*	*Littledale's whistling Rat*		LC	
Rodentia	Muridae	*Rhabdomys pumilio*	*Striped Mouse*		LC	
Rodentia	Nesomyidae	*Petromyscus collinus*	*Pygmy Rock Mouse*	X	LC	
Soricomorpha	Soricidae	*Crocidura cyanea*	*Reddish-Grey Musk Shrew*		LC	

APPENDIX III. Reptile species list

ENDEM: An X indicates endemic species (> 75% of total population confined to Namibia).
IUCN: CR: Critically Endangered, EN: Endangered, VU: Vulnerable, NT: Near threatened, LC: Least Concern, LR: Lower Risk, NE: Not Evaluated, DD: Data Deficient.
NAM: Namibian legal protection. NCO: PG = Protected Game, SP = Specially Protected Game, HG = Huntable Game. CITES: C1, C2 = Appendix 1 or 2.

			CONSERVATION STATUS		
FAMILY	SPECIES	COMMON NAME	ENDEM	IUCN	NAMIBIA
Chamaeleonidae	*Chamaeleo namaquensis*	Namaqua Chameleon	X	LC	C2
Gekkonidae	*Chondrodactylus turneri*	Turner's thick-toed Gecko		LC	
	Colopus kochii	Koch's thick-toed Gecko	X	LC	
	Lygodactylus bradfieldi	Bradfield's dwarf Gecko		LC	
	Pachydactylus bicolor	Velvety thick-toed Gecko	X	LC	
	Pachydactylus rangei	Web-footed Gecko	X	LC	
	Pachydactylus scherzi	Scherz's thick-toed Gecko	X	LC	
	Pachydactylus werneri	Gecko	X	LC	
	Ptenopus carpi	Carp's barking Gecko	X	LC	
	Rhoptropus afer	Common Namib day Gecko	X	LC	
	Rhoptropus bradfieldi	Bradfield's Namib day Gecko	X	LC	
Lacertidae	*Meroles reticulatus*	Reticulated desert Lizard	X	LC	
	Meroles suborbitalis	Spotted desert Lizard		LC	
	Pedioplanis branchi	Branch’s sand Lizard	X		
	Pedioplanus husabensis	Husab sand Lizard	X		
Lamprophiidae	*Dipsina multimaculata*	Dwarf beaked Snake	X	LC	
	Lycophidion capense	Cape wolf Snake		LC	
	Lycophidion namibianum	Namibian wolf Snake	X	LC	
	Psammophis namibensis	Namib sand Snake	X		
	Psammophis notostictus	Karoo sand Snake		LC	
	Pythonodipsas carinata	Western keeled Snake	X	LC	
Scincidae	*Trachylepis variegata*	Variegated Skink		LC	
	Typhlacontias brevipes	FitzSimons' burrowing Skink	X	LC	
Viperidae	*Bitis caudalis*	Horned Adder		LC	
	Bitis peringueyi	Peringuey's Adder	X	LC	

APPENDIX IV. Vegetation species list

A list of the plant species that are expected to occur in the QDS 2214DA, according to the National Herbarium of Namibia, BRAHMS database, National Botanical Research Institute (WIND). Possible occurrences were also sourced from Mannheimer & Curtis (2009) and the Tree Atlas of Namibia web page (Curtis & Mannheimer, 2022).

Endem: An X indicates endemic species (> 75% of total population confined to Namibia).
Namibia: National legislative protection status, either the Nature Conservation Ordinance 4 of 1975 (as amended) or the Forestry Act 12 of 2004 (as amended).

		CONSERVATION STATUS	
SPECIES	FAMILY	ENDEM	NAMIBIA
Adenolobus pechuelii	Fabaceae		
Aizoanthemum galenioides	Aizoaceae	X	
Arctotis venusta	Asteraceae		
Arthraerua leubnitziae	Amaranthaceae	X	
Atriplex lindleyi	Chenopodiaceae		
Atriplex semibaccata	Chenopodiaceae		
Blepharis grossa	Acanthaceae	X	
Boscia albitrunca	Capparaceae		FA
Brownanthus kuntzei	Mesembryanthemaceae		
Camptoloma rotundifolium	Scrophulariaceae		
Chascanum garipense	Verbenaceae		
Chenopodium murale	Chenopodiaceae		
Citrullus ecirrhosus	Cucurbitaceae	X	
Cladoraphis spinosa	Poaceae		
Cleome elegantissima	Capparaceae		
Cleome foliosa	Capparaceae		
Codon royenii	Boraginaceae		
Commiphora wildii	Burseraceae		
Cordia sp.	Boraginaceae		
Cotula anthemoides	Asteraceae		
Cotula coronopifolia	Asteraceae		
Cotyledon orbiculata	Crassulaceae		
Crotalaria colorata	Fabaceae	X	
Cucumis africanus	Cucurbitaceae		
Cullen tomentosum	Fabaceae		
Cynodon dactylon	Poaceae		
Cyperus laevigatus	Cyperaceae		
Cyperus marginatus	Cyperaceae		
Dauresia alliariifolia	Asteraceae		
Dichrostachys cinerea	Fabaceae		
Doellia cafra	Asteraceae		
Dyerophytum africanum	Plumbaginaceae		
Eleocharis seydeliana	Cyperaceae		
Entoplocamia aristulata	Poaceae		
Eragrostis annulata	Poaceae		
Eriocephalus pinnatus	Asteraceae	X	
Euclea pseudebenus	Ebenaceae		
Euphorbia phylloclada	Euphorbiaceae		
Faidherbia albida	Fabaceae		FA

Felicia anthemidodes	Asteraceae		
Felicia smaragdina	Asteraceae	X	
Ficus cordata	Moraceae		FA
Flaveria bidentis	Asteraceae		
Frankenia pulverulenta	Frankeniaceae		
Galenia africana	Aizoaceae		
Galenia papulosa	Aizoaceae		
Galenia papulosa	Aizoaceae		
Gazania jurineifolia	Asteraceae	X	
Glinus lotoides	Molluginaceae		
Helichrysum argyrosphaerum	Asteraceae		
Helichrysum candolleanum	Asteraceae		
Helichrysum herniarioides	Asteraceae		
Helichrysum roseo-niveum	Asteraceae		
Heliotropium curassavicum	Boraginaceae		
Heliotropium ovalifolium	Boraginaceae		
Heliotropium tubulosum	Boraginaceae		
Hermannia affinis	Sterculiaceae		
Hexacyrtis dickiana	Colchicaceae	X	
Hoodia currorii	Apocynaceae		NCO
Hypertelis salsoloides	Molluginaceae		
Indigofera auricoma	Fabaceae		
Indigofera heterotricha	Fabaceae		
Jamesbrittenia canescens	Scrophulariaceae		
Jamesbrittenia maxii	Scrophulariaceae		
Juncus rigidus	Juncaceae		
Kissenia capensis	Loasaceae		
Lepidium englerianum	Brassicaceae		
Limeum myosotis	Molluginaceae		
Lobelia thermalis	Lobeliaceae		
Lolium rigidum	Poaceae		
Lophiocarpus polystachyus	Phytolaccaceae		
Lycium oxycarpum	Solanaceae		
Lycium tetrandrum	Solanaceae		
Mesembryanthemum cryptanthum	Mesembryanthemaceae		
Mesembryanthemum guerichianum	Mesembryanthemaceae		
Microcharis disjuncta	Fabaceae		
Monechma cleomoides	Acanthaceae		
Monechma desertorum	Acanthaceae	X	
Monechma divaricatum	Acanthaceae		
Myxopappus hereroensis	Asteraceae	X	
Nidorella resedifolia	Asteraceae		
Odyssea paucinervis	Poaceae		
Ornithogalum stapffii	Hyacinthaceae	X	
Ornithoglossum vulgare	Colchicaceae		
Orthanthera albida	Apocynaceae		
Osteospermum microcarpum	Asteraceae		
Panicum repens	Poaceae		
Parkinsonia africana	Fabaceae		FA
Paspalum vaginatum	Poaceae		
Pechuel-loeschea leubnitziae	Asteraceae		
Pelargonium otaviense	Geraniaceae		
Phragmites australis	Poaceae		
Poa annua	Poaceae		
Polygonum plebeium	Polygonaceae		

Polypogon monspeliensis	Poaceae		
Polypogon viridis	Poaceae		
Potamogeton pectinatus	Potamogetonaceae		
Psilocaulon kuntzei	Mesembryanthemaceae		
Psilocaulon salicornioides	Mesembryanthemaceae	X	
Ruppia maritima	Ruppiaceae		
Salsola aphylla	Chenopodiaceae		
Salsola arborea	Chenopodiaceae		
Salsola gemmifera	Chenopodiaceae		
Salsola swakopmundi	Chenopodiaceae	X	
Sarcocornia natalensis	Chenopodiaceae		
Senecio engleranus	Asteraceae	X	
Sesbania pachycarpa	Fabaceae	X	
Spergularia media	Caryophyllaceae		
Sporobolus consimilis	Poaceae		
Sporobolus virginicus	Poaceae		
Stipagrostis ciliata	Poaceae		
Stipagrostis hermannii	Poaceae	X	
Stipagrostis namaquensis	Poaceae		
Stipagrostis subacaulis	Poaceae		
Suaeda merxmuelleri	Chenopodiaceae		
Suaeda plumosa	Chenopodiaceae		
Tamarix ramosissima	Tamaricaceae		
Tamarix usneoides	Tamaricaceae		
Tapinanthus oleifolius	Loranthaceae		
Tetraena stapffii	Zygophyllaceae	X	
Tetragonia reduplicata	Aizoaceae		
Tribulus zeyheri	Zygophyllaceae		
Tripteris microcarpa	Asteraceae		
Vahlia capensis	Vahliaceae		
Verbesina encelioides	Asteraceae		
Welwitschia mirabilis	Welwitschiaceae	X	NCO, FA
Xanthium strumarium	Asteraceae		
Zannichellia palustris	Zannichelliaceae		

APPENDIX V. SLR Impact Assessment criteria

PART A: DEFINITIONS AND CRITERIA*		
Definition of SIGNIFICANCE		**Significance = consequence x probability**
Definition of CONSEQUENCE		**Consequence is a function of intensity, spatial extent and duration**
Criteria for ranking of the INTENSITY of environmental impacts	**VH**	Severe change, disturbance or degradation. Associated with severe consequences. May result in severe illness, injury or death. Targets, limits and thresholds of concern continually exceeded. Substantial intervention will be required. Vigorous/widespread community mobilization against project can be expected. May result in legal action if impact occurs.
	H	Prominent change, disturbance or degradation. Associated with real and substantial consequences. May result in illness or injury. Targets, limits and thresholds of concern regularly exceeded. Will definitely require intervention. Threats of community action. Regular complaints can be expected when the impact takes place.
	M	Moderate change, disturbance or discomfort. Associated with real but not substantial consequences. Targets, limits and thresholds of concern may occasionally be exceeded. Likely to require some intervention. Occasional complaints can be expected.
	L	Minor (Slight) change, disturbance or nuisance. Associated with minor consequences or deterioration. Targets, limits and thresholds of concern rarely exceeded. Require only minor interventions or clean-up actions. Sporadic complaints could be expected.
	VL	Negligible change, disturbance or nuisance. Associated with very minor consequences or deterioration. Targets, limits and thresholds of concern never exceeded. No interventions or clean-up actions required. No complaints anticipated.
	VL+	Negligible change or improvement. Almost no benefits. Change not measurable/will remain in the current range.
	L+	Minor change or improvement. Minor benefits. Change not measurable/will remain in the current range. Few people will experience benefits.
	M+	Moderate change or improvement. Real but not substantial benefits. Will be within or marginally better than the current conditions. Small number of people will experience benefits.
	H+	Prominent change or improvement. Real and substantial benefits. Will be better than current conditions. Many people will experience benefits. General community support.
	VH+	Substantial, large-scale change or improvement. Considerable and widespread benefit. Will be much better than the current conditions. Favourable publicity and/or widespread support expected.
Criteria for ranking the DURATION of impacts	**VL**	Very short, always less than a year. Quickly reversible
	L	Short-term, occurs for more than 1 but less than 5 years. Reversible over time.
	M	Medium-term, 5 to 10 years.
	H	Long term, between 10 and 20 years. (Likely to cease at the end of the operational life of the activity)
	VH	Very long, permanent, +20 years (Irreversible. Beyond closure)
Criteria for ranking the EXTENT of impacts	**VL**	A part of the site/property.
	L	Whole site.
	M	Beyond the site boundary, affecting immediate neighbours
	H	Local area, extending far beyond site boundary.
	VH	Regional/National

PART B: DETERMINING CONSEQUENCE							
			EXTENT				
			A part of the site/property	Whole site	Beyond the site, affecting neighbours	Local area, extending far beyond site.	Regional/ National
			VL	L	M	H	VH
INTENSITY = VL							
DURATION	Very long	VH	Low	Low	Medium	Medium	High
	Long term	H	Low	Low	Low	Medium	Medium
	Medium term	M	Very Low	Low	Low	Low	Medium
	Short term	L	Very low	Very Low	Low	Low	Low
	Very short	VL	Very low	Very Low	Very Low	Low	Low
INTENSITY = L							
DURATION	Very long	VH	Medium	Medium	Medium	High	High
	Long term	H	Low	Medium	Medium	Medium	High
	Medium term	M	Low	Low	Medium	Medium	Medium
	Short term	L	Low	Low	Low	Medium	Medium
	Very short	VL	Very low	Low	Low	Low	Medium
INTENSITY = M							
DURATION	Very long	VH	Medium	High	High	High	Very High
	Long term	H	Medium	Medium	Medium	High	High
	Medium term	M	Medium	Medium	Medium	High	High
	Short term	L	Low	Medium	Medium	Medium	High
	Very short	VL	Low	Low	Low	Medium	Medium
INTENSITY = H							
DURATION	Very long	VH	High	High	High	Very High	Very High
	Long term	H	Medium	High	High	High	Very High
	Medium term	M	Medium	Medium	High	High	High
	Short term	L	Medium	Medium	Medium	High	High
	Very short	VL	Low	Medium	Medium	Medium	High
INTENSITY = VH							
DURATION	Very long	VH	High	High	Very High	Very High	Very High
	Long term	H	High	High	High	Very High	Very High
	Medium term	M	Medium	High	High	High	Very High
	Short term	L	Medium	Medium	High	High	High
	Very short	VL	Low	Medium	Medium	High	High
			VL	L	M	H	VH
			A part of the site/property	Whole site	Beyond the site, affecting neighbours	Local area, extending far beyond site.	Regional/ National
			EXTENT				

PART C: DETERMINING SIGNIFICANCE							
PROBABILITY (of exposure to impacts)	Definite/ Continuous	**VH**	**Very Low**	**Low**	**Medium**	**High**	**Very High**
	Probable	**H**	**Very Low**	**Low**	**Medium**	**High**	**Very High**
	Possible/ frequent	**M**	**Very Low**	**Very Low**	**Low**	**Medium**	**High**
	Conceivable	**L**	**Insignificant**	**Very Low**	**Low**	**Medium**	**High**
	Unlikely/ improbable	**VL**	**Insignificant**	**Insignificant**	**Very Low**	**Low**	**Medium**
			VL	**L**	**M**	**H**	**VH**
			CONSEQUENCE				

PART D: INTERPRETATION OF SIGNIFICANCE	
Significance	**Decision guideline**
Very High	Potential fatal flaw unless mitigated to lower significance.
High	It must have an influence on the decision. Substantial mitigation will be required.
Medium	It should have an influence on the decision. Mitigation will be required.
Low	Unlikely that it will have a real influence on the decision. Limited mitigation is likely to be required.
Very Low	It will not have an influence on the decision. Does not require any mitigation
Insignificant	Inconsequential, not requiring any consideration.

***VH = very high, H = high, M= medium, L= low and VL= very low and + denotes a positive impact.**

Abc