Rio Tinto

Rössing Uranium Limited

SOCIAL AND ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED RÖSSING URANIUM DESALINATION PLANT NEAR SWAKOPMUND

DRAFT SCOPING REPORT

PROJECT REFERENCE NO: 110914

DATE: SEPTEMBER 2014

PREPARED BY

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SLR

ON BEHALF OF

Rio Tinto

Rössing Uranium

Working for Namibia

Project Details

PROJECT: Social and Environmental Impact Assessment for the Proposed Rössing Uranium Desalination Plant, near Swakopmund, Namibia.

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LIST OF ACRONYMS AND UNITS OF MEASURE

%	Percentage
°C	Degrees centigrade
AIDS	Acquired immune deficiency syndrome
Aurecon	Aurecon Namibia (Pty) Ltd
BID	Background Information Document
cm/s	Centimetres per second
CSIR	Council for Scientific and Industrial Research
dB	Decibels
Gecko	Gecko Namibia (Pty) Ltd
GIS	Geographic Information System
GPS	Global Positioning System
GRP	Glass reinforced plastic
GTZ	German Federal Enterprise for International Cooperation
Ha	Hectare
HDPE	High density poly ethylene
HIV	Human immunodeficiency virus
Hz	Hertz
I&APs	Interested and Affected Parties
IFC	International Finance Corporation
Kg	Kilogram
Km	Kilometres
km^2	Square kilometres
KOP	Key Observation Point: KOPs refer to receptors (people affected by the visual influence of a project) located in the most critical locations surrounding the landscape modification, who make consistent use of the views associated with the site where the landscape modifications are proposed. KOPs can either be a single point of view that an observer/evaluator uses to rate an area or panorama, or a linear view along a roadway, trail or river corridor.
Kpa	Kilopascals
kV	Kilovolt

m	Metres
m/s	Metres per second
m^2	Square metres
m^3/day	Cubic metres per day
MAWF	Ministry of Agriculture Water and Forestry
MET	Ministry of Environment and Tourism
MET: DEA	Ministry of Environment and Tourism: Department of Environmental Affairs and Development
MFMR	Ministry of Fisheries and Marine Resources
mg/ℓ	Milligrams per litre
min	Minutes
Mℓ	Megalitre (1 Megalitre = 1,000 cubic metres)
Mℓ/d	Megalitres per day
Mlb/a	Million pounds per annum
mm	Millimetres
Mm^3	Million cubic metres
Mm^3/a	Million cubic metres per annum
NamWater	Namibia Water Corporation
Omdel	Omaruru Delta (Aquifer)
pH	Potenx Hydrogen. A figure expressing the acidity or alkalinity of a solution on a logarithmic scale on which 7 is neutral, lower values are more acid and higher values more alkaline. The pH is equal to −log10 c, where c is the hydrogen ion concentration in moles per litre.
RDP	Rössing Desalination Plant
RO	Reverse osmosis
RUL	Rössing Uranium Limited
SADC	Southern African Development Community
SEIA	Social and Environmental Impact Assessment
SEMP	Social and Environmental Management Plan
SLR	SLR Environmental Consulting (Namibia) (Pty) Ltd
spp.	Species
t/km^2	Tons per square kilometre
UNEP	United Nations Environment Programme
USAID	United States Agency for International Development

EXECUTIVE SUMMARY

This executive summary provides a non-technical overview of the draft scoping report. The draft scoping report sets out the legal framework for the Social and Environmental Impact Assessment (SEIA) process. The draft scoping report provides a description of the environmental and social baseline, and provides an indication of the anticipated and potentially significant social and environmental impacts that will be assessed in greater detail in the impact assessment phase. The reader is referred to the draft scoping report should they require more information than is provided here.

Rio Tinto Rössing Uranium Limited (Rössing Uranium) would like to develop a new desalination plant, approximately 10km north of Swakopmund at the existing Swakopmund Salt Works, to supply the mine's water needs. SLR Environmental Consulting (Namibia) (Pty) Limited (SLR), in association with Aurecon Namibia (Pty) Ltd (Aurecon), have been appointed to undertake the Social and Environmental Impact Assessment (SEIA) process.

Proposed Rössing desalination plant in the local context

Rössing Uranium is urgently considering ways to improve the efficiency and overall economic viability of their mining operations near Arandis. The mine currently purchases water through NamWater, via the Areva Desalination Plant, which constitutes a significant overhead cost for the mine. Rössing Uranium have determined that having their own seawater desalination plant, may save costs and lead to a more efficient and resilient mining operation, especially during the current low uranium market prices. It is estimated that the cost of water from the new plant would decrease from the current average of US$4.00/m^3 to less than US$2.00/m^3 at point of supply, thus saving Rössing Uranium upwards of US$6 Million per annum (approximately NAD60 million per annum).

The cost of US$2.00/m^3 to US$2.50 is widely accepted as a benchmark cost for desalinated water supply. Several years of negotiation attempts have however remained unsuccessful in bringing the current desalination supply cost down to such a level. Progress on the NamWater

Mile 6 plant has also been slow, and the October 2014 date for completion of that plant has not been met. This leaves the mining community exposed to the current very high desalination cost as the only alternative supply of water to the supply from the Omdel aquifer, at least for the next five years.

The proposed plant will be designed to have a 10 year operational life, which ties in with the current Rössing Uranium Life of Mine plan. The plant will be designed to produce up to 10Mℓ of potable water in every 24 hour cycle (10,000m^3/d). The plant would produce approximately 3Mm^3 per annum (or average of 8,200m^3/d), which is consistent with Rössing Uranium's water demand. At full production, the plant will abstract 25,000m^3/d of seawater; produce 10,000m^3/d of drinking water and discharge 15,000m^3/d back to the ocean as concentrated seawater or brine (possibly containing left-over water treatment chemicals).

The project can be divided into the following main components:

- Seawater intake system;
- Seawater pretreatment system;
- Desalination plant;
- Ancillary structures and infrastructure;
- Electrical supply system;
- Clearwater system and pipeline; and
- Effluent treatment and disposal system.

The plant will be designed for electrical efficiency since reverse osmosis requires significant electrical power. During the operational phase, the plant will be staffed with an estimated 12 to 18 contract staff and will be operated by Gecko on Rössing Uranium's behalf. It should take about 18 months to build the plant, following approval. At the end of its life, the plant may be refurbished for ongoing use, or closed, broken down and the site rehabilitated, or possibly sold to another mining operation or NamWater, depending on the needs at that time.

The project is currently at a conceptual design stage. Many design options are under consideration, but these will be reduced until only the feasible design alternatives remain. A preferred alternative and any other feasible alternatives, together with the "no go" alternative, will be assessed during the SEIA phase. The assessment of alternatives must at all times include the consideration of the "no-go" option against which all other alternatives can be measured. It is best practise to consider at least two alternatives against the no-go option.

The aim of the SEIA process is to review the relevant legal requirements, undertake the processes as prescribed, identify and investigate potentially significant socio-economic and bio-physical impacts and provide an opportunity for the public and key stakeholders to provide input and participate in the process.

The impact assessment will consider impacts associated with:

- Project design and pre-construction impacts and considerations;
- Construction phase impacts,
- Operational phase impacts;
- Decommissioning phase impacts; and
- Cumulative impacts, taking into consideration existing pressures or impacts on the local socioeconomic and biophysical environments.

for

- A preferred alternative (before and after proposed mitigations);
- At least one other alternative (before and after proposed mitigations); and
- The "no-go" alternative.

Through the investigations, suitable mitigation and management measures will be identified and proposed and carried forward in the Social and Environmental Management Plan (SEMP) which aims to guide responsible environmental management throughout its lifecycle.

Through the scoping phase the following potentially significant impacts have been identified, which will be investigated in greater detail during the impact assessment phase of the study:

- Impacts to avifauna (birds) ~
  - Physical disturbance ~ increased activity of people and vehicles in the area during the construction of both the desalination plant and associated infrastructure will result in possible noise, vibration, movement and light disturbances of breeding, roosting and foraging birds. In particular, the site coincides with a key breeding area for the Damara Tern.
  - Habitat destruction/modification ~ construction of the desalination plant will result in habitat destruction within the project footprint. Changes to the existing surface water structures in the area (e.g. the use of buffer ponds next to the desalination plant) may also impact on local faunal residents and migrants. Birds may move away from these areas during construction/implementation, but if the habitat is suitable they could also move back afterwards.
  - Interactions with powerline structures ~ collisions occur when a bird in mid-flight do not see the overhead cables until it is too late to take evasive action. These impacts could take place on any parts of the line, but are more likely in sections where the powerline crosses flight corridors such as drainage lines. Electrocution may occur when a bird attempts to perch on an electrical structure and causes an electrical short circuit by physically bridging the air gap between live components and/or live and earthed components. Electrocutions of waterbirds and raptors may take place on poles, transformers and substation structures
- Heritage impacts ~ the proposed desalination plant may affect important evidence of shoreline processes associated with gross sea level fluctuations on the Namib coast. It is likely however that the disturbance of the area through previous industrial activities would already have compromised such evidence. Possible impacts to be addressed during the impact assessment phase will include:
  - Significant evidence related to late Pleistocene sea level high stands;
  - Below present surface evidence of human occupation on the margins of the presumed paleo-lagoon feature; and
  - Historical remains of salt-mining activity.
- Marine ecology impacts ~
  - Construction phase impacts~
    - ~ Onshore construction (human activity, air, noise and vibration pollution, dust, blasting and piling driving, disturbance of coastal flora and fauna);
    - ~ Construction and installation of pipeline intakes and discharge (construction site, pipe lay-down areas, and trenching in the marine environment, vehicular traffic on the beach and consequent disturbance of intertidal and subtidal biota).
    - ~ Temporary loss of seafloor habitat and associated communities due to pipeline laying and associated activities (e.g. jetties);
    - ~ Temporary loss of upper beach habitat as a result of vehicular traffic and earth moving equipment on the shore, and associated spoils dumping, backfilling and stockpiling activities;
    - ~ Possible impacts on habitat health due to turbidity generated during construction;
    - ~ Disturbance of marine creatures, particularly marine mammals and turtles, due to construction activities in the surf zone);
    - ~ Interruption of longshore sediment movement by sheet piling and jetty structure resulting in increased erosion and/or accretion around the construction site;

    - Possible impacts to marine water quality and sediments through hydrocarbon pollution by marine construction infrastructure and plant; and
    - Potential contamination of marine waters and sediments by poor disposal of spoil and/or surplus rock from construction activities, trenching and backfilling, used oils and human wastes, which could impact on marine ecology.
  - Operational phase impacts ~
    - Altered flows at the intake and discharge resulting in ecological impacts (e.g. sucking small creatures into the intake, changes at the discharge, and effects on natural sediment dynamics);
    - Potential for habitat health impacts/losses resulting from elevated salinity in the vicinity of the brine discharge;
    - The effect of the discharged effluent potentially having a higher temperature than the receiving environment;
    - Biocidal action of residual chlorine in the effluent;
    - The effects of co-discharged constituents in the waste-water;
    - The abstraction of large volumes of feed water resulting in the local removal of particulate matter from the water column where it is a significant food source, as well as changes in phytoplankton production due to changes in nutrients, reduction in light, water column structure and mixing processes; and
    - Direct changes in dissolved oxygen content due to the difference between the ambient dissolved oxygen concentrations and those in the discharged effluent, and indirect changes in dissolved oxygen content of the water column and sediments due to changes in phytoplankton production as a result of nutrient input.
- Noise impacts ~ the closest neighbors to the proposed project to be assessed from a noise perspective, include: the Swakopmund Salt Works; the northernmost suburbs of Swakopmund; the Mile 4 Caravan Park; and the Correction Services residence (1km to the north-northeast of the desalination plant). Potential noise sources to be assessed:
  - Construction phase ~
    - General construction (small plant), earthworks and associated equipment,
    - Construction traffic, and
    - Marine blasting and pile driving (if required).
  - Operations phase ~
    - High pressure pumps, energy recovery systems, air compressors; and
    - Traffic.
- Socio-economic ~
  - Positive impacts ~
    - Additional water source, with non-government funding, for a growing coastal economy and population; and
    - Job creation and economic opportunities.
  - Negative impacts ~
    - Traffic and Road Safety;
    - Impact on tourism to the salt pans and fishing from the beach; and
    - Possible impact on house prices at Mile 4 (due to visual, noise, and other impacts).
- Visual impact ~ Views from Swakopmund are mainly to those located to the outer north-eastern extents of the town, and would have moderate to low views of the proposed plant and substation, but high exposure views of the proposed transmission line (if pursued). Due to the existing structures around the Salt Works, it is likely that their sensitivity to landscape modification would be moderate to low. The main viewpoints of the desalination plant and associated infrastructure to be assessed, will include:
    - From the C34 southbound views towards the proposed transmission line road crossing;

  - From the C34 southbound views to the proposed plant and substation;
  - From the C34 northbound views towards the proposed plant and substation; and
  - From the Swakopmund residential views towards the proposed transmission line.
- Other impacts ~ The impacts identified above and for which specialist investigations will be undertaken are not an exhaustive list of potential impacts associated with the project, but rather those that are deemed to be potentially significant and key in informing a decision on the acceptability of the project. There are a number of lower significance, transient or generic impacts that can be readily mitigated, including the following:
  - Air quality impacts (most notably dust generation during the construction phase);
  - Groundwater quality, as a result of construction and operation phase activities and pollution events;
  - Hydrological impacts, including concentration and deviation of natural stormwater paths leading to erosion and sedimentation;
  - Pollution prevention and waste management;
  - Soil impacts including compaction and erosion; and
  - Terrestrial ecology impacts, including loss of plants and habitat area.

The following specialist studies are proposed during the SEIA phase and will assist with the investigation and assessment of the key impacts, identified above, and then also provide recommendations to reduce and manage those impacts as best as possible:

SPECIALIST FIELD	SPECIALIST	DESCRIPTION
Avifauna	Mike and Ann Scott (African Conservation Services CC)	Identify and assess the potential impacts on local birdlife associated with the construction and operations of the proposed Rössing Uranium desalination plant and associated infrastructure (most notably a possible overhead powerline).
Heritage & Archaeology	Dr. John Kinahan (Quaternary Research Services)	This study will focus on the probable impacts of the proposed project on heritage and archaeological impacts within the footprint of the proposed project.
Marine ecology	Dr. Andrea Pulfrich (Pisces Environmental Services (Pty) Ltd)	Identify and assess the potential impacts to marine and coastal ecology associated with the construction and operation of the proposed Rössing Uranium desalination plant. The study will rely on the marine discharge and modelling study to be undertaken by WSP.
Marine pollution modelling	Christoph Soltau (WSP Group)	Assess the marine discharge options and undertake a hydrodynamic modelling exercise to determine the likely movement and dissipation of the discharge plume.
Noise	Nicolette von Reiche (Airshed Planning Professionals)	Identify and assess the potential noise impacts associated with the construction and operation of the proposed Rössing Uranium desalination plant.
Socio-economic	Dr. Jonathan Barnes (Economic) (Design & Development Services cc) and Ms. Auriol Ashby (Social) (Ashby Associates CC)	Identify and assess the potential Socio-economic impacts associated with the construction and operation of the proposed Rössing Uranium desalination plant.
Visual	Stephen Stead (Visual Resource Management Africa)	Assess the potential visual impact caused by the proposed Rössing Uranium desalination plant.

During the initial stages of the project, as many potential Interested and Affected Parties (I&APs) were notified and contacted about the project as possible, using media advertisements, site notices boards and other communications. A number of meetings were then held with I&APs to assist with the early identification of potential issues associated with the proposed desalination plant.

In the next stage of the public participation process, this non-technical summary will be made available to all registered I&APs and they will be told where they may find the full report. I&APs will then have a window of opportunity to review the report and submit any comments or raise any issues or concerns that they may have regarding the proposed project or the Terms of Reference for the impact assessment phase.

On completion of the public comment period, the Scoping Report will be finalised and submitted to the Ministry of Environment and Tourism: Department of Environmental Affairs (MET:DEA) for their review and decision. All comments received, together with the applicant's responses, will be included in the Comments and Response Report, which will be made available to I&APs for information, and submitted to the MET:DEA together with the report to help them with taking a decision or making additional recommendations regarding the impact assessment phase.

1 INTRODUCTION

This section provides a brief overview of the project and the legislated Social and Environmental Impact Assessment (SEIA) process to be followed and guides the reader as to where certain information may be found within the document.

Rio Tinto Rössing Uranium Limited (Rössing Uranium) has operated an open pit uranium mine in the Erongo Region of Namibia since 1976. As a result of reduced uranium prices, Rössing Uranium is urgently considering ways to enhance efficiency and overall economic viability of their mining operations near Arandis. Rössing Uranium currently purchases water through NamWater, which constitutes a significant overhead cost for the mine. The Erongo Region is a water scarce environment, relying predominantly on the Omaruru Delta (Omdel) aquifer for its supply. The Erongo region is also a centre for growth in Namibia and central to the country's economic vitality. As the demand for water increases, so does the value of water supplied. Rössing Uranium has determined that securing its own water supply, by way of a seawater desalination plant, may save costs and lead to a more efficient and resilient mining operation.

Rössing Uranium is investigating the design, constructing and operating of a new desalination plant, approximately 10km north of Swakopmund, to supply the mine's water needs. SLR Environmental Consulting (Namibia) (Pty) Limited (SLR), in association with Aurecon Namibia (Pty) Ltd (Aurecon), have been appointed as the independent environmental consultants and tasked to undertake the Social and Environmental Impact Assessment (SEIA) process for the proposed desalination plant.

The aim of the SEIA process is to identify and investigate potentially significant socio-economic and bio-physical impacts associated with the proposed project and provide an opportunity for the public and key stakeholders to provide input and participate in the process. Lastly, based on specific nature of the potentially affected environment, specialist input will be sourced as required.

This Scoping report is structured as follows:

- Section 2: Provides an overview of the legislation and policy framework for the SEIA process. The SEIA will be undertaken in compliance with the relevant Namibian environmental legislation as well as taking into account international best practice for impact assessments. The SEIA involves a public participation process which is aimed at providing stakeholders and the general public the opportunity to become involved and raise concerns or make comments about the proposed project. This is considered a fundamental to ensure the integrity of the environmental assessment process.
- Section 3: Provides a conceptual overview of the proposed project and project components. In addition, a description of potential design option alternatives is provided and a summary of the advantages and disadvantages of the various alternatives is provided. All feasible alternatives will remain under consideration and the preferred alternative will only be determined and investigated in detail, in the SEIA phase.
- Section 4: provides a summary and the key advantages and disadvantages of the various project alternatives currently under consideration.
- Section 5: Provides an overview of the social and environmental characteristics of the study area at present and onto which any potential impacts will be superimposed.
- Section 6: Aims to describe the potentially significant impacts associated with the proposed desalination plant activities and infrastructure that have been identified to date and identifies the specialist investigations.
- Section 7: Outlines the assessment methodology that will be undertaken to assess the identified impacts and provides and Terms of Reference for the SEIA phase.

- Section 8: Describes the public participation process that has been conducted to date. The Public Participation Process has incorporated the requirements of Namibia's legislation, southern African Development Community (SADC) guidelines and the Namibian EIA Regulations.
- Section 9: This section concludes the report and briefly touches on a few key procedural aspects going forward.

In terms of the Environmental Assessment Policy of 1995, the Environmental Management Act (Act 7 of 2007) (Environmental Impact Assessment (EIA) Regulations of Government Notice 28, 29, and 30 promulgated on 6 February 2012, the activities required for the construction of the proposed desalination plant requires an Environmental Clearance Certificate from the competent authority, namely the Department of Environmental Affairs at the Ministry of Environment and Tourism (MET:DEA). On completion of the SEIA process a final SEIA Report will be submitted to the MET:DEA, who are required to take an informed decision as to whether the project may proceed on social and environmental grounds.

The SEIA process will be undertaken in accordance with the above mentioned EIA Regulations. A flow diagram below provides an outline of the SEIA process that is being followed, with opportunities to participate in the process highlighted in bold font. More details regarding the Public Participation Process is provided in Section 8.

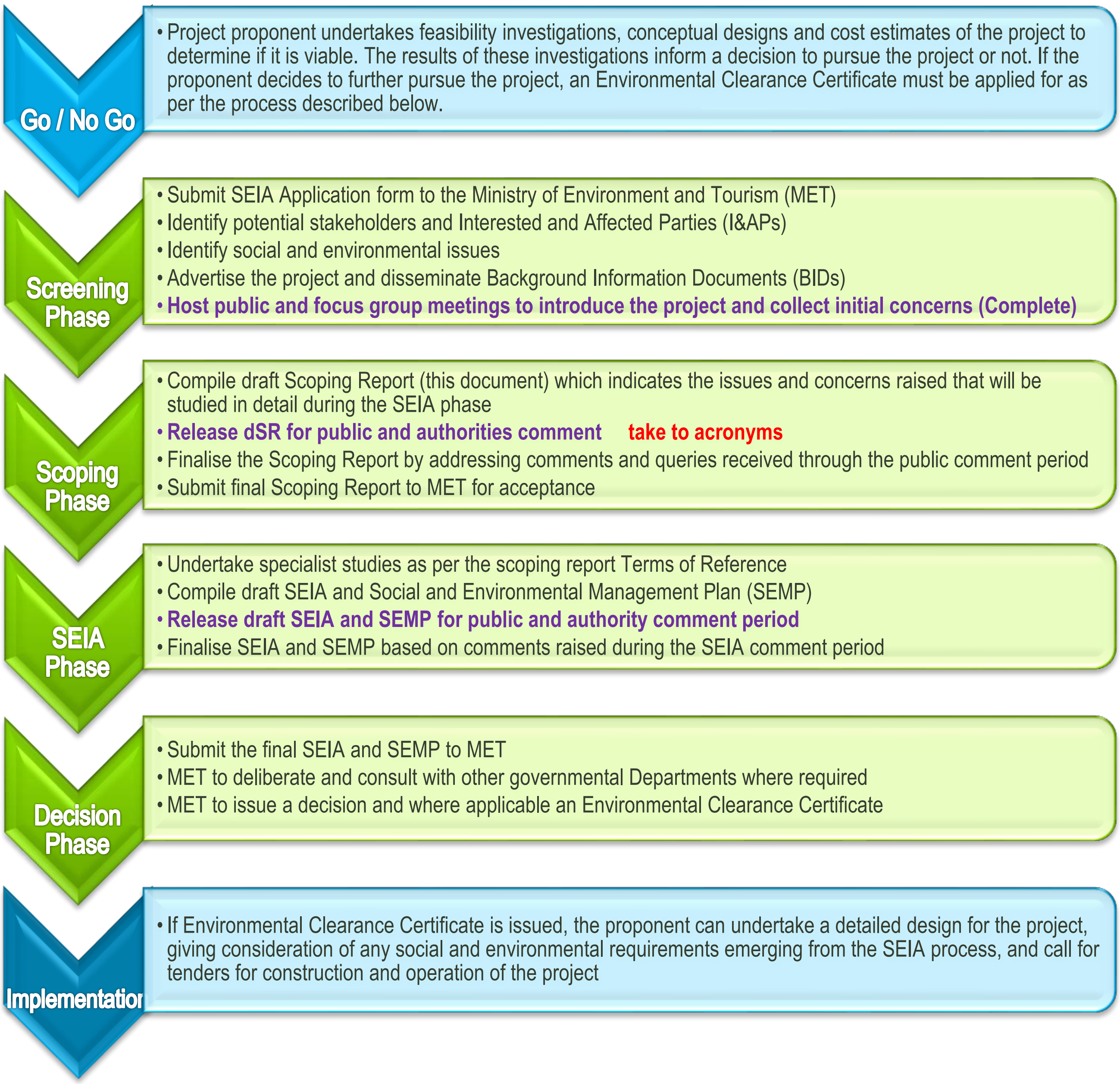

Figure 1: SEIA process overview

2 LEGAL FRAMEWORK

This section provides an overview of the legislation and policy framework for the SEIA process. The SEIA will be undertaken in compliance with the relevant Namibian environmental legislation, as well as taking into account international best practice for impact assessments. The SEIA involves a public participation process which is aimed at providing stakeholders and the general public the opportunity to become involved and raise concerns or make comments about the proposed project. This is considered fundamental to ensure the integrity of the environmental assessment process.

Much of the legislation outlined below has applicability from a biophysical perspective. While certain relevance is highlighted, such documents are relevant on a variety of levels.

2.1 The Constitution of the Republic of Namibia (Act 1 of 1990)

There are two clauses contained in the Namibian Constitution that are of particular relevance to sound environmental management practice, viz. Articles 91(c) and 95(l). In summary, these refer to:

- Guarding against over-utilisation of biological natural resources;
- Limiting over-exploitation of non-renewable resources;
- Ensuring ecosystem functionality;
- Protecting Namibia's sense of place and character;
- Maintaining biological diversity; and
- Pursuing sustainable natural resource use.

The above therefore commits the State to actively promote and sustain environmental welfare of the nation by formulating and institutionalising policies to accomplish the abovementioned sustainable development objectives.

2.2 Environmental Management Act (Act 7 of 2007)

In giving effect to Articles 91(c) and 95(l) of the Constitution of Namibia, general principles for sound management of the environment and natural resources in an integrated manner have been formulated. This resulted in the Environmental Assessment Policy of 1995. To give statutory effect to this Policy, the Environmental Management Act (Act 7 of 2007) was gazetted on 27 December 2007 in, Government Gazette No. 3966. Part 1 of the Environmental Management Act describes the various rights and obligations that pertain to citizens and the Government alike, including an environment that does not pose threats to human health, proper protection of the environment, broadened *locus standi*[1] on the part of individuals and communities, and reasonable access to information regarding the state of the environment. Part 2 of the Act sets out a number of principles of environmental management, as follows:

[1] *The right or capacity to bring an action or to appear in a court, from Latin: a place for standing.*

- Renewable resources shall be utilized on a sustainable basis for the benefit of current and future generations.
- Community involvement in natural resource management and sharing in the resulting benefits shall be promoted and facilitated.
- Public participation in decisions affecting the environment shall be promoted.
- Fair and equitable access to natural resources shall be promoted.
- Equitable access to sufficient water of acceptable quality and adequate sanitation shall be promoted and the water needs of ecological systems shall be fulfilled to ensure the sustainability of such systems.
- The precautionary principle and the strategy of preventative action shall be applied.
- There shall be prior environmental assessment of projects and proposals which may significantly affect the environment or use of natural resources.
- Sustainable development shall be promoted in land-use planning.
- Movable and immovable cultural and natural heritage, including biodiversity, shall be protected and respected for the benefit of current and future generations.
- Generators of waste and polluting substances shall adopt the best practicable environmental option to reduce such generation at source.
- The polluter pays principle shall be applied.
- Reduction, reuse and recycling of waste shall be promoted.
- There shall be no importation of waste into Namibia.
- Promotion of the coordinated and integrated management of the environment.
- The Minister of Environment and Tourism was enabled to give effect to Namibia's obligations under international environmental conventions.
- Sustainable Development Commission and Environmental Commissioner have been provided for.

As the organ of state responsible for the management and protection of its natural resources, the MET:DEA is committed to pursuing these principles of environmental management.

The recently gazetted regulations promulgated in terms of the Environmental Management Act, identify certain activities which could have a substantially detrimental effect on the environment. These listed activities require Environmental Clearance from the competent environmental authority, i.e. MET:DEA, prior to commencing. The following activities identified in the regulations apply to the proposed project:

Table 1: List of potential activities triggering the need to conduct a SEIA

ACTIVITY	DESCRIPTION OF RELEVANT ACTIVITY	RELEVANCE
Activity 1 (b) ~ Energy generation, transmission and storage activities	The construction of facilities for the transmission and supply of electricity.	A new 11kV powerline will link to the plant to the substation near Swakopmund.
Activity 7.8 ~ Agriculture and aquaculture activities	The introduction of alien species into local ecosystems.	A new biological treatment process (Progreen®), that prevents the need for chemical pre-treatments, may be used. This system / plant may be seeded with foreign microorganism species (to be confirmed).
Activity 8.1 ~ Water Resource Developments	The abstraction of ground or surface water for industrial or commercial purposes.	Seawater will be abstracted to supply the plant.
Activity 8.5 ~ Water Resource Developments	Construction of dams, reservoirs, levees and weirs.	A new pond may be constructed near the Swakopmund Salt Works to serve as a stilling basin and abstraction point. This is not in a river system, but rather an extension of the existing Swakopmund Salt Works seawater ponds.

ACTIVITY	DESCRIPTION OF RELEVANT ACTIVITY	RELEVANCE
Activity 8.6 ~ Water Resource Developments	Construction of industrial and domestic wastewater treatment plants and related pipeline systems.	The desalination plant may undertake effluent treatment (or conditioning) prior to discharge to the ocean.
Activity 8.12 ~ Water Resource Developments	The release of brine back into the ocean by desalination plants.	The desalination plant will discharge brine back to the ocean.
Activity 9.1 ~ Hazardous substance treatment, handling and storage	The manufacturing, storage, handling or processing of a hazardous substance defined in the Hazardous Substances Ordinance, 1974.	The desalination plant may store chlorine gas for the pre-treatment of seawater.
Activity 9.2 ~ Hazardous substance treatment, handling and storage	Any process or activity which requires a permit, licence or other form of authorisation, or the modification of or changes to existing facilities for any process or activity which requires an amendment of an existing permit, licence or authorisation or which requires a new permit, licence or authorisation in terms of a law governing the generation or release of emissions, pollution, effluent or waste.	The discharge of the brine back into the ocean requires an effluent discharge permit from the Ministry of Water Affairs and Forestry. Any sewage discharged into municipal sewerage systems would also have to be included in the effluent discharge permit.
Activity 10.1 ~ Infrastructure	The construction of- (a) oil, water, gas and petrochemical and other bulk supply pipelines; and (e) any structure below the high water mark of the sea.	(a) the project requires the construction of a seawater pipeline from the intake structure to the plant and the construction of a product water pipeline from the plant to the NamWater tie in point. (e) The construction of the seawater intake systems and brine outlet may result in construction activities below the high water mark.

2.2.1 Environmental Guidelines

Section 5 of the Environmental Management Act states that if a proposal is likely to affect people, the following guidelines should be considered in Scoping:

- The location of the development in relation to I&APs, communities or individuals;
- The number of people likely to be involved;
- The reliance of such people on the resources likely to be affected, the resources, time and expertise available for scoping;
- The level of education and literacy of parties to be consulted;
- The socio-economic status of affected communities;
- The level of organisation of affected communities;
- The degree of homogeneity of the public involved;
- History of any previous conflict or lack of consultation;
- Social, cultural or traditional norms within the community; and
- The preferred language used within the community.

The MET also released Draft Procedures and Guidelines for conducting impact assessments and compiling management plans in April 2008. These guidelines outline the procedures and principles that are to be followed and will be consulted throughout the SEIA process.

2.2.2 Content of Scoping Report

Section 8 of the gazetted impact assessment Regulations requires specific content to be addressed in the Scoping Report. Table 2 below provides the required contents of a Scoping Report (as per the Environmental Management Act) and assists the reader to find the relevant information in this report.

Table 2: Requirements in terms of Environmental Management Act Regulation 30 pertaining to Scoping Phase

REGULATION	REQUIREMENT	RELEVANT SECTION
8 (a)	The curriculum vitae of the EAPs who prepared the report.	Annexure A
8 (b)	A description of the proposed activity.	Sections 3
8 (c)	A description of the site on which the activity is to be undertaken and the location of the activity on the site.	Sections 3
8 (d)	A description of the environment that may be affected by the proposed activity and the manner in which the geographical, physical, biological, social, economic and cultural aspects of the environment may be affected by the proposed listed activity.	Sections 5
8 (e)	An identification of laws and guidelines that have been considered in the preparation of the scoping report.	Section 2
8 (f)	Details of the public consultation process conducted in terms of Regulation 7(1) in connection with the application, including: ~	Section 7
	• The steps that were taken to notify potentially interested and affected parties of the proposed application;	Section 7
	• Proof that notice boards, advertisements and notices notifying potentially interested and affected parties of the proposed application have been displayed, placed or given;	Annexure B3 & B4
	• A list of all persons, organisations and organs of state that were registered in terms of Regulation 22 as I&APs in relation to the application; and	Annexure C7
	• A summary of the issues raised by interested and affected parties, the date of receipt of and the response of the EAP to those issues.	Annexure C8
8 (g)	A description of the need and desirability of the proposed listed activity and any identified alternatives to the proposed activity that are feasible and reasonable, including the advantages and disadvantages that the proposed activity or alternatives have on the environment and on the community that may be affected by the activity.	Sections 3.2 and 4
8 (h)	A description and assessment of the significance of any significant effects, including cumulative effects, that may occur as a result of the undertaking of the activity or identified alternatives or as a result of any construction, erection or decommissioning associated with the undertaking of the proposed listed activity.	To follow in the SEIA Phase report
8 (i)	Terms of reference for the detailed assessment.	Section 0

2.3 Water Resources Management Act (Act 24 of 2004)

This Act provides a framework for managing water resources based on the principles of integrated water resources management. It provides for the management, development, protection, conservation and use of water resources. Relevant principles of the Act include, *inter alia*:

- Equitable access for all people to safe drinking water is an essential basic human right to support a healthy productive life;
- Harmonisation of human water needs with the requirements of environmental ecosystems and the species that depend on them, while recognising that the water resource quality for those ecosystems must be maintained;
- Promotion of the sustainable development of water resources based on an integrated water resources management plan which incorporates social, technical, economic, and environmental issues;
- Development of the most cost effective solutions, including conservation measures, to infrastructure for the provision of water; and
- Promotion of water awareness and the participation of persons having interest in the decision-making process should form an integral part of any water resource development initiative.

This Act is relevant since the project will abstract seawater and discharge effluent back to the ocean, with product water being entered into the NamWater system. In terms of the Act "water source" is defined as “water from a watercourse, an aquifer or the sea, and includes meteoric water” while "water resource" includes a “watercourse, an aquifer and the sea and meteoric water” and thus the provision of the Act apply to seawater abstraction.

The consequence is that Rössing Uranium will have to obtain a licence to abstract and use seawater and will have to comply with the various provisions of the Act set out in Part VIII of the Act (Sections 32 to 45). Section 32 prohibits the abstraction or use of water without a licence and significantly specifically states that the term “abstract water” includes the abstraction of marine water for any purpose (Section 32(1)). The required Water Use License will be applied for by Rössing Uranium independently and as a separate process to the SEIA.

There are a number of requirements which must accompany the application to abstract water. Of particular importance is Section 33(3)(c) which stipulates that an application for a licence to abstract and use water must be accompanied by a number of requirements including “an environmental impact analysis of the proposed abstraction of water upon the environment and existing water users and water resources” .

Part XI of the Act (Sections 56 to 71) which deals with Water Pollution Control is relevant to the proposed desalination plant in light of the brine discharges back to the ocean. The opening section stipulates that a person may not discharge effluent directly or indirectly to any ‘water resource’ (defined to include the sea as seen above) unless such person is in compliance with a permit issued in terms of Section 60. The term “effluent” is defined to mean “…any liquid discharged as a result of domestic, commercial, industrial or agricultural activities”. Section 59 gives details on the information required for an effluent discharge permit.

It should be noted that this may be repealed by the new Water Resources Management Act (Act 11 of 2013), which has been accepted by parliament but not yet promulgated. Under the new act, Rössing Uranium may be required to register as a water services provider in terms of Section 41, which reads:

41 (1) A person may not operate as a water services provider without holding a licence as a water services provider issued by the Minister under this Act that authorises the person -
(a) to distribute water to end-consumers; and
(b) to operate a water treatment facility.

Under the new Act, a combined abstraction and discharge licence may also be applied for in terms of Section 47, as follows:

47. The Minister may, with the consent of the applicant concerned, grant a combined licence to abstract and use water and to discharge effluent if the requirements prescribed by this Act for a separate licence for each type of work or activity are complied with.

Rössing Uranium acknowledges the requirements in terms of the new Act and will adhere to these as required after promulgation.

2.4 The National Heritage Act (Act 27 of 2004)

The Act makes provision for the protection and conservation of places and objects of heritage significance and the registration of such places and objects. The National Heritage Council has been established to identify, conserve, manage and protect places and objects of heritage significance.

2.5 The Soil Conservation Act (Act 76 of 1969)

The Act makes provision for the prevention and control of soil erosion and the protection, improvement and conservation of soil, vegetation and water supply sources and resources, through directives declared by the Minister.

Care is to be taken in identifying any potential impacts on soil, vegetation and water supply sources and resources and firstly try to avoid these impacts, but where they can't be avoided, implement management measures to reduce the significance of the impact(s).

2.6 The National Policy on Coastal Management for Namibia (2013)

The policy aims to "provide a framework to strengthen governance in Namibia's coastal areas to realise long-term national goals defined in Vision 2030 and the more specific targets of National Development Plans, namely sustainable economic growth, employment creation and reduced inequalities in income". One of the objectives of the policy is to provide a foundation for improving the quality of life of coastal communities while doing so responsibly. The proposed project is therefore in line with this policy as it aims to increase water security.

2.7 The Integrated Coastal Management Bill (2014)

Once enacted the bill aims to establish a system of integrated coastal management in Namibia in order to promote the conservation of the coastal environment, maintaining the natural attributes of the coastal landscapes and seascapes, and ensuring the sustainable development and use of the natural resources within the coastal zone that is also socially, economically and ecologically justifiable. To define the rights and duties in relation to coastal areas; to determine the responsibility of the organs of state in relation to the coastal areas; to control pollution in the coastal zone, development of the coastal environment and other adverse effects on the coastal environment; to give effect to Namibia's international obligations in relation to coastal matters; and to provide for related matters connected therewith.

2.8 The National Policy on Human-Wildlife Conflict Management (2009)

The aim of the policy is to manage human-wildlife conflict efficiently and effectively, for example the destruction of water supply infrastructure.

The location of the project near the Dorob National Park and Important Bird Area of the salt pans necessitates the need to address potential conflicts between humans and wildlife during the construction phase as well as the operational phase.

2.9 Proposed Climate Change Strategy and Action Plan (2009)

The purpose of this document is to put Namibia's commitment to achieving its Millennium Development Goals into action. The plan list, *inter alia*, the following guiding principles:

- Sustainable development and ensuring environmental sustainability;
- Sustainable and equitable use of natural resources; and

- Human rights-based development.

The project therefore addresses some of the above as it will increase water security, as well as provide a medium-term integrated water supply system that would ensure sustainable utilisation of the available resources.

2.10 The Namibia Vision 2030

The principles that underpin Vision 2030[2], a policy framework for Namibia's long-term national development, comprise the following:

- Good governance;
- Partnership;
- Capacity enhancement;
- Comparative advantage;
- Sustainable development;
- Economic growth;
- National sovereignty and human integrity;
- Environment; and
- Peace and security.

Vision 2030 states that natural environments are disappearing quickly. Consequently the solitude, silence and natural beauty that many areas in Namibia provide are becoming sought after commodities and must be regarded as valuable natural assets. Vision 2030 emphasises the importance of promoting healthy living which includes that the majority of Namibians are provided with safe drinking water. The importance of developing wealth, livelihood and the economy is also emphasised by Vision 2030. This includes infrastructure provision like transport, communication, water and electricity. This development will improve the viability of the Rössing Uranium mine, a significant employer and contributor to the local economy. Rössing Uranium's desalination plant will also inadvertently free up much needed water in the Erongo region which can be applied to alternative social and developmental objectives in the region.

2.11 Biodiversity Legislation and Policies

The following legislation and policies, aimed at biodiversity conservation and management, may also be relevant for the proposed project:

- Convention on Biological Diversity (2000);
- Convention to Combat Desertification (1997);
- RAMSAR Convention (1975);
- Soil Conservation Act (Act 76 of 1969);
- United Nations Framework Convention on Climate Change (1992); and
- Climate Change Policy (draft).

[2] *Derived from Namibia's Green Plan drafted by MET in 1992 and followed by the sequence of National Development Plans.*

The applicability of the aforementioned policies and legislation will be explored in further detail during the SEIA phase, based on the findings of the impact assessment and specialist investigations. The applicability and relevance of the legal framework will unfold during the SEIA phase.

2.11.1 Rio Tinto Environmental and Sustainability Policies[3]

The following policy statement is provided on the Rio Tinto web page and provides a brief overview of their sustainability policies.

Sustainable development is commonly defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. While it cannot be achieved by one organisation on its own, Rio Tinto believe that our business can make an important contribution to the ongoing, global transition to sustainable development.

Because Rio Tinto recognise that we have a responsibility to all our stakeholders and to the wider world, our commitment to sustainable development is integrated into everything we do. Rio Tinto operations give us the opportunity to bring long-lasting positive change to the communities, regions and countries where we work, and our metals and minerals are transformed into end products that contribute to higher living standards.

To build and protect Rio Tinto’s reputation, we have a relentless focus on embedding and living our values – accountability, respect, teamwork and integrity – and on deepening our sustainable development capabilities.

Rio Tinto must maintain safety as our absolute priority – eliminating workplace fatalities, and continuing to reduce incident, injury and illness rates towards our goal of zero harm. Recognising that strong leadership is essential for achieving our safety goals, we will continue to improve our leaders’ engagement around safety risks.

Rio Tinto’s approach to sustainable development and business integrity are, we believe, competitive advantages for us. They help us gain access to high quality resources and business development opportunities. In addition they allow us to attract talented people, engage with communities, reduce environmental impacts, manage risks effectively and decrease operating costs. This enables us to give more confidence, and deliver higher returns, to our stakeholders. Key policy aims are to:

- Wherever possible we prevent, or otherwise minimise, mitigate and remediate, harmful effects of the Group’s operations on the environment.
- Excellence in environmental performance is essential to our business success. Compliance with all environmental laws and regulations is the foundation on which we build our environmental performance.
- Rio Tinto develops Group wide standards and builds systems to identify, assess and manage environmental risk to achieve continuous improvement in environmental performance.
- Rio Tinto businesses, projects, operations and products should contribute constructively to the global transition to sustainable development.
- Rio Tinto contributes to sustainable development by helping to satisfy global and community needs and aspirations, whether economic, social or environmental. This means making

[3] *Source: http://www.riotinto.com/sustainabledevelopment2012/strategy/our_sustainable_development_strategy.html*

sustainable development considerations an integral part of our business plans and decision making processes.

2.11.2 Rössing Uranium Limited Policies

In order to accomplish Rössing Uranium's vision and commitment to social responsibility and sustainability, Rössing Uranium will:

- Commit to operate Rössing Uranium's business with respect and care for both the local and global environment in order to prevent and mitigate residual pollution;
- Be in full compliance with all applicable legislation, standards and requirements;
- Provide adequate training and resources to employees, contractors and visitors; and
- Enhance biodiversity protection by assessing and considering ecological values and land-use aspects in investment, operational and closure activities.

2.12 Social Policies

2.12.1 The MET Policy on HIV & AIDS

The relevance of this policy for the proposed project stems from the fact that construction activities may involve the establishment temporary construction workforce. Experience with other construction projects in a developing-world context has shown that, where construction workers have the opportunity to interact with local community, a significant risk is created for the development of social conditions and behaviors that contribute to the spread of Human Immune-deficiency Virus (HIV) and Acquired Immune Deficiency Syndrome (AIDS).

In response to the threat the pandemic poses, MET has developed a policy on HIV and AIDS. This policy, which was developed with support from United States Agency for International Development (USAID) and German Federal Enterprise for International Cooperation (GTZ) a (German Development Fund), provides for a non-discriminatory work environment and for workplace programs managed by a Ministry-wide committee.

3 PROJECT DESCRIPTION

The purpose of this Chapter is to provide a conceptual overview of the conceptual project and project components. In addition, a description of potential alternatives is provided and a summary of the advantages and disadvantages of the various alternatives are provided.

3.1 A background to desalination

As the global human population expands so does the pressure on the environment to provide adequate quantities of clean water for ecological, domestic, industrial, and agricultural purposes. Global water supplies are rapidly approaching upper supply limits and in many countries where resources are already overexploited, resulting in significant impacts to both social and biophysical environments. The number of people affected by water scarcity is expected to grow from approximately half a billion in 1995 to over four and half billion by 2050. Increasing human population drives ongoing industrial and agricultural development and urbanisation, amongst other water intensive pursuits. This situation is compounded by growing environmental problems such as desertification, soil erosion and deforestation, loss of wetlands and other impacts which either reduce the supply potential or increase the demand potential.

This background reveals the growing need to seek and implement alternative water supply strategies in order to secure adequate fresh water and cater for future demand without causing irreparable harm to existing fresh water resources. The world's total water resources are comprised of 97.5% saltwater and only 2.5% freshwater. Of the 2.5% freshwater, a mere 0.3% is available in lakes and rivers, 30.8% is found as groundwater (which includes soil moisture, swamp water and permafrost), and the remaining 68.9% is locked up as ice as glaciers and areas covered permanently in snow (Figure 2).

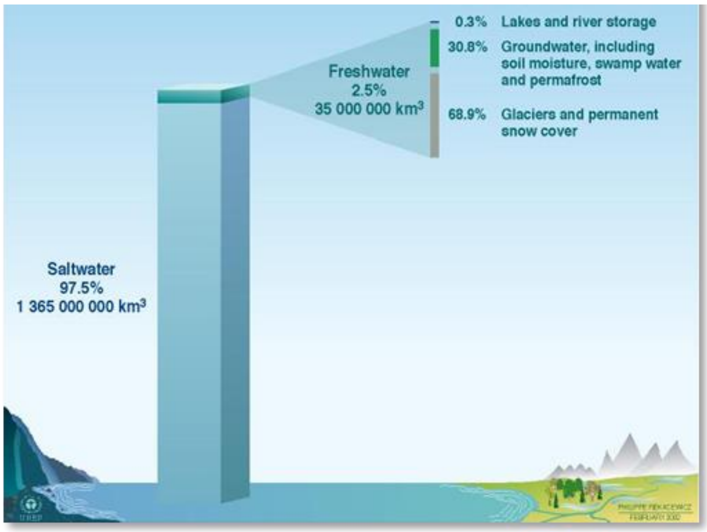

Figure 2: Total global water resource estimates[4]

[4]Source: UNEP. 2010.

Desalination of saltwater therefore provides a means to access a vast supply of water from the world's oceans. Consequently there has been an increasing interest and investment into desalination since its conception. Many coastal areas, arid and/or island nations have had to resort to desalinated water for potable and development needs as demand currently outstrips the supply of traditional freshwater resources. The regions and rate of growth in the desalination industry between 1950 and 2006 are depicted in Figure 3. With the rapid growth and development of the desalination industry, the technology has undergone continual refinement, becoming more energy and cost efficient as the technology matures. Desalination is able to provide safe, high quality water at virtually any quantity, provided the required energy requirements can be met and not only is water available during drought periods, but it also alleviates pressures on the freshwater resources[5].

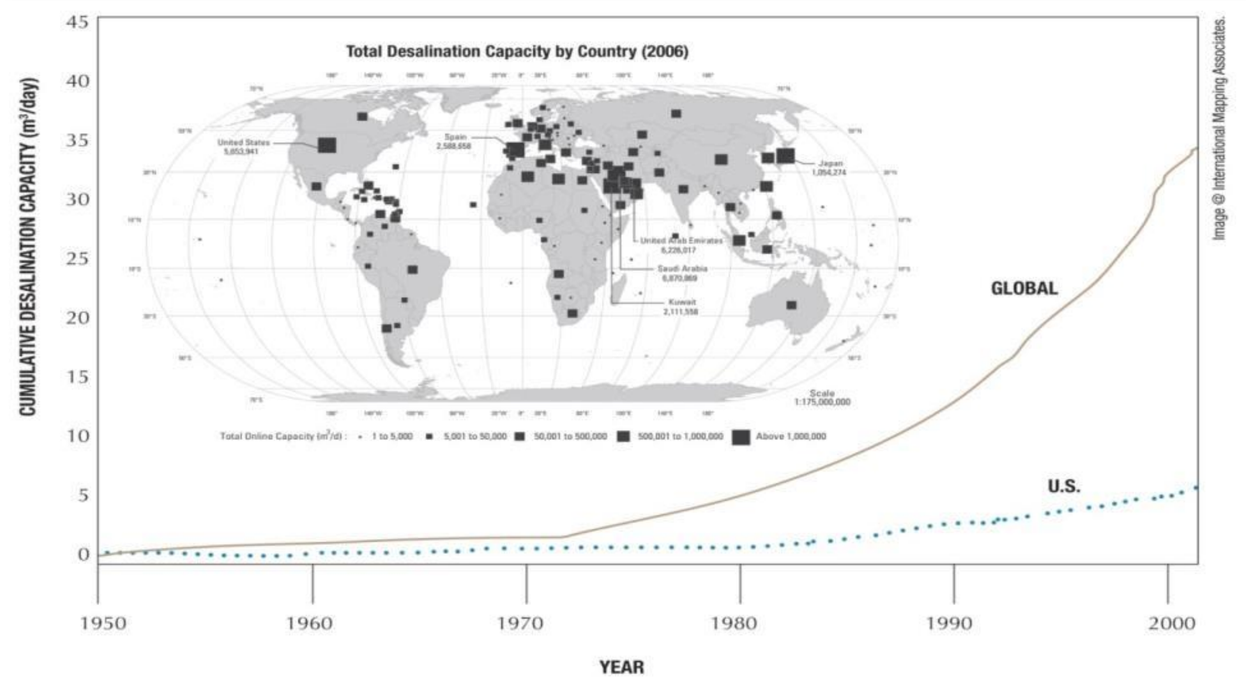

Figure 3: Cumulative desalination capacity of the world[6]

Desalination has emerged as one of the leading alternative water supply strategies internationally. The technology has been used on a small scale on ships and submarines; however it is now increasingly being used on a larger scale to provide potable water for human consumption. The technology has been around since the mid-twentieth century, and has become common practise in some of the more populous and arid regions of the world. Regional centres, where desalination plants are prominent include the Mediterranean Sea, the Red Sea, the Caribbean, and the coastal areas of China and Australia[7].

[5]*Source: UNEP, 2008.*
[6]*Source: UNEP, 2008.*
[7]*Source: UNEP, 2008.*

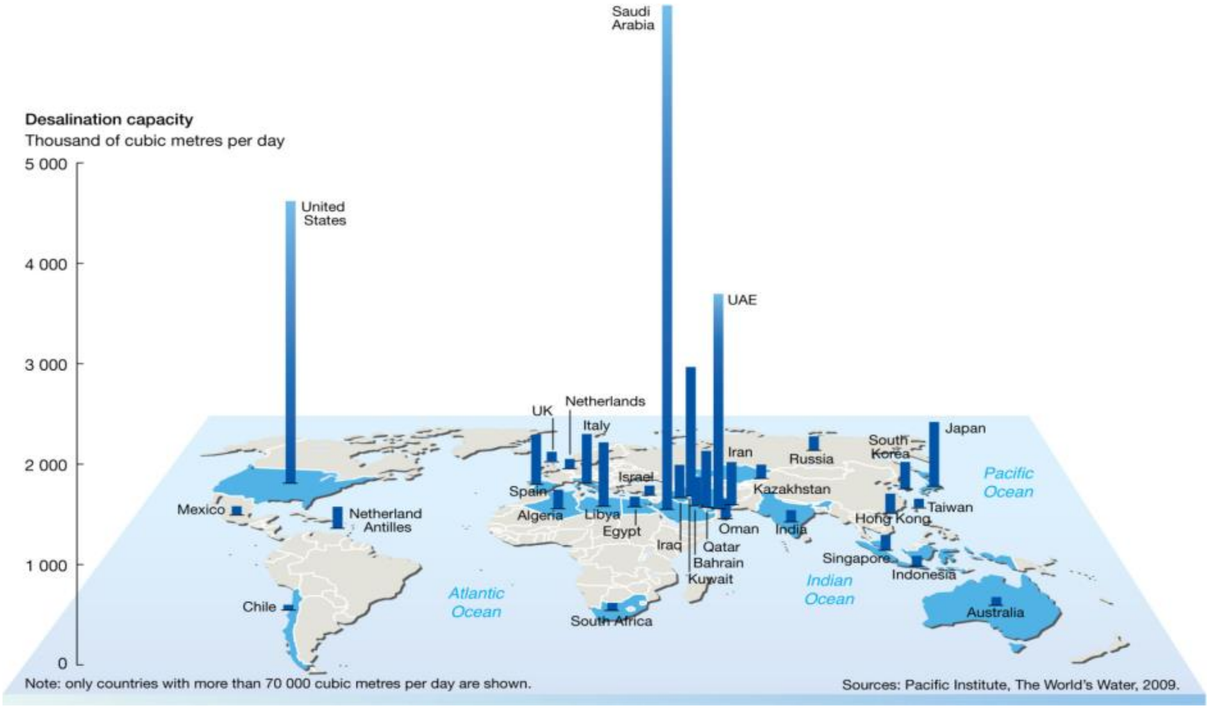

Figure 4 depicts the total global installed desalination capacity as of 2009.

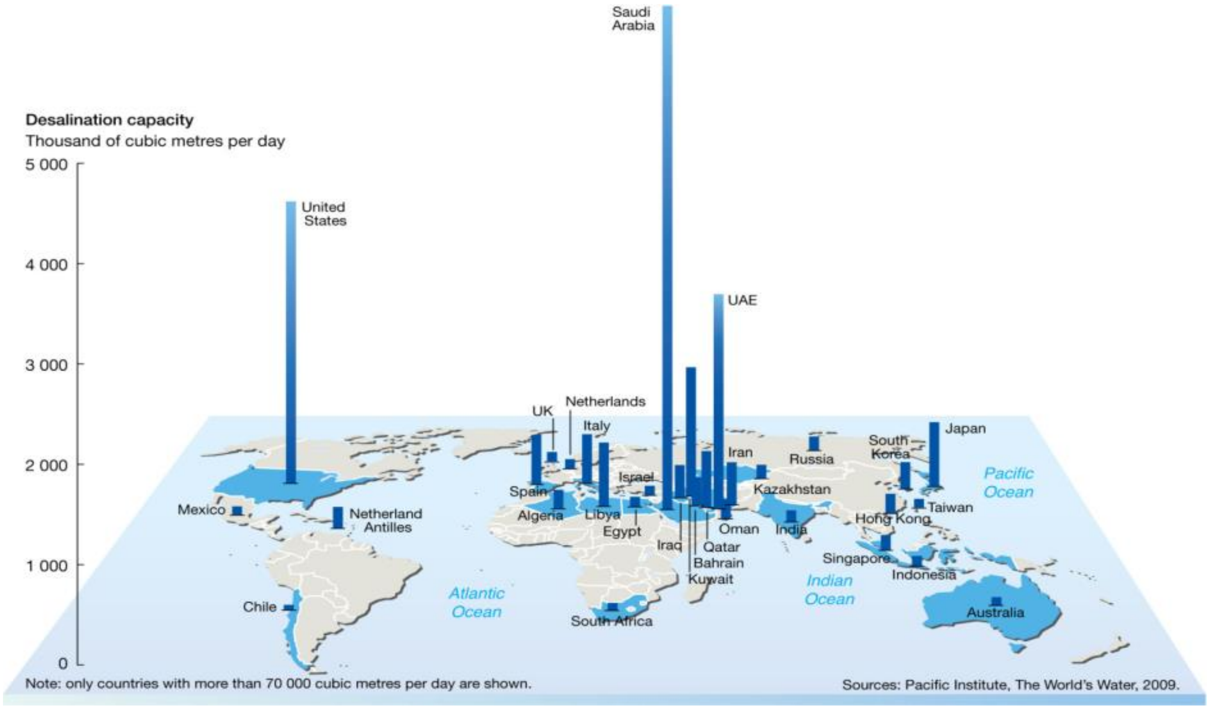

Figure 4: Regions of the world which have implemented desalination plants/facilities[8]

Desalination offers a number of socio-economic, environmental and public health benefits resulting in the technologies having undergone rapid and extensive development, and is now considered a mature technology. There are a number of desalination plants in operation across southern Africa , and they are likely to become more prevalent in future.

[8] *Source: Pacific Institute. 2010.*

Desalination refers to a suite of processes, whereby clean water is separated from polluted, brackish or sea-water by effectively removing the dissolved mineral salts and other impurities. The process separates the feed water into two streams, one clean water stream and one containing all dissolved matter removed. The effluent stream typically has the same chemical make-up as the original feed water only that the minerals and impurities are at a concentrated level.

The technology that will be employed by the Rössing Uranium desalination plant is referred to as reverse osmosis (RO). The process purifies water by removing dissolved mineral salts and other impurities from seawater[9], making it suitable for human consumption. Desalination technology is now being used increasingly as a means of providing fresh water for human consumption in regions with a scarcity of water resources or where the demand for potable (drinking) water is exceeding traditional freshwater supplies.

Seawater is abstracted from the ocean and pumped to the desalination plant where it is placed under pressure in the presence of a semi-permeable membrane. This pressurisation process can be energy intensive. As a result of the high pressures exerted on the seawater, water molecules escape through the semi-permeable membrane, leavening behind the impurities such as mineral salts and dissolved organic matter, as shown in Figure 5. This is mostly as a result of the physiological size of the water molecule as in comparison with the impurities it adheres to. The pressure applied is enough to break the chemical bonds and overcome osmotic pressure and is why it is referred to a RO.

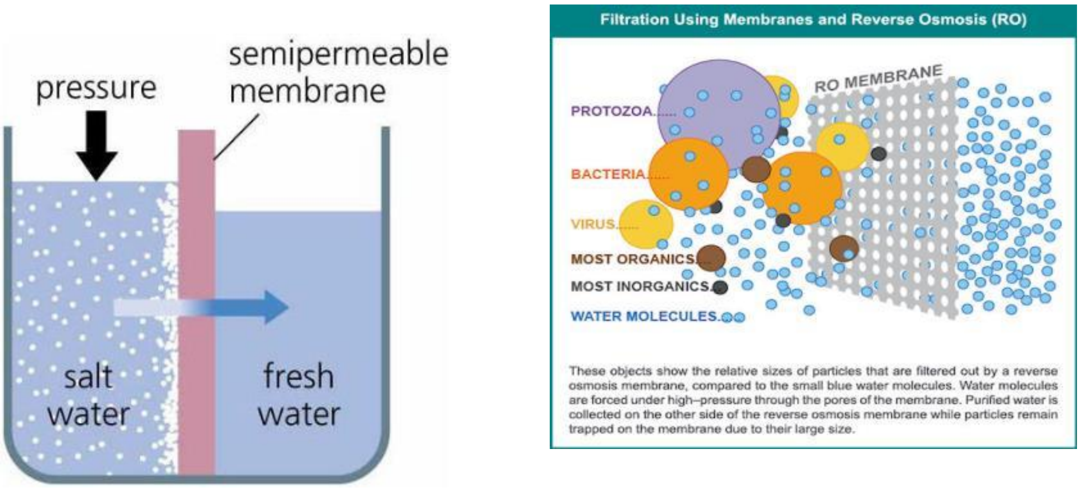

Figure 5: Principle of RO and semi-permeable membrane[10]

The freshwater or permeate produced by the RO process, which represents approximately 40% of the feed water, is devoid of almost all impurities. This results in the water becoming aggressively corrosive as it attempts to reform molecular bonds with substances in its environment. In this form it can be damaging to municipal and domestic water reticulation infrastructure, including pipework and pumps due to its strong oxidative chemistry, and is unfit for human consumption. To address this, permeate must undergo a re-mineralisation process to reduce these corrosive characteristics and make it suitable for distribution and human consumption. Alternatively, permeate can be pumped to reservoirs where it is allowed to dilute

[9] *Note: Desalination technologies are also employed for the treatment of brackish water, the recycling of wastewater and treatment of effluents.*
[10] Source: http://images.yourdictionary.com/reverse-osmosis and http://sfwater.org/detail.cfm/MC_ID/13/MSC_ID/377/C_ID/5163/ListID/1

with fresh water from other water sources (containing more impurities) as a means of diluting and reducing these oxidative characteristics.

The brine or highly concentrated seawater left behind, consists of about 60% of the total seawater intake volume and contains all the impurities and mineral salts that were unable to pass through the membrane during the RO process. The brine is typically discharged back to the ocean and allowed to dilute back to ambient levels. Other concentrate disposal options include deep well injection into aquifers (not affecting aquifers used for other purposes), land application, evaporation ponds, brine concentrators and zero liquid discharge technologies.

3.2 Project Need and Desirability

As of the 1st of November 2013, Rössing Uranium has been receiving water from the desalination plant built by Areva at Wlotzkasbaken. For years, it has been known to both NamWater and the mines in the Central Coastal Area that the Omdel underground aquifer has been depleting and that this would be unable to sustain the coastal towns and the mines at the current rate of abstraction.

When the Trekkopje mine was built by Areva, Areva were required to provide their own desalination plant, as they would not be able to obtain water from the Omdel aquifer. The permissible Omdel aquifer abstraction was formally reduced on 31 October 2013 by the Ministry of Agriculture, Water and Forestry (MAWF) from 9Mm^3 to 4.5Mm^3. Therefore, as from the 1st of November 2013, all the mines in this region were transferred to desalinated water supply from the Areva plant.

The desalinated water from the Areva plant is extremely expensive. The water is purchased on a take or pay arrangement on unfavourable commercial terms, the only terms to which NamWater, the country's official water distributor, was prepared to enter into a back to back arrangement between the mines and Areva for this water supply. The water from this source will always remain expensive.

The Areva desalination plant was built to serve a capacity of 20Mm^3 per annum, with a power feed equivalent to provide electricity for 40Mm^3. The three mines currently in operation and development require in total 6Mm^3 per annum, and the demand will grow to approximately 10Mm^3 per annum over the next three years. The smaller off-take therefore has to cover the fixed charges and related finance charges to a plant that has been over-specified for the present situation.

The production of desalinated water at between US$2.00/m^3 and US$2.50 is widely accepted as a benchmark cost for desalinated water. Several years of negotiation attempts between Rössing Uranium and the key stakeholders have however remained unsuccessful in bringing the cost of water into this cost envelope. Progress on the NamWater Mile 6 plant has also been slow, and the October 2014 date for completion of that plant will not be met. This leaves the mining community exposed to the current very high desalination water costs as the only alternative supply of water to the supply from the Omdel aquifer, at least for the next five years.

Rössing Uranium's off-take is approximately 3Mm^3 per annum. Therefore it effectively carries half the cost of this plant. In 2012 (the last full year on aquifer water), Rössing Uranium's water cost was N$32 million. In 2014 (the first full year on desalinated water), the cost for water is expected to be N$132 million.

Where Rössing Uranium manages to take its full allocation of water in terms of the take or pay arrangement, the average cost of the water is approximately US$4.50/$m^3$ (inclusive of conveyancing costs). However, in the two months where Rössing Uranium suffered curtailed operations due to an unfortunate leach tank failure, the effective unit cost of water became approximately US$9.00/$m^3$.

This is a commercially unsustainable situation and needs to be rectified in order for Rössing Uranium remain globally competitive.

Rössing Uranium is therefore proposing to build, own and operate its own desalination plant, designed to a much lower capacity than the Areva plant. It is expected that the total cost of water for Rössing Uranium will then decrease to between US$2.00/$m^3$ and US$2.50/$m^3$ at point of supply.

A modular solution is being proposed, following an initial concept study that was done by Gecko Namibia (Pty) Ltd (Gecko). It is intended to proceed with this venture, utilising Gecko as project managers for the feasibility study.

During the proposed desalination plant will have immediate commercial benefits, as it will be catering for a much smaller capacity and operating at capacity. The plant will also be under Rössing Uranium's control, providing supply surety. Since the desalination plant will be modular, it would be easy to increase or decrease capacity in line with Rössing Uranium's requirements that may vary from month to month, without having to incur a take or pay penalty.

3.3 Project Location

The desalination plant will be located within the northern extremities of the Swakopmund Local Authority area, positioned on the eastern side of the evaporation ponds within the Swakopmund Salt Works, situated approximately 6km north of Swakopmund (locally known as Mile 4). The plant will be situated on Erf 4007 Swakopmund Extension 10, which is currently zoned for mining. The Swakopmund Salt Works is registered as a private nature reserve and thus compatibility with conservation objectives will remain an important consideration of which the resident birdlife is the key aspect. The preliminary coordinates of the plant are 22°35'27.88"S and14°31'32.32"E, although these are subject to change based on recommendations of the social, environmental and technical investigations. The seawater intake structure is likely to be adjacent, or relatively close to the existing seawater intake structure for the Swakopmund Salt Works. A number of options for the discharge infrastructure are under consideration, but are likely to be in the vicinity of the existing outlet of the Swakopmund Salt Works. The site can be accessed off the C34 between Swakopmund and Henties Bay via the existing Swakopmund Salt Works roads. The following maps place the project in a regional and local context.

Figure 6: Preliminary location of the proposed Rössing Uranium desalination plant in the regional context

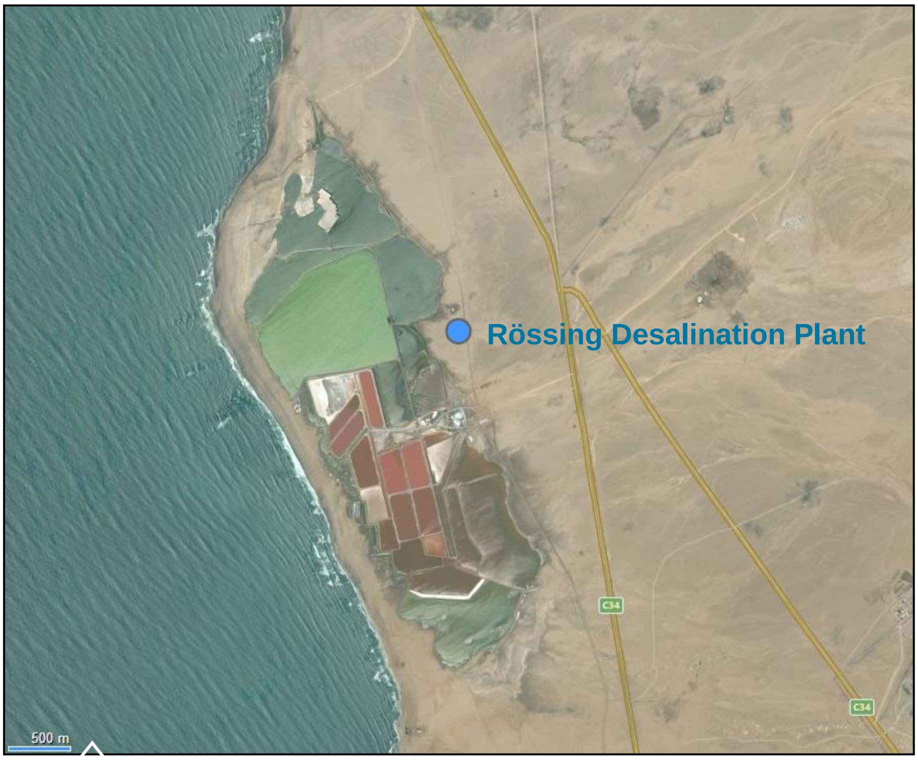

Figure 7: Preliminary location of the proposed Rössing Uranium desalination plant in the local context

3.4 Project Overview

The proposed desalination plant can produce up to 10Mℓof potable water in every a 24 hour cycle (10Mℓ/d). Water production times and rates will vary depending on demand at the mine, peak and off-peak electrical demand periods (and associated electrical rates), routine maintenance shutdowns, breakdowns and upset conditions (i.e. ocean storms or red tide conditions). The production rate for the plant should however average at 8.2Mℓ/d or approximately 3Mm^3 per annum. At peak production the plant will abstract up to 25Mℓ/d of seawater, produce 10Mℓ/d of potable water and discharge 15Mℓ/d back to the ocean as brine. The plant will be designed to optimise electrical efficiency and will be equipped with energy recovery systems to further improve the electrical efficiency and performance of the plant. The construction period is expected to be approximately 18 months.

During the operational phase, the plant will be staffed with an estimated 12 to 18 contract staff working on a shift basis as required. It is likely that the plant will be operated by Gecko under an Operation and Maintenance Contract with Rössing Uranium.

The plant will be designed to have a 10 year operational life, which ties in with the current Rössing Uranium Life of Mine plan. At the end of the design life period, the plant may be refurbished for continued operation, or may be decommissioned, broken down and the site rehabilitated, or sold as a going concern to another mining house or NamWater, depending on the situation and needs at that time.

3.5 Project Components

The project can be divided into the following main components, which are described in greater detail under respective headings to follow and conceptually shown in Figure 8:

- Seawater intake system;
- Seawater pretreatment system;
- Desalination plant;
- Ancillary structures and infrastructure;
- Electrical supply system;
- Clearwater system and pipeline; and
- Effluent treatment and disposal system.

These components are described in further detail below, in terms of design, capacity and footprint. A description of alternatives being considered, together with the associated advantages and disadvantages to the surrounding environment (refer to Section 4).

Figure 8: Conceptual project layout

3.5.1 Seawater intake system

Conceptually, the seawater abstraction system would involve a shallow water direct abstraction system, with relatively simple screens around the pump intakes to prevent the abstraction of marine creatures and flotsam. A set of pumps and pipes placed on a new jetty would abstract water from the shallow surf zone. The jetty would be an upgraded version, similar in concept, to that already used by the Swakopmund Salt Works, and shown here in Figure 9.

Figure 9: Existing seawater abstraction jetty for the Salt Works

Two low-lift, high-volume pumps and parallel 650mm diameter pipelines (one duty and one standby) would abstract up to 25Mℓ/d of seawater from the ocean and drain into the existing Swakopmund Salt Works seawater canal system. The canal extends around the northern and eastern most sides of the Swakopmund Salt Works pond complex. The seawater canal is a gravitational system and seawater would flow the approximately 3.2km from the intake to the ponds nearest to the desalination plant. From here the seawater would again be abstracted directly from the canal or the existing Swakopmund Salt Works buffer pond, or a combination.

Using the canal and / or a pond system as part of the seawater intake system is expected to have the added benefit of reducing the suspended solids load in the seawater and provide a high quality and more homogenous (biological, physical and chemical) feed water quality than a direct abstraction from the sea. The system will also provide operational storage and a buffer against sudden changes in ocean conditions, such as red tide, sulphur eruptions and ocean storms. It should be noted that prior to using the canal and pond it will probably need to be dredged and modified to ensure it is capable of accommodating the maximum daily volumes, whilst continuing to service the needs of the existing Swakopmund Salt Works operations. The oyster farming activities currently conducted in the pond are also seen as an advantage for the desalination plant as the oysters act as an additional natural filtration mechanism. The increased water flow through the system may also beneficiate the oyster farming activities, by increasing food prevalence. A final benefit of the canal and pond system is that it may slightly increase the temperature of the feed water which improves the efficiency of the desalination process. Whilst the canal and pond option appears promising it remains subject to some technical investigation and validation.

The proponent is considering a number of design options associated with the seawater intake system, which are briefly described as follows:

- The reconditioning of the existing Salt Works intake jetty for the dual purpose intake as opposed to constructing a new jetty. Technical teams are assessing the structural integrity and confirming if this is a possibility, although the structure is old and nearing the end of life.
- A direct pipeline option, linking the intake jetty and pipelines directly to the desalination plant using a 500mm to 600mm diameter High Density Polyethylene (HDPE) or Glass-Reinforced Plastic (GRP) pipeline. This may be required if it is found that the use of the canal and ponds at the Swakopmund Salt Works together with the desalination plant requirements are incompatible. In that event, the pipeline would likely follow the existing seawater channel as its route. The route of the pipeline is shown in Figure 8 on page 21. If this option is selected, the intake water may be shock dosed with chlorine gas at the intake to minimise biological growth inside the intake pipeline.
- The proponent is also considering the option of constructing a new, exclusive use buffer pond for the desalination plant, which would be situated adjacent to the existing Swakopmund Salt Works ponds near the proposed desalination plant. This may be required if it is found that the Swakopmund Salt Works' and desalination plant's needs are incompatible and the dual use severely compromises either of the processes. The Salt Works' existing buffer pond may need to undergo modification to ensure that it meets the needs of the desalination plant abstraction system. The Swakopmund Salt Works currently uses the pond as a balancing pond and to farm oysters.

3.5.2 Seawater pretreatment system

Pre-treatment of the feed water aims to limit RO membrane fouling. An accumulation of one or more foreign substances on the surface of a membrane will result in a loss of rate of flow through the membrane. This results in the need for higher operating pressures to achieve the specified water production which in turn results in an increased energy consumption and associated cost. Membrane fouling generally occurs through one of the following:

- Precipitation of inorganic salts (scaling) due to super-saturation;
- Deposition of silt or other suspended solids;
- Interaction of organics with the membrane; and

- Biological fouling caused by excessive microbial growth.

Seawater from the holding tank or buffer pond and canal will pass through a series of fine sieve screens to remove larger particulates and debris. The feed water may then be chlorinated and subjected to a Dissolved Air Filtration (Dissolved Air Flotation) process. In this process, chemical flocculants are added to the feed water and then aerated water is passed through the incoming water body, causing the flocs (a loosely clumped mass of fine particles) to float to the surface where they can be recovered. The recovered sludge can then be mixed into the brine tank for discharge back to the ocean.

The feed water may also be conditioned using sulphuric acid which is used to correct the pH and ensures flocculation occurs at an optimised rate. Ferric chloride coagulates optimally at around pH 7.0 and by correcting the pH the optimal dosing rates can be achieved which reduces the overall chemical demand and chemical residue in the discharges.

Chlorine gas may be used to eliminate biological contaminants in the feed water and reduce biological growth in the pipes and pumps of the desalination plant and various holding tanks. If chlorine is used then, prior to entering the RO trains (or module), the water is treated with sodium metabisulphite (SMBS) and, potentially, antiscalants. Chlorine is detrimental to the RO membranes and so the SMBS is used to neutralise any free chlorine before coming into contact with the RO membranes. The antiscalant reduces the build-up of deposits inside the RO units or on the membrane itself which could lead to fouling of the membrane and reducing operational efficiencies.

The concentration of chlorine in the ocean discharges is expected to be low and within relevant standards due to the application of SMBS (if chlorine is used). Chlorine gas would be stored in 1-ton drums within a purpose built storage facility meeting the requirements for hazardous installations (i.e. leak detection systems and alarms, shut-off valves, specialist safety equipment and secondary containment, amongst other requirements).

The RO trains are also fitted with disposable cartridge filters just before the RO membranes which will filter the feed water to the micro scale just prior to desalting.

The proponent is considering a number of design options associated with the pretreatment system, as follows:

- A new bio-flocculation pretreatment technology, Progreen®, is being investigated to form part of the pretreatment process. This system is a proprietary bio-flocculation pretreatment step similar to a membrane bio-reactor (MBR) and employs a biological process, similar to those widely employed in existing wastewater treatment plants, to pretreat the feed water and has the potential to eliminate, or to reduce, the use of pretreatment chemicals.
- Modifications to the canal and pond systems discussed under the foregoing heading are also seen to form part of the pretreatment process.

3.5.3 Desalination plant

The desalination plant will be situated on the eastern side of the Swakopmund Salt Works ponds. The exact location for the desalination plant has not been fixed and may shift a little in any direction depending on the availability of suitable founding conditions, accommodation of other structures and infrastructure, social and environmental constraints (including Damara Tern nesting sites). The proponent's technical team is looking at an area of approximately 30ha in which to place the desalination plant. The desalination plant complex itself (including the pretreatment and post-treatment systems and all associated infrastructure) is likely to have a permanent footprint of less than 5ha depending on the final suite of design options. This excludes any additional footprint area associated with the upgrading and modification of the canal and buffer pond, or new buffer pond. By the time the impact assessment phase of the study commences, it is expected that the project team will have gained consensus on a preferred site location for the plant.

The desalination plant will represent the most significant of the structures associated with the project. The plant will take the form of a large enclosed structure (to protect the various equipment and processes against the corrosive sea breezes). The plant will house the following, within an enclosed security fenced area with a gate to control access:

- Pretreatment systems;
- Post-treatment systems;
- A series of RO trains with associated filters, piping, pumps and valves, access ladders gangways, cleaning and maintenance facilities, energy recovery systems, etc.;
- Feedwater, product water, and brine/waste buffer tanks;
- Clean In Place systems, tanks, and associated facilities;
- Water treatment chemical storage areas and dosing equipment;
- Electrical and mechanical control centre;
- Spares and maintenance stores and workshop area
- Offices, ablutions, kitchen, parking, sewerage, communications (possibly overhead telephone lines) and solid waste storage facilities and other amenities; and
- The 6m wide, and approximately 800m long, existing salt and gravel access road intersecting with the C34 is proposed to be upgraded to provide safe access to the proposed plant.

3.5.4 Clean In Place System

Even with good quality feed water, good pretreatment practices, and the proposed cleaning systems, it is possible that the RO membranes may experience fouling and may lose efficiency over time. To overcome this, each RO membrane may be cleaned about once every six to eight weeks (in conventional plants). The cleaning chemicals used for the RO membranes constitute mainly high and low pH solutions prepared by adding caustic soda or acid to product water. Small amounts of surfactant or chelating agent (e.g. citric acid) may also be added to the mix. These solutions are then passed through the RO membranes a number of times, alternating between the high and low pH solutions. Once complete both solutions are sent to the brine buffer tank where they mix with one another (which has a pH neutralising affect), the brine, the sludge and multimedia filter filtrate, before being disposed of via the brine discharge system. The waste from this intermittent process would be fed back into the brine discharge system over a time period, for example up to 24 hours, to achieve suitable dilutions.

A proprietary direct osmotic cleaning system, which replaces the conventional process including all associated chemicals, is being investigated, and is the preferred option for the plant.

3.5.5 Electrical supply system

The desalination plant and associated facilities will be powered via a new 11kV cable running from the existing Tamarisk substation, located 6km away along the C34 on the outskirts of Swakopmund. The cable will run alongside the C34 towards Henties Bay in an existing electrical servitude and may potentially use the existing wooden transmission poles (from which 11kV power line was stolen). The cable will cross the C34 and follow the access road or the new product water pipeline route to the new transformer and substation buildings at the plant. If the transmission line is overhead along this section, it will necessitate additional pylons, or more likely wooded transmission poles as already used for the remainder of the transmission line. The option exists that the entire transmission line will be an underground cable, or partly underground and partly overhead.

The Tamarisk substation is currently able to provide more than 3MW of electricity, which is adequate for the purposes of the desalination plant. The desalination plant is expected to consume approximately of 1.5MW at full production.

A new 11kV underground cable is proposed to run from the plant, alongside the existing Salt Works' canal to provide electrical supply to the seawater intake pumps situated on the intake jetty. The cable will terminate in a new small building close to the new intake jetty (similar to the existing Swakopmund Salt Works intake mini-substation building). The option of using the existing electrical supply to the existing intake is also being investigated.

During plant operation, it is possible to operate the plant mainly during electrical standard and off-peak times, as a means to improve the cost efficiency and avoid overloading of the regional electrical supply at these critical times.

3.5.6 Clearwater system and pipeline

Clearwater produced by the desalination process will be pumped via a new 350mm to 400mm diameter pipeline (steel, ductile iron and GRP piping are being considered) to intersect with the existing 700mm diameter NamWater pipeline that runs alongside the C34, approximately 850m to the east of the site.

Water will need to be inserted into the pipeline at a pressure that is compatible with the system. The clearwater will be fully pH corrected, re-mineralised (using soda ash and calcium) and chlorinated to the relevant potable water standards and will form part of the NamWater supply. Rössing Uranium will then be supplied with the equivalent volume of treated water by NamWater from the Swakopmund Base Reservoirs.

The proponent is considering the following option associated with the clearwater system:

- A possibility exists that clearwater produced by the plant cannot be inserted directly into the NamWater pipeline 850m east of the desalination plant.
- Should this be the case then clearwater will need to be piped approximately 11km to the NamWater Swakopmund base station. This pipeline would then follow the route of the existing NamWater pipeline.

3.5.7 Effluent treatment and disposal system

Brine is the saltwater concentrate remaining on the upstream side of the RO membrane, after the separation process. The brine stream contains higher concentrations of salts and other impurities than are found in the intake water, and which must be disposed of in safe and acceptable way. Due to the chemical makeup of the brine water, essentially a concentrate of the source water, the brine is often returned to the source where it is diluted with the source water, returning it to its original concentration over time. The brine will also contain traces of the water treatment chemicals that were introduced during the pre-treatment phase.

The brine (which is approximately 1.85 times the saline concentration of seawater) may be mixed with the filter backwash, Clean In Place backwash and sludge from the Dissolved Air Flotation process before being returned to the ocean, resulting in a final estimated brine concentration of about 1.70 times that of ambient seawater salinity. The sludge and filter backwashes may also be desiccated in drying beds and disposed of as a solid waste, although these options remain under investigation.

The brine will be piped from the desalination plant via a buried 400mm diameter HDPE pipe. The pipe will follow the existing road network through the Swakopmund Salt Works to the existing Swakopmund Salt Works bitterns discharge area, as shown in Figure 8. The brine will be discharged directly into the surf zone where the turbulence and mixing caused by energetic wave conditions, the long shore and cross shore currents and tidal exchanges will aid with the expected rapid mixing, dilution and distribution of the brine discharges. This must, however, be confirmed through the near-field dilution modelling as part of the SEIA process hereafter a preferred discharge option may be selected and assessed together with any other identified feasible alternative emerging from the list of options currently being investigated.

The proponent is considering a number of design options associated with the effluent treatment and disposal system, as follows:

- A settling pond with drying beds may be investigated to deal with the Clean In Place backwash, filter backwash and sludge from the Dissolved Air Flotation and bio-flocculation process. Once dried, these materials will be disposed of at a landfill, assuming there is adequate capacity.
- There are a number of discharge options under consideration, the location of discharge will be dependent on the type of discharge selected (mostly where there is suitable rock formation onto which a pipe can be founded) and any environmental oceanographic (dilution) constraints identified through the study. The discharge options are as follows:
    - The current preferred option is a pipeline, fitted with a single port diffuser, discharging underwater into the surf zone below the spring low water mark. It is believed that this option offers the best opportunity for dilution and mixing whilst minimising any visible structures or disruption of the beach.
    - An open beach discharge located near the existing Swakopmund Salt Works discharge. Brine would be discharged above the high water mark and allowed to run across the open beach and into the surf where mixing and dilution can happen.
    - Excavate an open trench on the beach, running parallel to the coastline. Brine can be discharged into the trench and allowed to infiltrate through the beach sand back into the sea.
    - Deeper discharge, situated beyond the surf break zone is also being considered. This option will require installation and fixing of the pipeline through the surf zone within an excavated and prepared trench. Typically a temporary jetty will be required to create access for equipment to excavate the trench. Trenching may require blasting as the sand cover over bedrock is limited. To achieve the required dilutions, a multi-port diffuser will be needed in deeper water where the pipeline terminates to achieve the required brine diffusion.

4 SUMMARY OF PROJECT ALTERNATIVES

This chapter provides an overview of the alternatives, and the main advantages and disadvantages associated with each, which have been considered by the project team as part of the conceptual project.

It is important to note that the project is currently at a conceptual design stage and the proponent's technical consultants, with input from the Social and Environmental Team, are actively investigating a variety of options for each of the components mentioned above. The current cost estimation is based on a study from Gecko costing the project at a pre-feasibility level. The project description provided in Section 3 aims to address the current thinking and introduce the main design alternatives currently under investigation. Only feasible design alternatives will be assessed in the SEIA phase. The reasoning behind the go-forward design options will however also be presented in the SEIA Report. This project description will be updated and refined on the basis of the technical and social and environmental investigations, which are running concurrently. Table 3 provides a summary of the alternatives currently under investigation. The table also provides the provisional advantages and disadvantages associated with the various alternatives. Since additional advantages and disadvantages may become apparent as the investigations proceed, so this list should not be seen as exhaustive.

In addition to the preferred alternative and any feasible alternative that is carried forward to the SEIA phase, the "no go" alternative will also be assessed. The "no go" alternative serves as a basis for comparison and can serve to validate the need and desirability for the project. The assessment of alternatives must at all times include the consideration of the "no-go" option as a baseline against which all other alternatives must be measured. The option of not proceeding with the activity must always be assessed. It is best practise to consider at least two alternatives against the no-go option.

Table 3: Summary of project options /alternatives under consideration

#	COMPONENT	ASPECT	ALTERANTIVE	POSSIBLE ADVANTAGES	POSSIBLE DISADVANTAGES
1a	Seawater intake system.	Intake structure / Jetty.	Place a new jetty next to existing Salt Works Jetty.	~ Structure that meets current design criteria and safety requirements. ~ Won't disrupt current operations associated with the Salt Works and Oyster farm.	~ Time, cost and resource intensive. ~ Will result in increased environmental impacts on the beach and marine environment. ~ May result in increased visual intrusion on the beach area.
1b			Rehabilitate and upgrade the existing Salt Works Intake Jetty.	~ Reduces impact to beach and marine ecology. ~ Relatively unchanged visual impact. ~ Reduced resource use, equipment, time, materials, etc.	~ Possible disruptions to the existing Salt Works and Oyster Farming activities. ~ May have residual structural issues requiring routine maintenance and repair interventions through the project implementation lifecycle.
1c			Alternative intake location(s)	~ Advantages and disadvantages still need to be further investigated, taking the marine ecology, distance from the discharge location, currents, etc. into consideration. ~ The advantage of this location is that it is at the existing Salt Works intake, minimise the footprint and potential disturbance impacts.	
2a		Seawater transference to the desalination plant.	Modify and upgrade existing Salt Works seawater channel & pond.	~ Reducing the suspended solids load in the seawater and provide a higher quality and more homogenous feed water. ~ Provide operational storage and a buffer against sudden changes in ocean conditions, such as red tide, sulphur eruptions and ocean storms. ~ Increased water through the system may also beneficiate the oyster farming activities by increasing food prevalence. ~ The canal and pond system may slightly increase the temperature of the feed water which could improve the electrical efficiency of the desalination process. ~ No additional pipeline from the intake jetty to desalination plant will be required and therefore reduced cost and project footprint.	~ Possible disruption of existing activities of the Salt works and Oyster farming. ~ Increased disruption of marine birds, during construction phase due to increased earthworks in close proximity to the pans.
2b			Place a new pipeline from the intake Jetty to the desalination plant seawater intake.	~ Less disruptive to marine birds during construction phase. ~ Less disruption to Salt Works, Guano and Oyster farming activities. ~ Lower risk of interference between the salt works, desalination and oyster farming operational objectives.	~ Increased costs in terms of time, materials. ~ Increased project footprint. ~ Would require chlorine shock dosing of intake water to keep pipeline clean, which is an added safety and pollution risk.

#	COMPONENT	ASPECT	ALTERANTIVE	POSSIBLE ADVANTAGES	POSSIBLE DISADVANTAGES
3a		Seawater intake pond.	Upgrade and modify existing ponds at Salt Works for abstraction.	~ Cost effective and resource efficient. ~ Reducing the suspended solids load in the seawater and provide a higher quality and more homogenous feed water quality. ~ Provide operational storage and a buffer against sudden changes in ocean conditions, such as red tide, sulphur eruptions and ocean storms. ~ Increased water through the system may also beneficiate the oyster farming activities by increasing food prevalence. ~ The canal and pond system may slightly increase the temperature of the feed water which could improve the electrical efficiency of the desalination process.	~ Possible disruption of existing activities of the Salt works and Oyster farming. ~ Increased disruption of marine birds during construction phase.
3b			New abstraction pond to be excavated next to the existing ponds.	~ Lower risk of interference between the salt works, desalination and oyster farming operational objectives ~ Reducing the suspended solids load in the seawater and provide a higher quality and more homogenous feed water quality. ~ Provide operational storage and a buffer against sudden changes in ocean conditions, such as red tide, sulphur eruptions and ocean storms. ~ The canal and pond system may slightly increase the temperature of the feed water which could improve the electrical efficiency of the desalination process.	~ Increased project footprint. ~ Significant earthworks resulting in disruption to birdlife. ~ Significantly increases project footprint.
3c			Use no intake pond and insert water directly (from the channel or pipeline) to the seawater intake tank.	~ Reduce potential interference or conflict with the Salt Works and Oyster Farming operations. ~ Reduces project footprint and the intensity of the construction disturbances to local birdlife.	~ Loose potentially beneficial, natural water pre-treatment processes. ~ Loose an operational water buffer and increase exposure to upset ocean water quality conditions (i.e. red tide, sulphur eruptions and ocean storms).
4a	Seawater pre-treatment system.	Seawater Pre-filtration and conditioning.	Chemical flocculation with Dissolved Air Flotation process.	~ Known technology with predictable performance and results.	~ Relies on chemicals in the pretreatment process which end up in the waste and by-product streams creating a potential pollution risk.
4b			Bio-flocculation with Dissolved Air Flotation process.	~ Reduces the need for pre-treatment chemicals and water conditioning eliminating some chemicals from waste stream and reducing the pollution risk and associated impacts to both terrestrial and marine ecosystems. ~ Reduced chemical transport, storage requirement.	~ New technology with unknown performance and results. ~ May introduce foreign / alien microorganisms into local marine environment (if filter backwash is discharged with brine).

#	COMPONENT	ASPECT	ALTERANTIVE	POSSIBLE ADVANTAGES	POSSIBLE DISADVANTAGES
5a	Desalination Plant.	Siting the desalination plant.	Engineers are looking at an area of approximately 30ha in extent. Depending on the various investigations, both environmental and technical, the approximately 5ha plant can be shifted within this area to best meet all requirements.	~ Optimised siting of the plant within identified 30ha area.	~ The area being assessed may fall within a sensitive area for the Damara Tern breeding sites and alternative site, within the Swkopmund Salt Works may need to be assessed.
6a	Electrical supply system.	Primary powerline.	Overhead transmission line using existing wooden transmission poles and new transmission poles for the remaining length.	~ Most cost effective power supply option. ~ Quick and easy to construct with reduced construction disturbance. ~ Very low disturbance footprint. ~ Visual impact.	~ Risk of theft of the power cables. ~ Moderate collision risk for birdlife.
6b			Overhead transmission line using new pylons.	~ Moderately cost effective. ~ Quick and easy to construct with reduced construction disturbance. ~ Low disturbance footprint.	~ Risk of theft of the power cables. ~ Additional construction disturbances. ~ Moderate Visual impacts. ~ Moderate collision risk for birdlife.
6c			Part overhead (using existing transmission poles) and part underground cable.	~ Most cost effective power supply option. ~ Reduced risk of bird collisions. ~ Slightly reduced visual impact. ~ Moderate disturbance footprint. ~ Reduced collision risk for birdlife.	~ Risk of theft of the power cables.
6d			Completely underground cable.	~ Reduced risk of cable theft. ~ No residual visual impact. ~ No bird collision risk.	~ Expensive and time consuming. ~ Possible disruptions associated with significant earthworks associated with trenching during the construction phase. ~ Larger disturbance footprint.
7a		Intake structure power supply.	Use existing Salt Works underground power supply cable (if adequate).	~ Cost effective and resource efficient. ~ No construction phase related disturbances.	~ Old infrastructure that may be aged, suboptimal and susceptible to failure / breakdown affecting safety and reliability of the plant. ~ Short term disruption of the existing Salt Works intake power supply.
7b			Place new underground power supply.	~ New, optimised cable ensuring effective operation for the equipment and which meets current design and safety standards. ~ Reduced possibility of disruption of power supply to Salt Works seawater intake system during construction.	~ Additional costs, materials and construction time. ~ Additional construction disturbances and increased disturbance footprint.

#	COMPONENT	ASPECT	ALTERANTIVE	POSSIBLE ADVANTAGES	POSSIBLE DISADVANTAGES
8a		Renewable energy in Power supply	Solar power generation to supply the plant (Pursuit of this option has already been discontinued)	~ Provide a portion of the projects energy requirements from renewable sources reducing the potential carbon footprint.	~ Would significantly increase the project footprint (3ha) ~ Would significantly increase the visual impact ~ Operational conditions around the Salt Works due to the fog belt and sea sprays renders the area unsuitable for a solar photo voltaic farm. ~ Would make the project considerably more expensive and would take a significant addiotional amount of time to construct (given that the project only has a ten year design life). ~ Possible energy shortage on cloudy days. ~ Potentially significant volumes of clean water are needed to wash the PV cells. ~ Additional impacts to terrestrial fauna and flora, including unknown potential risk to avifauna.
9a	Clearwater system and pipeline.	Clearwater pipeline.	850m pipeline connecting with the NamWater pipeline east of the site.	~ Cost effective. ~ Small construction phase disturbance. ~ Time and material efficient.	~ Meeting and managing possible challenges associated with the operating pressure of the NamWater Pipeline.
9b			11km pipeline connecting with the NamWater Swakopmund Base Station.	~ Less sensitive to operational pressure requirements of the NamWater pipeline.	~ Significant additional cost, materials and construction time. ~ Larger and more disruptive construction phase disturbance. Construction impacts will extend into town limits, with added public safety and security risks and possible disruption of traffic and commercial activities. ~ Significantly increased construction footprint. These pipelines may require a new, additional EIA process having cost and time implications for the project.
9c			New pipeline from the desalination plant to Rössing Uranium mine.	~ Less sensitive to operational pressure requirements of the NamWater pipeline. ~ No need for Rössing Uranium to register as a Water Services provider. ~ Water does not need to be treated to potable standards, opening up design options that could increase the operational cost efficiency of the plant.	~ Significant additional cost, materials and construction time. ~ Larger and more disruptive construction phase disturbance. Construction impacts will extend into town limits, with added public safety and security risks and possible disruption of traffic and commercial activities. ~ Significantly increased construction footprint. ~ These pipelines may require a new, additional EIA process having cost and time implications for the project.

#	COMPONENT	ASPECT	ALTERANTIVE	POSSIBLE ADVANTAGES	POSSIBLE DISADVANTAGES
10a	Effluent treatment and disposal system.	Solid wastes treatment and disposal (Filter back wash and Dissolved Air Flotation sludge).	Drying beds and disposal by landfill.	~ Reduces discharge of solids and associated pretreatment chemicals together with the brine back to the ocean, reducing impact risks to marine ecology.	~ Additional solid waste stream requiring disposal and utilising landfill airspace. ~ Additional solid waste stream may have traffic implications. ~ Possible risk to marine birds wading and feeding in drying beds. ~ Additional footprint and construction phase disturbances. ~ Additional costs, time and materials. ~ Additional operational procedure and facility.
10b			Disposal of solid by-products via the brine discharge system.	~ No additional solid waste stream utilising landfill airspace. ~ No additional traffic associated with waste transportation and disposal. ~ Reduced project footprint and disturbances. ~No possible risk to marine birds exposed to drying beds and their contents.	~ Potential additional pollution and associated impacts to marine ecology and local ocean biochemistry.
11a		Brine discharge options.	Deep discharge, beyond the surf zone with a multi-port diffuser.	~ Lower risk of brine and pollutant accumulation in the near shore / intertidal zone and associated marine impacts. ~ Diffusers will be used to encourage active mixing and diffusion of concentrate.	~ High energy demands to discharge concentrate at required pressure to ensure efficient diffuser operation. ~ Significant construction phase disturbances to the beach, intertidal and surf zone habitats resulting in additional marine impacts. ~ Significant additional cost, time, material resources.
11b			Surf discharge below the low water mark.	~ Uses the turbulent surf conditions to mix and distribute effluent theoretically avoiding brine accumulation. ~ No visible pipeline on beach (Buried pipe and discharging beneath the low water mark). ~Moderate construction phase disturbances to the seafloor and tidal zone habitats.	~ Construction disturbances across the beach and intertidal zones affecting marine biota. ~ Additional cost, time, material resources. ~ Brine may accumulate in the biologically active near shore habitats if surf is unable to cause adequate mixing.
11c			Open beach discharge, above high water mark.	~ Cost effective, simple construction, fewer materials. ~ Pipeline structure not exposed to potentially damaging ocean. ~ No construction in the intertidal zone or across beach area. ~ Uses beach sand as a soak away and filter before brine re-enters the ocean.	~ No active mixing of the brine before seeping through the sand and back to the ocean. ~ Brine may accumulate in the biologically active near shore habitats if surf is unable to cause adequate mixing.

#	COMPONENT	ASPECT	ALTERANTIVE	POSSIBLE ADVANTAGES	POSSIBLE DISADVANTAGES
11d			Beach trench discharge, above high water mark.	~ Cost effective, simple construction, fewer materials. ~ Pipeline structure not exposed to potentially damaging ocean. ~ No construction in the intertidal zone or across beach area. ~ Uses beach sand as a soak away and filter before brine reenters the ocean.	~ No active mixing of the brine before seeping through the sand and back to the ocean. ~ Additional earthworks and disruptions to the beach zone habitat. ~ Brine may accumulate in the biologically active near shore habitats if surf is unable to cause adequate mixing.
11e			Discharge brine into Salt Works	~ No, or lower volume of discharge to the sea. ~ Cost savings as no discharge infrastructure needs to be constructed in to the sea, ~ Possible reduced impacts on the marine ecology. ~ Could accelerate salt production process.	~ Chemicals in the brine could significantly impact the Salt Works operation and reduce product quality. ~ Co-discharge chemicals could impact on the suitability of the evaporation ponds for filter feeding bird species and oyster farming practices.
11f			Alternative discharge location(s)	~ Advantages and disadvantages still need to be further investigated, taking the marine ecology, distance from the intake location, currents, etc. into consideration.	

5 DESCRIPTION OF THE AFFECTED ENVIRONMENT

This section provides an overview of the social and environmental characteristics of the study area at present and onto which any potential impacts will be superimposed.

5.1 Socio-economic Environment[11]

5.1.1 The Erongo Region

The 2011 Population and Housing Census found that the population of the Erongo Region was 150,809 which is an increase of 43,146 from 107,663 in 2001. This represents an overall annual growth rate of 3.4%. The towns of Swakopmund and Walvis Bay have however experienced growth rates of 5.3% and 5% respectively. More than three quarters of the region's population live in the towns of Walvis Bay, Swakopmund, Henties Bay and Arandis.

Walvis Bay sources its water from the Kuiseb aquifer while the other three towns and three large uranium mines source their water from the Omdel aquifer and more recently the Areva desalination plant. Of relevance to this project is the socio-economic description of the activities reliant on the Omdel aquifer. For this reason, Walvis Bay's activities are excluded from the baseline.

The region has seven constituencies and the planned project is within the northern boundary of Swakopmund constituency, adjacent to the very elongated Arandis constituency and bounded by the Walvis Bay Constituency to the south, as shown in Figure 10.

[11] *The socio-economic section was authored by Auriol Ashby of Ashby Associates cc (and Dr. Jonathan Barnes of Design & Development Services cc).*

Figure 10: Constituencies in the Erongo Region[12]

The main employment sectors in the Erongo Region are mining (11.7%), manufacturing (11.5%), fishing and agriculture (11.5%), construction (9%), repair of motor vehicles (9%) and administrative/support services (8%). The region's growth has been largely driven by the mining sector, the port and fishing industry based in Walvis Bay, and the tourism sector which is focused around Swakopmund. All these industries are dependent on a reliable supply of fresh and potable water. The mining industry will be the biggest water consumer, followed by the municipalities, once Husab mine is operational.

As a measure of living standards, the Erongo Region has the second highest per capita consumption of domestic goods of all Namibia's regions, estimated at N$22,700/person/year in 2009/10 and this has grown by 54% in 5 years from N$14,700/person/year (Central Bureau of Statistics, 2004). When this is compared to six of the northern regions where rates are below N$9,000/person/year, it partly explains why the region experiences high in-migration (NSA, 2011). Oshiwambo languages are the most commonly used as the main household language of 39% of households. Other main language groups are Afrikaans (20%) and Nama/Damara (19%), with English (5%) and German (3%) making up a small minority.

5.1.2 Swakopmund

The Swakopmund Constituency had a total population of 44,700 in 2011, made up of slightly more males than females (23,700 to 21,000, respectively), largely due to the inward migration of men seeking work in the mines and supporting industries. The Swakopmund constituency is entirely

[12] *Source: http://www.erc.com.na/maps/constituencies/*

urban and Swakopmund is the fourth largest town in Namibia (after Windhoek, Rundu and Walvis Bay). The town grew by 18,000 people from 2001 to 2011, however, it is much less densely populated with 228 people/km^2 compared with Walvis Bay which has a population of 62,096 and a density of almost 1,900 people/km^2.

Swakopmund's spatial development is constrained by the Swakop River to the south which is the border with the Walvis Bay constituency, the Atlantic Ocean to the west and the Namib desert to the north and east. The town's growth northwards along the coast has developed the middle to upper income residential suburbs of Vineta, Hage Heights and Mile 4, with the Swakopmund Salt Works (and site for the proposed project), being the only large scale industrial site.

The lower income suburbs of Mondesa and the DRC have smaller erven (plots) and are to the east of the town centre. Industrial precincts are north and eastwards of the DRC, with good road access to the B2 main road which links Swakopmund to Walvis Bay and the Trans-Caprivi and Trans Kalahari Highways. Further up-market residential developments are spreading eastwards where there are views of the Swakop River valley and dunes beyond.

The long term town plan of 2008 has not yet been updated (Table 4). Note that the proposed site is off the map, to the north.

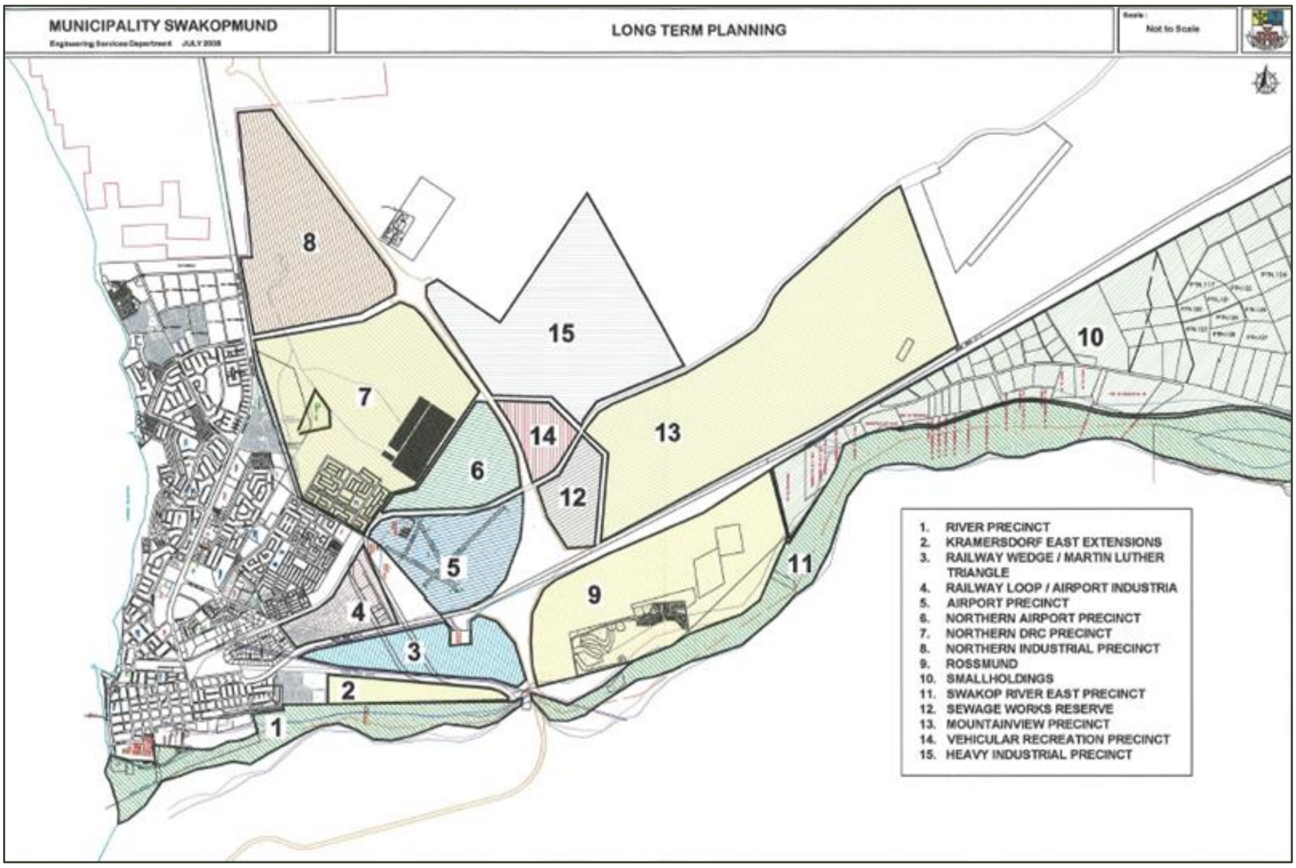

Figure 11: Long term town plan for Swakopmund[13]

Households in Swakopmund are the smallest in the region with an average of 3.1 persons, compared to a regional average of 3.3 people per household. Forty four percent of households own their own home (with or without mortgage / bond), compared to those who rent (42%). The

[13] *Source: (CSIR, 2009)*

large majority of households use electricity as their main fuel source for cooking (81%) and lighting (84%). Almost all households (99.7%) have access to safe drinking water.

Almost 80% of Swakopmund's population over the age of 15 is economically active – i.e. they are part of the potential labour force. Of those, three quarters (over 19,000 people) are employed while over 6,600 people are unemployed. About 5,000 people are economically inactive, being pensioners, students or homemakers. As a result of this high employment rate (comparatively speaking), 77% of households rely on wages and salaries as their main source of income and a further 10% rely on income from business.

5.1.3 Arandis and Henties Bay

Arandis is located about 60km east of Swakopmund, off the main B2 road to Windhoek and the national railway to Walvis Bay. The 2011 Population Census found that Arandis had a population of 5,170 people while Henties Bay, a small town 67km north of Swakopmund had a population of 4,720. Both towns are dependent on water from the Omdel aquifer.

Arandis was established in 1970 to house employees of the Rössing Uranium mine and it has always been very economically dependent on Rössing Uranium with most residents either working at Rössing Uranium mine or for contractors of Rössing Uranium. Higher income earning employees prefer to live in Swakopmund, thereby causing the local buying power to be insufficient for some basic commodities such as fuel, until recently. During the depressed uranium prices of the 1990s, the Rössing Uranium mine was threatened with closure and the town of Arandis barely survived. Since then, the Arandis Town Council, Rössing Uranium and the Rössing Foundation have made significant strides in diversifying the town's economy and securing its sustainability, even after Rössing Uranium mine closure in future.

New life was breathed into Arandis with Rössing Uranium's planned mine extension, the development of Areva's Trekkoppje mine, the Husab mine and the forthcoming Arandis Power Heavy Fuel Oil Plant. These activities have spurred the town to plan for expansion and as a result the constituency has showed an average annual population growth rate of 2.9% since 2001.

Henties Bay, at the Omaruru river mouth, is primarily a coastal resort town with the ocean and miles of beaches as its main attractions. It supports a thriving angling community and it is one of the few places from whence 4x4 off-road driving and quad biking is still permitted in designated areas within the Dorob National Park. The University of Namibia has established the Sam Nujoma Marine and Coastal Resources Research Centre at Henties Bay, which focuses on mushroom development, coastal agriculture and plant biodiversity, renewable energy sources, water resources, as well as the coastal environment.

Nearly three quarters of the constituency's labour force is employed (72%), as compared to the national average of 63%, and depend on employment derived wages and salaries. The unemployment rate stands at 28% compared to the national average of 37% (NSA, 2011).

5.1.4 The mining economy

The contribution of the mining economy to the Erongo Region and Namibia as a whole is significant. It contributes to the overarching goals of Namibia's Fourth National Development Plan 2012 to 2017 (National Planning Commision, 2012):

- High and sustainable growth;
- Employment creation; and
- Increase in income equality.

The mining sector is dominated by uranium mining and exploration which is dependent on water from the Omdel aquifer, and on desalinated water from Areva since November 2013. Since the March 2011 tsunami and subsequent severe damage to the Fukushima reactors in Japan, the uranium industry in Namibia has suffered from global uranium prices. Although some countries have cut back their nuclear energy programmes, there are still 1,100 nuclear reactors worldwide with a further 72 under construction, 173 planned and 309 proposed. Morgan Stanley Research predicts that supply cutbacks (from Paladin and Cameco) are likely to cause a gradual increase in uranium price. It also expects nine nuclear plants to restart by year end 2014 and another seven in 2015 (Japan) (CoM, 2014).

Although the current spot price is about 30US$/lb for uranium oxide (Diniz, 2014), most uranium transactions and mines depend on longer term contracts rather than the spot price, hence the continued development of the Husab mine and the survival of Langer Heinrich Uranium and Rössing Uranium. Rössing Uranium's sales portfolio has a mix of long-term and short-term price exposures including a number of sales contracts running beyond 2017. However, it announced in June 2014 that to survive the low spot price and market over-supply, Rössing Uranium will only produce sufficient quantities to supply into existing long term contracts where official prices are 45$/lb. This will make Rössing Uranium less sensitive to further spot price reductions but will still keep options open in the event that spot prices increase significantly (RUL, 2014).
In 2013, Rössing Uranium employed about 1,140 employees of whom 98% were Namibian. It produced 2,409 tons of uranium oxide which accounts for approximately 3.4% of the world production of primary produced uranium. In spite of the impact of lower prices, it reported a net profit of N$32 million, following losses in 2010, 2011 and 2012. This profit resulted from improvements in uranium production and unit costs, and Rössing Uranium's turnover in 2013 was N$2.96 billion, up from N$2.88 billion in 2012. Rössing Uranium's spending in Namibia is significant, which leads to a long chain of value addition throughout the economy. In 2013 Rössing Uranium:

- Spent N$1.9 billion on goods and services;
- Generated N$83 million in royalty payments;
- Generated N$143 million in Pay-As-You-Earn (PAYE) payments;
- Made N$289 million of payments to state owned enterprises; and
- Paid N$783 million in employment costs.

The Rössing Uranium mine currently uses approximately 3Mm^3 per annum of water for its mining operations.

The Husab mine is in the construction phase; mining operations have begun to remove the overburden and the processing plant is to be commissioned into operation by the fourth quarter 2015. At full production, it expects to produce 15Mlb of uranium oxide per annum, which will require 8 Mm^3/a of water (Metago, 2010). It is 90% Chinese-owned and 10% owned by the Namibian State-owned mining company Epangelo Mining Company. The Husab mine expects to have 1,600 permanent employees (Chinese and Namibian) and a further 8,000 indirect jobs in Namibia through the multiplier effect. The initial life of mine is 20 years. During operations, employees are expected to find housing in the nearby towns of Swakopmund, Arandis and Walvis Bay. It anticipates contributing N$1.1billion to N$1.7 billion per year in corporate tax including N$220 million per year in royalty payments and pay employee income tax, duties, withholding and other taxes (Swakop Uranium, 2014).

Langer Heinrich Uranium has completed two expansions and is now producing uranium oxide at a rate of 5.7Mlb pa. In January 2014, Paladin entered into an agreement to sell a 25% stake in the Langer Heinrich Mine to a wholly owned subsidiary of China National Nuclear Corporation. The offtake component of the agreement allows the China National Nuclear Corporation to purchase its pro-rata share of product at the prevailing market spot price. There is also opportunity for Paladin to secure additional long-term offtake agreements with the China National Nuclear Corporation. It is expected that the agreement will enhance the long-term growth and development of the Langer Heinrich operation. Further expansion could increase production up to 8.7Mlb per annum, when higher uranium prices occur to justify expansion (Project Status for the Langer Heinrich Mine, 2014). The life of mine is 17 years inclusive of the potential expansion.

In 2013, Langer Heinrich Uranium provided employment for over 1,100 permanent staff and contractors (Chamber of Mines, 2013). Its water use in 2012/13 was approximately 2Mm^3 per annum, supplied from NamWater (1.69Mm^3 per annum), a bore field, runoff water collected in the mine pits, and supernatant recovery from the tailings storage facilities. The licence limit for abstraction from the groundwater is 0.5Mm^3 per year although the total abstraction during 2012/13 was 0.28Mm^3 which is 57% of the limit (Paladin Energy Ltd, 2013). Langer Heinrich Uranium's water demand would increase to approximately 7Mm^3 per annum once the proposed expansion is operational (Metago, 2011).

The Strategic Environmental Assessment for the Central Namib Uranium Rush of 2010 constructed various scenarios of mining and associated industrial development up to 2020 (SAIEA, 2010):

- Scenario 1: the 2010 situation with two operating mines (Rössing Uranium and Langer Heinrich Uranium and two other mines under construction (Trekkopje and Valencia).
- Scenario 2 included these four mines (and their expansions) plus two others e.g. Bannerman's Etango Project and the Husab mine. It predicted that these projects are likely to be accompanied by the construction of NamWater's desalination plant, an emergency diesel power plant, a 400MW coal-or gas-fired power station and two chemical plants to supply the mines with reagents.
- Scenario 3 built on Scenario 2 with further expansion of those mines and the addition of at least two more mines, such as Reptile Uranium's Omahola Project and west Australian Metals' Marenica Project.
- Scenario 4 assumed that most or all of the mines will close down at a similar time on an unplanned basis, leaving an un-rehabilitated legacy of mine infrastructure, mass unemployment and excess capacity in all public and private infrastructure (including water supply).

Even with depressed uranium prices, Langer Heinrich and the Rössing Uranium mines continue to operate and the Husab mine is fast coming on track. The Husab mine will require 8Mm^3 of water per annum, Langer Heinrich Uranium requires 2Mm^3 to 7Mm^3 per annum and Rössing Uranium 3Mm^3/a of water. The continued population growth of the coastal towns and the mining and industrial development will require a reliable water supply for the Erongo Region to maintain and increase its growth.

5.1.5 Water Supply and Demand

5.1.5.1 Current Supply Options

In the absence of current official data from the Department of Water Affairs and NamWater, the following varying estimates of water availability have been found from internet searches. Current water supply sources in Erongo's coastal region are the Omdel and Kuiseb Aquifers, and the desalination plant built and owned by Areva.

The Omdel dam and aquifer recharge scheme was completed in 1994 and has a sustainable yield of 9.8Mm^3/a (based on year 2000 figures) (NamWater, 2014). Water Scarcity Solutions (WSS) estimated the extractable recharge of Omdel to be about 7.1Mm^3/a (2030 Water Resources Group, 2013). It concluded that by doubling the natural recharge, it enabled the delay in a desalination plant being built which "permitted the use of newer and more cost-effective desalination technology than would have been possible in 1990" (2030 Water Resources Group, 2013).

The Department of Water Affairs estimates that the sustainable yield for the active Kuiseb between Swartbank and the Delta is in the order of 7Mm^3 per annum (MAWF, 2008). As this is the main source for Walvis Bay and its future developments, it is noteworthy only because the Department of Water Affairs cite it as a possible source for Langer Heinrich Uranium: "The current available natural water resources of the Kuiseb & Omdel scheme, excluding the recent upgrades at Omdel to accommodate Langer Heinrich, are 12.9Mm^3 per annum. This can be increased to a maximum of 15.9Mm^3 per annum by developing other natural resources within both catchments*"* (MAWF, 2008).

Water Scarcity Solutions estimated the total extractable volume of groundwater from Omdel, Kuiseb and Swakop Aquifers at 10.9Mm^3 per annum for the coastal towns and mining activities (2030 Water Resources Group, 2013).

To conclude, the sustainable yield of aquifer water available for all coastal users ranges from 10.9Mm^3 per annum (Water Scarcity Solutions) to 15.99Mm^3 per annum including upgrades (MAWF, 2008).

Areva's desalination plant has the potential of producing 20Mm^3 per annum with a surplus of 8Mm^3 per annum of water available for other users, if Trekoppie reaches full production (Areva Resources Namibia, 2014).

5.1.5.2 Comparison of Water Demand and Supply

In 2009, the Erongo Region consumed about 12Mm^3 of water annually, with the main users being Walvis Bay that used 4.3Mm^3, the Rössing Uranium mine used 3.3Mm^3 and Swakopmund used 3Mm^3. All of the water was then sourced from alluvial aquifers in the Kuiseb and Omaruru Rivers (CSIR, 2009, p. 2).

Thus, based on the considerations above, assuming no significant recovery in the uranium price, and matching supply with demand, the following very rough estimates can be made:

Table 4. *Crude estimate of future water demand and supply*

	POINT	(Mm^3/a)	SOURCE OF INFORMATION
DEMAND	Swakopmund	4	Estimate based on an increase from 3.3Mm^3 in 2009
	Arandis and Henties Bay	0.5	Estimate based on a proportion of Swakopmund's use
	Rössing Uranium	3	Capacity of proposed desalination plant
	Langer Heinrich Uranium	7	Langer Heinrich Uranium and Metago
	Husab	8	Metago
	Total demand:	22.5	
SUPPLY	Omdel aquifer	9.8	NamWater current website
	Areva desalination plant	20	Areva
	Total	29.8	
BALANCE	Excess capacity	7.3	

Table 4 shows that if Areva's desalination plant was available for the three main mines, there might still be a surplus of approximately 7.3Mm3/a. This comparison depends on a number of assumptions about what mining developments will actually take place. If the uranium price were to recover significantly, development of a number of new mines including Trekkopje, Etango, Omahola and Marenica could significantly increase demand resulting in shortfall and the need for water. The issues are both about inadequate supply of desalinated water, as well as the cost at which it is or can be produced and sold to users.

5.1.5.3 Water Tariffs

Water Scarcity Solutions estimated the cost of Omdel water is N$2.5/$m^3$ (2030 Water Resources Group, 2013). The Swakopmund, Arandis and Henties Bay municipalities are supplied from and pay for Omdel aquifer water, and only the mines currently pay for desalinated water. NamWater and the municipalities have significantly increased their charges above inflation in recent years. Swakopmund water tariffs for domestic and business users are similar. Domestic tariffs increased from May 2014 to the following (pers. comm. Swakopmund Municipality):

- Up to 9 m^3 — N$61.75
- 9m^3 to 30 m^3 — 11.65 N$/$m^3$
- 30m^3 to 60 m^3 — 16.30 N$/$m^3$
- 60 m^3 and above — 24.10 N$/$m^3$

Rössing Uranium is currently paying 45N$/$m^3$ to 50N$/$m^3$ for desalinated water. However, these contracts are on a take or pay basis and therefore during periods of low usage, the actual water tariff could easily increase (and has done so) to over 90N$/$m^3$. Anticipated cost from the proposed project is substantially lower and affordable for Rössing Uranium. Rössing Uranium's preliminary indications are that it can produce water at below 2USD/m^3 (approximately 22N$/$m^3$), before conveyancing costs. This is substantially less than the existing water price, which is well above 3US$/$m^3$ (approximately 33N$/$m^3$), before conveyancing costs. (Rössing Uranium assumes conveyancing costs to be cost neutral). By constructing its own desalination plant, Rössing Uranium is anticipating a saving in water costs of approximately N$40 million to N$60 million per year against the current water cost.

5.1.6 History of Swakopmund and surrounds[14]

Due to the general scarcity of fresh water along the Namibian coastline, human habitation has been sporadic consequently there remains little evidence such habitation, although a collection of original musical instruments, wood carvings, weapons and domestic utensils does exist at the Swakopmund Museum. The first Europeans entering Namibia, the Portuguese navigator Bartolomeu Diaz in 1487 entered the Namibian coast near Swakopmund at Cape Cross. He erected a stone cross and named the place Terra de Santa Barbara. Dutch sailors first anchored at the mouth of the Swakop in 1793.

In August 1892, the German gunboat "Hyena" marked a landing site for boats, north of the mouth of the Swakop. The national commissioner and commander of the "Schutztruppe" (security force), Captain Curt von Francois, established a base that would later lead to the establishment of military and civilian facilities. Swakopmund was chosen as a settlement area for its availability of fresh

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[14] *Facts about Swakop, 2014*

water. Swakopmund quickly became the main port for imports and exports for the territory, and was one of six towns which received municipal status in 1909. Many government offices for German South-West Africa had offices in Swakopmund. The Hamburg-based shipping company Woermann started in 1894 offered regular freight traffic to the colony. In the following years, everything that was needed by the colony was imported via Swakopmund. Trading and shipping companies founded branches in Swakopmund and a number of these early buildings still exist. After German South-West Africa was taken over by the Union of South Africa in 1915, all harbour activities were transferred from Swakopmund to Walvis Bay. Many of the Central Government services ceased in Swakopmund, businesses closed down, the number of inhabitants diminished and the town became less prosperous.

The discovery of uranium at Rössing, 70km outside the town, led to the development of the world's largest openpit uranium mine. This had an enormous impact on all facets of life in Swakopmund which necessitated expansion of the infrastructure of the town to make it one of the most modern in Namibia.

Production of the concentrated brine at the salt pan known as Panther Beacon began in 1933, but by 1952 the salt source was exhausted. Seawater has since been pumped into open evaporation and concentration ponds from which crystallised salt is removed with mechanical scrapers. The pans are shallow and of varying salinity (Simmons, Barnes, Jarvis, & Robertson, 1999). A large wooden commercial guano platform covering 31,000m^2 was built in one of the northern pans after the 1930’s and remain productive. Guano production rates have fallen and this is associated, in part, to the reduction in pelagic shoaling fish species along the coastline, which served as a primary food source for marine birds (Burger & Cooper, Unkown). The Richwater Oyster Company started cultivating oysters in the pan 1985 (Simmons, Barnes, Jarvis, & Robertson, 1999).

5.2 Biophysical Environment

5.2.1 Surrounding landuses

The proposed project is situated within the Swakopmund Salt Works. The primary landuse associated with the salt pans is the production of salt, guano and oysters. The site is also a private nature reserve and is identified as an important bird area, and is frequented by a variety of marine bird species. The gravel plains surrounding the salt pans are used as nesting sites by the rare Damara Tern.

East of the site is the C34, a secondary route providing a scenic drive to Henties Bay along the coastline. The road is a popular tourist route and provides access to the Dorob National Park and its natural attractions, associated recreation areas and tourism facilities.

Dorob National Park (Dorob meaning "dry land") is a 1,600km long strip of land, encompassing a spectacular coastal dune belt, vast gravel plains, rich botanical diversity (including extensive lichen fields), major ephemeral river systems and their river mouths and Namibia's richest coastal area for birds. Some 75 species of birds flock to this coast, with nearly 1.6 million birds recorded here at times.[15] Apart from several Ramsar listed wetlands, the Dorob has been included under the category of “Important Bird Areas” by BirdLife International. The Damara Tern, a breeding seabird

[15] Source: http://travelnewsnamibia.com/news/2012-2013-rules-regulations-dorob-national-park/#.UYdhYb26ZLM

that is endemic to Namibia, is considered a flagship species of the coastal area. It is found in the park, although non-breeding individuals will migrate to the north in winter. Figure 12 provides a map of the Dorob National Park and the major natural features and tourist attractions of the region.

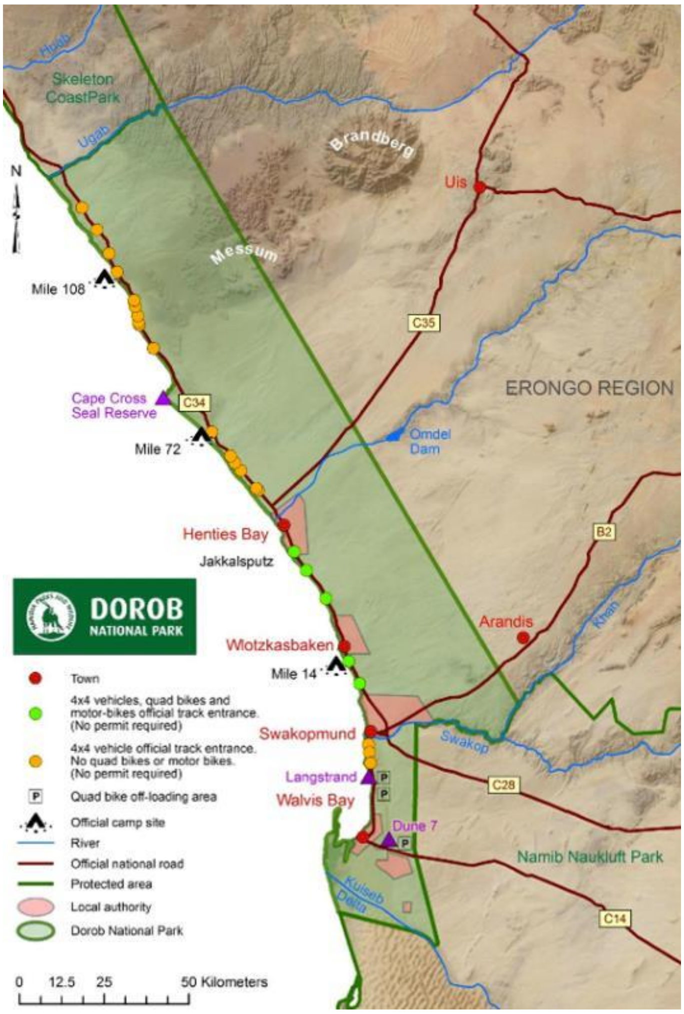


Figure 12: The Dorob National Park[16]

The town of Swakopmund is expanding, and is generally moving northward along the coastline, toward the Swakopmund Salt Works. The Swakop River and dune systems to the south of Swakopmund act as a natural barrier to town expansion. The town of Swakopmund has a rich heritage and is characterised by a Germanic and European influenced architecture, adding to its tourism appeal. Traditionally a coastal resort town, Swakopmund has seen significant growth due to its proximity to the uranium mining areas of the Erongo Region. Uranium mining in the area grew rapidly as a result of favourable global uranium market prices, although this growth has subsided as a result of changing market conditions. Numerous migrant workers seeking jobs with the mines, or commercial fishing and associated industries, have taken up residence in the towns of Swakopmund and Walvis Bay, which has spurred the rapid growth of both towns. A number of mining support enterprises have also established themselves in Swakopmund and use it as a base from whence to serve the major mining operations in the area.

The Benguela upwelling supports a significant commercial fishing industry. Fishing trawlers and associated industry are mostly based in Walvis Bay due to the port facilities. Natural fish stocks

[16] Source: http://stories.namibiatourism.com.na/blog/bid/352325/The-National-Parks-of-Namibia-Nkasa-Lupala-and-Dorob

are however declining and the fishing industry are likely to diminish, with a few fish processing facilities already having closed operations. In the face of declining fishing stocks, mariculture has been identified as a good diversification strategy for the industry and investigations into this avenue continue and are likely to witness a growing impetus.

5.2.2 Climate

Swakopmund's climate is strongly moderated by its proximity to the Atlantic Ocean and the associated cold Benguela current which brings cold water up from the polar regions and flows along the Namibian coastline. Swakopmund has a cool, hyper arid desert climate with very little rainfall throughout the year (average annual rainfall is a mere 11mm). Most rainfall occurs in March and August is the driest month. The average annual temperature is 15.3^{o}C. The warmest month is February with an average temperature of 18.3^{o}C compared to August, which is the coldest month, with an average temperature of 12.9^{o}C (Climate-Data.org, 2014). The highest temperatures recorded (up to 40^{o}C) typically only occur during the winter months and are associated with bergwind conditions which blow hot and dry air from the inland areas.

A thick coastal fog is a frequent occurrence along the Namibian coast and provides sufficient moisture for a number of highly adapted fauna and flora species to survive in the arid environment. The fog extends inland as far as 50km (World Wildlife Fund, 2014). Fog occurs more frequently along the Central Namib Desert coast than elsewhere, probably due to the upwelling off that part of the coast. An average of 146 days of fog per year has been recorded at Walvis Bay (Mendelsohn *et al*. 2002). Of relevance to this project is that the heavy fog combined with ocean salt spray, results in a highly corrosive environment near the coast and all equipment, structures and facilities must be designed to contend with this environment.

For more information on wind characteristics please refer to the wind roses presented in the Figure 40 in Section 5.2.9.1.

The following climate maps (Ministry of Environment and Tourism, 2002) provide an additional overview of the prevailing climatic conditions in Swakopmund, set in the national context.

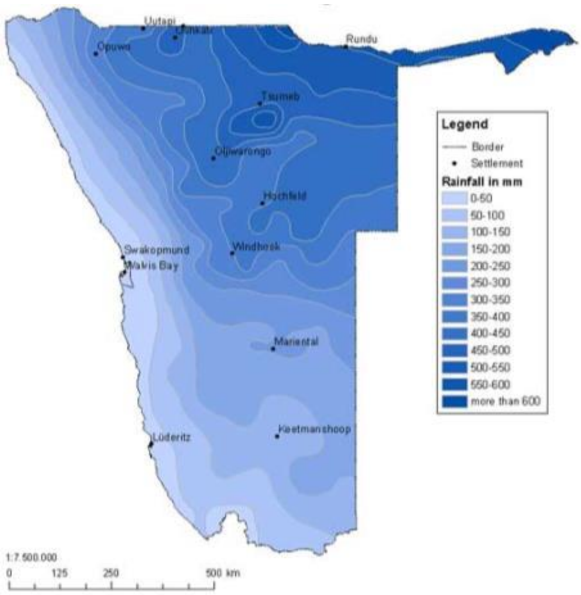


Figure 13: Average annual precipitation

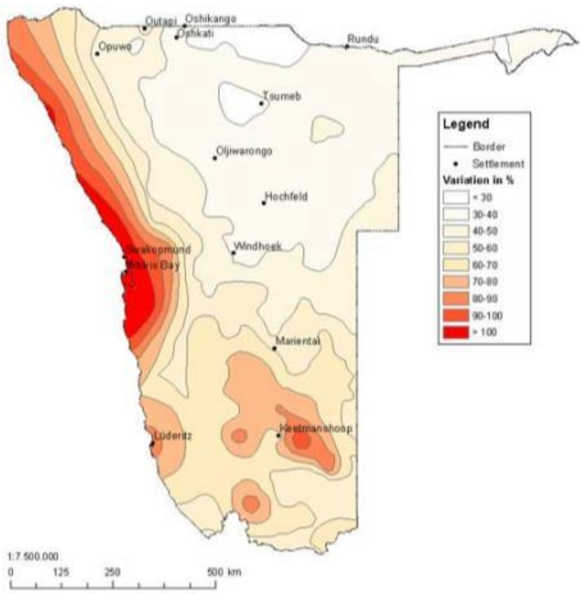


Figure 14: Rainfall variability

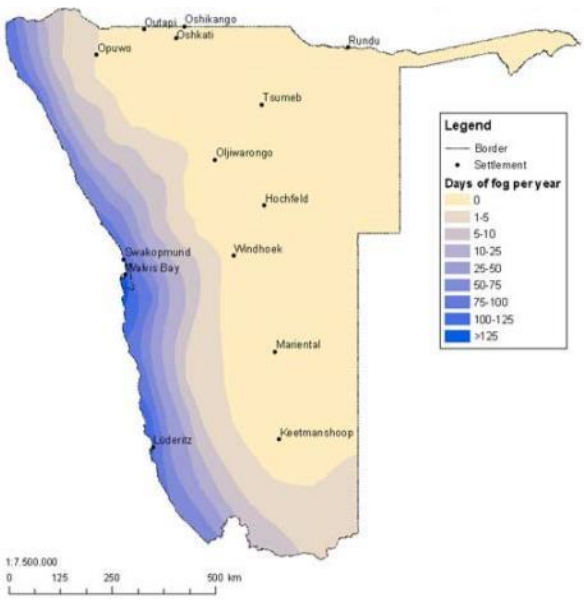


Figure 15: Average annual number of days with fog

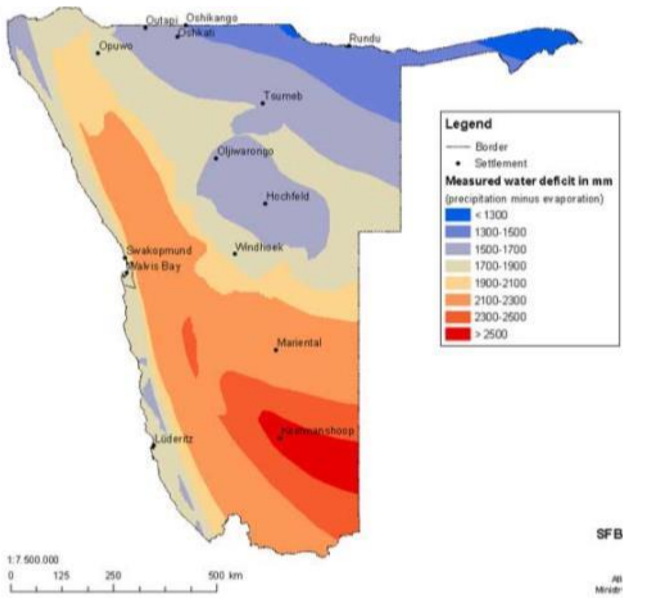


Figure 16: Average annual water deficit

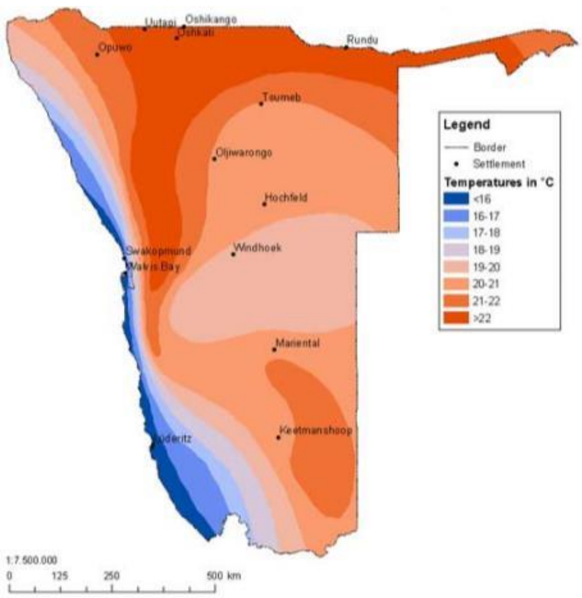


Figure 17: Average annual temperature

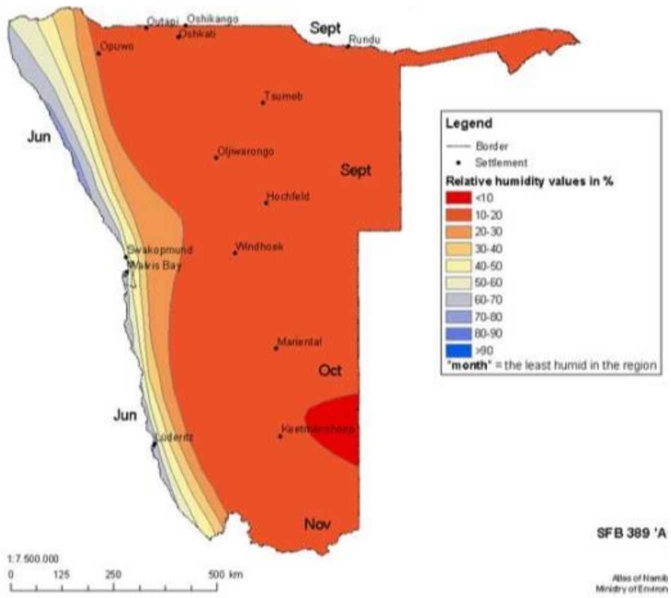


Figure 18: Average annual relative humidity

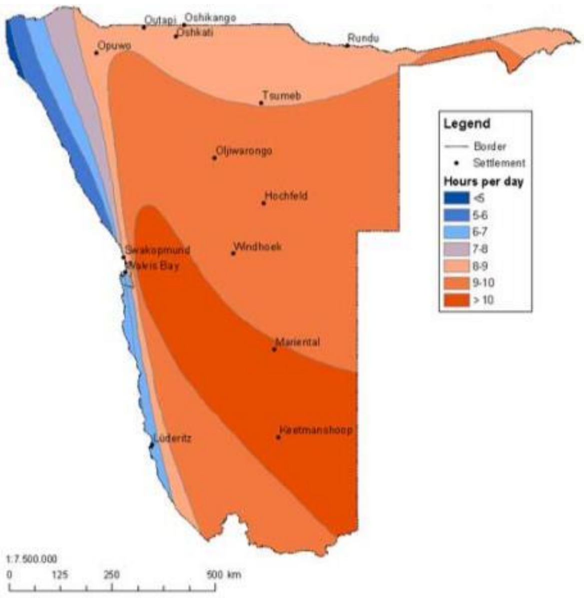


Figure 19: Average annual daylight hours

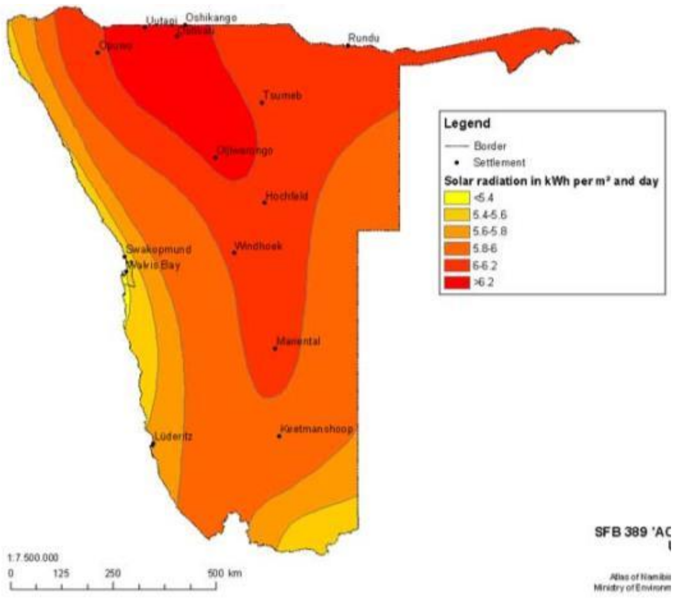


Figure 20: Average annual solar radiation

5.2.3 Geology and geomorphology

The geology of the Swakopmund area is characterised by schists and dolomites of the Swakop Group, falling within the Damara Supergroup and Gariep Complex, with Damara Granites and Kalahari and Namib Sands. Extensive gypsum and calcrete deposits have developed in low lying areas. Gypsum plains are found within 60km of the coast and generally coincide with the regular fog zone (CSIR, 2009). The dominant landscape is mainly Central-western Plains. Broad geomorphological characteristics include a shore of mixed sand and rock, with gravelly coastal plains in the study area, with the Arandis Mountain (just over 600m high) further to the east and a narrow dune belt further to the south. Natural surface water is limited to drainage lines and coastal pans. To the south lies the Swakop River Valley, deeply incised by an ephemeral river. Man-made aquatic habitats in the vicinity of the study area include the Swakopmund Salt Works and Municipal sewage works.

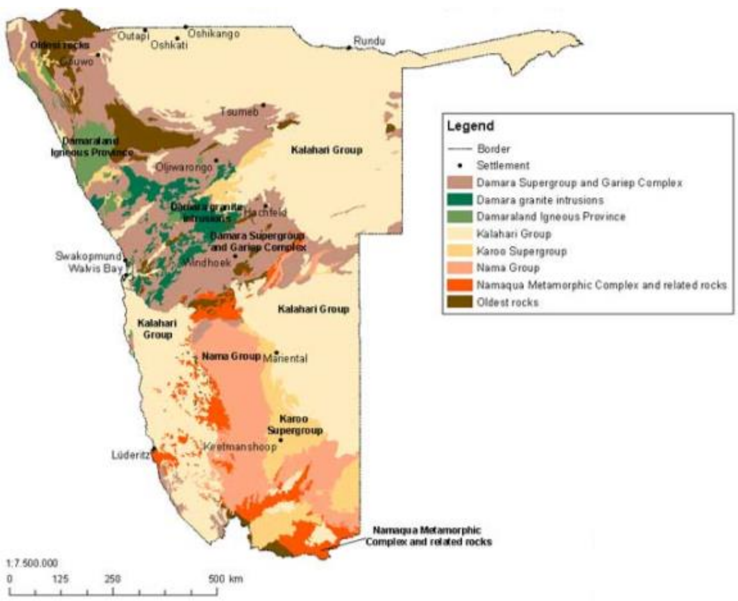


Figure 21: Major geology

5.2.4 Topography

The Swakopmund Salt Works is situated in the Central-Western Plains (Figure 22), on a gently sloping, low relief coastal plain. The Swakopmund Salt Works is characterised by an absence of topographical features and takes advantage of a natural depression in local topography which facilitates its use for salt evaporation ponds. The evaporation pans cover approximately $4km^2$ representing an area of naturally low elevation bounded on the western, or seaward, side by a wide bar of sandy gravel. This latter feature appears to have been augmented by artificial embankment construction, but remains a largely natural remnant of a late Pleistocene sea level high stand. The area occupied by the evaporation pans may represent a palaeo-lagoon feature associated with a series of sea level high stands, which is associated with evidence of a 2.5m sea level rise at several points on the Namib coast. The low relief character and particularly the vertical proximity to the ocean is advantageous for the purposes of a desalination plant, as seawater does not have to be pumped to a significant height, which adds to the electrical efficiency of the facility.

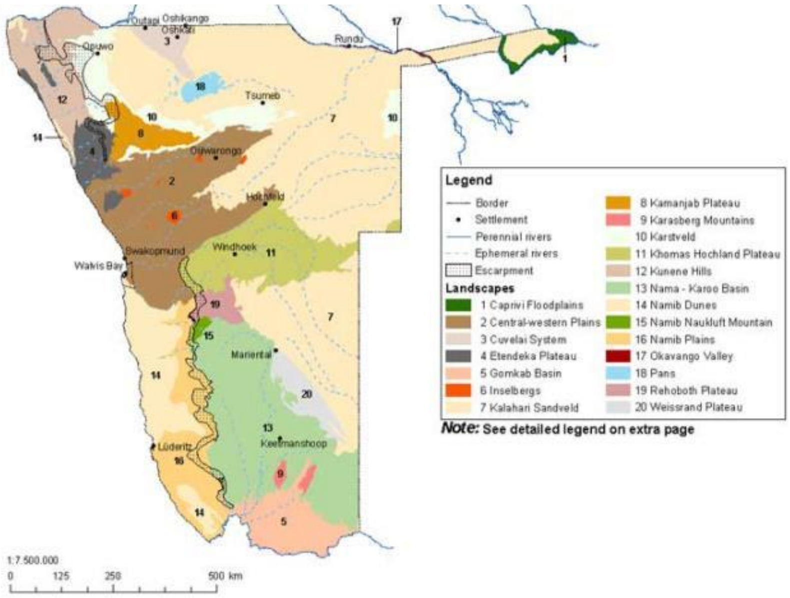


Figure 22: Broad landscape types of Namibia[17]

Figure 23 provides a view of the proposed desalination plant site with the salt works evaporation ponds in the background and reveals the near featureless landscape that characterises the area.

Figure 23: General view of the proposed desalination plant site

[17] Source: (Ministry of Environment and Tourism, 2002)

5.2.5 Soils

The soils surrounding the Swakopmund Salt Works can be described as Petric Gypsisols, and Petric Calcysols (Mendelsohn *et al.* 2002). Together with a challenging climate, these are regarded as having a low agricultural potential (Ministry of Environment and Tourism, 2002). The coastline is characterised by deep, sandy, poor and fragile soils that are prone to degradation. Soil conservation is of critical importance in these areas, where vegetation is sparse, leaving the soil exposed to the elements and erosive forces. Lichens play an important role in paedogenesis and soil stabilisation through their contribution to the formation of biological soil crusts in the Namib Desert areas. The lichens are however prone to disturbance by man and are very slow to recover from disturbances.

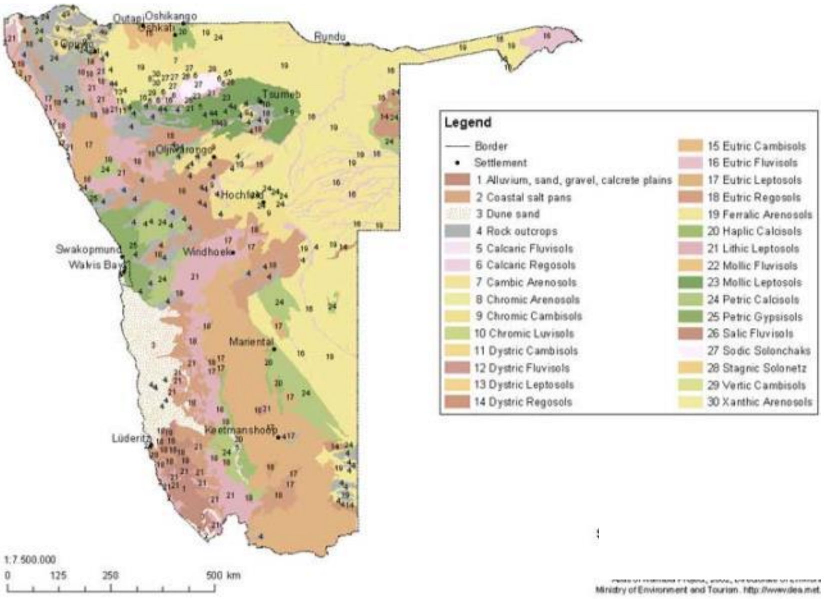


Figure 24: Dominant soils[18]

The coastline of central Namibia is dominated by sandy beaches, with rocky habitats being represented only by occasional rocky outcrops. The beaches surrounding the project area are also littered with gravel and cobble stones and the sea sand is described as damp, light yellowish brown, very loose, medium to fine sand dispersed with darker mineral sands, as shown in Figure 25.

Figure 25: View of the beach areas of the Swakopmund Salt Works area

[18] *Source: (Ministry of Environment and Tourism, 2002)*

5.2.6 Hydrology

There are a number of poorly defined ephemeral drainage lines in the area which drain the stormwater toward the salt pans and ocean. As a result of the low annual precipitation, the region is characterised by a lack of surface water features. The nearest river of significance is the Swakop River which is a non-perennial river situated south of Swakopmund, approximately 10km to the south of the proposed project. The project is unlikely to impact on surface freshwater features and standard engineering protocols will be applied with regard to stormwater controls.

Groundwater reserves in the vicinity of the study area are limited to the Kuiseb, Swakop and Omaruru alluvial bed aquifers of the Erongo groundwater basin, which supply Henties Bay, Swakopmund and Walvis Bay as well as Arandis, and historically Rössing Uranium and Langer Heinrich Mines (CSIR, 2009). A groundwater study undertaken for the Wlotzkasbaken desalination plant, 30km north of Swakopmund, detected no freshwater table at the beach, and seawater penetrated inland to at least 500m from the high water mark at a depth of 1.5m. The salt water intrusion is expected to be greater in the areas surrounding the Swakopmund Salt Works as a result of the salt evaporation ponds and an associated infiltration of seawater, and in some instances concentrated seawater, into the soils.

5.2.7 Oceanography[19]

5.2.7.1 Seabed Topography, Bathymetry and Sediments

The coastal strip around Swakopmund is covered by a 2 to 3m thick layer of very loose, medium to fine grained sea sand, which stretches approximately 200m inland. Only in the vicinity of Henties Bay is the shore backed by low sandy cliffs.

As part of the pre-feasibility phase for the NamWater Desalination Plant Project, the (CSIR, 2008) conducted a geophysical and hydrographical survey of the area directly north of the salt works using sub-bottom profiling and echo sounding. Although the salt works are located on a slight promontory, it is expected that the bathymetry offshore will be very similar to that recorded during the NamWater Study. This bathymetric data showed a gently sloping seabed reaching the -10m depth contour at around 1,700m offshore. No bathymetric data are available for depths inshore of -3m to -4m contour, but existing information suggests a rock plate sloping very gently into the intertidal area. This rocky shelf is prominent between the old concrete intake structure and the current seawater intake for the Swakopmund Salt Works, and to the western-most point of the salt works (Figure 26a), becoming patchy further south (Figure 26b). Offshore blinders occur to the west and south of the old bitterns disposal site. There is a prominent berm on the upper beach along much of the coastline (Figure 26c). From there, the beach slopes steeply to the low water mark.

[19] *Section written by Dr Andrea Pulfrich of Pisces Environmental and Christoph Soltau of WSP Coastal Engineers*

a)
b)
c)

Figure 26: The coastline west of the salt works[20]

The surficial sediments in the intertidal and low-shore areas are generally dominated by moderately to well-sorted fine to medium sand with median particle sizes of 200µm to 400µm and heavy minerals present in the sediments. In the south of the study area, the sediments become coarser and can contain substantial proportions of gravel and pebbles, with occasional extensive pebble beds in the mid- and low-shore (Figure 26c).

Further offshore, the seafloor is dominated by undulated rock or hard sediment with occasional rock outcrops or reefs running either parallel or at an angle to the coastline. The rock surface appears rough with a micro relief of approximately 0.5m to1.0m. Sandy areas are sparse, and generally occur in small isolated patches scattered over the area. The sediment accumulations are thin with a maximum observed thickness of 1.8m.

[20] *Notes: The coastline is characterised by a rocky intertidal shelf in the north, and pebble beaches with a prominent berm further south (Photos: Christoph Soltau, WSP Coastal Engineers).*

Further offshore, beyond the -100m depth contour, the seabed is dominated by a tongue of sandy mud, which extends from south of Sandwich Harbour to the north past Henties Bay (Figure 27) These biogenic muds, which comprise organically rich diatomaceous oozes originating from planktonic detritus, are the main determinants of the formation of low-oxygen waters and sulphur eruptions off central Namibia.

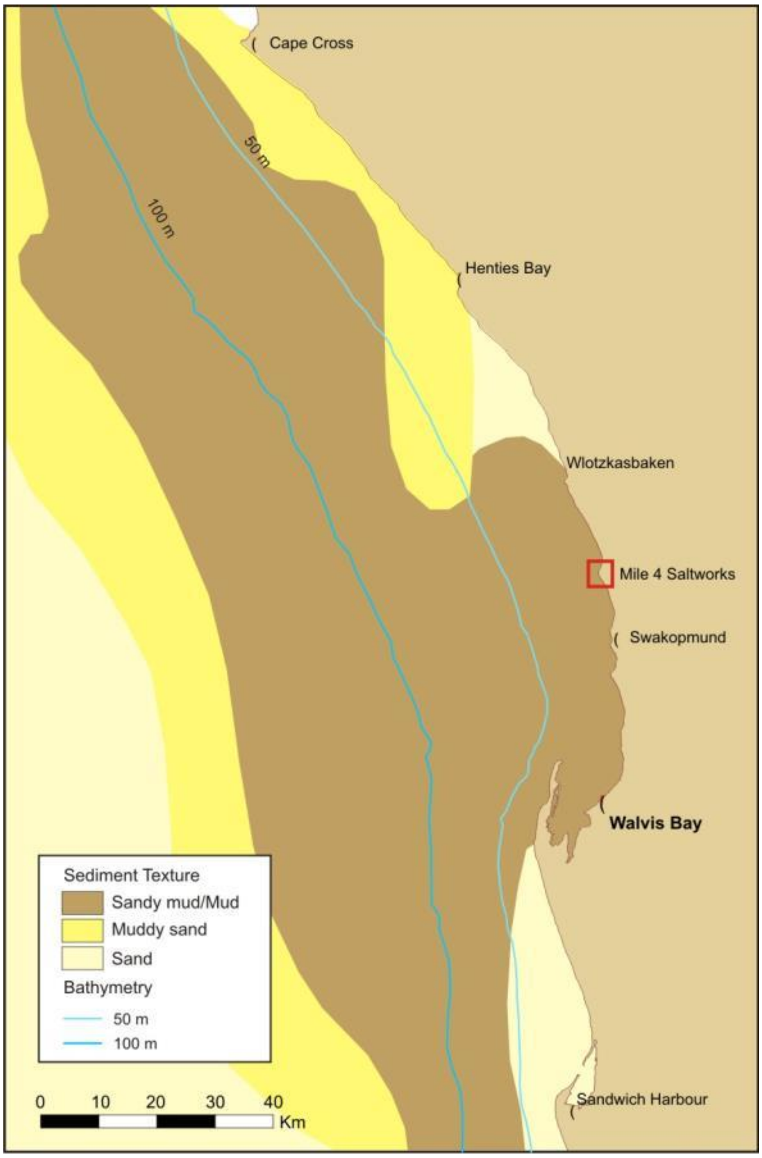


Figure 27: The proposed desalination plant (red rectangle) in relation to the regional offshore seabed sediments

The central Namibian continental shelf is covered by layers of sediments primarily of biogenic (biological) origin as a result of the high productivity in the upwelled waters. A significant feature of the central Namibian middle shelf is an extensive mud belt.

5.2.7.2 Waves

The central Namibian coastline is influenced by major swells generated in the Roaring Forties, as well as significant sea waves generated locally by the persistent south-westerly winds. Apart from Walvis Bay and Swakopmund, wave shelter in the form of west to north-facing embayments, and coast lying in the lee of headlands are extremely limited.

No measured wave data are available for the Swakopmund to Henties Bay area. However, data collected by voluntary observing ships indicate that wave heights in the range of 1.5m to 2.5m occur most frequently, with a mean wave height of 2.14m and mean wave periods in the range of

8s to 13s (Figure 28). Longer period swells with mean periods of 11s to 15s generated by mid-latitude cyclones, occur about 30% of the time.

Wind-induced waves on the other hand have shorter wave periods (approximately 8s), and are generally steeper than swell-induced waves. Storms occur frequently with significant wave heights over 3m occurring 10% of the time. The largest waves recorded originate from the south to southwest sectors and may attain 4 to 6m.

The annual distribution indicates that 43% of the waves come from the south with 30% and 12% coming from the Swakopmund Salt Works and southwest respectively. There is no strong seasonal variation in the wave regime except for slight increases in swell from west-southwest to west direction in winter.

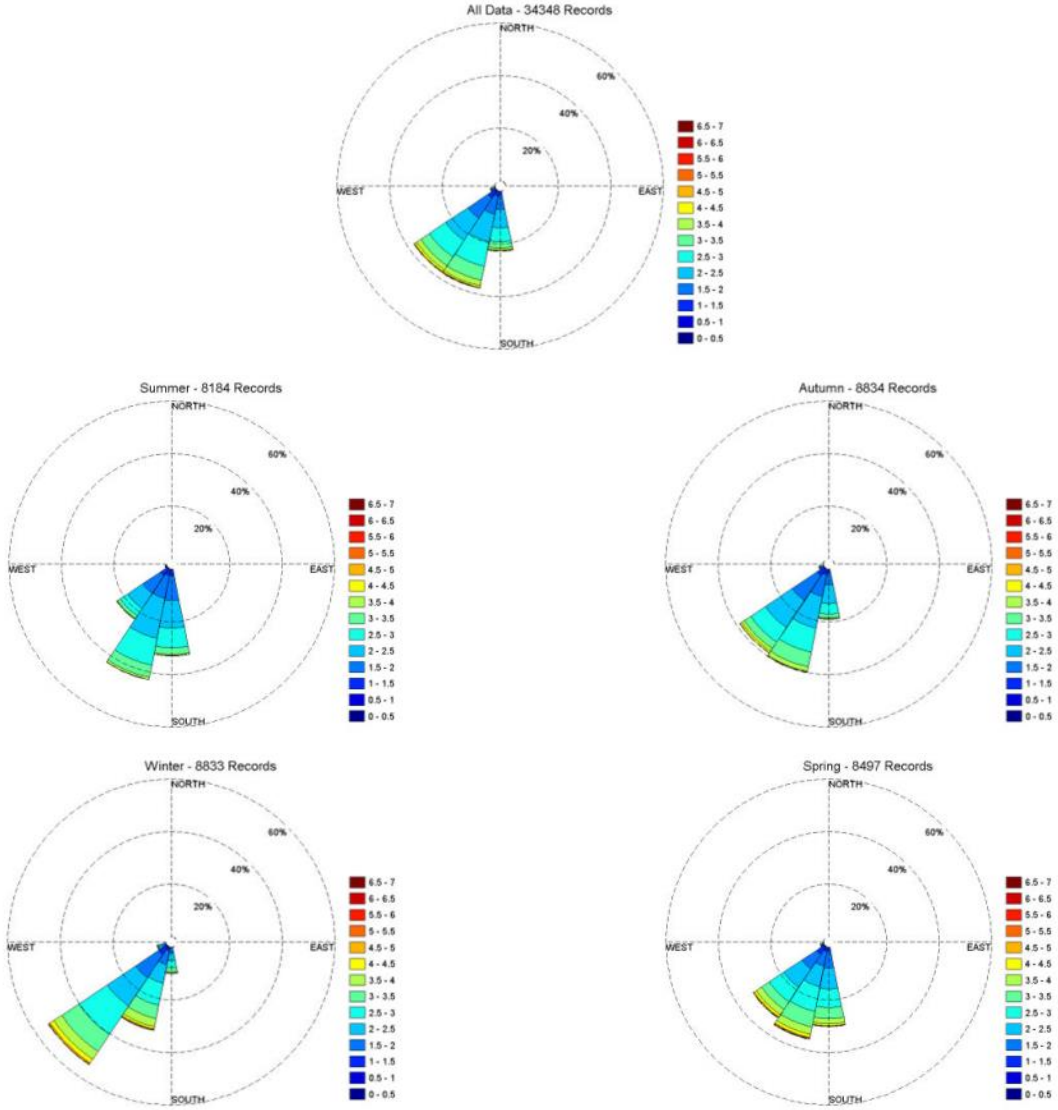


***Figure 28: Seasonal offshore wave conditions*[21]**

[21] *Notes: Data point located at 23° S, 13.75°E (CSIR, 2009)*

5.2.7.3 Tides

In common with the rest of the southern African coast, tides in the study area are regular and semi-diurnal. The maximum tidal variation is approximately 2m, with a typical tidal variation of approximately 1m. Variations of the absolute water level as a result of meteorological conditions such as wind and waves can, however, occur adjacent to the shoreline and differences of up to 0.5m in level from the tidal predictions are not uncommon. Tidal currents are minimal with measurements of 0.1m/s reported at Walvis Bay. Table 5 lists mean tidal levels for Walvis Bay.

Table 5: Tide statistics for Walvis Bay[22]

DESCRIPTION	LEVEL IN M
Highest Astronomical Tide	+1.97
Mean High Water of Spring Tide	+1.69
Mean High Water of Neap Tide	+1.29
Mean Level	+0.98
Mean Sea Level	+0.97
Mean Low Water of Neap Tide	+0.67
Mean Low Water of Spring Tide	+0.27
Lowest Astronomical Tide	0.00

5.2.7.4 Coastal Currents

Current velocities in continental shelf areas of the Benguela region range generally between 10cm/s to 30cm/s (Boyd & Oberholster, 1994). The flows are predominantly wind-forced, barotropic and fluctuate between poleward and equatorward flow (Hutchings & Nelson, 1983) and (Shillington, et al., 1990). Fluctuation periods of these flows are 3 to10 days, although the long-term mean current residual is in an approximate northwestern (alongshore) direction. Currents in the nearshore environment along the coastline of the study area have not been well studied, but some surface-current measurements were done at Swakopmund between 1971 and 1972 (CSIR, 2005). Surface currents in the area appear to be quite variable, with flows primarily less than 30cm/s and an average velocity of 14cm/s. Current speeds in reverse flows observed between Walvis Bay and Henties Bay range between 2cm/s to 17cm/s. Near bottom shelf flow is mainly poleward (Nelson, 1989) with low velocities of typically 5cm/s.

5.2.7.5 Surf-zone Currents

Typically wave-driven flows dominate in the surf-zone (characteristically 150m to 250m wide), with the influence of waves on currents extending out to the base of the wave effect (approximately 40m) (Rogers, 1991). The influence of wave-driven flows extends beyond the surf-zone in the form of rip currents. Longshore currents are driven by the momentum flux of shoaling waves approaching the shoreline at an angle, while cross-shelf currents are driven by the shoaling waves. The magnitude of these currents is determined primarily by wave height, wave period, angle of incidence of the wave at the coast and bathymetry. Surf-zone currents have the ability to transport unconsolidated sediments along the coast in the northward littoral drift.

[22] *Note: All levels are referenced to Chart Datum. Source: (South African Navy, 2007)*

Nearshore velocities have not been reported and are difficult to estimate because of acceleration features such as surf-zone rips and sandbanks. However, computational model estimates using nearshore profiles and wave conditions representative of this coastal region suggest time-averaged northerly longshore flows which have a cross-shore mean of between 0.2m/s to 0.5m/s. Instantaneous measurements of cross-shore averaged longshore velocities are often much larger. Surf-zone-averaged longshore velocities in other exposed coastal regions commonly peak at between 1.0m/s to 1.5m/s, with extremes exceeding 2m/s for high wave conditions (CSIR, 2002). The southerly longshore flows are considered to remain below 0.5m/s.

5.2.7.6 Upwelling

The major feature of the Benguela system is upwelling and the consequent high nutrient supply to surface waters leads to high biological production and large fish stocks. The prevailing longshore, equatorward winds move nearshore surface water northwards and offshore. To balance the displaced water, cold, deeper water wells up inshore. Although the rate and intensity of upwelling fluctuates with seasonal variations in wind patterns, the most intense upwelling tends to occur where the shelf is narrowest and the wind strongest. The largest and most intense upwelling cell is in the vicinity of Lüderitz, and upwelling can occur there throughout the year (Figure 29). Off northern and central Namibia, secondary upwelling cells occur. Upwelling in these cells is perennial, with a late winter maximum (Shannon L.V., 1985).

5.2.7.7 Water Masses and Temperature

South Atlantic Central Water comprises the bulk of the seawater in the study area, either in its pure form in the deeper regions, or mixed with previously upwelled water of the same origin on the continental shelf (Hutchings & Nelson, 1983). Salinities range between 34.5‰ and 35.5‰ (Shannon L.V., 1985). Data recorded over a ten year period at Swakopmund (1988 to 1998) show that seawater temperatures vary between 10°C and 23°C, averaging 14.9°C. They show a strong seasonality with lowest temperatures occurring during winter when upwelling is at a maximum (Figure 30).

During the non-upwelling season in summer, daily seawater temperature fluctuations of several degrees are common along the central Namibian nearshore coast. It appears that the thermal regime of the surf-zone is controlled by locally-forced offshore transport, which leads the associated temperature fluctuations by one day (Hagen & Bartholomae, 2007). This time-lag suggests the existence of a persistent recirculation cell in nearshore waters in this region.

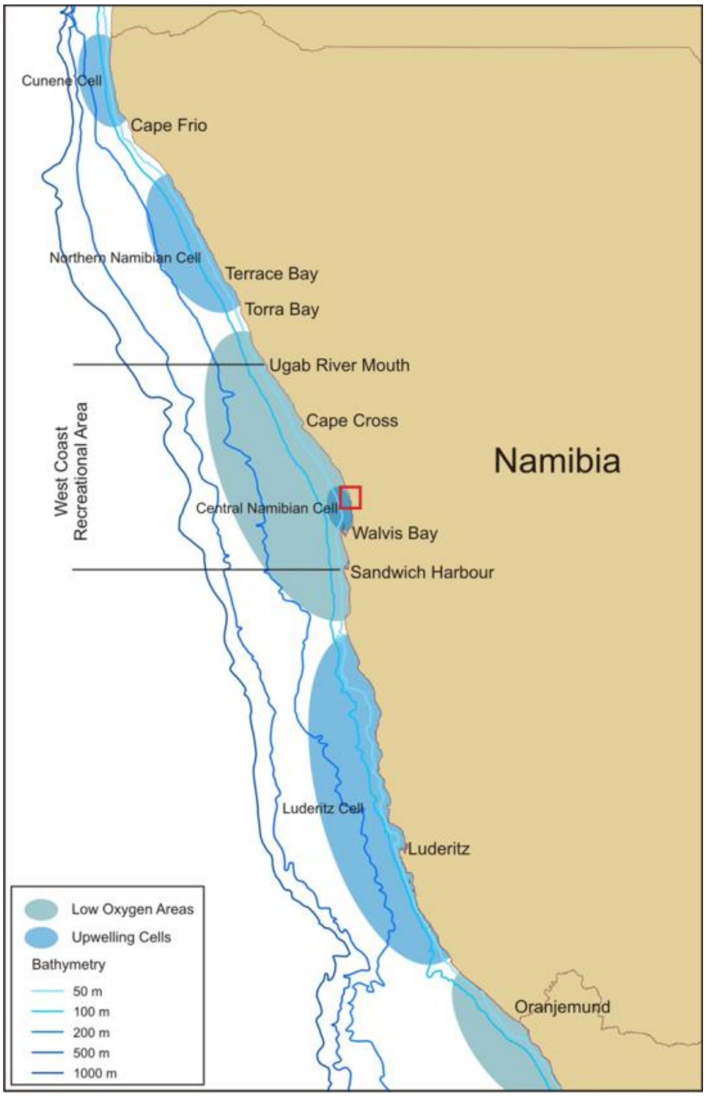


Figure 29: The location in relation to the upwelling cells and the formation zones of low oxygen water

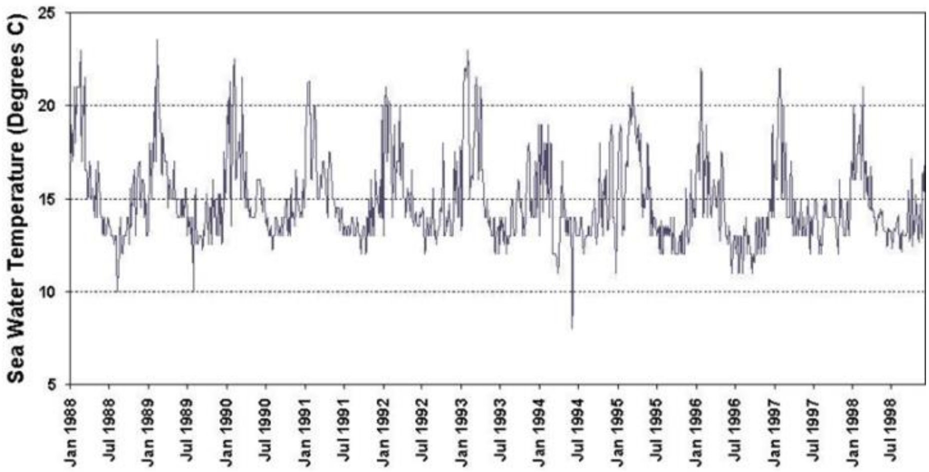


Figure 30: Seawater temperatures at Swakopmund recorded between 1988 and 1998

The continental shelf waters of the Benguela system are characterised by low oxygen concentrations, especially on the bottom. The South Atlantic Central Water itself has depressed oxygen concentrations (approximately 80% saturation value), but lower oxygen concentrations (of less than 40% saturation) frequently occur (Visser, 1969), (Bailey, Beyers, & Lipschitz, 1985) and (Chapman & Shannon, 1985).

Nutrient concentrations of upwelled water of the Benguela system attain 20µM nitrate-nitrogen, 1.5µM phosphate and 15µM to 20µM silicate, indicating nutrient enrichment (Chapman & Shannon, 1985). This is mediated by nutrient regeneration from biogenic material in the sediments (Bailey, Beyers, & Lipschitz, 1985). Modification of these peak concentrations depends upon phytoplankton uptake which varies according to phytoplankton biomass and production rate. The range of nutrient concentrations can thus be large, but in general concentrations are high.

5.2.7.8 Turbidity

Turbidity is a measure of the degree to which the water transparency is lost due to the presence of suspended particulate matter. Total Suspended Particulate Matter is typically divided into Particulate Organic Matter and Particulate Inorganic Matter and the ratios between them varying considerably. The Particulate Organic Matter usually consists of detritus, bacteria, phytoplankton and zooplankton, and serves as a source of food for filter-feeders. Seasonal microphyte production associated with upwelling events will play an important role in determining the concentrations of Particulate Organic Matter in coastal waters. Particulate Inorganic Matter, on the other hand, is primarily of geological origin consisting of fine sands, silts and clays. Particulate Inorganic Matter loading in nearshore waters is strongly related to natural inputs from rivers or from bergwind events, or through re-suspension of material on the seabed.

Concentrations of suspended particulate matter in shallow coastal waters can vary both spatially and temporally, typically ranging from a few mg/ℓ to several tens of mg/ℓ (Bricelj & Malouf, 1984), (Berg & Newell, 1986) and (Fegley, Macdonald, & Jacobsen, 1992). Field measurements of Total Suspended Particulate Matter and Particulate Inorganic Matter concentrations in the Benguela current system have indicated that outside of major flood events, background concentrations of coastal and continental shelf suspended sediments are generally less than 12mg/ℓ, showing significant long-shore variation (Zoutendyk, Turbid water in the Elizabeth Bay region: A review of the relevant literature, 1992) and (Zoutendyk, 1995). Considerably higher concentrations of Particulate Inorganic Matter have, however, been reported from southern African west coast waters under stronger wave conditions associated with high tides and storms, or under flood conditions.

The major source of turbidity in the swell-influenced nearshore areas off Namibia is the redistribution of fine inner shelf sediments by long-period Southern Ocean swells. The current velocities typical of the Benguela (10cm/s to 30cm/s) are capable of re-suspending and transporting considerable quantities of sediment equatorwards. Under relatively calm wind conditions, however, much of the suspended fraction (silt and clay) that remains in suspension for longer periods becomes entrained in the slow poleward undercurrent (Shillington, et al., 1990) and (Bremmer & Rogers, 1991).

Superimposed on the suspended fine fraction, is the northward littoral drift of coarser bedload sediments, parallel to the coastline. This northward, nearshore transport is generated by the predominantly south-westerly swell and wind-induced waves. Longshore sediment transport, however, varies considerably in the shore-perpendicular dimension. Sediment transport in the surf-zone is much higher than at depth, due to high turbulence and convective flows associated with breaking waves, which suspend and mobilise sediment (Smith & Mocke, 2002).

On the inner and middle continental shelf, the ambient currents are insufficient to transport coarse sediments, and re-suspension and shoreward movement of these by wave-induced currents occur primarily under storm conditions (Drake *et al.* 1985 and Ward 1985).

The powerful easterly bergwinds occurring along the Namibian coastline in autumn and winter also play a significant role in sediment input into the coastal marine environment (Figure 31), potentially contributing the same order of magnitude of sediment input as the annual estimated input of sediment by the Orange River (Zoutendyk, 1992). For example, for a single bergwind event it was estimated that 50 million tons of dust were blown into the sea by extensive sandstorms along much of the coast from Cape Frio (Namibia) in the north to Kleinzee, (South Africa) in the south (Shannon & O'Toole, 1982) with transport of the sediments up to 150km offshore.

Figure 31: Satellite image showing dust plumes being blown offshore from the Namibia coast[23]

5.2.7.9 Organic Inputs

The Benguela upwelling region is an area of particularly high natural productivity, with extremely high seasonal production of phytoplankton and zooplankton. These plankton blooms in turn serve as the basis for a rich food chain up through pelagic baitfish (anchovy, pilchard, round-herring and others), to predatory fish (snoek), mammals (primarily seals and dolphins) and seabirds (jackass penguins, cormorants, pelicans, terns and others). All of these species are subject to natural mortality, and a proportion of the annual production of all these trophic levels, particularly the plankton communities, die naturally and sink to the seabed.

Balanced multispecies ecosystem models have estimated that during the 1990s the Benguela region supported biomasses of 76.9t/km^2 of phytoplankton and 31.5t/km^2 of zooplankton alone (Shannon *et al*., 2003). Thirty six percent of the phytoplankton and 5% of the zooplankton are estimated to be lost to the seabed annually. This natural annual input of millions of tons of organic material onto the seabed off the southern African west coast has a substantial effect on the ecosystems of the Benguela region. It provides most of the food requirements of the particulate and filter-feeding benthic communities that inhabit the sandy-muds of this area, and results in the high organic content of the muds in the region. As most of the organic detritus is not directly consumed, it enters the seabed decomposition cycle, resulting in subsequent depletion of oxygen in deeper waters overlying these muds and the generation of hydrogen sulphide and sulphur eruptions along the coast.

An associated phenomenon ubiquitous to the Benguela system are red tides (dinoflagellate and/or ciliate blooms) (Shannon & Pillar, 1985 and Pitcher 1998). Also referred to as harmful algal blooms, these red tides can reach very large proportions, sometimes with spectacular effects. Toxic dinoflagellate species can cause extensive mortalities of fish and shellfish through direct poisoning, while degradation of organic-rich material derived from both toxic and non-toxic blooms results in oxygen depletion of subsurface water. Periodic low oxygen events associated with massive algal blooms in the nearshore can have catastrophic effects on the biota.

[23] *Source: www.intute.ac.uk*

5.2.7.10 Low Oxygen Events

The low oxygen concentrations are attributed to nutrient remineralisation in the bottom waters of the system (Chapman & Shannon, 1985). The absolute rate of this is dependent upon the net organic material build-up in the sediments, with the carbon rich mud deposits playing an important role. As the mud on the shelf is distributed in discrete patches, there are corresponding preferential areas for the formation of oxygen-poor water, the main one being off central Namibia (Chapman & Shannon, 1985). The distribution of oxygen-poor water is subject to short (daily) and medium term (seasonal) variability in the volumes of oxygen depleted water that develops (De Decker, 1970) and (Bailey & Chapman 1991). Subsequent upwelling processes can move this low-oxygen water up onto the inner shelf, and into nearshore waters, often with devastating effects on marine communities.

Oxygen deficient water can affect the marine biota at two levels. It can have sub-lethal effects, such as reduced growth and feeding, and an increased intermoult period specifically in the rock-lobster population (Beyers *et al.* 1994). The oxygen-depleted subsurface waters, characteristic of the southern and central Namibian shelf, are an important factor determining the distribution of rock lobster in the area. During the summer months of upwelling, lobsters show a seasonal inshore migration (Pollock & Shannon, 1987) and during periods of low oxygen become concentrated in shallower, better-oxygenated nearshore waters.

On a larger scale, periodic low oxygen events in the nearshore region can have catastrophic effects on the marine communities. Low-oxygen events associated with massive algal blooms can lead to large-scale stranding of rock lobsters, and mass mortalities of other marine biota and fish (Newman & Pollock, 1974; Matthews & Pitcher, 1996; Pitcher, 1998; Cockroft *et al.,* 2000). Very recently, in March 2008, a series of red tide or algal blooms dominated by the (non-toxic) dinoflagellate *Ceratium furca* occurred along the central Namibian coast (MFMR, 2008). These bloom formations ended in disaster for many coastal marine species and resulted in what was possibly the largest rock lobster walkout in recent memory (Figure 32). Other fish mortalities included those of rock suckers, rock fish, sole, eels, shy sharks, and other animals such as octopuses and red bait, which were trapped in the low oxygen area below the surf zone (Louw, 2008). The main cause for these mortalities and walkouts is oxygen starvation that results from the decomposition of huge amounts of organic matter. The blooms developed during a time where high temperatures combined with a lack of wind. These anoxic conditions were further exacerbated by the release of hydrogen sulphide - which is highly toxic to most marine organisms. Algal blooms usually occur during summer to autumn (February to April) but can also develop in winter during the bergwind periods, when similar warm windless conditions occur for extended periods.

Figure 32: 'Walk-outs' and mass mortalities of rock lobsters at the central Namibian coast[24]

5.2.7.11 Sulphur Eruptions

Closely associated with seafloor hypoxia, particularly off central Namibia between Cape Cross and Conception Bay, is the generation of toxic hydrogen sulphide and methane within the organically-rich, anoxic muds following decay of expansive algal blooms. Under conditions of severe oxygen depletion, hydrogen sulphide (H_2S) gas is formed by anaerobic bacteria in anoxic seabed muds (Brüchert *et al.* 2003). This is periodically released from the muds as sulphur eruptions, causing upwelling of anoxic water and formation of surface slicks of sulphur discoloured water (Emeis *et al,.* 2004), and even the temporary formation of floating mud islands (Waldron, 1901). Such eruptions are accompanied by a characteristic pungent smell along the coast and the sea takes on a lime green colour (Figure 9). These eruptions strip dissolved oxygen from the surrounding water column. Such complex chemical and biological processes are often associated with the occurrence of harmful algal blooms, causing large-scale mortalities to fish and crustaceans.

Sulphur eruptions have been known to occur off the Namibian coast for centuries (Waldron, 1901), and the biota in the area are likely to be naturally adapted to such pulsed events, and to subsequent hypoxia. However, satellite remote sensing has recently shown that eruptions occur more frequently, are more extensive and of longer duration than previously suspected, and that resultant hypoxic conditions last longer than thought (Weeks *et al.,* 2004).

Recently, the role of micro-organisms in the detoxification of sulphidic water was investigated by a collaborative group of German and Namibian scientists[25]. During a research cruise in January 2004, the scientists hit upon a sulphidic water mass off the coast off Namibia covering 7,000km^2 of coastal seafloor. The surface waters, however, were well oxygenated. In the presence of oxygen, sulphide is oxidized and transformed into non-toxic forms of sulphur. Surprisingly though, there was an intermediate layer in the water column, which contained neither hydrogen sulphide nor oxygen. Further investigation indicated that sulphide diffusing upwards from the anoxic bottom water is consumed by autotrophic denitrifying bacteria below the oxic zone. The intermediate water layer is the habitat of detoxifying microorganisms, which by using nitrate transform sulphide

[24] *Image source: Louw, 2008.*
[25] *Source: http://www.mpi-bremen.de/ Projekte_9.html and http://idw-online.de/pages/de/news 292832*

into finely dispersed particles of sulphur that are non-toxic. Thus, the microorganisms create a buffer zone between the toxic deep water and the oxygenated surface waters. These results, however, also suggest that animals living on or near the seafloor in coastal waters may be affected by sulphur eruptions more often than previously thought. Up to now, sulphidic water masses were monitored with the help of satellites, taking pictures of the sea surface while orbiting the earth, as they show up as whitish/turquoise discolorations of surface water (Figure 33). However, many of these sulphidic events may go unnoticed by satellite because bacteria consume the hydrogen sulphide before it reaches the surface.

Figure 33: Near shore sulphur eruption[26]

5.2.8 Visual Character[27]

Landscape character is defined by the United Kingdom Institute of Environmental Management and Assessment as the “distinct and recognisable pattern of elements that occurs consistently in a particular type of landscape, and how this is perceived by people”. It reflects particular combinations of geology, land form, soils, vegetation, land use and human settlement’. It creates the specific sense of place or essential character and ”spirit of the place”. The following landmarks were identified as significant in defining the surrounding areas characteristic landscape:

- Swakopmund town;
- C34 National Road;
- Swakopmund Salt Works structures and works;
- Seabird Guano Company and other structures; and
- Atlantic Ocean coastline.

[26] *Notes: Satellite image showing discoloured water offshore the Namib Desert resulting from a near shore sulphur eruption (satellite image source: www.intute.ac.uk). Inset shows a photograph taken from shore at Sylvia Hill, north of Lüderitz, during such an event.*
[27] *Section written by Stephen Stead of VRMA.*

These landmarks are described in greater detail to follow:

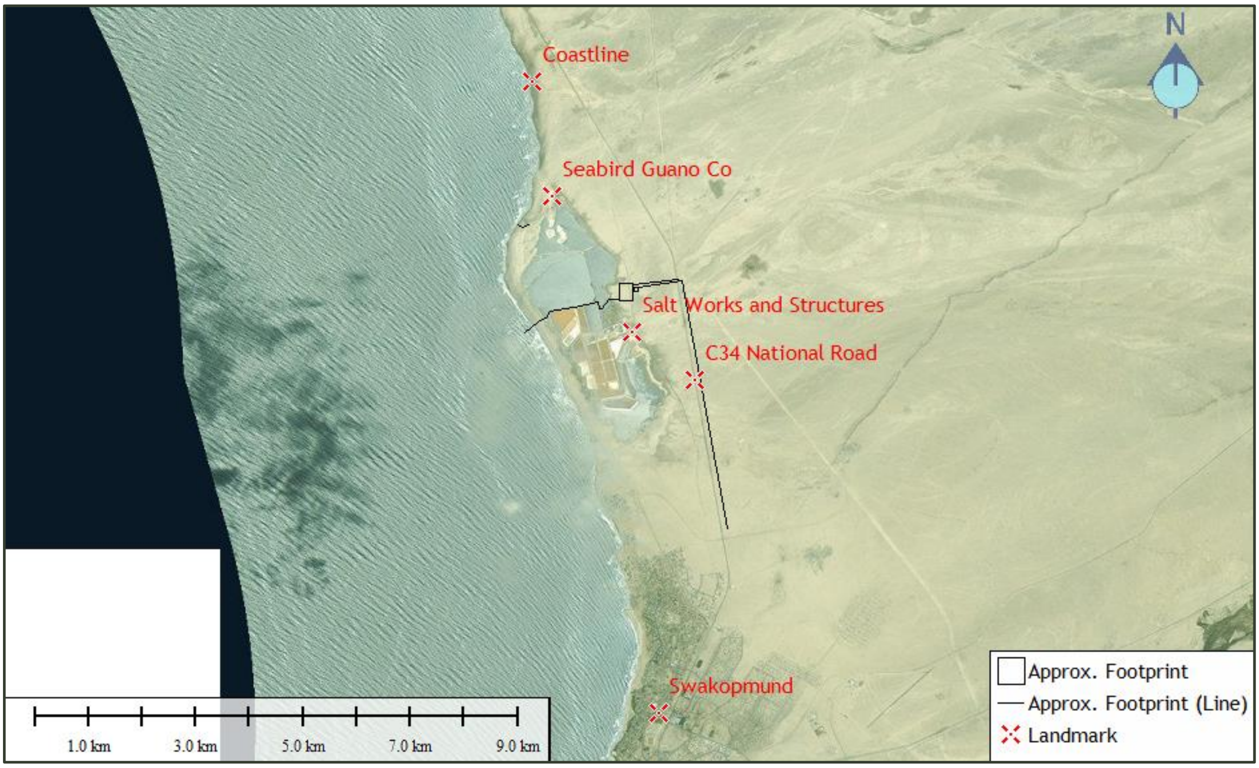


Figure 34: Landscape Context Photograph Points overlay onto Satellite Image

5.2.8.1 Swakopmund town

Figure 35: Panoramic photograph of Swakopmund town from the renowned Jetty south of the main beach

Swakopmund lies on the B2 road and the Trans-Namib Railway from Windhoek to Walvis Bay. It is served by Swakopmund Airport and Swakopmund Railway Station. Visual significance of the town is increased due to the heritage of the town.

5.2.8.2 C34 National Road

Figure 36: Photograph taken south of the C34 National Road with Swakopmund town in the background

The C34 is a salt road which links the town of Swakopmund with the small fishing and tourist town of Henties Bay. The road follows the coastline northwards and in certain areas the contrasting views of the Atlantic Ocean to the west and flat desert landscapes to the east create higher levels of scenic quality which add to the experience of the sense of place of the Namibian coastline. This route is utilised for tourism activities which radiate out from Swakopmund and as such it is likely that tourists utilising the road would have higher sensitivities to landscape change.

5.2.8.3 Salt works and structures

Figure 37: Photograph depicting the existing Salt Company (Pty) Ltd structures and salt stockpiles and warehouse

The Swakopmund Salt Works was established in 1936 and comprises a series of ad hoc structures, a small light house replica, salt stockpiles and extensive evaporation pans. The older structures are painted a yellow colour which generates higher levels of colour contrast, but the more recent warehouse is a light grey-brown which significantly reduces the colour contrast. The area is an important birding destination due to birdlife being attracted to the large pans.

5.2.8.4 Seabird Guano Company and Other Structures

The Guano Company comprises one medium sized administrative building and a large warehouse. Colours are muted and grey which reduce colour contrast and visual intrusion. The green coloured governmental building generates strong colour contrast to the grey-browns of the characteristic landscape.

The Swakopmund Salt Work evaporation ponds are an important bird area and used for bird watching and photography activities. New structures in this viewshed may impact on these activities and the sense of place, and will need to be considered in the impact assessment phase.

Figure 38: The Guano Company structures and the green Correctional Services residence as seen from the C34 road

5.2.8.5 Atlantic Ocean Coastline

Figure 39: Photograph taken north of the coastline from the existing Swakopmund Salt Work inlet structure

The coastline is an important tourist destination due to good coastal fishing with many camping sites located at defined “Miles” from the town of Swakopmund. Receptors driving along the coast would have low exposure to the proposed plant and substation, but would have high exposure views to any modifications proposed for the existing jetty. Although this is a tourist destination, due to the existing built precedent and lower levels of visual exposure (to the proposed plant) it is likely that receptors would have moderate sensitivity to landscape change. The intake structure, which comprised of a jetty, has the potential to create a significant, albeit local visual intrusion and will be considered during the SEIA phase.

5.2.9 Noise Character[28]

Many factors affect the propagation of noise from source to receiver. The most important of these are:

- The type of source and its sound power;
- The distance between the source and the receiver;
- The extent of atmospheric absorption (attenuation);
- Wind speed and direction;
- Temperature and temperature gradient;
- Obstacles such as barriers or buildings between the source and receiver;
- Ground absorption;
- Reflections;
- Humidity; and
- Precipitation.

[28] *Section authored by Nicolette von Reiche of Airshed Planning Professionals.*

To arrive at a representative result from either measurement or calculation, all these factors must be taken into account (Brüel & Kjær Sound & Vibration Measurement A/S, 2000).

The extent of noise impacts as a result of an intruding industrial noise depends largely on existing noise levels in the project area. Higher ambient noise levels will result in less noticeable noise impacts and a smaller impact area. The opposite also holds true. Increases in noise will be more noticeable in areas with low ambient noise levels.

Further, if the dimensions of a noise source are small compared with the distance to the listener, it is called a point source. All sources of noise (except traffic source) at the proposed desalination plant will be quantified as point sources. The sound energy from a point source spreads out spherically, so that the sound pressure level is the same for all points at the same distance from the source, and decreases by 6dB per doubling of distance. This holds true until ground and air attenuation noticeably affect the level.

The impact of an intruding industrial noise on the environment will therefore rarely extend over more than 5km from the source and is therefore always considered “local” in extent.

Impacts on the following individuals or communities will be considered:

- Employees of the Swakopmund Salt Works (industrial Noise Sensitive Receptors). The Swakopmund Salt Works plant area is situated within 1km south of the proposed site for the desalination plant.
- Residents of the northernmost suburbs of Swakopmund. The nearest residences of Swakopmund lie approximately 3.8km south-southeast of the proposed site for the desalination plant.
- Holiday makers at the Mile 4 Caravan Park (residential Noise Sensitive Receptors). The Mile 4 Caravan Park lies approximately 3.6km south of the proposed site for the desalination plant.
- Correctional services buildings/infrastructure approximately 1km to the north-northeast of the desalination plant. Six wardens currently reside there.

5.2.9.1 Atmospheric Absorption and Meteorology

The main meteorological parameters affecting the propagation of noise include wind speed, wind direction and temperature. These, along with other parameters such as relative humidity, air pressure, solar radiation and cloud cover affect the stability of the atmosphere and the ability of the atmosphere to absorb sound energy. Average day- and night-time wind speed, wind direction, temperature, relative humidity, pressure and solar radiation that will eventually be used as input to the selected noise propagation model during the impact assessment phase of the project are provided in Table 6. Wlotzkasbaken data was obtained from a study completed by Airshed in 2011 (Liebenberg-Enslin & Krause, 2011). Wlotzkasbaken is located approximately 20km north of the proposed desalination plant.

It is well known that wind speed increases with altitude. This results in the “bending” of the path of sound to focus it on the downwind side and creating a “shadow” on the upwind side of the source. Depending on the wind speed, the downwind level may increase by a few decibels but the upwind level can drop by more than 20dB (Brüel & Kjær Sound & Vibration Measurement A/S, 2000). It should be noted that at wind speeds of more than 5m/s ambient noise levels are mostly dominated by wind generated noise. The diurnal wind field at Wlotzkasbaken, the nearest representative meteorological station is presented in Figure 40. Wind roses represent wind frequencies for the 16 cardinal wind directions. Frequencies are indicated by the length of the shaft when compared to the circles drawn to represent a frequency of occurrence. Wind speed classes are assigned to illustrate the frequencies with high and low winds occurring for each wind vector. The frequencies of calms, defined as periods for which wind speeds are below 1m/s, are also indicated.

On average, during the day, noise impacts are expected to be most notable to the south and north-north east. During the night it is expected to be most significant to the south of proposed operations.

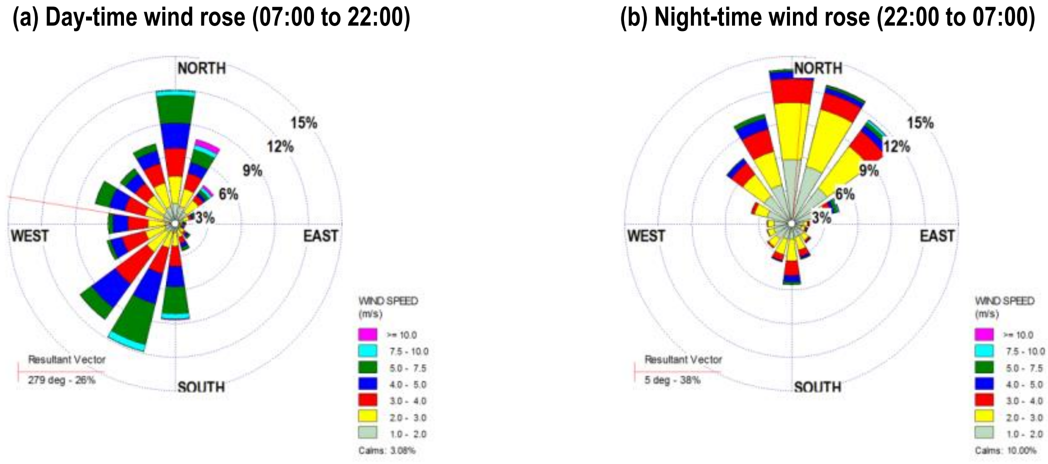


Figure 40: Diurnal wind roses generated from data recorded at Wlotzkasbaken between 2001 and 2007

Temperature gradients in the atmosphere create effects that are uniform in all directions from a source. On a sunny day with no wind, temperature decreases with altitude and creates a "shadowing" effect for sounds. On a clear night, temperatures may increase with altitude thereby "focusing" sound on the ground surface. Noise impacts are therefore generally more notable during the night.

Table 6: Average diurnal meteorological parameters

Type of Industry	Average Diurnal Meteorological Parameters	
	Day-time	Night-time
Temperature	18 °C	14 °C
Relative Humidity	+100% (106%)	+100% (126%)
Wind Speed	3.5 m/s	2.1 m/s
Wind Direction (° from)	0°[(a)]	0°[(a)]
Air Pressure	101.3 kPa[(b)]	101.3 kPa[(b)]
Solar Radiation	353 W/m²	not applicable

Notes:

(a) Since the closest communities are all located to the south of the proposed desalination plant, a wind direction of 0° will be considered in the assessment.

(b) Air pressure at 0 m above sea level.

5.2.9.2 Terrain, Ground Absorption and Reflection

Noise reduction caused by a barrier (i.e. natural terrain, installed acoustic barrier or building) feature depends on two factors, namely the path difference of the sound wave as it travels over the barrier compared with direct transmission to the receiver, and the frequency content of the noise (Brüel & Kjær Sound & Vibration Measurement A/S, 2000). There are no features with the local study area that may act as acoustic barriers.

Sound reflected by the ground interferes with the directly propagated sound. The effect of the ground is different for acoustically hard (e.g. concrete or water), soft (e.g. grass, trees or vegetation) and mixed surfaces. Ground attenuation is often calculated in frequency bands to take into account the frequency content of the noise source and the type of ground between the source and the receiver (Brüel & Kjær Sound & Vibration Measurement A/S, 2000). Ground cover includes sand and gravel plains and is considered acoustically hard, i.e. not conducive to noise attenuation.

5.2.9.3 Sampled Baseline Noise Levels

A summary of sampling locations, times, weather conditions and observations made during sampling is provided in Table 7 and locations are shown on the map in Figure 41 and photographs of the baseline monitoring sites shown in Figure 42.

Table 7: Summary of sampling locations, times, weather conditions and general acoustic environment

Sampling Location	Coordinates	Sampling Date and Time	General Description of Environment from a Noise Perspective	Conditions During Sampling
1	14°31.672' E 22°35.792' S	Day-time 20-Aug-14 10:00	Audible noise sources included activities at the Swakopmund Salt Works, traffic towards the Swakopmund Salt Works and along the C34 as well as ocean surf.	Wind speed 1.9m/s (average) and 2.5m/s (maximum) Temperature 16°C Relative humidity 75% Thin clouds, 90% cloud cover
		Night-time 20-Aug-14 22:00	Audible noise sources included traffic along the C34 as well as ocean surf and some nocturnal birds.	Wind speed 1.8m/s (average) and 2m/s (maximum) Temperature 14°C Relative humidity 82% Clear skies
2	14°31.558' E 22°35.344' S	Day-time 20-Aug-14 10:24	Audible noise sources included birds, distant noise from the Swakopmund Salt Works, and traffic along the C34 as well as ocean surf.	Wind speed 1.9m/s (average) and 2.5m/s (maximum) Temperature 17°C Relative humidity 72% Thin clouds, 85% cloud cover
		Night-time 20-Aug-14 22:24	Audible noise sources included occasional traffic along the C34 and ocean surf.	Wind speed 2m/s (average) and 2.5m/s (maximum) Temperature 13°C Relative humidity 82% Clear skies
3	14°31.825' E 22°37.460' S	Day-time 20-Aug-14 10:58	Audible noise sources included construction noise to the south, occasional air traffic and road traffic along the C34.	Wind speed 3.8m/s (average) and 4.9m/s (maximum) Temperature 16°C Relative humidity 84% Thin clouds, 90% cloud cover
		Night-time 20-Aug-14 22:55	Audible noise sources included occasional traffic along the C34 and ocean surf.	Wind speed 0.8m/s (average) and1.9 m/s (maximum) Temperature 15°C Relative humidity 78% Clear skies

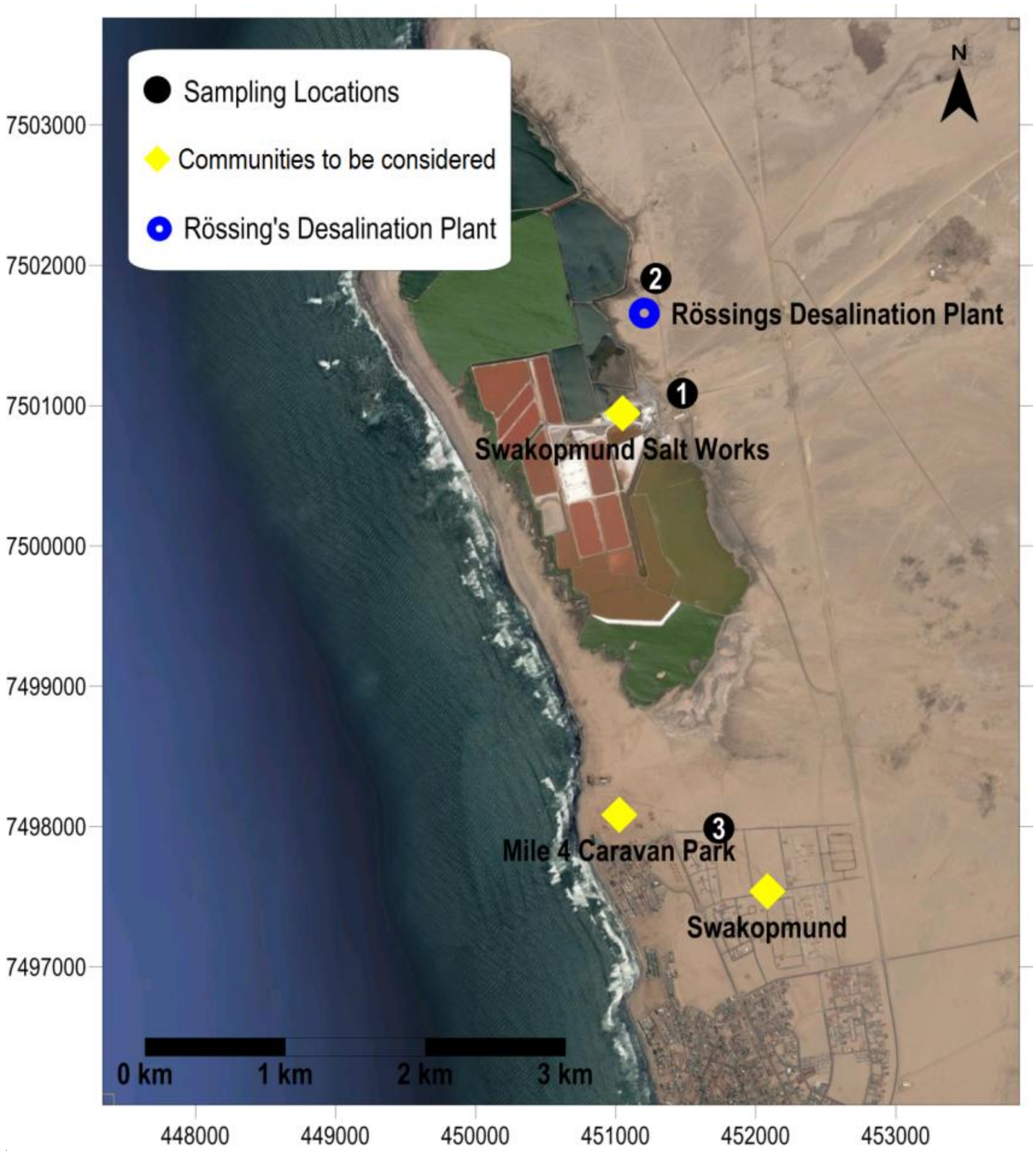


Figure 41: Environmental baseline noise sampling locations

Figure 42: Pictures of sampling locations

Sampled baseline day- and night-time L_{Aeq} and L_{A90} as well as L_{AFmax} values are given in Table 8. Time series and 3rd octave band frequency spectra are graphically presented in Figure 43 to Figure 51. The following is noted:

- Baseline noise levels during the day and notes taken during sampling indicate the Swakopmund Salt Works to be the most notable local noise source. Traffic along the C34 also contributes significantly to local baseline day- and night-time noise levels. At night, ocean surf noise becomes more observable than during the day.
- The International Finance Corporation (IFC) day-time guideline of 55dBA for residential areas was only marginally exceeded at Location 1 near the Swakopmund Salt Works.

- Sampled night-time noise levels exceed the IFC guideline of 45dBA for residential areas only at Location 3. The exceedance was as a result of a vehicle passing on the C34 at high speed. Without this incidence, the night-time L_{Aeq} (20min) reduces to 40.6dBA. This is illustrated in Figure 50.
- The large difference (more than 5dBA) between sampled L_{Aeq} and L_{A90} at Location 1 and 3 during the day as well as at Location 3 during the night indicate the presence of noisy incidences i.e. passing vehicles and Swakopmund Salt Works activities.
- The large difference between day-and night-time noise levels sampled at Location 1 supports the supposition that the Swakopmund Salt Works is currently the most notable noise source in the local study area. The Swakopmund Salt Works was observed not to be operational at night.
- Day and night levels at Location 2 differed by less than 5dBA indicating the presence of a constant noise source in the area. Frequency spectra also indicate the relative small difference between day-and night-time noise levels. This is typical of noise levels close to the ocean or in areas with little human activity.

Table 8: Summary of sampled baseline noise levels

Sampling Location	Day-time			Night-time			Frequency Spectra
	L_{Aeq} (20 min) (dBA)	L_{A90} (dBA)	L_{AFmax} (dBA)	L_{Aeq} (20 min) (dBA)	L_{A90} (dBA)	L_{AFmax} (dBA)	
1	55.4 (Figure 43)	40.9	79.9	39.9 (Figure 44)	38.6	50.1	(Figure 45)
2	37.4 (Figure 46)	35.3	52.1	41.0 (Figure 47)	39.2	53.6	(Figure 48)
3	51.3 (Figure 49)	42.8	47.2	50.5 (Figure 50)	38.5	80.7	(Figure 51)

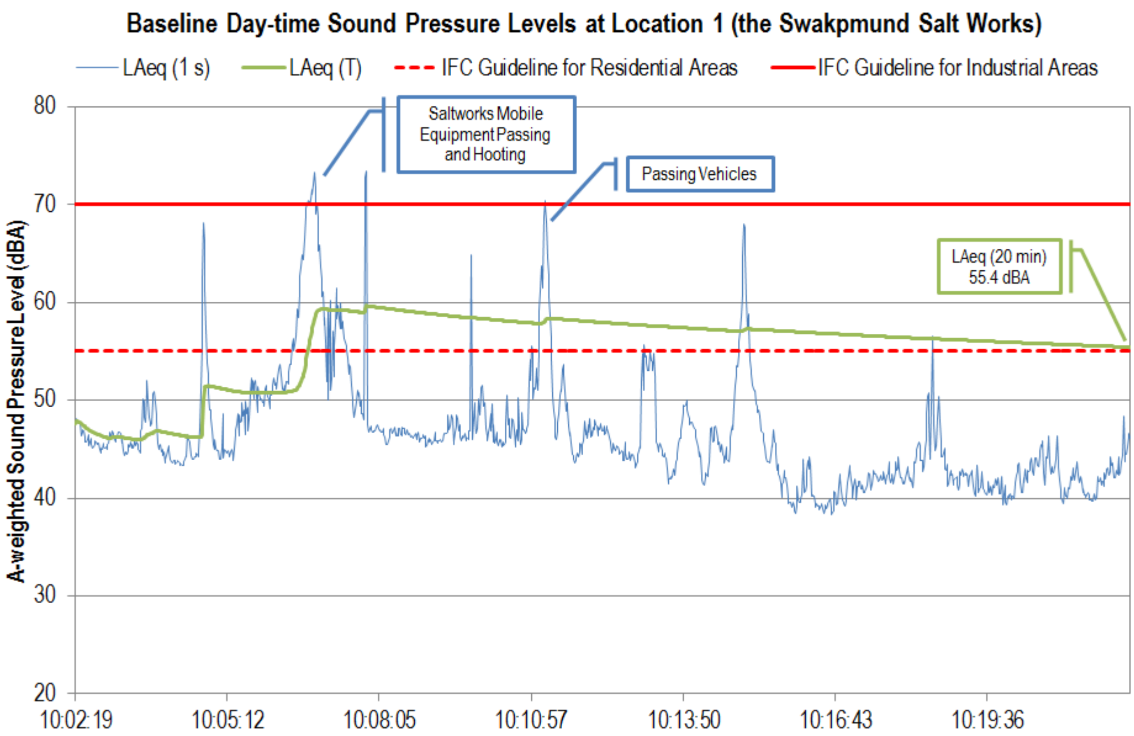


Figure 43: 20-minute day-time sample at Location 1, the Swakopmund Salt Works on 20-Aug-14

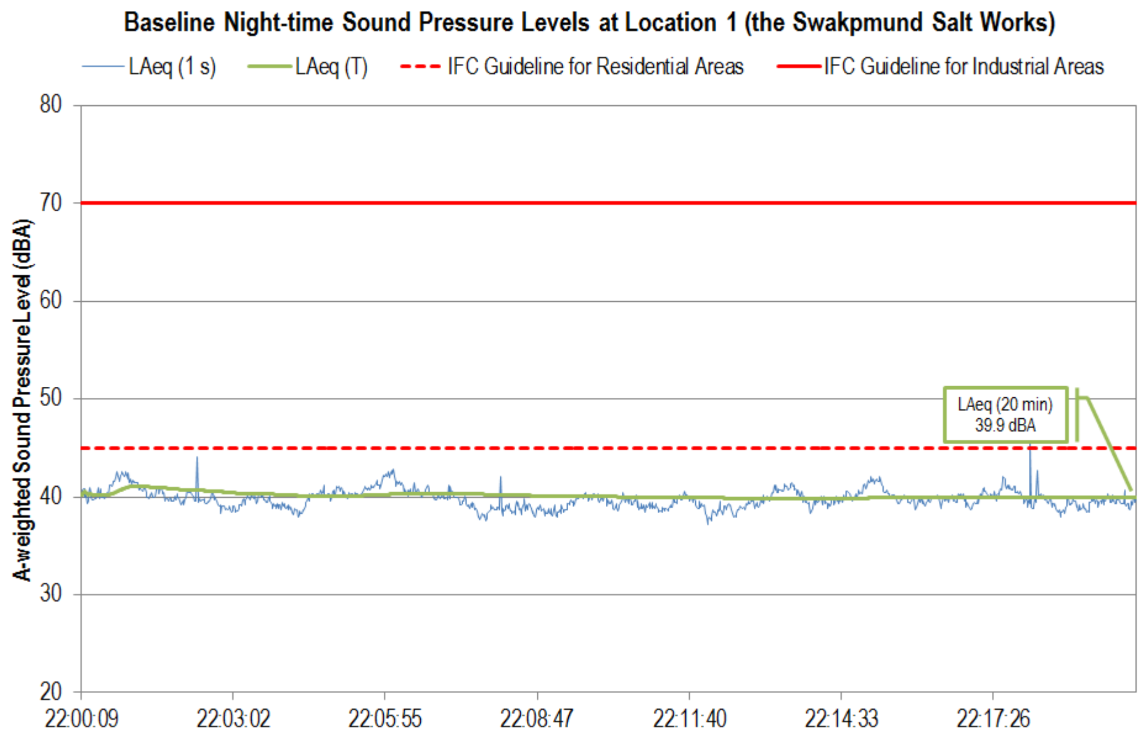


Figure 44: 20-minute night-time sample at Location 1, the Swakopmund Salt Works on 20-Aug-14

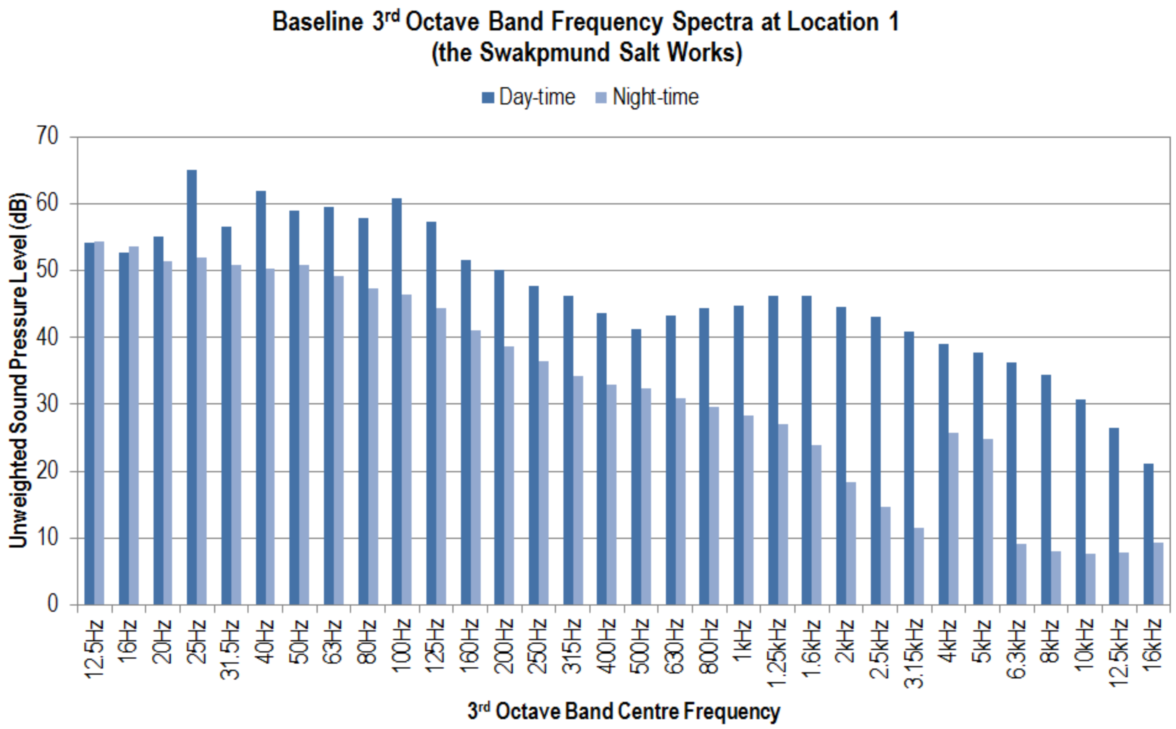


Figure 45: 3rd octave band frequency spectra at Location 1, the Swakopmund Salt Works

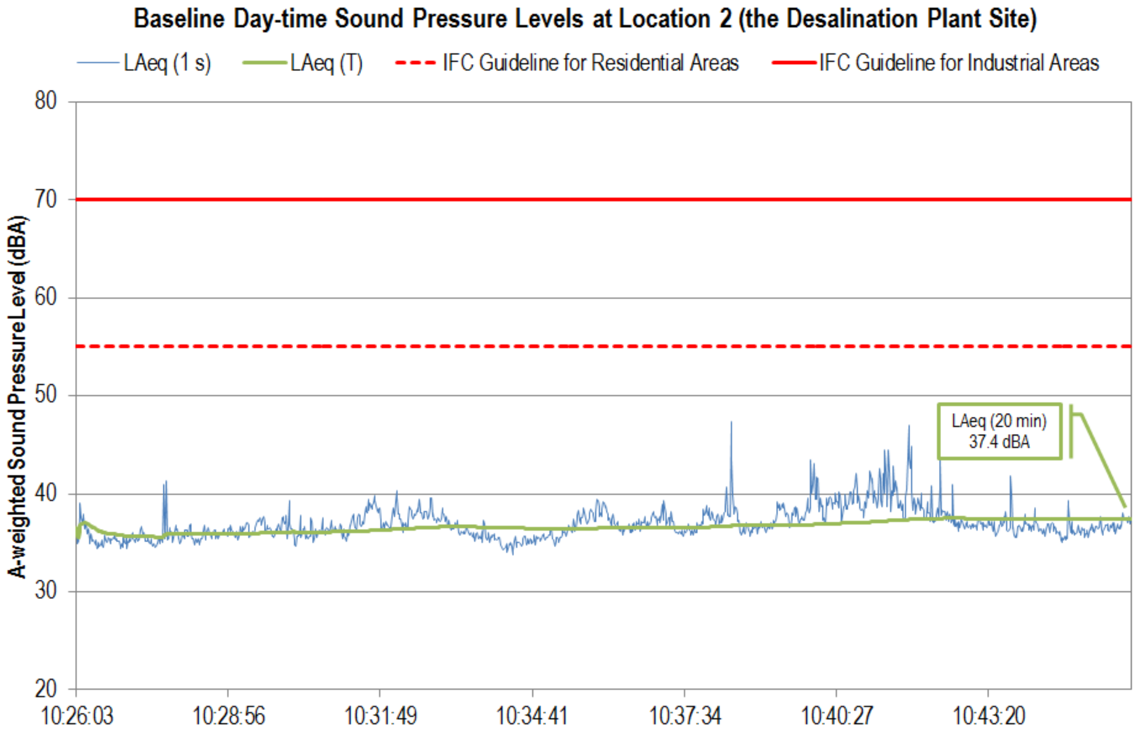


Figure 46: 20-minute day-time sample at Location 2, the desalination plant site on 20-Aug-14

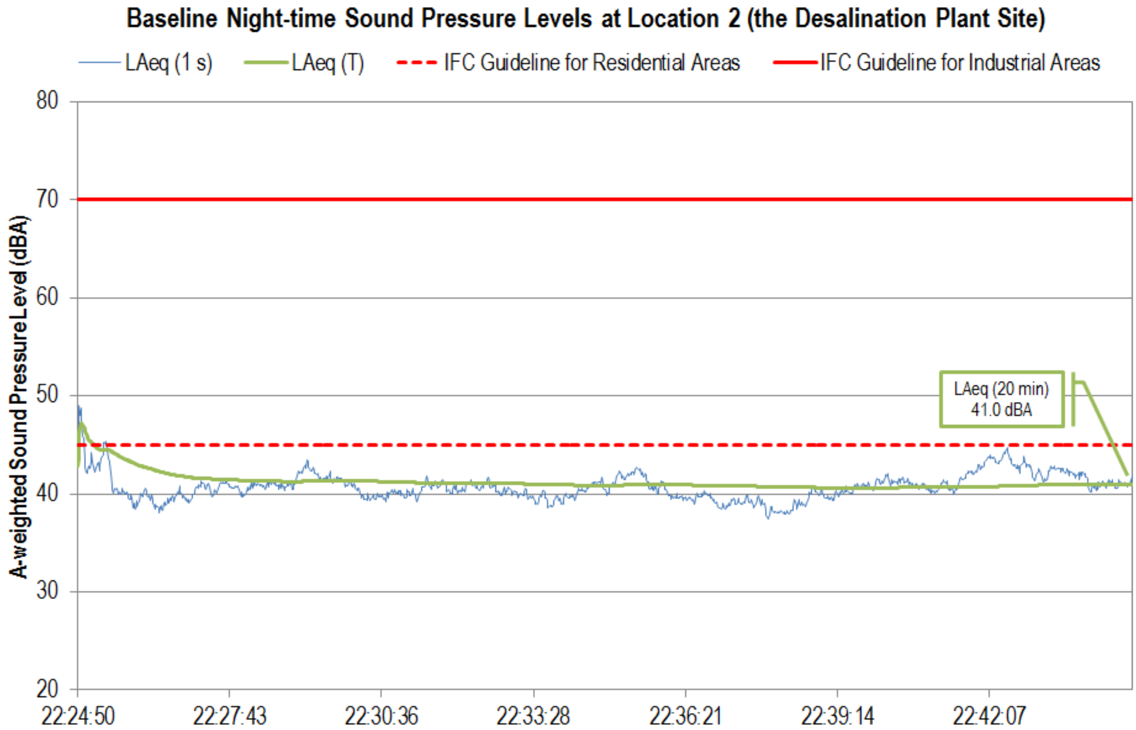


Figure 47: 20-minute night-time sample at Location 2, the desalination plant site on 20-Aug-14

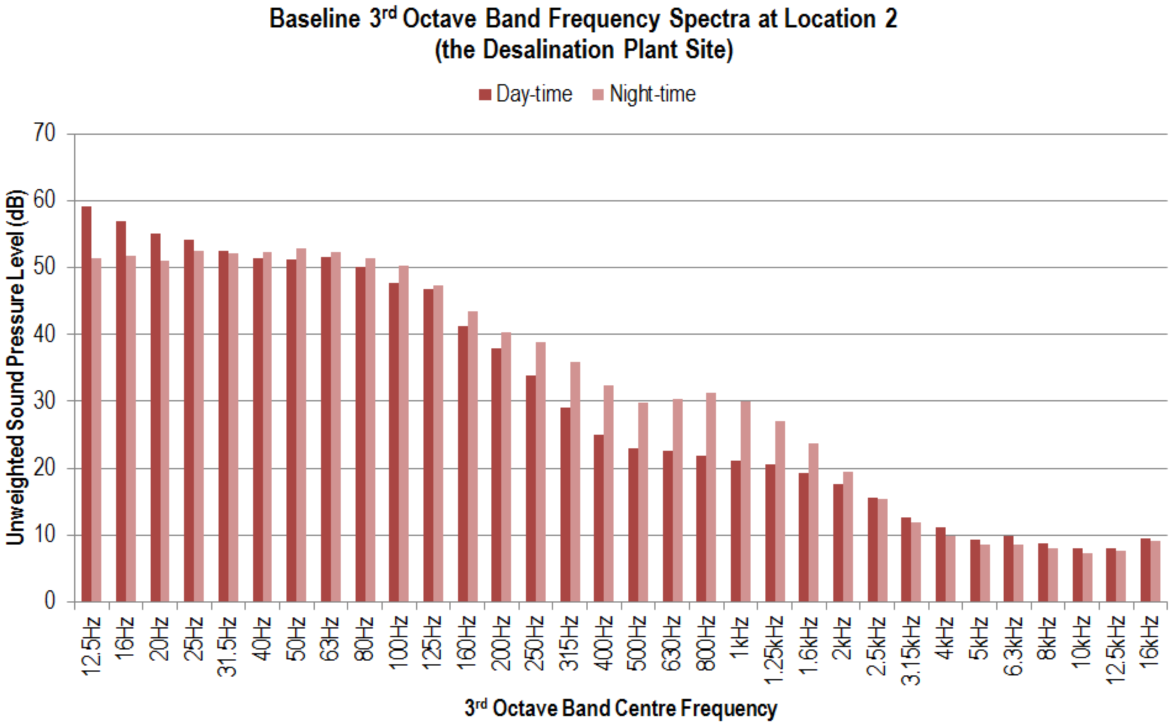


Figure 48: 3rd octave band frequency spectra at Location 1, the Swakopmund Salt Works

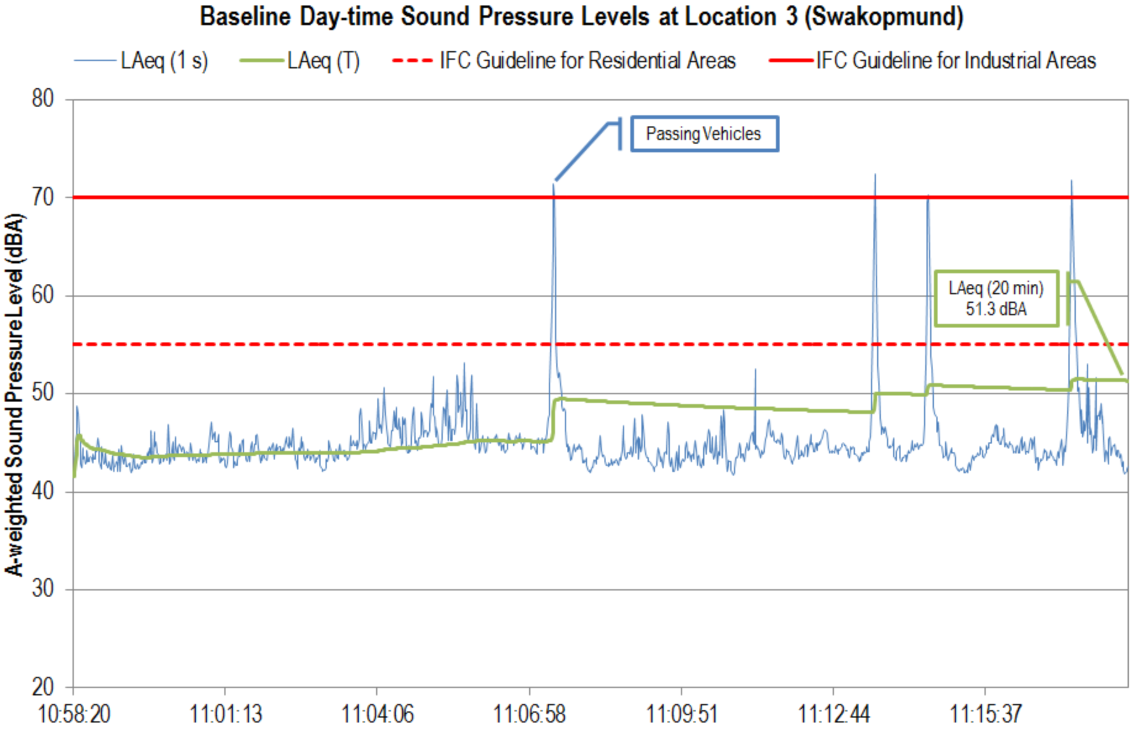


Figure 49: 20-minute day-time sample at Location 3, Swakopmund on 20-Aug-14

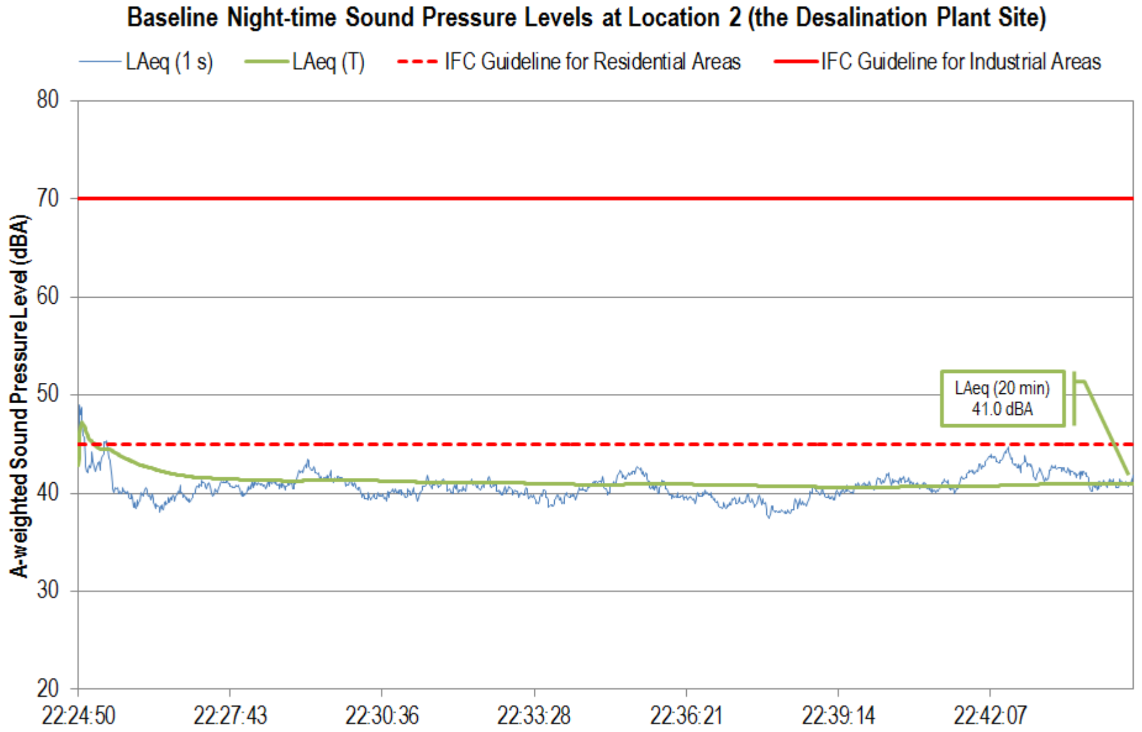


Figure 50: 20-minute night-time sample at Location 3, Swakopmund on 20-Aug-14

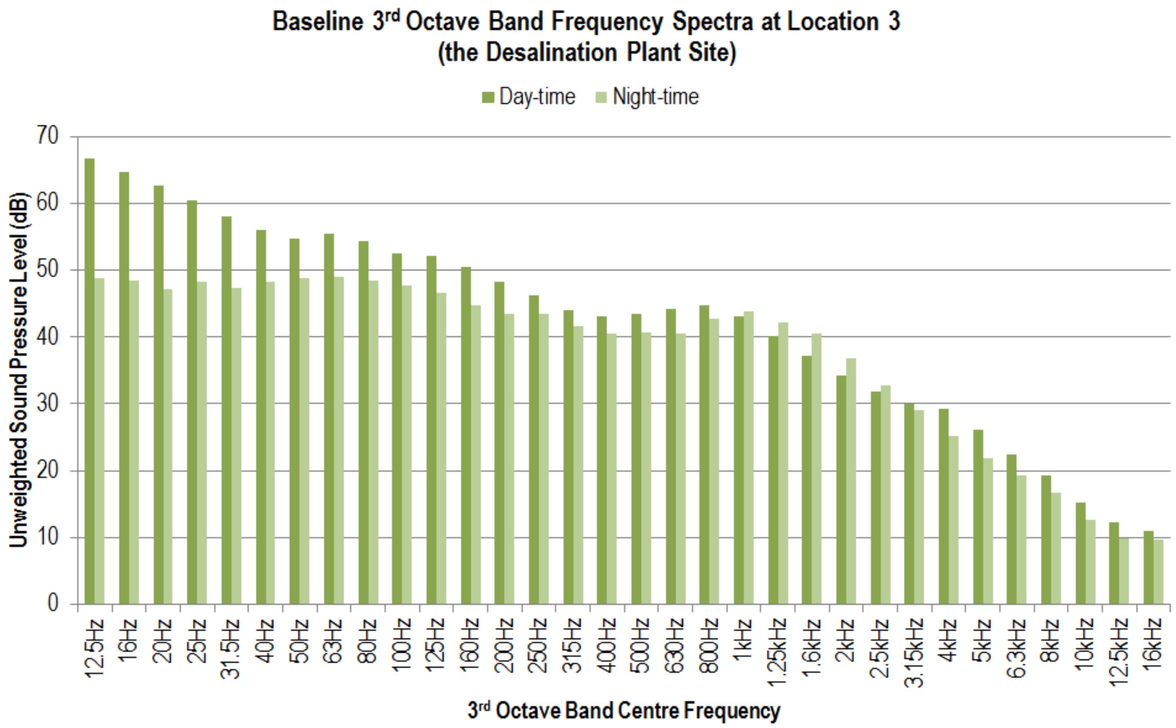


Figure 51: 3rd octave band frequency spectra at Location 2, Swakopmund

5.3 Ecology

5.3.1 Flora

The study area lies within the Central Namib Desert Biome. The dominant vegetation structure is sparse shrubs and grasses (Mendelsohn *et al*., 2002); the vegetation cover, however is extremely limited. The specific proposed site for the Rössing Uranium desalination plant can be described as a disturbed site generally devoid of vegetation. This characteristic is partially due to the repetitive disturbance (which has occurred over a period of time, since 1933) by vehicles, equipment and activities associated with the Swakopmund Salt Works and other activities in the area. The other influencing factor is the harsh saline environment created by the site's proximity to the ocean and the salt evaporation ponds which creates a very saline environment in which only the hardiest of plants can survive.

Just over 400 plant species occur in the Central Namib, making up to 10% of the flora of Namibia. The northern Namib supports approximately 100 to 200 plant species and the southern Namib is home to well over 600 species of plants, making the region a global biodiversity hotspot (CSIR, 2009).

Botanical Surveys in similar habitats indicate that shrubs and herbs such as Blepharis grossa, and *Arthraerua leubnitziae* (pencil bush), *Zygophyllum stapfii*, *Zygophyllum clavatum*, *Psilocaulon kuntzei* and *Salsola sp*. are likely to occur. Occasional specimens of *Commiphora saxicola* and *Sarcocaulon marlothi* (bushman's candle) occur, often in patches in the lower lying areas (CSIR, 2009).

Some plain areas, especially closer to the coast, are characterised by lichen fields and are considered to have a high biodiversity and conservation value. Lichens play a dominant role with respect to structure, cover and biomass and are an important component of arid to semi-arid ecosystems. They form biological soil crusts together with other organism groups (e.g. cyanobacteria and bryophytes), which occur in all hot, cool, cold arid and semi-arid regions of the world. They play an important role in these ecosystems, since they are able to retain soil moisture, reduce wind and water erosion of the soil, reduce deflation, fix atmospheric nitrogen (cyanolichens), and contribute to soil organic matter and nutrient richness. They have a host of other important roles, i.e. they provide food for beetles and ungulates and provide shelter for the nests of the vulnerable breeding endemic Damara Tern (Barnard, 1998). Lichens are among the most important ecological indicators and can be used to monitor various kinds of environmental impacts. None of the main lichen fields occur on the site for the proposed Rössing Uranium Desalination Plant.

The Namib coastal zone's lichen community encrustations cover nearly the whole area of the central Namib Desert (CSIR, 2009), but are concentrated to numerous larger lichen fields in a globally unique way (Wessels & van Vuuren, 1986) (Ullman & Brudel, 2001). Large lichen fields include the lichen community north-east of Wlotzkasbaken (approximately $200km^2$), the lichen fields east of Cape Cross (more than $400km^2$) and the soil crust lichen community north and east of Swakopmund (especially those situated around Mile 8 and Mile 12 and inland).

Frequent and intense disturbances may alter lichen distribution patterns due to slow recovery rates, while other disturbances may only cause fluctuations in ecosystem equilibrium. Disturbance can severely affect the cover, species composition, and the physiological functioning of a biological soil crust (Belnap & et al, 2001). In a typical biological soil crust, more than 75% of the photosynthetic biomass and almost all photosynthetic productivity are located within organisms in the top 3mm of the soil, making it very vulnerable to mechanical disturbance (natural and anthropogenic) (Garcia-Pichel & Belnap, 1996). Major natural disturbances impacting lichen communities of the Central Namib Desert result from a severe increase of soil erosion rates following erosion and deflation by windstorms as well as water run-off, with the aeolian processes prevailing (Belnap & Gillette, 1998) (Belnap & Elridge, 2001). Anthropogenic disturbances include mechanical disturbance caused by off-road driving, dust due to vehicles, legal or illegal mining activities and powerline or pipeline maintenance activities. The ability of lichens to absorb water from fog will also be reduced and even prevented by an increase of sand/dust deposition on affected species. None of the known lichen fields of the central Namib occur on the site for the proposed Rössing Uranium Desalination Plant.

Given the disturbed nature of the study site, a detailed botanical assessment will not be undertaken as part of the SEIA, since the potential impacts are not deemed to play a significant role in a decision on project acceptability. Given however, that desert plants are highly susceptible to disturbance and can take many years or decades to recover from such disturbances, the SEMP will make recommendations aimed at reducing and controlling potential disturbances so that the disturbances of the local flora is kept to a reasonable minimum and that activities are restricted to already disturbed areas as far as possible.

5.3.2 Avifauna[29]

Namibia has a proud conservation record that is recognised internationally. The country's commitment to the conservation of biological diversity (biodiversity) is evidenced by the establishment and management of some 20 Protected Areas, proclaimed under the Nature Conservation Ordinance of 1975. Apart from these formally protected areas, this reputation also rests extensively on conservation outside parks and reserves on freehold and communal land (MET, 2010). In total, almost 20% of Namibia is protected, an area totalling some 130,000km^2.

In 1995 Namibia acceded to the Ramsar Convention, an international treaty to protect waterbird habitat that covers all aspects of wetland conservation and wise use (Kolberg undated). Four wetlands have been designated to the *List of Wetlands of International Importance*, namely Walvis Bay, Sandwich Harbour, the Orange River Mouth and the Etosha Pan.

The Walvis Bay Ramsar Site lies about 45km south of the study site. It is regarded as the most important coastal wetland in the southern Sub-region and is probably one of the most important coastal wetlands in Africa (Simmons *et al*., 1998a). This area regularly supports over 100,000 birds (up to 150,000 birds) in summer; these comprise mostly non-breeding intra-African and Palearctic migrant species and between *80-90%* of the Sub-region's flamingos spend winter here. The Swakopmund Salt Works is the only man-made wetland in Namibia qualifying for, but yet to be awarded, the above international Ramsar status. The central coastal wetlands (including Sandwich Harbour, Walvis Bay, Swakopmund Salt Works and Cape Cross) form an important inter-linked system of critical importance for large numbers of waterbirds.

Namibia also boasts 21 Important Bird Areas, ten of which lie on the coast. Important Bird Areas are places of international significance for the conservation of birds at the Global, Regional (Continental) or Sub-regional (southern African) level, selected according to stringent criteria (Barnes, 1998) (Simmons, Boix-Hinzen, Barnes , Jarvis, & Robertson, 1998). The Swakopmund Salt Works is accorded Global Important Bird Area status on account of the presence of three globally threatened species: the Damara Tern, Lesser Flamingo and African (Black) Oystercatcher (Simmons, Boix-Hinzen, Barnes , Jarvis, & Robertson, 1998).

5.3.2.1 Damara Tern

The tiny Damara Tern (Figure 52) is globally classified as Near Threatened and also classified as Near Threatened in Namibia (IUCN, 2014) (Simmons & Brown, In Press). The species is little known and faces several conservation issues (Braby, 2011).

[29] *Section written by Mike and Ann Scott of African Conservation Services CC.*

A recent review of all accessible information of breeding populations in Angola, Namibia and South Africa identified 70 breeding colonies globally for the species (Braby, 2011). Most of the population (98%) breeds in Namibia, where overall breeding success (measured as the probability of fledging one chick per pair per season) is estimated at only 0.36.

In 2011 the total breeding population of Damara Terns was estimated at 1,001 to 2,685 breeding pairs or 5,370 breeding individuals (Braby, 2011). This estimate is substantially lower than the 13,500 individuals initially estimated (Simmons, Boix-Hinzen, Barnes , Jarvis, & Robertson, 1998) (IUCN, 2014), which is now considered a probable over-estimate (Braby, 2011). A more recent (conservative) estimate places the entire breeding population at only 900 pairs (Braby pers. comm.). Estimates for the species at Swakopmund Salt Works include 24 adults in 1977 (Underhill & Whitelaw, 1977); and 10 to 20 pairs in 2008 to 2010 (Braby, 2011) and 10 to 15 pairs in 2013-2014 (M Boorman pers. comm.). At least some of the chicks are ringed on a regular basis, including eight in 2014 (Boorman, pers. comm.).

Threats faced by Damara Terns throughout their breeding range include the following (Braby, 2011):

- Coastal development causing colony extinctions; as coastal development has been the major cause of declines in similar species;
- Off-road driving causing disturbance to breeding areas, resulting in low reproductive success; and
- Anthropogenic activities that result in increases in predator densities (e.g. offal from fishing that attracts larger numbers of black-backed jackals).

Conservation actions (Braby, 2011), (IUCN, 2014) should focus on the protection of important breeding colony sites in Namibia, and also at the extremities of the range in South Africa and Angola; disturbance-free areas on nesting beaches should be designated, and population trends monitored.

Figure 52: The Damara Tern[30]

[30] *Notes: The Damara Tern is an endemic breeding seabird and a flagship species for coastal conservation efforts in Namibia; however, it is highly threatened by coastal development and uncontrolled off-road driving (photo Ron Knight).*

5.3.2.2 Lesser Flamingo

The Lesser Flamingo is also classified as “Globally Near Threatened” (IUCN, 2014), and “Vulnerable” in Namibia (Simmons & Brown, In Press).

The population is estimated at 15,000 to 25,000 individuals in west Africa; 1,500,000 to 2,500,000 in east Africa; 55,000 to 65,000 in South Africa and Madagascar; and 650,000 in south Asia (IUCN, 2014). The population estimate for Namibia is 40,000 to 64,500 adults (Simmons & Brown, In Press). This local population fluctuates, with recent increases in the 1990s.

Their preferred habitat is coastal lagoons, flooded salt pans and salt works. This species is more restricted in distribution in southern Africa than the Greater Flamingo, where it breeds in mass concentrations at only two flooded salt pans, namely Etosha (Namibia) and Sua Pan (Botswana) (Berry, 1972), (McCulloch & Irvine, 2004). In east Africa it also breeds regularly at Lake Natron in Tanzania (Brown *et al.,* 1982).

Threats include low breeding frequency and success, and water abstraction from the breeding sites. Collisions are frequently reported with cattle fences that cross Sua Pan in Botswana, and with overhead power lines in both Botswana and Zimbabwe (McCulloch pers. obs. and PJ Mundy, pers. obs.).

In Namibia, direct threats include low level organochlorine pesticide residues used extensively in the catchment area of the Ekuma River against malaria mosquitoes (Simmons & Brown, In Press). A growing number of records of collisions with power lines (hitherto underestimated) is also cause for concern .

5.3.2.3 African (Black) Oystercatcher

The African (Black) Oystercatcher is classified as “Globally Near Threatened” (IUCN, 2014), and also Near Threatened in Namibia (Simmons & Brown, In Press).

The species has a coastal breeding range that stretches from Mazeppa Bay in South Africa to Lüderitz in Namibia (IUCN, 2014). In the early 1980s the global breeding population was estimated at less than 2,000 pairs and 4,800 individuals (Hockey, 1983), making it the third rarest, as well as one of the most range restricted oystercatcher species in the world (Stattersfield & Capper, 2000). The total population is now estimated at 5,000 to 6,000 individuals, with about half occurring along the western cape (South Africa) coastline, and half of these on its near-shore islands (IUCN, 2014).

In Namibia, recent research has increased the Namibian population estimates (originally 1,200 birds: (Hockey, 1983) to 1,840 birds, or 38% of the world population (Simmons, Boix-Hinzen, Barnes , Jarvis, & Robertson, 1998) (Simmons & Brown, In Press). This is considered to represent a real increase (rather than enhanced census), given the increased chick production in South Africa (Hockey, 2001), 40% of which are estimated to make their way to Namibian nurseries (Lessenberg, 2001) (Hockey, Leseberg, & Loewenthal, 2003), as well as increases in bird densities in South Africa (Underhill, 2000) and the increased food resource in the form of the alien invasive Mediterranean mussel *Mytilus galloprovincialis* throughout the region (Simmons & Brown, In Press).

The four largest nurseries for the oystercatchers (three situated north of Lüderitz around Hottentot's Point, Caravan Beach and Douglas Point, and the fourth at Walvis Bay) support 300-350 juvenile birds (Simmons & Roux 2000, Simmons *et al.* MS, Leseberg 2001, Wheeler 2001). Estimates at Swakopmund Salt Works, a roosting area, include a mean of 18 ± 11 and a maximum of 34 for seven counts (Braby *et al*., Unknown). In July 2014, 43 individuals were counted at this site (M Boorman pers. comm.).

The single largest cause of breeding failure in this species is human disturbance (Leseberg *et al*. 2000; Scott *et al*., 2011; Simmons & Brown, In Press). Off-road vehicles enable more people to reach otherwise remote stretches of coast, exacerbating disturbance effects and reducing productivity. Non-breeding birds, such as those at Swakopmund Salt Works, are relatively less sensitive to such disturbance.

It is presumed that the high frequency of jackals on Namibia's coast (Griffin, pers. comm.) keeps the number of breeding birds on all but the islands at very low levels (Simmons *et al.,* MS). Disturbance of Namibian nurseries is minimal at present, but predation by gull populations on the islands (Underhill, 2000) can be detrimental to the few pairs that do breed. Some evidence of a reduction in roost size is apparent from Elizabeth Bay, where sediment deposition in the bay may have smothered foraging grounds and has increased beach accretion by 500m since 1990 (Simmons, 2005).

5.3.2.4 National and regional context on conservation areas

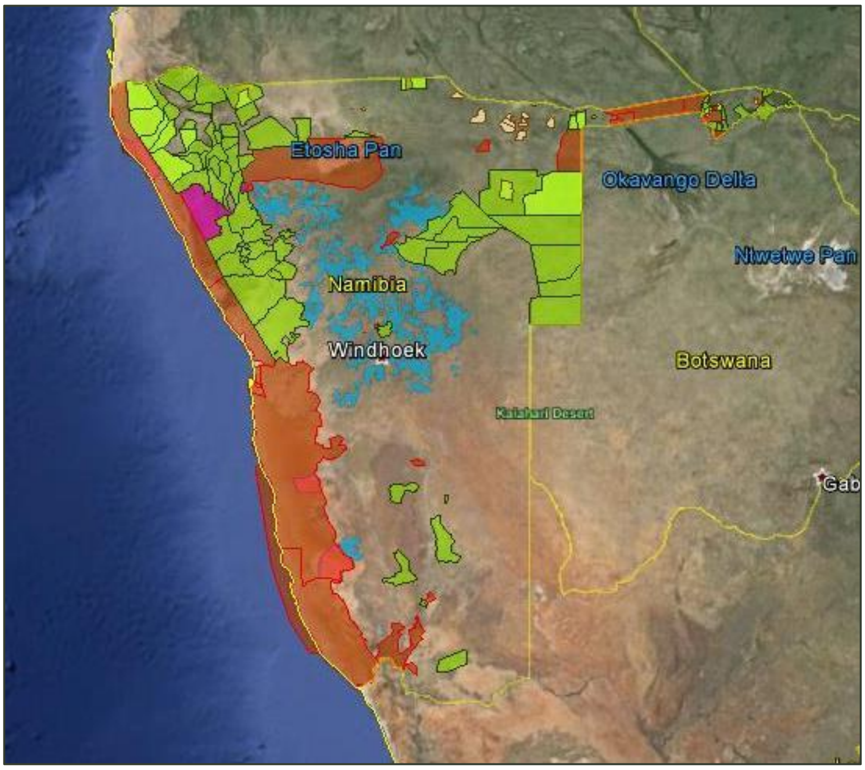


Figure 53: Protected areas in Namibia[31]

Protected or conservation areas in Namibia include those areas formally protected by the State (Parks and Reserves), communal conservancies, freehold conservancies, community forests, concessions and Marine Protected Areas (Figure 53).

[31] *Notes: Protected/conservation areas in Namibia: State/formally protected areas (orange), communal conservancies (green), freehold conservancies (blue), community forests (beige), concessions (pink) and Marine Protected Areas (red; EIS 2014)*

With the declaration of the Dorob National Park in 2010, the coastline from the Kunene River on the Angolan border to the Orange River on the South African border became a solid continuum of parks. Namibia has become the first and only country to have its entire coastline protected through a national parks network.

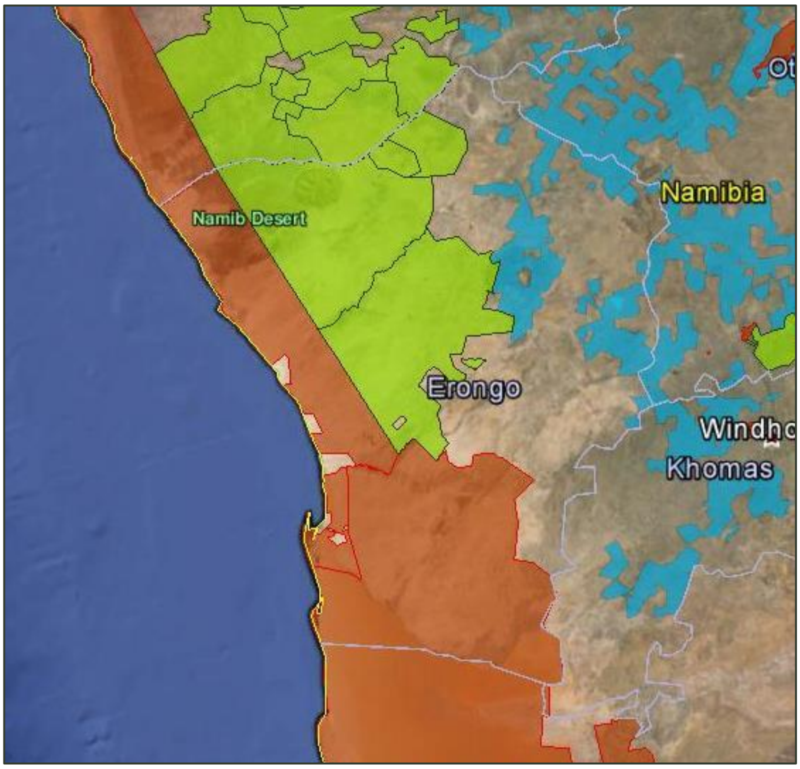


Figure 54: Protected areas in the Erongo Region[32]

5.3.2.5 Important Bird Areas

"Important Bird Areas" are places of international significance for the conservation of birds at the Global, Regional (Continental) or Sub-regional (southern African) level, selected according to stringent criteria (Barnes, 1998).

Six Important Bird Areas lie within the Erongo Region, namely the Brandberg Mountain , Cape Cross Lagoon , Swakopmund Salt Works, 30km Beach, Walvis to Swakopmund , Walvis Bay, Sandwich Harbour and the Namib-Naukluft Park (Figure 55).

[32] *Notes: Protected areas within the Erongo Region: national parks (orange), communal conservancies (green) and freehold conservancies (blue; EIS 2014)*

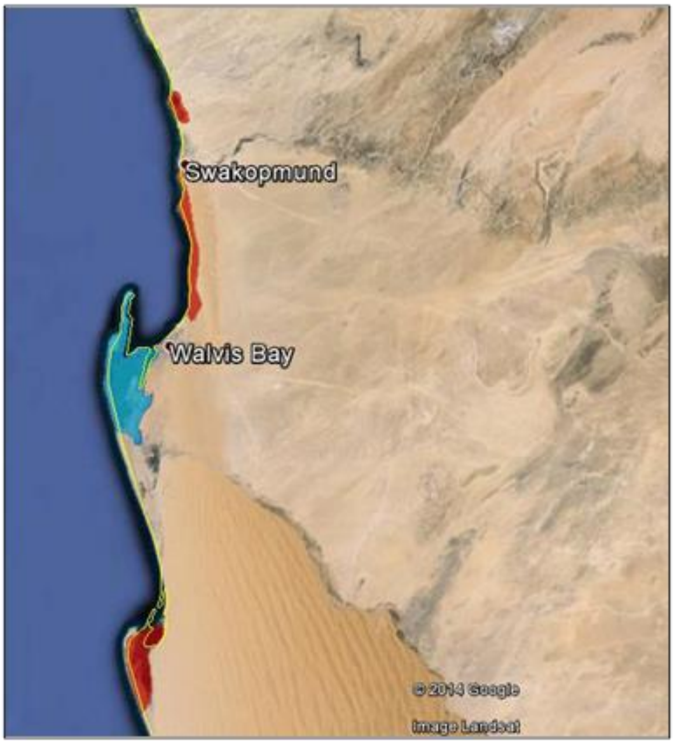


Figure 55: Important Bird Areas within the Erongo Region

5.3.2.6 Local and site context

Local habitats

The Swakopmund Salt Works is an Important Bird Area of 3,400ha in total, and described as fully protected (Simmons *et al*., 1998a). This coastal Important Bird Area comprises a private nature reserve (the aquatic portion of 400ha, known as "Panther Bake") and a salt works. It is accorded Global Important Bird Area status on account of the following criteria:

- A1: Globally threatened species;
- A4 i: Site known to hold or thought to hold, on a regular basis, more than 1% of a biogeographic population of congregator waterbird species; and
- A4 iii: Site known or thought to hold, on a regular basis, more than 20,000 waterbirds or more than 10,000 pairs of seabirds of one or more species.

The Important Bird Area lies adjacent to the sea on the central Namib coast and has been extensively altered to create numerous evaporation ponds (Simmons *et al*., 1998a). Immediately inland lie the gravel plains of the Namib Desert. The salt works is situated about 7km north of Swakopmund. Production of the concentrated brine at the salt pan, known as "Panther Bake" (Beacon) began in 1933, but by 1952 the salt source was exhausted. Seawater has since been pumped into the open evaporation and concentration ponds, from which crystallised salt is removed by means of mechanical scrapers. The pans are shallow and of varying salinity. A large wooden commercial guano platform covering 31,000m^2 has been built in one of the northern pans. Apart from a few halophytes, the salt works are devoid of vegetation.

Mile 4 occasionally supports massive numbers of waterbirds and the guano platform has supported up to 700,000 Cape Cormorants in the past, with an average of 45,000 in the years up to 1998 (Simmons *et al*. 1998a). Apart from the cormorants, the area may hold more than 50,000 other waterbirds, including relatively large numbers of Greater Flamingo, Lesser Flamingo and African (Black) Oystercatcher, and up to 100,000 Common Tern.

Breeding species at the salt works include Damara Tern, Chestnut-banded Plover, Kelp Gull, Hartlaub's Gull and Caspian Tern (Simmons *et al*., 1998a), and Black-winged Stilt, South African Shelduck, White-fronted Plover and Swift Tern (M Boorman pers. comm.).

White Pelicans have attempted to breed on the platforms (Boorman, pers.. comm.), but due to their disruption of cormorant breeding and their poor quality guano, they are dissuaded by the owners. In 1997, the area witnessed the first recorded attempt of Greater Flamingo and Lesser Flamingo breeding in coastal areas (Simmons *et al*., 1998a). Just over 100 nests were built in the salt pan and eggs were laid, but presumed disturbance by black-backed jackal led to early failure. Recent breeding attempts (in 1998) on small islands in the salt pans by Bank Cormorants and the occurrence and possible breeding of the near-endemic Gray's Lark immediately inland add to the reserve's importance.

Oyster production and guano scraping appear to be compatible with maintaining good populations of wetland birds, judging by the large numbers present, and the breeding of terns, cormorants and plovers in and around the salt works. The value of these commercial salt pans as habitat for waders and other birds is obvious from biannual wetland counts up to 93,000 birds of 35 species at any one time up to 1998.

Recent counts at the salt works are reflected in Table 9. Note that these counts exclude the thousands of Cape Cormorants on the guano platforms. The dominant groups in the counts are waders/shorebirds and flamingos. Note that the cormorants are not present when the guano platforms are being scraped for harvesting.

Table 9: Recent counts at the Swakopmund Salt Works[33].

Date	Total no. of birds	Total no. of species
January 2010	3,056	27
July 2012	5,247	24
July 2013	3,434	21
July 2014	5,845	21

The terns usually breed between late October and mid-November on gravel plains in northern Namibia, but in the south they prefer to nest on salt pans. Most nests are close to feeding sites, although breeding colonies are sometimes found up to 11.5km inland on gravel plains between the dunes. The highest densities of breeding pairs are found in the central coast between Sandwich Harbour and the Ugab River. The densest breeding colony known is at Caution Reef, south of Swakopmund. Nesting pairs and their single chicks are highly sensitive to human disturbance. Although it lies within the Dorob National Park, the Caution Reef site is currently under threat due to a proposed development.

Micro-habitats that would be attractive to birds are shown in Figure 56. These appear to be important for the following groups:

[33] *Source: African Waterbird Census: M Boorman in litt.*

- Damara Tern breeding area (potentially a highly sensitive site) and feeding areas over all the pans that contain small fish;
- Chestnut-banded Plover (breeding early 2000s);
- Flamingos, including a once-off breeding site (1997);
- Cape Cormorants breeding on the platforms in large numbers;
- African (Black) Oystercatcher roosts;
- Tern roosts (varying sites and species and numbers);
- Cormorant roost on present inlet pipe; and
- Red-capped Lark and (seldom) Gray's Lark.


Chestnut-banded Plover (large breeding effort in the early 2000s)


Regular Damara Tern breeding area


Red-capped Lark and (seldom) Gray's Lark on gravel plains


Flamingos: feeding and roosting


(Lesser) Flamingo: feeding and roosting; African (Black) Oystercatcher and tern roost; guano platforms in background


Cormorant roost on present inlet pipe

Figure 56: Micro-habitats for birds in the study area

Potential sensitivity of bird species

The potential sensitivity of the bird species for the study area is assessed according to the following criteria: Red Data status, endemism/habitat specialisation and nomadic/migrant habits, together with other physiological, behavioural and/or ecological sensitivities, all of which act synergistically to increase the likelihood of impacts becoming cumulative.

Red Data bird species

The 233 bird species recorded for the broad study area include 26 (11%) that are classified as Threatened in Namibia; eight of these (3%) are also globally classified as ‘Threatened’. Red data status is an indication of the potentially increased vulnerability of a species to negative impacts.

The following species are included in each Red Data category:

- Endangered (7):
    - Great Crested Grebe, Cape Gannet, African Penguin, Black-browed Albatross, Atlantic Yellow-nosed Albatross, Martial Eagle, Black Stork;
- Near Threatened (11);
    - Damara Tern, African (Black) Oystercatcher, Chestnut-banded Plover, Black-necked Grebe, Maccoa Duck, Cape Cormorant, Crowned Cormorant, Bank Cormorant, Peregrine Falcon, Verreauxs' Eagle, Rüppell's Parrot ;
- Vulnerable (8);
    - Lesser Flamingo, Greater Flamingo, Great White Pelican, Caspian Tern, Hartlaub's Gull, White-chinned Petrel, Lappet-faced Vulture, African Fish-eagle ;
- Species above that are also Globally Threatened (9); and
    - Damara Tern, Lesser Flamingo, African (Black) Oystercatcher, Cape Cormorant, Crowned Cormorant, Bank Cormorant, Cape Gannet, African Penguin, Lappet-faced Vulture.

5.3.2.7 Endemic bird species

The broad study area is home to 42 endemic/near-endemic species (18% of the total species occurring here). These species have a restricted distribution range. Such habitat specialisation increases the vulnerability of a species to impacts such as disturbance and habitat destruction.

Seven of the above species are endemic/near-endemic to Namibia. The Damara Tern is a breeding endemic with a very restricted habitat. The Dune Lark is endemic to the Namib Desert. Near-endemics are Gray's Lark, Rüppell's Korhaan, Rüppell's Parrot, Rosy-faced Lovebird and Bradfield's Swift.

Thirty-five species are endemic/near-endemic to southern Africa. These include Red-billed Spurfowl, South African Shelduck, Cape Shoveler, Monteiro's Hornbill, Southern Yellow-billed Hornbill, Namaqua Sandgrouse, Hartlaub's Gull, Cape Cormorant, Crowned Cormorant, Bank Cormorant, Southern Pale Chanting Goshawk and a diversity of other smaller species.

5.3.2.8 Resident, migrant and nomadic bird species

Of the total species occurring here, 150 species (64%) are resident, 80 (34%) are nomadic at times and 72 (31%) are migrant at times.

Migrant species undertake large-scale, regular seasonal movements, usually to the northern hemisphere and back. In contrast, nomadic species generally remain within the southern African Sub region, moving around widely and in no fixed pattern to exploit patchy and unpredictable food, water and other environmental resources, mainly in response to climatic conditions (Brown *et al.*, 2011). Numbers of species and abundance may thus vary markedly over time. Both migrant and nomadic movements increase the vulnerability of species to impacts such as collisions with overhead structures.

Among the migrant aquatic birds are Damara Tern, Southern Pochard, Lesser Moorhen, Black-tailed and Bar-tailed Godwit, Common Whimbrel, Eurasian Curlew, Common Redshank, Marsh Sandpiper, Wood Sandpiper, Terek Sandpiper, Common Sandpiper, Common Greenshank, Ruddy Turnstone, Red Knot, Sanderling, Little Stint, Curlew Sandpiper, Ruff, two phalaropes, Greater Painted-snipe, African Jacana, Black-winged Stilt, Pied Avocet, nine plovers (including Grey Plover, Common Ringed Plover, Kittlitz's plover, Chestnut-banded Plover), two lapwings, Subantarctic Skua, nine terns (including Swift, Sandwich, Common), two jaegers, four cormorants (including Cape, Bank, Crowned), Little Egret, two flamingos and White Stork.

Species that are nomadic (at times) in the study area include aquatic species such as White-faced Duck, White-backed Duck, Maccoa Duck, Egyptian Goose, South African Shelduck, Cape Teal, Cape Shoveler, Red-billed Teal, Hottentot Teal, Rüppell's Parrot, Rosy-faced Lovebird, Common Moorhen, Red-knobbed Coot, Namaqua sandgrouse, African (Black) Oystercatcher, Black-winged Stilt, Pied Avocet, three plovers, African Wattled Lapwing, Grey-headed Gull, Hartlaub's Gull, Caspian Tern, Little Grebe, Black-necked Grebe, Cape Gannet, Reed Cormorant, White-breasted Cormorant, Cape Cormorant, Bank Cormorant, three egrets, two flamingos, African Spoonbill, Great White Pelican, Black Stork, two storm-petrels, three albatrosses, two petrels, Sooty Shearwater, Pied Crow and a number of other smaller species.

Recent satellite tracking data for three Greater Flamingos and one Lesser Flamingo (NamPower/NNF Strategic Partnership, 2014) in Namibia illustrate the degree of nomadism in these aquatic species; large-scale migratory movements inland have not yet taken place due to the present relatively unsuitable breeding conditions there in summer (Figure 57, Figure 58 & Figure 59).

Flamingos usually fly at night or under conditions of poor light (Figure 59), which renders them vulnerable to collisions with man-made structures, including powerlines, during day-to-day nomadic movements that are usually at low altitudes. On migratory flights inland and back to the coast, flights are at higher altitudes except when taking off and coming in to land.

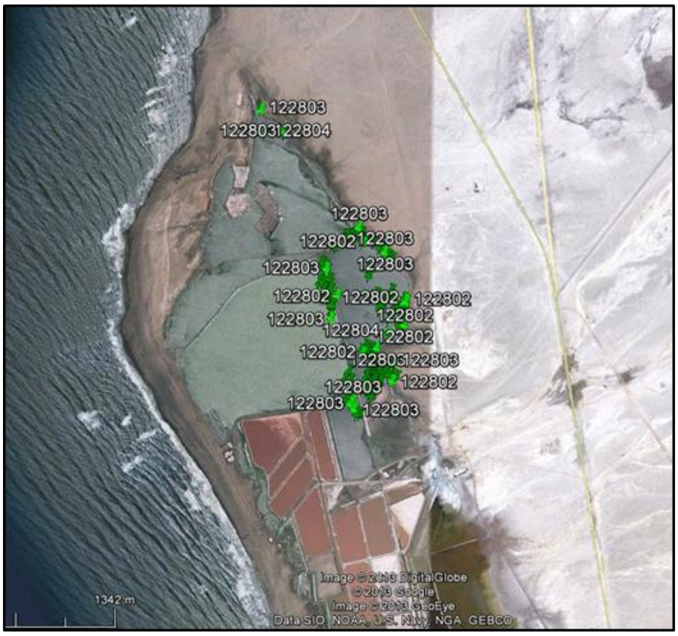


Figure 57: Satellite tracking data for three Greater Flamingos and one Lesser Flamingo[34]

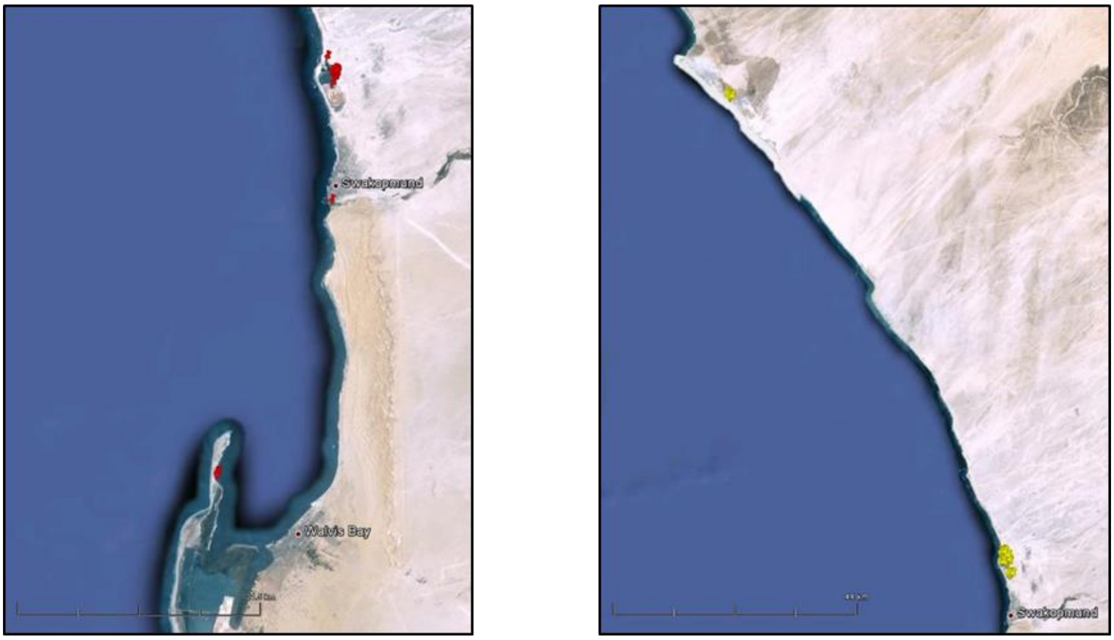


Figure 58: Satellite tracking data for three Greater Flamingos (a) and one Lesser Flamingo (b)[35]

[34] *Notes: Recent satellite tracking data for three Greater Flamingos and one Lesser Flamingo on 9 March 2013 illustrate the areas apparently preferred by these species at Swakopmund Salt Works (NamPower/NNF Strategic Partnershi,p 2014).*

[35] *Notes: Recent satellite tracking data for three Greater Flamingos (a) and one Lesser Flamingo (b) show nomadic movements on the Namibian coast, from Swakopmund Salt Works (where the tracking devices were fitted) to the Swakop River Mouth and Walvis Bay Lagoon in the south (a: red dots), and to Cape Cross Lagoon in the north (b: yellow dots); the exact flight paths are unfortunately not recorded (NamPower/NNF Strategic Partnership, 2014).*

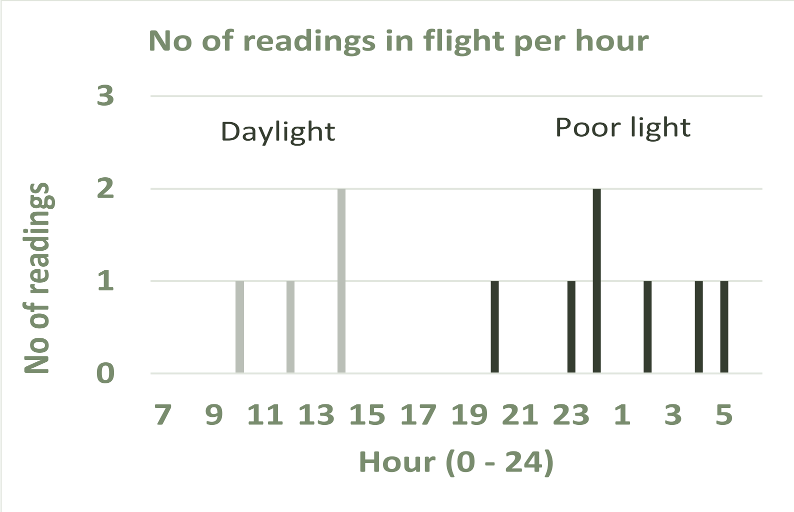


Figure 59: Selection of short local movements at Cape Cross Lagoon for a Lesser Flamingo[36]

5.3.3 Fauna

The Namib Desert is one of five coastal deserts world-wide. The frequent coastal fog is a significant source of moisture and supports a unique terrestrial ecology. The Namib Desert is estimated to be around 80 million years old. The long evolutionary history and occurrence of diverse ecological niches have given rise to an exceptional biodiversity (Seely, 2004) with a high level of endemism (Barnard, 1998). In this hyper-arid environment species redundancy is low and the ecosystem is highly susceptible to disturbance and slow to recover.

The protection of the coastline has a high priority on the political agenda at all levels. More than 90% of the two northern coastal regions (Kunene and Erongo) fall within Namibia's national protected areas system (NACOMA, 2008). The coast of Namibia falls within a series of contiguous protected and recreational areas, namely the Skeleton Coast National Park, the recently proclaimed Dorob National Park, the Namib-Naukluft National Park and the proposed Sperrgebiet National Park, formerly a mining concession completely off-limits to the public and accessible to only a few scientists. The coastline of Namibia is, in fact, part of a continuum of protected areas that stretches from Southern Angola into Namaqualand in South Africa and is considered to enjoy a relatively high level of protection.

The strip north of Swakopmund between the beach and the C34 road includes coastal plains which host Damara Tern breeding areas, dune hummocks which contain endemic coastal invertebrates and reptiles, as well as marine life and surf zone species. (Environmental Managment Plan for the Town of Swakopmund, 2010). Terrestrial invertebrates include insects such as tenebrionid beetle and tan beetles, arachnids, isopods. These invertebrates form the lower level of the food chain along the coast and are critical as food for birds and small terrestrial mammals (CSIR, 2009). The coastal plains around the Swakopmund Salt Works have been highly disturbed by a range of human activities including the ongoing operations associated with the Salt Works, guano harvesting and oyster farming operations. Vehicle tracks are abundant and human activity disturbances frequent, and the current levels of disturbance are extremely high.

[36] *Notes: Selection of more reliable altitude data for short local movements at Cape Cross Lagoon (May-June 2014) for a Lesser Flamingo fitted with a GPS PTT, showing number of readings taken per hour when the speed data indicated that the bird was in flight (NamPower/NNF Strategic Partnership, 2014).*

The marine birds and associated biodiversity in the evaporation pans may serve to attract predator species of the region and may encourage intermittent visits from aardwolf (*Proteles cristatus*), brown hyena (*Hyaena brunnea*), African wild cat (*Felis sylvestris*), bat-eared fox (*Otocyon megalotis*) and Cape fox (*Vulpes chama*), all of which are considered vulnerable.

The West Coast Recreation Area (now part of the Dorob National Park) is host to a distinct reptile and amphibian fauna. Approximately 60 reptile species (approximately 23% of all Namibian reptile species and 50% of Namibian endemic reptile species) are endemic to, or found mainly in, the Namib Desert (Barnard, 1998). Overall, 77 indigenous reptile species occur in the larger Skeleton Coast area.

5.3.4 Marine ecology[37]

The following section is technical in nature and so we have provided a glossary of terms to assist the reader in understanding the various technical terms used here.

Benthic	Referring to organisms living in or on the sediments of aquatic habitats (lakes, rivers, ponds, etc.).
Benthos	The sum total of organisms living in, or on, the sediments of aquatic habitats.
Benthic organisms	Organisms living in or on sediments of aquatic habitats.
Biodiversity	The variety of life forms, including the plants, animals and micro-organisms, the genes they contain and the ecosystems and ecological processes of which they are a part.
Biomass	The living weight of a plant or animal population, usually expressed on a unit area basis.
Biota	The sum total of the living organisms of any designated area.
Bivalve	A mollusk with a hinged double shell.
Community structure	All the types of taxa present in a community and their relative abundance.
Community	An assemblage of organisms characterized by a distinctive combination of species occupying a common environment and interacting with one another.
Dilution	The reduction in concentration of a substance due to mixing with water.
Effluent	A complex waste material (e.g. liquid industrial discharge or sewage) that may be discharged into the environment.
Epifauna	Organisms, which live at or on the sediment surface being either attached (sessile) or capable of movement.
Ecosystem	A community of plants, animals and organisms interacting with each other and with the non-living (physical and chemical) components of their environment.
Guideline trigger values	These are the concentrations (or loads) of the key performance indicators measured for the ecosystem, below which there exists a low risk that adverse biological (ecological) effects will occur. They indicate a risk of impact if exceeded and should 'trigger' some action, either further ecosystem

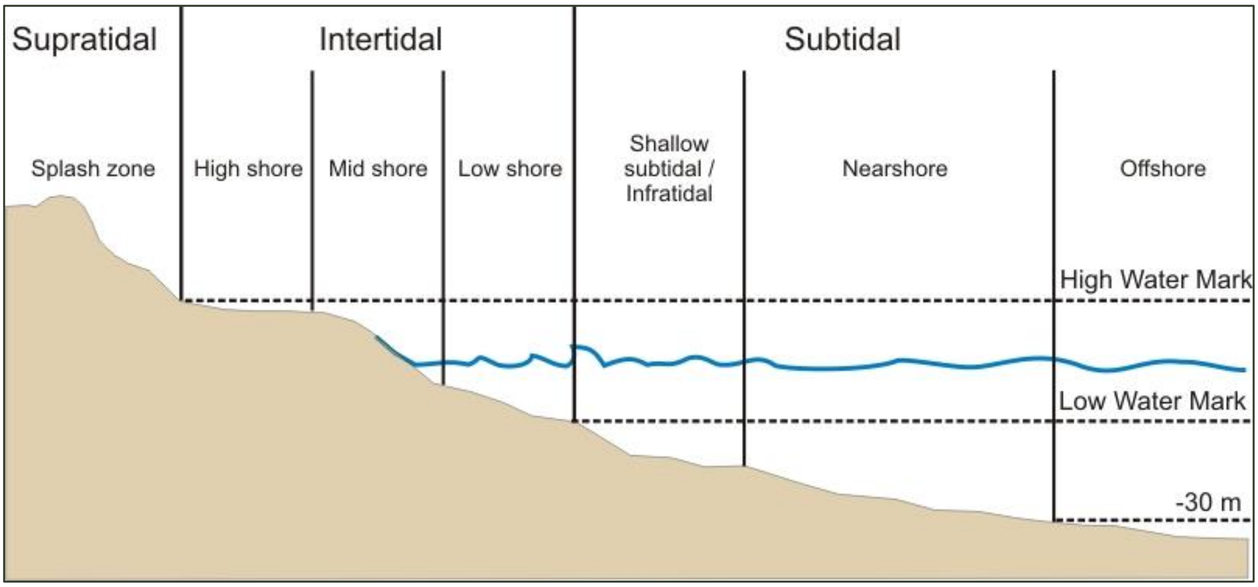
[37] *Section authored by Dr. Andrea Pulfrich of Pisces Environmental Services.*

	specific investigations or implementation of management/remedial actions.
Habitat	The place where a population (e.g. animal, plant, micro-organism) lives and its surroundings, both living and non-living.
Infauna	Animals of any size living within the sediment. They move freely through interstitial spaces between sedimentary particles or they build burrows or tubes.
Inter-specific stress	Biological stress between co-existing species
Macrofauna	Animals >1 mm.
Macrophyte	A member of the macroscopic plant life of an area, especially of a body of water; large aquatic plant.
Meiofauna	Animals <1 mm.
Mariculture	Cultivation of marine plants and animals in natural and artificial environments.
Marine discharge	Discharging wastewater to the marine environment either to an estuary or the surf-zone or through a marine outfall (i.e. to the offshore marine environment).
Marine environment	Marine environment includes estuaries, coastal marine and near-shore zones, and open-ocean-deep-sea regions.
Pollution	The introduction of unwanted components into waters, air or soil, usually as result of human activity; e.g. hot water in rivers, sewage in the sea, oil on land.
Population	Population is defined as the total number of individuals of the species or taxon.
Dissolved oxygen	Oxygen dissolved in a liquid, the solubility depending upon temperature, partial pressure and salinity, expressed in milligrams/litre or millilitres/litre.
Effluent	Liquid fraction after a treatment process (i.e. preliminary, primary, secondary or tertiary) in a wastewater treatment works.
Environmental impact	A positive or negative environmental change (biophysical, social and/or economic) caused by human action.
Environmental quality objective	A statement of the quality requirement for a body of water to be suitable for a particular use (also referred to as Resource Quality Objective).
Recruitment	The replenishment or addition of individuals of an animal or plant population through reproduction, dispersion and migration.
Sediment	Unconsolidated mineral and organic particulate material that settles to the bottom of aquatic environment.
Species	A group of organisms that resemble each other to a greater degree than members of other groups and that form a reproductively isolated group that will not produce viable offspring if bred with members of another group.
Sludge	Residual sludge, whether treated or untreated, from urban wastewater treatment plants.
Subtidal	The zone below the low-tide level, i.e. it is never exposed at low tide.
Surf-zone	Also referred to as the 'breaker zone' where water depths are less than half the wavelength of the incoming waves with the result that the orbital pattern of the waves collapses and breakers are formed.
Suspended material	Total mass of material suspended in a given volume of water, measured in mg/ℓ.
Suspended matter	Suspended material.
Suspended sediment	Unconsolidated mineral and organic particulate material that is suspended in a given volume of water, measured in mg/ℓ.

Taxon (Taxa)	Any group of organisms considered to be sufficiently distinct from other such groups to be treated as a separate unit (e.g. species, genera, families).
Turbidity	Measure of the light-scattering properties of a volume of water, usually measured in nephelometric turbidity units.
Vulnerable	A taxon is vulnerable when it is not Critically Endangered or Endangered but is facing a high risk of extinction in the wild in the medium-term future.

The following illustration provides a reader with an overview of the physiological construct and habitat types found in the littoral zone which will aid understanding of the sections to follow.

Morphology and habitat zones of a typical rock shore



Morphology and habitat zones of a typical sandy shore

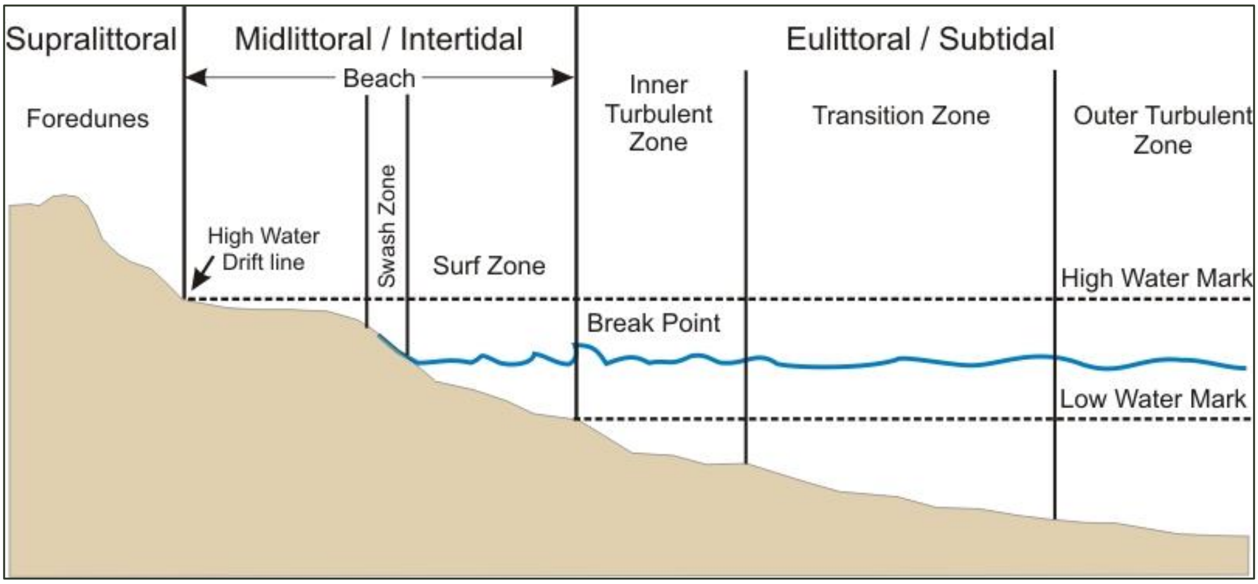


Figure 60: Cross-section of the coastal zone showing the typical habitats and morphology

Biogeographically the central Namibian coastline falls into the warm-temperate Namib which extends northwards from Lüderitz into southern Angola (Emanuel *et al*., 1992). The coastal, wind-induced upwelling characterising the Namibian coastline, is the principle physical process which shapes the marine ecology of the central Benguela region.

The coastline of central Namibia is dominated by sandy beaches, with rocky habitats being represented only by occasional small rocky outcrops. Consequently, marine ecosystems along the coast comprise a limited range of habitats that include:

- Sandy intertidal and subtidal substrates;
- Intertidal rocky shores and subtidal reefs; and
- The water body.

The benthic communities within these habitats are generally ubiquitous throughout the southern African west coast region, being particular only to substratum type, wave exposure and/or depth zone. They consist of many hundreds of species, often displaying considerable temporal and spatial variability. The biological communities “typical” of each of these habitats are described briefly below, focusing both on dominant, commercially important and conspicuous species, as well as potentially threatened or sensitive species, which may be affected by the proposed project.

5.3.4.1 Rocky Habitats and Biota

Intertidal Rocky Shores

The central and northern coasts of Namibia are bounded to the east by the Namib Desert and are characterised primarily by gravel plains and shifting dunes. In common with most semi-exposed to exposed coastlines on the southern African west coast, the rocky shores that occur in the region are strongly influenced by sediments, and include considerable amounts of sand intermixed with the benthic biota. This intertidal mixture of rock and sand is referred to as a mixed shore, and constitutes 40% of the coastline between the Kunene River and Walvis Bay (Bally *et al*., 1984). In the study area, mixed shores are limited to small low-shore outcrops that are exposed only at low water spring, which alternate with stretches of low-shore platform reefs and extensive pebble and sandy beaches.

Typically, the intertidal area of rocky shores can be divided into different zones according to height on the shore. Each zone is distinguishable by its different biological communities, which is largely a result of the different exposure times to air. The level of wave action is particularly important on the low shore. Generally, biomass is greater on exposed shores, which are dominated by filter-feeders. Sheltered shores support lower biomass, and algae form a large portion of this biomass (McQuaid & Branch 1984 and McQuaid *et al*., 1985).

Mixed shores incorporate elements of the trophic structures of both rocky and sandy shores. As fluctuations in the degree of sand coverage are common (often adopting a seasonal affect), the fauna and flora of mixed shores are generally impoverished when compared to more homogenous shores. The macrobenthos is characterised by sand-tolerant species whose lower limits on the shore are determined by their abilities to withstand physical smothering by sand (Daly & Mathieson, 1977; Dethier, 1984 and van Tamelen, 1996). The rocky shores along the coastline of the salt works appear to be heavily influenced by mobile sediments as large expanses of rock are barren of biota and appear scoured. Patchy dominance in the mid- and low-shore by ephemeral green algae (*Ulva* spp., *Cladophora* spp.) also suggest that these shores are periodically smothered by sands, as these algae proliferate as soon as sediments are eroded away.

The published data on rocky intertidal biota is restricted to the areas south of Lüderitz (Penrith & Kensley, 1970a; Pulfrich *et al*., 2003a, 2003b; Pulfrich, 2004b, 2005, 2006, 2007a; Clark *et al*. 2004, 2005, 2006; Pulfrich & Atkinson, 2007), and north of Rocky Point (Penrith & Kensley, 1970b and Kensley & Penrith, 1980), with only a single published study documenting the area between Walvis Bay and Swakopmund (Nashima, 2013). The information sourced from these publications, is complemented by unpublished data on rocky biota in the Wlotzkasbaken area supplied by MFMR (Currie, MFMR, unpublished data), an unpublished student report on invertebrate macrofauna occurring at three shores between Walvis Bay and Swakopmund (Ssemakula, 2010) and visual observations by the author.

Typical species in the high shore include the tiny snail *Afrolittorina knysnaensis*, the false limpet *Siphonaria capensis*, the limpet *Scutellastra granularis*, and often dense stands of the barnacle *Chthamalus dentatus*. Further down the shore the mytilid mussels, *Semimytilus algosus*, *Choromytilus meridionalis*, and *Perna perna* occur. The invasive alien Mediterranean mussel *Mytilus galloprovincialis* is also present. Foliose algae are represented primarily by the red algae *Caulacanthus ustulatus*, *Ceramium* spp., *Plocamium* spp. and *Mazzaella capensis* and the ephemeral green algae *Ulva* spp. and *Cladaphora* spp. In sand influenced areas the sand-tolerant algae *Nothogenia erinacea* and *Gelidium capense* and the anemone *Aulactinia reynaudi* also occur. The species encountered at the rocky outcrops in the study area were similar to those recorded from rocky intertidal areas in southern Namibia, and further to the north.

Although not directly harbouring any rare faunal or floral species, rocky intertidal shores are food-rich habitats for seabirds and wetland birds, attracting higher numbers of birds than the surrounding sandy beaches. Rocky intertidal fauna most sensitive to disturbance are the large limpet species. They tend to be the first ones eliminated by disturbance and the last to recover because of possible narrow tolerance limits to changes in environmental conditions. They act as keystone species on rocky shore, controlling the abundance of foliose algae and hence many other species (Branch, 1981).

***Figure 61: Intertidal rocky communities*[38]**

Rocky Subtidal Reefs

Reports on the benthic biota of nearshore reefs are restricted primarily to research undertaken in the vicinity of Lüderitz (Beyers, 1979; Tomalin, 1995; Pulfrich, 1998 and Pulfrich & Penney 1998, 1999, 2001) and information on rocky subtidal habitats in central Namibia is lacking. No scientific surveys have been undertaken of rocky subtidal habitats in the study area, and no information exists on the faunal and floral communities (Basson, pers. com.).

[38] *Notes: Intertidal rocky communities in the vicinity of the proposed desalination plant area showing intertidal zonation (left) and inundation by mobile sediments (right).*

A hydrographical and geophysical survey conducted indicates that the area is characterised by gently sloping, low-relief rock outcrops intersected by sandy gullies and depressions (CSIR, 2008). The flat and featureless nature of the reefs suggests that they may intermittently be covered by a veneer of unconsolidated sediments. Although kelp occurs sparsely for up to 100m offshore, the benthic communities inhabiting these reefs can be expected to be dominated by sand-tolerant and deposit feeding species.

A diving survey with the purpose of investigating the sea floor communities in the vicinity of the proposed brine discharge points of the then proposed NamWater Desalination Plant was conducted 2008 (Pulfrich & Steffani, 2008). Unfortunately only limited information on the benthic communities in the area could be gathered due to poor underwater visibility, however, it was ascertained that the seabed in the area was primarily bedrock covered by sand of various thickness. Benthic organisms present included tube worms, which had constructed compact sandy reefs of 0.75m to 1.0m in diameter and up to 0.6m in height, inhabited by various rocky bottom species including polychaetes, amphipods, isopods, rock boring bivalves and sea anemones. Sparse clumps of large mussels (*Perna perna*) were interspersed among the tube-worm colonies. Rocky outcrops or larger boulders were densely covered by red filamentous and foliose algae, with clumps of very large *Perna* (up to 135mm in length) occurring between the algal patches. The predatory gastropod *Thais haemastoma*, which apparently can occur in large numbers, was also recorded.

5.3.4.2 Sandy Substrate Habitats and Biota

The benthic biota of soft bottom substrates constitutes invertebrates that live on (epifauna), or burrow within (infauna), the sediments, and are generally divided into megafauna (animals larger than 10mm), macrofauna (larger than 1mm) and meiofauna (less than 1mm).

Intertidal Sandy Beaches

Sandy beaches are one of the most dynamic coastal environments. The composition of their faunal communities is largely dependent on the interaction of wave energy, beach slope and sand particle size, which is called beach morphodynamics. Three morphodynamic beach types are described: dissipative, reflective and intermediate beaches (McLachlan *et al.* 1993 and Defeo & McLachlan 2005). Generally, dissipative beaches are relatively wide and flat with fine sands and high wave energy. Waves start to break far from the shore in a series of spilling breakers that “dissipate” their energy along a broad surf-zone. This generates slow swashes with long periods, resulting in less turbulent conditions on the gently sloping beach face. These beaches usually harbour the richest intertidal faunal communities. Reflective beaches have low wave energy, and are coarse grained (larger than 500µm sand) with narrow and steep intertidal beach faces. The relative absence of a surf-zone causes the waves to break directly on the shore causing a high turnover of sand. The result is faunal communities is lacking in numbers and variety. Intermediate beach conditions exist between these extremes and have a very variable species composition (McLachlan *et al.* 1993 and Jaramillo *et al.,* 1995). This variability is mainly attributable to the amount and quality of food available. Beaches with a high input of e.g. kelp wrack have a rich and diverse drift-line fauna, which is sparse or absent on beaches lacking a drift-line (Branch & Griffiths, 1988; Field & Griffiths, 1991).

In the area between Walvis Bay and the Kunene River, beaches make up 44% of the coastline (Bally *et al*., 1984). A number of studies have been conducted on sandy beaches in central Namibia, including Sandwich Harbour (Stuart, 1975; Kensley & Penrith, 1977), the Paaltjies (McLachlan, 1985) and Langstrand (McLachlan, 1985, 1986; Donn & Cockcroft 1989), beaches near Walvis Bay and Cape Cross (Donn & Cockcroft, 1989), and recently a beach survey was conducted near Wlotzkasbaken as part of the baseline study for the Areva desalination plant (Pulfrich, 2007b). A further study by Tarr *et al*. (1985) investigated the ecology of three beaches further north on the Skeleton Coast. The results of these studies are summarised below.

Most beaches on the central Namibian coastline are open ocean beaches receiving continuous wave action. They are classified as exposed to very exposed on the 20-point exposure rating scale (McLachlan 1980), and intermediate to reflective and composed of well-sorted medium to coarse sands. The beaches tend to be characterised by well-developed berms, and are well-drained and oxygenated.

Numerous methods of classifying beach zonation have been proposed, based either on physical or biological criteria. The general scheme proposed by Branch & Griffiths (1988) is used below, supplemented by data from central Namibian beach studies (Stuart 1975; Kensley & Penrith 1977; McLachlan 1985, 1986; Donn 1986 and Donn & Cockcroft 1989) (Figure 62).

Supralittoral zone - The supralittoral zone is situated above the high water spring (HWS) tide level, and receives water input only from large waves at spring high tides or through sea spray. The supralittoral is characterised by a mixture of air breathing terrestrial and semi-terrestrial fauna, often associated with and feeding on kelp deposited near or on the driftline. Terrestrial species include a diverse array of beetles and arachnids and some oligochaetes, while semi-terrestrial fauna include the oniscid isopod *Tylos granulatus*, and the talitrid amphipod (Amphipoda, Crustacea) *Talorchestia quadrispinosa*. Community composition depends on the nature and extent of wrack, in addition to the physical factors structuring beach communities, as described above.

Midlittoral zone - The intertidal zone, also termed the mid-littoral zone, has a vertical range of about 2m. This mid-shore region is characterised by the cirolanid isopods *Pontogeloides latipes*, *Eurydice (longicornis) kensleyi*, and *Excirolana natalensis*, the deposit-feeding polychaete *Scolelepis squamata* (Polychaeta) and various species of the polychaete genus *Lumbrineris*, and the amphipods of the families Lysianassidae and Phoxocephalidae. In some areas, juvenile and adult sand mussels *Donax serra* (Bivalvia, Mollusca) may also be present in considerable numbers.

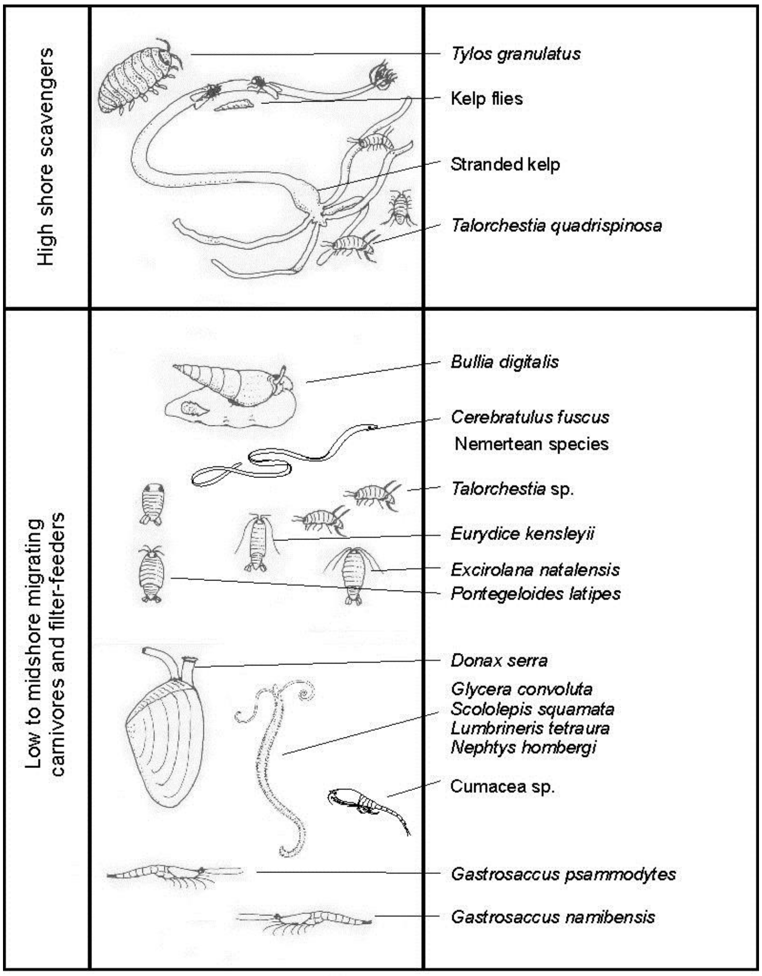


Figure 62: West Coast intertidal beach zonation[39]

Inner turbulent zone - The inner turbulent zone extends from the low water spring tide level to about -2m depth, and is characterised by highly motile specie. The bentho-planktic mysids *Gastrosaccus namibensis* and *G. psammodytes* (Mysidacea, Crustacea), the ribbon worm *Cerebratulus fuscus* (Nemertea) and the cumacean *Cumopsis robusta* (Cumacea) are typical of this zone, although they generally extend partially into the midlittoral above. In areas where a suitable swash climate exists, the gastropod *Bullia digitalis* (Gastropoda, Mollusca) may also be present in considerable numbers.

Transition zone - The transition zone spans approximately 2m to 3m depth and marks the area to which the break point might move during storms. Extreme turbulence is experienced in this zone, and as a consequence this zone typically harbours the lowest diversity on sandy beaches. Typical fauna of this zone include the polychaetes *Nephtys hombergi*, *Diopatra neopolitana* and *Glycera convoluta*, nemertean worms, amphipods such as *Urothoe elegans* and *Mandibulophoxus stimpsoni*, and the isopods *Cirolana hirtipes* and *Eurydice (longicornis=) kensleyi*.

Outer turbulent zone - Below 3m depth extends the outer turbulent zone, where turbulence is significantly decreased and which is marked by a sudden increase in species diversity and biomass. In addition to the polychaetes found in the transition zone, other polychaetes in this zone include *Diopatra neopolitana* and *Glycera convoluta*. The abundance of nemertean worms

[39] *Notes: Schematic representation of the West Coast intertidal beach zonation (adapted from Branch & Branch 1981). Species commonly occurring on the central Namibian beaches are listed.*

increases significantly from that in the transition zone. Amphipods such as *Urothoe elegans* and *Mandibulophoxux stimpsoni* are also more abundant, as are the isopods *Cirolana hirtipes* and *Pontogeloides latipes*, the mysid *G. namibensis*, the decapods *Diogenes extricatus* and *Ogyrides saldanhae*, and the three spot swimming crab *Ovalipes punctatus*, as well as the gastropods *Bullia laevissima* and *Natica forata*.

The surf-zone in the study area is rich in phytoplankton (primarily dinoflagellates and diatoms) and zooplankton. Particulate organic matter is commonly deposited on the beaches as foam and scum. The organic matter, both in suspension and deposited on the sand, is thought to represent the main food input into these beaches, thereby accounting for the dominance of filter-feeders in the macrofaunal biomass (McLachlan 1985).

Most of the macrofaunal species recorded from beaches in central Namibia are ubiquitous throughout the biogeographic province, and no rare or endangered species are known. The invertebrate communities are similar to those recorded from beaches in southern Namibia (McLachlan & De Ruyck, 1993; Nel *et al*., 1997; Meyer *et al*., 1998; Clark & Nel, 2002; Clark *et al.,* 2004; Pulfrich, 2004a; Clark *et al.,* 2005, 2006; Pulfrich & Atkinson, 2007 and Pulfrich *et al*. 1013). The beaches are characterised by a relatively depauparate invertebrate fauna, both with regard to species diversity and biomass, which is typical of high-energy west coast beaches.

Subtidal Sandy Habitats

In the subtidal region, the structure and composition of benthic soft bottom communities is primarily a function of water depth and sediment grain size, but other factors such as current velocity, organic content, and food abundance also play a role (Snelgrove & Butman, 1994; Flach & Thomsen, 1998; Ellingsen, 2002).

With the exception of numerous studies on the benthic fauna of Walvis Bay lagoon (Kensley, 1978; CSIR, 1989, 1992 and Cowi, 2003; Tjipute & Skuuluka, 2006), there is a noticeable scarcity of published information on the subtidal soft sediment biota along the rest of the central Namibian coast. The only reference sourced was that of Donn & Cockcroft (1989) who investigated macrofauna to 5m depth at Langstrand (see description for outer-turbulent zone above). In general, almost no scientific work on subtidal benthic communities has been done in the vicinity of the study area, or within the general region (Basson, MFMR, pers. comm.) and no further information could be obtained.

Beyond the outer turbulent zone to 80m depth, species diversity, abundance and biomass generally increases with communities being characterised equally by polychaetes, crustaceans and molluscs. The midshelf mudbelt is a particularly rich benthic habitat where biomass can attain 60g/m^2 dry weight (Christie, 1974; see also Steffani, 2007b). The comparatively high benthic biomass in this mudbelt region represents an important food source to carnivores such as the mantis shrimp, cephalopods and demersal fish species (Lane & Carter, 1999). In deeper water beyond this rich zone biomass declines to 4.9g/m^2 at 200m depth and then is consistently low (less than 3g/m^2) on the outer shelf (Christie, 1974).

Typical species occurring at depths of up to 60m included the snail *Nassarius* spp., the polychaetes *Orbinia angrapequensis*, *Nepthys sphaerocirrata*, several members of the spionid genera *Prionospio*, and the amphipods *Urothoe grimaldi* and *Ampelisca brevicornis*. The bivalves *Tellina gilchristi* and *Dosinia lupinus orbignyi* are also common in certain areas. All these species are typical of the southern african west coast (Christie, 1974; 1976; McLachlan, 1986; Parkins & Field, 1998; Pulfrich & Penne,y 1999b; Goosen *et al.,* 2000; Steffani & Pulfrich, 2004a; 2007 and Steffani, unpublished data) (Figure 63).

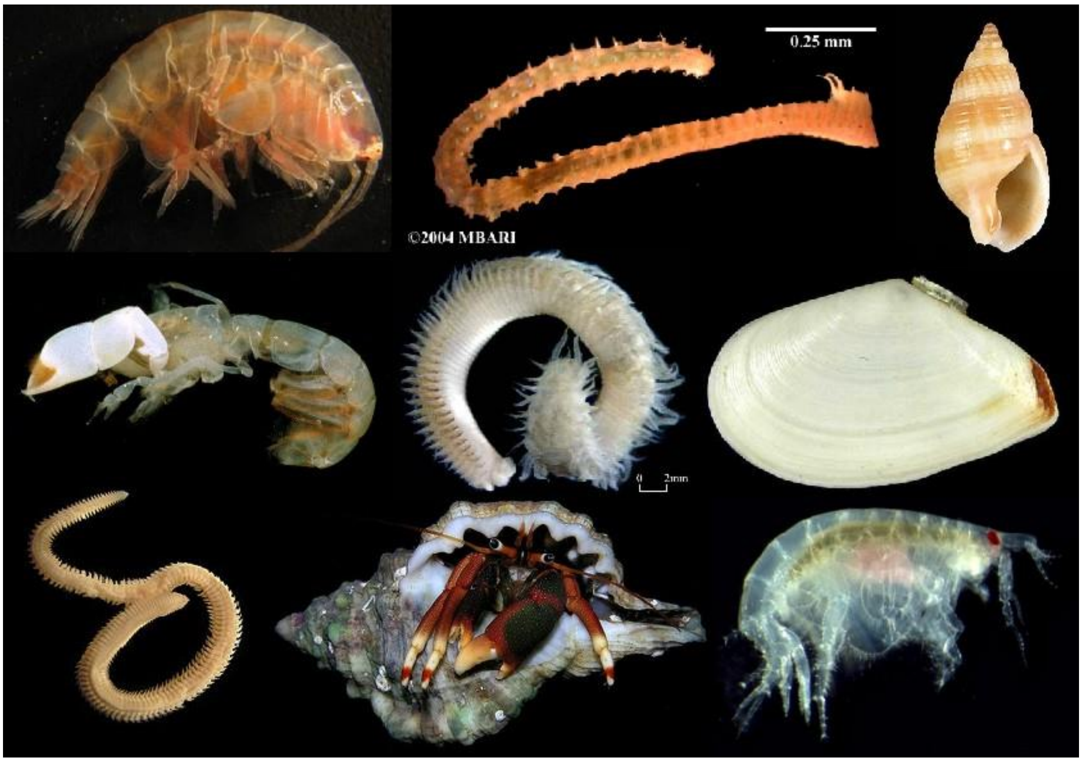


Figure 63: Benthic macrofaunal genera commonly found in nearshore sediments[40]

Whilst many empirical studies related community structure to sediment composition (e.g. Christie, 1974; Warwick *et al,.* 1991; Yates *et al.,* 1993; Desprez, 2000 and van Dalfsen *et al.,* 2000), other studies have illustrated the high natural variability of soft-bottom communities, both in space and time, on scales of hundreds of metres to metres (e.g. Kenny *et al.,* 1998; Kendall & Widdicombe, 1999; van Dalfsen *et al.,* 2000; Zajac *et al.* 2000 and Parry *et al,.* 2003), with evidence of mass mortalities and substantial recruitments (Steffani & Pulfrich, 2004a). It is likely that the distribution of marine communities in the mixed deposits of the coastal zone is controlled by complex interactions between physical and biological factors at the sediment–water interface, rather than by the granulometric properties of the sediments alone (Snelgrove & Butman, 1994 and Seiderer & Newell, 1999). For example, off central Namibia it is likely that periodic intrusion of low oxygen water masses is a major cause of this variability (Monteiro & van der Plas, 2006 and Pulfrich *et al.,* 2006). Although there is a poor understanding of the responses of local continental shelf macrofauna to low oxygen conditions, it is safe to assume that in areas of frequent oxygen deficiency the communities will be characterised by species able to survive chronic low oxygen conditions, or colonising and fast-growing species able to rapidly recruit into areas that have suffered complete oxygen depletion. Local hydrodynamic conditions, and patchy settlement of larvae, will also contribute to small-scale variability of benthic community structure.

It is evident that an array of environmental factors and their complex interplay is ultimately responsible for the structure of benthic communities. Yet the relative importance of each of these factors is difficult to determine as these factors interact and combine to define a distinct habitat in which the animals occur. However, it is clear that water depth and sediment composition are two of the major components of the physical environment determining the macrofauna community

[40] *Notes: (top: left to right) Ampelisca, Prionospio, Nassarius; (middle: left to right) Callianassa, Orbinia, Tellina; (bottom: left to right) Nephtys, hermit crab, Bathyporeia.*

structure off southern Namibia (Steffani & Pulfrich, 2004a, 2004b, 2007 and Steffani 2007a, 2007b, 2009a, 2009b, 2009c, 2010).

5.3.4.3 Pelagic Communities

The pelagic communities are typically divided into plankton and fish, and their main predators, marine mammals (seals, dolphins and whales), seabirds and turtles. Seabirds are dealt with in a separate specialist study and will thus not be discussed further here.

Plankton

Plankton is particularly abundant in the shelf waters off Namibia, being associated with the upwelling characteristic of the area. Plankton range from single-celled bacteria to jellyfish of 2m diameter, and include bacterio-plankton, phytoplankton, zooplankton, and ichthyoplankton (Figure 64).


Figure 64: Phytoplankton and zooplankton associated with upwelling on the Namibian shelf[41]

Off the Namibian coastline, phytoplankton are the principle primary producers with mean annual productivity being comparatively high at 2g C/m^2/day. The phytoplankton is dominated by diatoms, which are adapted to the turbulent sea conditions. Diatom blooms occur after upwelling events, whereas dinoflagellates are more common in blooms that occur during quiescent periods, since they can grow rapidly at low nutrient concentrations (Barnard, 1998). A study on phytoplankton in the surf zone off two beaches in the Walvis Bay and Cape Cross area showed relatively low primary production values of only 10mg to 20mg C/m^2/day compared to those from oceanic waters. This was attributed to the high turbidity in this environment (McLachlan, 1986). In the surf-zone, diatoms and dinoflagellates are nearly equally important members of the phytoplankton, and some silicoflagellates are also present. Characteristic species belong to the genus *Gymnodinium*, *Peridinium*, *Navicula*, and *Thalassiosira* (McLachlan, 1986).

Namibian zooplankton reaches maximum abundance in a belt parallel to the coastline and offshore of the maximum phytoplankton abundance. Samples collected over a full seasonal cycle (February to December) along a 10 to 90-nautical-miles transect offshore Walvis Bay showed that the mesozooplankton (less than 2mm body width) community included egg, larval, juvenile and

[41] *Notes: Phytoplankton (left, photo: hymagazine.com) and zooplankton (right, photo: mysciencebox.org) is associated with upwelling cells on the Namibian shelf.*

adult stages of copepods, cladocerans, euphausiids, decapods, chaetognaths, hydromedusae and salps, as well as protozoans and meroplankton larvae (Hansen *et al*., 2005). Copepods are the most dominant group making up *70 to 85%* of the zooplankton. The four dominant calanoid copepod species, in order of abundance, are *M. lucens*, *C. carinatus*, *R. nasutus* and *Centropages* spp. During the period of intense upwelling, the two herbivorous species, *C. carinatus* and *R. nasutus*, increase in abundance inshore, leading to a shift in dominance from *C. carinatus* to *M. lucens* with increasing distance offshore. Seasonal patterns in copepod abundance, with low numbers during autumn (March–June) and increasing considerably during winter/early summer (July–December), appear to be linked to the period of strongest coastal upwelling in the northern Benguela (May–December), allowing a time lag of about 3 to 8 weeks, which is required for copepods to respond and build up large populations (Hansen *et al*., 2005). This suggest close coupling between hydrography, phytoplankton and zooplankton. Timonin *et al*. (1992) described three phases of the upwelling cycle (quiescent, active and relaxed upwelling) in the northern Benguela, each one characterised by specific patterns of zooplankton abundance, taxonomic composition and inshore-offshore distribution. It seems that zooplankton biomass closely follows the changes in upwelling intensity and phytoplankton standing crop. Consistently higher biomass of zooplankton occurs offshore to the west and northwest of Walvis Bay (Barnard, 1998).

Ichthyoplankton constitutes the eggs and larvae of fish. As the preferred spawning grounds of numerous commercially exploited fish species are located off central and northern Namibia, their eggs and larvae form an important contribution to the ichthyoplankton in the region.

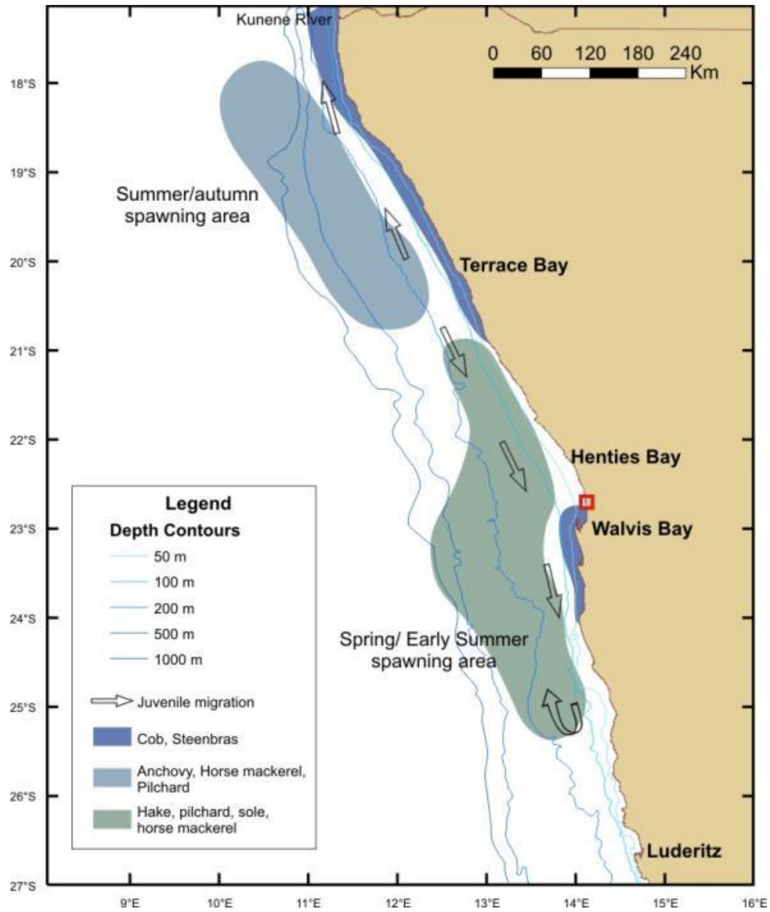


Figure 65: Major spawning areas in the central Benguela region[42]

[42] *Notes: Major spawning areas in the central Benguela region (adapted from Cruikshank 1990) in relation to the study area (red rectangle – not to scale).*

Fish

The surf zone and outer turbulent zone habitats of sandy beaches are considered to be important nursery habitats for marine fishes (Modde, 1980; Lasiak, 1981; Kinoshita & Fujita, 1988 and Clark *et al.,* 1994). However, the composition and abundance of the individual assemblages seems to be heavily dependent on wave exposure (Blaber & Blaber, 1980; Potter *et al.* 1990; Clark, 1997a, b). Surf-zone fish communities off the coast of southern Namibia have been studied by Clark *et al.* (1998) and Meyer *et al.* (1998), who reported only five species occurring off exposed and very exposed beaches, these being southern mullet/harders (*Liza richardsonii*), white stumpnose (*Rhabdosargus globiceps*), False Bay klipfish (*Clinus latipennis*), Super klipvis (*C. superciliosus*) and galjoen (*Dichistius capensis*). Linefish species common off the central Namibian coastline include snoek (*Thyrsites atun*), silver kob (*Argyrosomus inodorus*), West Coast Steenbras (*Lithognathus aureti*), blacktail (*Diplodus sargus*), white stumpnose, Hottentot (*Pachymetopon blochii*) and galjoen (*Dichistius capensis*). From the surf zone off Langstrand beach near Walvis Bay, McLachlan (1986) recorded galjoen, West Coast steenbras, flathead mullet (*Mugil cephalus*), and southern mullet. Off Cape Cross only two species were recorded, these being sandsharks (*Rhinobatos annulatus*) and West Coast Steenbras.

No systematic surveys of the fish fauna of Walvis Bay, the lagoon and surrounding areas appear to have been undertaken. Glasson & Branch (1997) refer to the presence of the sandshark in Walvis Bay. Both mullet species enter the lagoon in large shoals, often pursued by flocks of Great White Pelicans or Cape Cormorants. Other fish species reported as occurring in the lagoon include silver kob, barbel (*Galeichthys feliceps*) and west coast steenbras. However, angling competition records for the lagoon indicate that no bony fishes have been caught since 2000 (Walvis Bay Angling Club), with only sandsharks, bull rays (*Pteromylacus bovinus*), blue sting rays (*Dasyatis pastinaca*) and hound sharks (*Mustelis mustelis)* being caught.

The biological, behavioural and life-history characteristics of the three most important linefish species in Namibian coastal waters are summarised below.

Silver kob, *Argyrosomus inodorus,* are distributed from northern Namibia to the warm temperate / subtropical transition zone on South Africa's east coast (Griffiths & Heemstra, 1995). Four stocks have been identified, one in Namibia, with its core distribution from Cape Frio in the north to Meob Bay in the south, a distance of 850km (Kirchner 2001). Maturity is reached at a length of 35cm and age of 1.5 years with a maximum recorded size of 36 kg (Kirchner *et al.,* 2001). Spawning occurs throughout the year but mostly in the warmer months from October to March when water temperatures are above 15°C and large adult fish occur in the nearshore, particularly in the identified spawning areas of Sandwich Harbour and Meob Bay. Adults are migratory whereas juveniles are resident in the surf zone.

The Namibian stock of *A. inodorus* is exploited by the commercial linefishery (deck and skiboats) and recreational shore angling with, until recently, a mean annual catch of 500t and 350t respectively. There is also a small recreational boat fishery (Kirchner, 2001). The stock is regarded as overexploited and near collapse with less than 25% of pristine spawner biomass remaining. The availability of *A. inodorus* and other fish species to shore and boat fishers is driven by environmental conditions. For example, strong south-westerly winds, large swells and upwelling all have a negative impact on catches. Warm-water events and sulphur eruptions inhibit feeding and the catchability of most species (Holtzhausen *et al.* 2001).

West Coast Dusky Kob, *Argyrosomus coronus,* are distributed from northern Namibia to northern Angola (Griffiths & Heemstra 1995), but do occur as far south as St Helena Bay in South Africa (Lamberth *et al.* 2008). Maturity is reached at a total length of 87cm and 4.5 years of age and a maximum size of 80kg attained (Potts *et al.,* 2012). Early juveniles frequent muddy sediments in

50-100m depth, moving inshore once they reach 300mm total length. These juveniles and adolescents are resident in the nearshore, and are especially abundant in the turbid plume off the Cunene River Mouth and in selected surf zones of northern and central Namibia (Potts *et al.* 2010). The adults are migratory according to the movement of the Angola-Benguela frontal zone, moving northwards as far as Gabon in winter and returning to southern Angola in spring where spawning occurs in the offshore (Potts *et al.* 2010).

In Angola and Namibia, *A. coronus* are exploited by the shore- and boat-based commercial, artisanal and recreational line fisheries. The Angolan beach-seine, gillnet and purse-seine fisheries also land this species. Overexploitation in its northern range is likely exacerbated by a distributional shift of adult fish out of Angolan waters. Ten years ago, the ratio of *A. inodorus* to *A. coronus* in the Namibian fishery was 10:1 (Kirchner & Beyer1999) compared to 10:15 in the present day (Potts *et al.* in prep). This is largely due to a distributional shift southwards also evidenced by a 58% reduction in relative abundance and a 27% reduction in mean length in Angolan waters (Potts *et al.* in prep). The overall forcer is thought to be warmer coastal waters in the northern Benguela coastal zone.

The populations of both kob species are under stress from fishing, climate change, distributional shifts and an increase in inter-specific interactions. Inter-specific stress has also become a factor. *A. inodorus* and *A. coronus* now overlap in distribution and hybridisation, which may at least partly be due to a stress-induced breakdown in mate recognition, has occurred. In fish, hybridisation is usually associated with increased resistance to disease and physiological tolerance of environmental stresses, and often allows species to expand their ranges to invade new niches. However, molecular support for potential reduced fitness in hybridized fish under environmental stress exists (David *et al.* 2004), providing a plausible explanation for the relatively rare occurrence of interspecies hybridisation in sympatric environments. Behavioural and biological responses such as distributional shifts and hybridisation make it clear that some population thresholds have already been reached and that even low-level anthropogenic forcers may precipitate further change.

Similar to the kob species described above, white steenbras, *Lithognathus lithognathus,* and west coast steenbras *Lithognathus aureti* are sister species and sympatric from St Helena Bay to the Orange River Estuary. White steenbras occur from the Orange River to the Umtamvuna River on South Africa's eastern seaboard, but spawning habitat appears to be restricted to less than 50ha throughout it's range (Sink *et al.,* 2011). Adults undertake an annual spawning migration to the edge of the species's distribution on the east coast. There is, however, circumstantial evidence for the "extinction" of a separate west coast spawning population due to overexploitation in the last century (Lamberth *et al.* 2011).

West coast steenbras, *Lithognathus aureti***,** are endemic to the west coast of southern africa, but rarely found outside Namibia's territorial waters (Holtzhausen 2000). However, they do occur as far south as St Helena Bay and historical abundance in south african waters is thought to have been a lot higher prior to the advent of the commercial beach-seine fishery (Lamberth *et al.,* 2008). In Namibia, *L. aureti* are exploited by commercial and recreational boat-based linefishers, as well as by recreational shore-anglers with a total landed catch of approximately 600t per annum (Holtzhausen & Mann 2000). Overexploitation in the early 1990s was arrested by the closure of the gillnet fishery for this species. Tagging studies have indicated that *L. aureti* comprise two separate closed populations; one in the vicinity of Meob Bay and one from central Namibia northwards (Holtzhauzen *et al.* 2001). Spawning localities are as yet unknown but tagging evidence suggests that males migrate considerable distances in search of gravid females (Holtzhausen, 2000).

The parallels between *L. aureti* and *L. lithognathus* suggest that the spawning habitat of west coast steenbras may also be limited. The bulk of the population exists in the nearshore at less than 10m depth, with juveniles occurring in the intertidal surf zone (McLachlan 1986). By inference, spawning occurs in the surf zone and eggs and larvae from both populations drift northwards (Holtzhausen, 2000). The fact that both populations of *L. aureti* exist entirely in the nearshore would make them susceptible to any coastal development that lies in the path of alongshore movement. Whereas juveniles occur in the surf zone throughout its range, spawning habitat may be extremely limited and has yet to be clearly identified.

Small pelagic species include the sardine/pilchard (*Sadinops ocellatus*) (Figure 66, left), anchovy (*Engraulis capensis*), chub mackerel (*Scomber japonicus*), horse mackerel (*Trachurus capensis*) (**Figure 66**, right) and round herring (*Etrumeus whiteheadi*). These species typically occur in mixed shoals of various sizes (Crawford et *al,.* 1987), and generally occur within the 200m contour, although they may often be found very close inshore, just beyond the surf zone. They spawn downstream of major upwelling centres in spring and summer, and their eggs and larvae are subsequently carried up the coast in northward flowing waters. Recruitment success relies on the interaction of oceanographic events, and is thus subject to spatial and temporal variability. Consequently, the abundance of adults and juveniles of these small pelagic fish is highly variable both within and between species. The Namibian pelagic stock is currently considered to be in a critical condition due to a combination of over-fishing and unfavourable environmental conditions as a result of Benguela Niños.

Figure 66: Small pelagic Fish of the area[43]

Since the collapse of the pelagic fisheries, jellyfish biomass has increased and the structure of the Benguelan fish community has shifted, making the bearded goby (*Sufflogobius bibarbatus*) the new predominant prey species. However, despite increased predation pressure, the gobies are thriving. Recent research has shown that gobies have a very high tolerance of low oxygen and high H_2S levels, which enables them to feed on benthic fauna within hypoxic waters during the day, and then move to oxygen-richer pelagic waters at night, when predation pressure is lower, to feed on live jellyfish (Utne-Palm *et al.,* 2010 and van der Bank *et al.,* 2011).

[43] *Notes: Cape fur seal preying on a shoal of pilchards (left). School of horse mackerel (right) (photos: www.underwatervideo.co.za; www.delivery.superstock.com).*

Turtles

Five of the eight species of turtle worldwide occur off Namibia (Bianchi *et al,.* 1999). Turtles that are occasionally sighted off central Namibia, include the Leatherback Turtle (*Dermochelys coriacea*), the largest living marine reptile. Limited information is available on marine turtles in Namibian waters, although leatherback turtles, which are known to frequent the cold southern ocean, are the most commonly-sighted turtle species in the region. Observations of Green (*Chelonia mydas*), Loggerhead (*Caretta caretta*), Hawksbill (*Eretmochelys imbricata*) and Olive Ridley (*Lepidochelys olivacea*) turtles in the area are rare.

Leatherbacks turtles inhabit deeper waters and are considered a pelagic species, travelling the ocean currents in search of their prey (primarily jellyfish). While hunting they may dive to over 600m and remain submerged for up to 54 minutes (Hays *et al,.* 2004). Their large size allows them to maintain a constant core body temperature and consequently they can penetrate colder temperate waters.

The south Atlantic population of leatherback turtles is the largest in the world, with as many as 40,000 females thought to nest in an area centred on Gabon, yet the trajectory of this population is currently unknown (Witt *et al,.* 2011). Namibia is gaining recognition as a feeding area for leatherback turtles that are either migrating through the area or undertaking feeding excursions into Namibian waters. The turtles are thought to be attracted by the large amount of gelatinous plankton in the Benguela ecosystem (Lynam *et al,.* 2006). Based on tag returns from animals found dead in Namibia, these turtles are thought to come mainly from Gabonese and Brazilian nesting grounds (R. Braby, pers. comm., Namibia Coast Conservation and Management Project – NACOMA, 25 August 2010).

Although they tend to avoid nearshore areas, they may be encountered in the area around Walvis Bay between October and April when prevailing north wind conditions result in elevated seawater temperatures. Elwen & Leeney (2011) reported 21 sightings of leatherback turtles in Walvis Bay between 2009 and 2010. Anecdotal evidence suggests that sightings of leatherback turtles have been fewer in the past two years (Leeney, pers. comm. with tourism industry operators). Leatherback turtles have recently washed up in significant numbers on the central Namibian shore (Figure 67), with some being recorded as far south as Mining Area 1 in the Sperrgebiet (28°27'S) (Pulfrich, pers. obs.). During the past five years 200 to 300 dead turtles were found (www.nacoma.org.na). The shell of a green turtle was found in Sandwich Harbour in March 2012 (NDP data).

Several anthropogenic factors threaten sea turtle populations including entanglement in fishing gear, incidental catches in fisheries, vessel strikes, ingestion of marine debris, pollution, decline of habitat along the western atlantic coast and loss of nesting habitat (Carr, 1987; National Research Council (NRC) 1990; Lutz & Alfaro-Shulman, 1991; Lutcavage *et al.,* 1997; Witzell 1999; Witherington & Martin, 2000; Dwyer *et al,.* 2003 and James *et al.,* 2005). Anthropogenic noise is also thought to be detrimental to sea turtles (Samuel *et al.,* 2005), with likely effects on their behaviour and ecology.

Figure 67: Dead Leatherback Turtle washed up at a beach north of Swakopmund, March 2008

Leatherback Turtles are listed as "Critically Endangered" worldwide by the IUCN and are in the highest categories in terms of need for conservation in CITES (Convention on International Trade in Endangered Species), and Convention on Migratory Species (Convention on Migratory Species). Although Namibia is not a signatory of Convention on Migratory Species, Namibia has endorsed and signed a Convention on Migratory Species International Memorandum of Understanding specific to the conservation of marine turtles. Namibia is thus committed to conserve these species at an international level.

Marine Mammals

Marine mammals occurring off the Namibian coastline include cetaceans (whales and dolphins) and seals. The cetacean fauna of the Namibian coast comprises between 22 and 31 species (Cetus Projects 2008; Currie *et al.,* 2009), the diversity reflecting both species recorded from the waters of Namibia (Williams *et al.,* 1990; Rose & Payne, 1991; Findlay *et al.* 1992; Griffin & Coetzee, 2005) and species expected to be found in the region based on their distributions elsewhere along the southern african west coast (Best, 2007; Elwen *et al.,* 2011a). The diversity is comparatively high, reflecting the cool inshore waters of the Benguela Upwelling system and the occurrence of warmer oceanic water offshore of this. The species confirmed to be present in Namibian waters are listed in Table 10.

Of the species recorded the endemic Heaviside's Dolphin *Cephalorhynchus heavisidii* (Figure 68, left) is found in the extreme nearshore region of the project area. Although there are no population estimates for Heaviside's dolphins as a whole, the size of the population utilising Walvis Bay in 2009 was estimated at 505 (Elwen & Leeney, 2009), and a degree of site fidelity of the species to Pelican Point was confirmed from images taken in 2008 and 2009. Sightings of this species in Walvis Bay occur mostly at Pelican Point; the few sightings in other parts of the bay occur more commonly in summer (January to March), when sightings at Pelican Point decrease, suggesting that these animals have a different primary habitat during those months. The range of the Heaviside's dolphins in this area is unknown, although aerial surveys (Leeney in prep.) have revealed that they utilises nearshore habitat along much of the Namibian coastline including south of Walvis Bay, with a hotspot of abundance just south of Sandwich Harbour. Acoustic detections of the species at Pelican Point are most numerous during the night, decreasing to a minimum in the early afternoon (Leeney, *et al.* 2011). This pattern is likely linked with prey availability at this site. Although considered numerous in south african waters, Heaviside's dolphins are vulnerable due to their use of human-impacted coastal habitats, the small home ranges of individuals and the restricted geographic range of the species.


Figure 68: Marine mammals[44]

The bottlenose dolphin (*Tursiops truncatus*) is found in the extreme nearshore region between Lüderitz and Cape Cross (Elwen *et al.,* 2011b; Leeney in prep.) (including the Sandwich Harbour lagoon), as well as offshore of the 200 m isobath along the Namibian coastline. This species has been a key element of the research conducted by the Namibian Dolphin Project in Walvis Bay, with the population in 2008 estimated (via photo-identification techniques) at 77 individuals. Since then there has been a *6 to 8%* annual reduction in the number of animals identified in the bay (Elwen *et al.* 2011b), with 19 individuals identified in 2008 not been seen since. This suggests some degree of emigration from the population. The reduction in the population is a serious concern and suggests that the species is under pressure in at least part of its range. Roughly twice as many individuals are identified in Walvis Bay in winter than during the summer months, suggesting that other habitats are more frequently utilised during the summer. A number of mother-calf pairs have been observed in Walvis Bay between 2008 and 2011. The reef north of Bird Island has been identified as an area used by these animals primarily for resting (Elwen & Leeney, 2009; Elwen *et al.,* 2011b), and has informally been designated as a no-go zone for tour boats.

Although common bottlenose dolphins are found worldwide, they often live in isolated populations that number up to a few hundred individuals only. If such localised populations decline due to human impacts they can potentially die out, as numbers are not supplemented by animals from elsewhere. The Namibian population is unique within the Benguela ecosystem as it occurs close inshore, with their nearest neighbours being in central Angola.

Table 10: Cetacean species present in Namibian waters

Species name	Common name	Source
Mysticetes (baleen whales)		
Eubalaena australis	Southern right whale	Bianchi *et al.* 1999; Roux *et al.* 2001 ; Best 2007 ; Roux *et al.* 2010
Caperea marginata	Pygmy right whale	Bianchi *et al.* 1999; Best 2007 ; Leeney *et al.* in rev.
Balaenoptera edenii	Bryde's whale	Best 2007; NDP
Balaenoptera bonaerensis	Antarctic minke whale	Best 2007

[44] *Notes: The endemic Benguela Dolphin* Cephalorhynchus heavisidii *(left) (Photo: De Beers Marine Namibia), and Southern Right whale* Eubalaena australis *(right) (Photo: www.divephotoguide.com; www.aad.gov.au.*

Balaenoptera acutorostrata subsp.	Dwarf minke whale	Bianchi *et al.* 1999; Best 2007
Megaptera novaeangliae	Humpback whale	Bianchi *et al.* 1999; Best 2007; Barendse *et al.* 2011
Balaenoptera physalus	Fin whale	Bianchi *et al.* 1999; Best 2007
Balaenoptera musculus	Blue whale	Bianchi *et al.* 1999; Best 2007
Balaenoptera borealis	Sei whale	Best 2007
Odontocetes (toothed whales)		
Physeter macrocephalus	Sperm whale	Bianchi *et al.* 1999; Best 2007
Kogia sima	Dwarf sperm whale	Findlay *et al.* 1992; NDP
Kogia breviceps	Pygmy sperm whale	Ross 1984; Findlay *et al.* 1992; NDP
Globicephala melas & Globicephala macrorhynchus	Long-finned pilot whale & short-finned pilot whale	Findlay *et al.* 1992; Bianchi *et al.* 1999; Best 2007; NDP
Cephalorhynchus heavisidii	Heaviside's dolphin	Bianchi *et al.* 1999; Best 2007; Elwen & Leeney 2008
Tursiops truncatus	Bottlenose dolphin	Bianchi *et al.* 1999; Best 2007; Elwen & Leeney 2008
Delphinus delphis	Short-beaked common dolphin	Findlay *et al.* 1992; Best 2007
Pseudorca crassidens	False killer whale	Findlay *et al.* 1992; Best 2007; NDP
Lagenorhynchus obscurus	Dusky dolphin	Findlay *et al.* 1992; Bianchi *et al.* 1999 ; Best 2007
Feresa attenuata	Pygmy killer whale	Findlay *et al.* 1992; Best 2007
Lissodelphis peronii	Southern right whale dolphin	Rose & Payne 1991; Findlay *et al.* 1992; Bianchi *et al.* 1999; Best 2007
Grampus griseus	Risso's dolphin	Findlay *et al.* 1992
Orcinus orca	Killer whale/ orca	Bianchi *et al.* 1999; Findlay *et al.* 1992
Ziphius cavirostris	Cuvier's beaked whale	Findlay *et al.* 1992; Best 2007
Hyperoodon planifrons	Southern bottlenose whale	Best 2007
Mesoplodon europaeus	Gervais' beaked whale	Griffin & Coetzee 2005; Best 2007
Mesoplodon grayi	Gray's beaked whale	Findlay *et al.* 1992; Best 2007
Mesoplodon layardii	Layard's beaked whale (/strap-toothed whale)	Findlay *et al.* 1992; Griffin 1998; Best 2007
Mesoplodon densirostris	Blainville's beaked whale	Best 2007

Note: NDP refers to information collected and held, if not published, by the Namibian Dolphin Project, in reports or in strandings database.

The dusky dolphin (*Lagenorhynchus obscurus*) is considered a pelagic species and often sighted by fishermen working in deeper waters. However, it is an occasional visitor to Walvis Bay, where they may beach (e.g. Elwen *et al.* 2011). Southern right-whale dolphins (*Lissodelphis peronii*) have an extremely localised year-round distribution associated with the continental shelf and the shelf-edge in the region between 24° and 28°S. A further 11 species are resident within the offshore area of the Namibian coastline in water depths of over 500m. Killer whales (*Orcinus orca*) are found throughout Namibian waters and likely range along the entire coastline (Elwen & Leeney, 2011). Pilot whales (*Globicephala* spp.) are commonly sighted by fishermen in considerable numbers, and have also frequently been observed during offshore seismic surveys.

Of the southern hemisphere migratory whale species, blue whales (*Balaenoptera musculus*), fin whales (*B. physalus*), sei whales (*B. borealis*), minke whales (*B. acutorostrata*), Bryde's whale (*B. edeni*) and humpback whales (*Megaptera novaeangliae*) (Figure 68, right), and two species of balaenid whale, the southern right whale (*Eubalaena australis*) and the pygmy right whale (*Caperea marginata*) have been recorded in Namibian waters, primarily off the continental shelf during winter months. Humpback whales commonly have a summer distribution in polar waters (feeding grounds) and a winter distribution lower latitudes (breeding/calving grounds), and these whales have become frequent visitors to Walvis Bay during the austral winter (June to August). Barendse *et al.* (2011) identified 35 individual humpback whales from photo-identification images taken in Walvis Bay, comparing these whales with catalogues of humpbacks from Angola, South Africa, Gabon and the Antarctic Humpback Whale Catalogue. No matches were found, however. Humpback whales off southern Africa were seriously depleted during the whaling era, but have since recovered well (Collins *et al.* 2008).

Southern right whales have also been documented in coastal waters (Roux *et al.* 2001; Leeney in prep) and are known to frequent Walvis Bay, particularly during the winter (June-September). The population was seriously depleted during the whaling era, but has recovered well and been increasing at 7% per year, with the African population estimated at approximately 4,600 animals in 2008 (Brandão *et al.* 2011). More frequent sightings of right whales off Namibia suggest that right whales are extending back into their old range, although most sightings within Namibia are still in the southern 400 km of the country (Roux *et al.* 2010). In recent years a number of the sheltered bays between Chameis Bay (27°56'S) and Conception Bay (23°55'S) have become popular calving sites for Southern Right whales (Roux *et al.,* 2010).

Minke whales are also commonly sighted in Namibian waters, but mostly in the Lüderitz area. Pygmy right whales have stranded on numerous occasions in Walvis Bay, both as live animals and as carcasses (Leeney *et al.* in rev), with the high proportion of juvenile animals in strandings records suggesting that a breeding ground or nursery area for this little-known, and possibly rare species may be located off the Namibian coast. Similarly, Pygmy right whales strand regularly along the Namibian coast, particularly in Walvis Bay. As the majority of strandings are juvenile individuals, there may likewise be a nursery ground offshore of the Walvis Bay area (Leeney *et al.* (in rev)). Stranding or skeletal records of southern bottlenose whales, rough toothed dolphin and Gervais' beaked whale have been recorded from the Namibian coast, although the level to which these may be extra-limital records is unknown. There are no data on the population status of these species off the southern African coast.

Of the migratory cetaceans, the blue, sei and fin whales are listed as "Endangered" and the Southern Right and Humpback whales as "Least Concern" in the International Union for Conservation of Nature (IUCN) Red Data book. All whales and dolphins are given absolute protection under the Namibian Law.

The Cape fur seal (*Arctocephalus pusillus pusillus*) (Figure 69) is common along the Namibian coastline, occurring at numerous breeding sites on the mainland and on nearshore islands and reefs. Currently the largest breeding site in Namibia is at Cape Cross north of Walvis Bay where about 51,000 pups are born annually (MFMR unpubl. Data). The colony supports an estimated 157,000 adults (Hampton, 2003), with unpublished data from Marine and Coastal Management (South Africa) suggesting a number of 187,000 (Mecenero *et al.,* 2006). A further colony of approximately 9,600 individuals exists on Hollamsbird Island south of Sandwich Harbour. The colony at Pelican Point is primarily a haul-out site. The mainland seal colonies present a focal point of carnivore and scavenger activity in the area, as jackals and hyena are drawn to this important food source.

Seals are highly mobile animals with a general foraging area covering the continental shelf up to 120 nautical miles offshore (Shaughnessy, 1979), with bulls ranging further out to sea than females. The timing of the annual breeding cycle is very regular occurring between November and January. Breeding success is highly dependent on the local abundance of food, territorial bulls and lactating females being most vulnerable to local fluctuations as they feed in the vicinity of the colonies prior to and after the pupping season (Oosthuizen, 1991). Namibian populations declined precipitously during the warm events of 1993/94 (Wickens, 1995), as a consequence of the impacts of these events on pelagic fish populations. Population estimates fluctuate widely between years in terms of pup production, particularly since the mid-1990s (MFMR unpubl. Data; Kirkman *et al.,* 2007).

There is a controlled annual quota, determined by government policy, for the harvesting of Cape fur seals on the Namibian coastline. The Total Allowable Catch (TAC) currently stands at 60,000 pups and 5,000 bulls, distributed among four licence holders. The seals are exploited mainly for their pelts (pups), blubber and genitalia (bulls). The pups are clubbed and the adults shot. These harvesting practices have raised concern among environmental and animal welfare organisations (Molloy & Reinikainen, 2003).

Figure 69: Cape Fur Seals[45]

[45] *Notes: Colony of Cape fur seals* Arctocephalus pusillus pusillus *(Photo: Dirk Heinrich).*

6 IDENTIFICATION OF POTENTIAL IMPACTS

This chapter aims to describe the potential social and environmental impacts associated with the proposed desalination plant activities and infrastructure that have been identified to date. The issues raised by I&APs were considered during the identification of the potential impacts to be assessed and any further issues raised will also be considered for investigation.

SLR and Aurecon used various sources to identify both the social and environmental issues (i.e. potential impacts) associated with the desalination plant and the terms of reference for specialist investigations. The main sources of information for the preparation of this Scoping Report include:

- Relevant information relating to the desalination plant, provided by Rössing Uranium and the appointed Engineers/contractors;
- Site visits by SLR and file investigations by their team of specialists;
- Consultation with the technical project team;
- Consultation with and input from various specialists;
- Review of relevant information from previous EIA Reports for the Mile 6 desalination plant and the existing Areva Desalination plant;
- Experience from previous seawater desalination SEIAs;
- Consultation with I&APs/stakeholders; and
- Consultation with relevant authorities.

The section below describes the activities and infrastructure associated with the construction; operations and closure phases of the proposed project and the associated potential social and environmental impacts on the environment.

6.1 Overview of specialist studies to be undertaken

Table 11 below outlines the specialist studies that will be undertaken during the SEIA Phase along with the specialist that will be undertaking the study:

Table 11: Specialist Studies to be undertake during SEIA Phase

SPECIALIST FIELD	SPECIALIST	DESCRIPTION
Avifauna	Mike and Ann Scott (African Conservation Services CC)	Identify and assess the potential impacts on local birdlife associated with the construction and operations of the proposed Rössing Uranium desalination plant and associated infrastructure (most notably a possible overhead powerline).
Heritage & Archaeology	Dr. John Kinahan (Quaternary Research Services)	This study will focus on the probable impacts of the proposed project on heritage and archaeological impacts within the footprint of the proposed project.
Marine ecology	Dr. Andrea Pulfrich (Pisces Environmental Services (Pty) Ltd)	Identify and assess the potential impacts to marine and coastal ecology associated with the construction and operation of the proposed Rössing Uranium desalination plant. The study will rely on the marine discharge and modelling study to be undertaken by WSP.
Marine pollution modelling	Christoph Soltau (WSP Group)	Assess the marine discharge options and undertake a hydrodynamic modelling exercise to determine the likely movement and dissipation of the discharge plume.

SPECIALIST FIELD	SPECIALIST	DESCRIPTION
Noise	Nicolette von Reiche (Airshed Planning Professionals)	Identify and assess the potential noise impacts associated with the construction and operation of the proposed Rössing Uranium desalination plant.
Socio-economic	Dr. Jonathan Barnes (Economic) (Design & Development Services cc) and Ms. Auriol Ashby (Social) (Ashby Associates CC)	Identify and assess the potential Socio-economic impacts associated with the construction and operation of the proposed Rössing Uranium desalination plant.
Visual	Stephen Stead (Visual Resource Management Africa)	Assess the potential visual impact caused by the proposed Rössing Uranium desalination plant.

SLR and Aurecon will co-ordinate specialist information and its interrogation, analysis and interpretation as reflected in the assessment documentation, i.e. Scoping Report and SEIA Report. The findings of the specialists studies will be integrated into the SEIA Report, allowing for overall assessment of the risk of the proposal.

To follow is a short description of the key social and environmental impacts that may arise as a result of the construction and operations of the proposed Rössing Uranium desalination plant at the Swakopmund Salt Works. These impacts, together with any other key issues identified through the public participation process will undergo detailed assessment in the SEIA phase.

6.2 Avifauna

6.2.1 Physical disturbance

Increased activity of people and vehicles in the area during the construction of both the desalination plant and associated infrastructure will result in disturbance of breeding, roosting and foraging birds.

In particular, the proposed site for the desalination plant coincides with a key breeding site for the Damara Tern. Some 10 to15 pairs regularly breed in this area at present (Boorman, pers. com.), and are likely to move away, possibly permanently, should disturbance increase. Damara Terns are increasingly under pressure in other parts of the coast, due to recreational disturbance and development (Braby 2011 and Braby, pers. comm.), and any further loss of breeding effort should be avoided.

Physical disturbance (due to noise) also has the potential to result in nest abandonment by cormorants and a consequent increase in the risk of predation (Borgmann, 2011).

6.2.1.1 Noise, vibration, movement and light disturbances

Noise levels will increase due to construction activities on site, and there is little relevant literature on the effects of this form of disturbance on African birds (Van Rooyen, 2009). High pressure pumps used during the operation of the plant will potentially produce noise and vibration, resulting in possible ongoing disturbance of nearby birdlife.

Species with the potential to be affected negatively by noise include breeding Damara Tern and breeding cormorants, especially the Cape Cormorant on the guano platforms. Other (non-breeding) species such as flamingos and the African (Black) Oystercatcher are likely to move away. The potential impacts of noise on coastal birds are reviewed comprehensively by Van

Rooyen (2009) and should be investigated in more detail with regard to the study area during the SEIA phase.

Lighting at night (particularly if unshielded) has the potential to disturb breeding birds and indirectly increase opportunities for predation which has the potential to impact negatively on all species but particularly on the breeding Damara Terns.

Underwater blasting

Whilst the need for underwater blasting is not anticipated as being required for this project, it can cause the disturbance, injury or death of marine bird species (Van Rooyen 2009). If underwater blasting is required, the potential impact significance to marine birds will be assessed.

Species likely to be affected by this impact are cormorants and the African Penguin, which forage by diving under water (Cooper, 1995 and Van Rooyen, 2009).

6.2.1.2 Habitat destruction/modification

The construction of the desalination plant will result in habitat destruction within the footprint. The habitat destruction of the Damara Tern breeding sites would be unacceptable, hence the importance of site selection.

Changes to the existing surface water structures in the area (e.g. the use of buffer ponds next to the desalination plant) may also impact on local faunal residents and migrants. Birds may move away from these areas during construction/implementation, but if the habitat is suitable they could also move back afterwards. These impacts are considered of less importance, given that the salt pan habitat has already been modified and a variety of other habitats are nearby.

Minor habitat destruction may occur with the construction (trenching and backfilling) of the powerline cable in the section between the plant to the C34 road, but from then on the line will run along an existing, already disturbed servitude. The pipeline construction will also have a limited impact on terrestrial species (e.g. Gray's Lark, Red-capped Lark) in the area during construction.

Brine discharge could impact on feeding marine birds, including oystercatchers and other coastal waders, cormorants and penguins, as the salinity is around 1.7 to1.85 times that of normal sea water and may result in habitat modification of bird prey organisms.

The effects of brine discharge on birds, or (indirectly) on their prey, is not considered a key issue as the seawater area affected by the brine is limited (Van Rooyen 2009). However, this aspect should be revisited once the relevant specialist report becomes available. Should drying ponds be created to treat sludge and filter backwash before being taken to the landfill, the use of the ponds by bird species would need to be monitored for possible negative impacts.

6.2.2 Interactions with powerline structures

6.2.2.1 Collisions

A bird collision occurs when a bird in mid-flight does not see the overhead cables until it is too late to take evasive action. These impacts could take place on any parts of the line, but are more likely in sections where the powerline crosses flight corridors such as drainage lines. Collisions may also take place on stay wires (e.g. on poles at bend points).

Bird species in the study area at risk from powerline collisions include Greater Flamingo, Lesser Flamingo, Black-necked Grebe and Great White Pelican.

6.2.2.2 Electrocutions

A bird electrocution occurs when a bird is perched or attempts to perch on an electrical structure and causes an electrical short circuit by physically bridging the air gap between live components and/or live and earthed components. Electrocutions of waterbirds and raptors may take place on poles, transformers and substation structures, and the risk is increased if birds are attracted to an open source of water nearby for bathing.

Bird species in the study area at risk from powerline electrocutions include raptors such as Peregrine Falcon, African Fish-eagle and Lappet-faced Vulture. The likelihood of electrocution is however considered to be very low.

6.2.2.3 Potential to disrupt power supply by nesting activities

Some birds, e.g. Pied Crow, have the potential to disrupt the power supply through their nesting activities. Crows may incorporate pieces of wire into their nesting material, which could result in short circuits. The potential of this impact is considered minimal in the study area.

6.3 Heritage

The proposed desalination plant may affect important evidence of shoreline processes associated with gross sea level fluctuations on the Namib coast. It is likely however that the disturbance of the area through previous industrial activities would already have compromised such evidence. Evidence relating to sea level fluctuations is well represented elsewhere on the Namib coast. It is unlikely that significant archaeological evidence of precolonial occupation will be found at the site, mainly due to the absence of fresh water in the immediate area. More recent evidence of historical activity including both salt mining and possible shipwrecks may well occur at the site. It would be important to establish whether evidence of salt mining exists from more than fifty years ago (i.e. within the purview of the National Heritage). Similarly, evidence of shipwrecks of this age if they occur in the area to be affected by the project, would need to be evaluated during the impact assessment phase.

Possible impacts to be addressed during the impact assessment phase will include:

- Significant evidence related to late Pleistocene sea level high stands;
- Below present surface evidence of human occupation on the margins of the presumed paleo-lagoon feature; and
- Historical remains of salt-mining activity.

6.4 Marine pollution and ecology

6.4.1 Construction Phase

The potential impacts associated with the construction of feed water intake and brine discharge structures into the marine environment are related to:

- Onshore construction (human activity, air, noise and vibration pollution, dust, blasting and piling driving, disturbance of coastal flora and fauna) (to be dealt with by others); and

- Construction and installation of pipeline intakes and discharge (construction site, pipe lay-down areas, and trenching in the marine environment, vehicular traffic on the beach and consequent disturbance of intertidal and subtidal biota).

The desalination plant including the pump station will be constructed a set-back distance from the existing shoreline. Consequently, issues associated with the location of the plant and pump station, and the associated pipelines leading to and from these constructions are not deemed to be of relevance to the marine environment, and will be dealt with by other specialist studies. However, infrastructure extending into the sea will potentially impact on intertidal and shallow subtidal biota during the construction phase in the following ways:

- Temporary loss of benthic habitat and associated communities due to preparation of seabed for buried pipeline laying and associated activities (e.g. jetties);
- Temporary loss of supratidal habitat as a result of vehicular traffic and earth moving equipment on the shore, and associated spoils dumping, backfilling and stockpiling activities;
- Possible temporary short-term impacts on habitat health due to turbidity generated during construction;
- Temporary disturbance of marine biota, particularly marine mammals and turtles, due to construction activities (blasting and piling driving, breakwater construction);
- Interruption of longshore sediment movement by sheet piling and jetty structure resulting in increased erosion and/or accretion around the construction site (to be informed by the Coastal Dynamics Specialist Study);
- Possible impacts to marine water quality and sediments through hydrocarbon pollution by marine construction infrastructure and plant; and
- Potential contamination of marine waters and sediments by inappropriate disposal of spoil and/or surplus rock from construction activities, trenching and backfilling, used lubricating oils from marine machinery maintenance and human wastes, which could in turn lead to impacts upon marine flora, fauna and habitat.

6.4.2 Commissioning Phase

Once construction has been completed, it will take about 3 months to commission the new desalination plant. During the commissioning phase, seawater will be pumped into the plant at up to peak production rates. However, any fresh water produced will be combined with the brine and discharged. As the discharge will have a salinity equivalent to that of normal seawater, it will not have an environmental impact during the commissioning phase.

It may be necessary to discard the membrane storage solution and rinse the membranes before plant start-up. If the storage solution contains a biocide or other chemicals which may be harmful to marine life and this solution is discharged to the sea, local biota and water quality may be affected.

6.4.3 Operational Phase

The key issues and major potential impacts are mostly associated with the operational phase. The key issues related to the presence of pipeline infrastructure and brine discharges into the marine environment are:

- Altered flows at the intake and discharge resulting in ecological impacts (e.g. entrainment and impingement of biota at the intake, flow distortion/changes at the discharge, and effects on natural sediment dynamics);

- Potential for habitat health impacts/losses resulting from elevated salinity in the vicinity of the brine discharge;
- The effect of the discharged effluent potentially having a higher temperature than the receiving environment;
- Biocidal action of residual chlorine in the effluent;
- The effects of co-discharged constituents in the waste-water;
- The abstraction of large volumes of feed water resulting in the removal of particulate matter from the water column where it is a significant food source, as well as changes in phytoplankton production due to changes in nutrients, reduction in light, water column structure and mixing processes; and
- Direct changes in dissolved oxygen content due to the difference between the ambient dissolved oxygen concentrations and those in the discharged effluent, and indirect changes in dissolved oxygen content of the water column and sediments due to changes in phytoplankton production as a result of nutrient input.

Additional engineering design considerations, not strictly constituting issues to be considered within this marine specialist study, include the following:

- Structural integrity of the intake and outfall pipelines or the breakwater (e.g. related to shoreline movement);
- Potential re-circulation of brine effluent;
- Pipeline maintenance and replacement requirements;
- Suitable disposal of solid waste, i.e. filter backwash, and sludge from pretreatment processes; and
- Water quality of feed-waters that should include consideration of possible deteriorating water quality (particularly algal blooms, sediments that may be stirred up during storms, or large-scale hypoxia or sulphur eruptions in bottom waters), that may require specific mitigation measures or planned flexibility in the operations of the desalination plant.

Mitigation measures and monitoring requirements as part of the commissioning and operational phases of the desalination plant will be developed as part of the SEIA, and will be included in the Environmental Management Programme compiled for the plant.

6.4.4 Decommissioning Phase

The minimum anticipated life of the desalination plant is approximately 10 years. The individual RO modules will be replaced as and when required during this period. No decommissioning procedures or restoration plans have been compiled at this stage. Being a modular plant, decommissioning should not involve extensive demolition of the plant area. In the case of decommissioning the pipeline will most likely be left in place. The potential impacts during the decommissioning phase are thus expected to be minimal in comparison to those occurring during the operational phase, and no key issues related to the marine environment are identified at this stage, since cessation in the operation of the plant will result in an immediate discontinuation of the majority of the identified marine impacts. As full decommissioning will require a separate EIA, potential issues related to this phase will not be dealt with further in this report.

6.5 Noise

Sound is defined as any pressure variation that can be detected by the human ear. The number of pressure variations per second is referred to as the frequency of sound and is measured in hertz (Hz). The hearing of a young, healthy person ranges between 20Hz and 20,000Hz.

In terms of sound pressure level, audible sound ranges from the threshold of hearing at 0dB to the pain threshold of 130dB and above. Even though an increase in sound pressure level of 6dB represents a doubling in sound pressure, an increase of 8 to 10dB is required before the sound subjectively appears to be significantly louder. Similarly, the smallest perceptible change is about 1dB (www.bksv.com, 2000).

Many factors affect the propagation of noise from source to receiver. The most important of these are:

- The type of source and its sound power;
- The distance between the source and the receiver;
- The extent of atmospheric absorption (attenuation);
- Wind speed and direction;
- Temperature and temperature gradient;
- Obstacles such as barriers or buildings between the source and receiver;
- Ground absorption;
- Reflections;
- Humidity; and
- Precipitation.

To arrive at a representative result from either measurement or calculation, all these factors must be taken into account (Brüel & Kjær Sound & Vibration Measurement A/S, 2000).

SANS 10103 (2008) provides a useful guideline for estimating community response to an increase in the general ambient noise level caused by intruding noise. The increase in noise level can be expected to result in the following response:

- Less than 0 dB: There will be no community reaction;
- Between 0 dB and 10 dB: There will be “little” reaction with “sporadic complaints”;
- Between 5 dB and 15 dB: There will be a “medium” reaction with “widespread complaints”. An increase of 10 dB is subjectively perceived as a doubling in the loudness of the noise;
- Between 10 dB and 20 dB: There will be a “strong” reaction with “threats of community action”; and
- Above 15 dB: There will be a ‘very strong’ reaction with “vigorous community action”.

The categories of community response overlap because the response of a community does not occur as a stepwise function, but rather as a gradual change. The following noise impacts are anticipated and will be assessed in the SEIA phase.

- Construction phase:
  - General construction (small plant), earthworks and associated equipment,
  - Construction traffic, and
  - Marine blasting and pile driving (if required);
- Operations phase:
  - High pressure pumps, energy recovery systems, air compressors,
  - Traffic (expected to be minimal).

The determination of the noise baseline noise will require further assessment and should be addressed during the impact assessment phase; a 24-hour road traffic noise profile for the C34 should be determined since it presents a major source of noise in the local study area[46]. To include this in the impact assessment the following is required:

- Diurnal hourly traffic profile (i.e. vehicles per hour),
- The average speed of vehicles, and
- The percentage heavy vehicles.

The key, potentially sensitive noise receptors in proximity to the proposed project that will be assessed, include:

- Employees of the Swakopmund Salt Works. The Swakopmund Salt Works plant area is situated within 1 km south of the proposed site for the desalination plant.
- Residents of the northernmost suburbs of Swakopmund. The nearest residences of Swakopmund lie approximately 3.8 km south-southeast of the proposed site for the desalination plant.
- Holiday makers at the Mile 4 Caravan Park. The Mile 4 Caravan Park lies approximately 3.6 km south of the proposed site for the desalination plant.
- Correction Services residence ~1km to the north-northeast of the desalination plant.

If noise pollution is likely to pose a significant impact, the noise specialist will make recommendations for buffering and acoustic dampening, where appropriate, for inclusion into the SEMP.

6.6 Socio-economic

The proposed desalination plant is needed to ensure survival of the Rössing Uranium mine, while uranium prices remain low and in the absence of a long-term realistic pricing agreement for water from Areva's desalination plant. No major socio-economic impacts have been identified which may be considered a fatal flaw to the proposal. Potential socio-economic impacts that may arise from the construction and operations of the proposed Rössing Uranium desalination plant are discussed hereunder.

6.6.1 Positive impacts

Additional water source, with non-government funding, for a growing coastal economy and population.

At present, the two sources of water available for mining, industrial and domestic use are the Omdel aquifer and Areva's desalination plant. Water is relatively inexpensive (approximately N$7/m^3 to the poorest consumers) compared to between N$45 to N$90/m^3 for Areva's water and Rössing Uranium estimates it can produce desalinated water at about N$22/m^3. Only the mines pay for desalinated water at present as the Omdel aquifer can supply all the municipalities' needs.

In future, water demand will rise because:

[46] SANS 10210 (2008), 'Calculating and predicting road traffic noise' will be used to determine the impact area of current traffic on the C34.

- the Husab mine is scheduled to come into operation in Q4 2015, requiring 8Mm^3 per annum
- the growth of Swakopmund is likely to continue (growth rate of 5.3% from 2001 to 2011)
- If the uranium price rises then other mines may increase or come into production – Rössing Uranium, Langer Heinrich Uranium, Bannerman, Areva, Valencia, Reptile[47]

In response, NamWater has planned to develop a desalination plant at Mile 6 (approximately 10km north of Swakopmund) but the outcome, timelines and commercial aspects of that project remain uncertain.

The Rössing Uranium plant is very small by comparison to the existing Areva plant but it could favourably delay NamWater of having to raise funds to build a desalination plant in the medium term. Although costs invariably escalate with time, new technological advances may be beneficial.

Rössing Uranium's water will "free up" water from Omdel and Areva for other domestic and industrial users near the coast.

Price of water

How the proposed project might impact on the price of water to other users' needs to be assessed in the SEIA, as well as job creation during construction and operations of the desalination plant. It is estimated that the Rössing desalination plant will provide between 12 and 18 permanent job opportunities during the operations phase.

6.6.2 Potential Negative Socio-economic Impacts

Traffic and Road Safety

During construction, traffic volumes on the C34 between Swakopmund and the desalination plant are likely to increase with the transport of construction workers, construction material and equipment to site.

Impact on tourism to the salt pans and fishing from the beach

The proposed site at Swakopmund Salt Works is a popular bird-watching site for local residents and tourists. It is not known to what extent the ponds will be affected. Once construction is complete the additional buildings and infrastructure are not likely to impact significantly on the bird feeding areas. Continuing open access for beach fishermen and the popular bird-watching view points at the Swakopmund Salt Works and the Rössing Uranium desalination plant should avoid this impact.

[47] *Source: (SAIEA.,. 2010.). Strategic Environmental Assessment for the central Namib Uranium Rush. The Ministry of Mines and Energy, Namibia.*

Reduction of house prices at Mile 4

In our view, it is unlikely that this project will cause any economic impact on home owners or developers at Mile 4. The additional infrastructure and operations of the project, on a site where industrial activity has been taking place for a long time, should not affect house prices.

6.7 Visual

The regional landscape character was assessed, the site surveyed and Key Observation Points (KOPs) defined. Preliminary findings regarding the visibility were that the C34 and the northern Swakopmund residential areas as well as birders visiting the pans would be exposed to views of the proposed project.

Views from Swakopmund residents are mainly restricted to those located to the outer north-eastern extents of the town, and would have moderate to low exposure views of the proposed plant and substation, but high exposure views of the proposed transmission line. Due to the existing structures visible in the landscape it is likely that their sensitivities to landscape modification would be moderate to low.

The C34 is a salt road which links the towns of Swakopmund with the small fishing and tourist town of Henties Bay. The road follows the coastline northwards and in certain areas, the contrasting views of Atlantic Ocean to the west and flat desert landscapes to the east create higher levels of scenic quality which add to the experience of the Namibian coastline sense of place. This route is utilised for tourism activities which radiate out from Swakopmund and as such it is likely that tourist receptors utilising the road would have higher sensitivities to landscape change, but seen with medium exposure.

It is also important to note that the area is an important birding destination due to birdlife being attracted to the large evaporation pans required to obtain the salt which is pumped from the Atlantic Ocean via a small jetty. It is likely that tourist receptors participating in birding activities at the pans would have high exposure and higher sensitivities to landscape change.

Within the landscapes, there exists a president for suitable and unsuitable colour utilisation for the structures. The older Salt Works structures are painted a yellow colour and the governmental building is a bright green colour, both which generate higher levels of colour contrast and should not be considered. The more recent warehouse is a light grey-brown which significantly reduces the colour contrast. In order to tie the proposed structures into the existing built landscape context as efficiently as possible, it is recommended that the colour and architectural style of the existing Salt Works warehouse be considered as suitable examples in the detail design for the plant and substation structures. Care to minimise excessive light spillage from night time security and operational lighting needs to be considered in the planning.

6.8 Other impacts and aspects

The impacts identified above and for which specialist investigations will be undertaken are not an exhaustive list of potential impacts associated with the project, but rather those that are deemed to be potentially significant and key in informing a decision on the acceptability of the project. There are a number of lower significance, transient or generic impacts that can be readily mitigated, including, *inter alia,* the following:

- Air quality impacts (most notably dust generation during the construction phase);

- Groundwater quality, as a result of construction and operation phase activities and pollution events;
- Hydrological impacts, including concentration and deviation of natural stormwater paths leading to erosion and sedimentation;
- Pollution prevention and waste management;
- Soil impacts including compaction and erosion; and
- Terrestrial ecology impacts, including loss of plants and habitat area.

It is unlikely that these impacts will be assessed as significant within the context of this project. However; best practice in environmental management encourages and responsible and holistic approach to impact management. As such these second tier impacts (which are unlikely to inform a decision of acceptability) will be considered during SEIA and more importantly during the compilation of the SEMP, where appropriate mitigations and management interventions will be proposed to ensure that these social and environmental aspects are responsibly managed throughout the project lifecycle.

6.9 Social and Environmental Management Plan

Based on the findings of the SEIA Report, a social and environmental management plan (SEMP) will be compiled which incorporates the recommended mitigation measures to ensure optimal environmental protection is achieved during the construction and operational phases of the proposed project. The SEIA Report together with the SEMP will be submitted to the MET:DEA for consideration and decision making. The SEMP aims to bridge the gap between the SEIA phase of the project and the implementation of the project. As such, the SEMP will be provided to the contractor / proponent to implement during the construction phase. The SEMP will also outline all monitoring requirements to ensure that all aspects of the proposed project comply with the agreed environmental management objectives. The SEMP will include specific mitigation measures aimed at managing the key environmental impacts but will also include mitigations and management measures aimed at managing a variety of generic construction phase social and environmental aspects. The SEMP will set out a management framework and assign responsibility for the various interventions as a measure to ensure accountability and ensure effective implementation and compliance. The SEMP will also include penalty clauses to be triggered in the event that the contractor fails to implement the environmental requirements successfully or respond to environmental issues with due diligence. The following SEMP framework can be provided as a provisional outline for the scope of a SEMP:

- Construction phase:
  - Background and introduction:
    - Purpose and objectives of the SEMP;
    - Legal requirements; and
    - Definition of responsible parties.
  - Planning and design considerations from the SEIA:
  - Pre-construction requirements:
    - Environmental control and supervision;
    - Site establishment;
    - Environmental awareness training; and
    - Employee eating, recess areas and other amenities.
  - Construction materials:
    - Materials handling, use and storage;
    - Hazardous substances management; and
    - Spoiling of excess material.

  - Land-based construction matters:
    - Public safety and community relations;
    - Emergency procedures;
    - Protection of natural features;
    - Protection of flora and fauna;
    - Protection of archaeological and paleontological remains;
    - Site clearance practices;
    - Topsoil stockpiling and management;
    - Access and haul roads;
    - Dust management and control;
    - Access to and driving on the beach and other sensitive areas;
    - Ablution facilities and sewage management;
    - Solid waste management;
    - Equipment use, maintenance and storage;
    - Fuel and oil management practices;
    - Noise and light pollution;
    - Cement and concrete batching;
    - Fire control;
    - Erosion protection, water quality and storm water control; and
    - Exiting and site rehabilitation.
  - Ocean-based construction matters:
    - Seaworthiness and construction staff competence;
    - Working times and conditions;
    - Archaeology;
    - Biodiversity; and
    - Pollution prevention and control.

- Operations phase:
  - Commissioning phase marine monitoring program:
    - Chemical monitoring and reporting requirements; and
    - Biological monitoring and reporting requirements.
  - Operations phase environmental management:
    - Organisational framework and environmental awareness;
    - Employment creation and skills development;
    - Plant operation and maintenance requirements / protocols; and
    - Conditions of authorisation and environmental compliance reporting.
    - Management framework:
      - Site access and security;
      - General plant maintenance;
      - Waste management, pollution, and management of chemicals;
      - Emergency prevention, planning, and response;
      - Maintenance of rehabilitated areas;
      - Protection of fauna and flora;
      - Visual impact management; and
      - Noise impact management.
  - Long-term marine monitoring program; and
  - Compliance reporting.

6.10 Proposed Programme

The following program is an indicative guideline of the proposed SEIA process, going forward, based on current timing. The suggested programme includes authority consultation as well. Please note that this may be subject to change.

- Phase 1: Project initiation/application:
  - Internal screening (site visits / identify social and environmental issues) ~ **complete.**

- Phase 2: Scoping:
  - Notification to IAPs ~ **complete**;
  - Place advert (24 July and 31 July 2014) and sent out BIDs (24 July 2014) ~ **complete**;
  - Public meetings and focus group meetings ~ **complete**;
  - Public meeting (31 July 2014 – Swakopmund Hotel) ~ **complete**;
  - Focus group meetings (31 July to 4 August 2014) **~ complete**;
  - Specialist input for Scoping – completed on 19 August 2014 ~ **complete**;
  - Scoping Report (draft completed for internal review – 1 September 2014 ~**complete**; and
  - I&APs review of Scoping Report from 11 September 2014.

- Phase 3: SEIA:
  - Specialist investigations completed by – 16 October;
  - SEIA Report and SEMP – draft for internal review – 12 November 2014;
  - Comment period on SEIA documents – 26 November to 20 January 2014; and
  - Submit final Reports to the MET – 26 January 2014.

7 TERMS OF REFERENCE FOR SEIA

This chapter outlines the Terms of Reference and assessment methodology for the specialist investigations that will be undertaken during the SEIA phase.

The following Terms of Reference are common to all the specialist studies and a list of aspects unique to each study is provided under separate headings to follow:

Compile a specialist report including the following:

- Legal requirements and relevant national and or international standards relevant to the field of study.
- A description of the key social and environmental impact associated with the field of study for the planning, construction, operations and decommissioning phase of the project.
- Asses the study area and surrounding land uses with the aim of identifying and describing the potential cumulative impacts associated with the project and surrounding land uses.
- Undertake an assessment of the identified impacts using the standard assessment methodology, for the "no-go" alternative, the preferred and any other feasible alternative presented by the proponent in the impact phase project description.
- Identify and assess potential cumulative impacts associated with the project, taking into consideration of surrounding landuses, activities and existing pressures on the socioeconomic and biophysical environment. Refer to 7.8, for a description of cumulative considerations stemming from the Central Namib Uranium Rush Strategic Environmental Assessment;
- Identify and propose reasonable mitigation measures and management interventions (Including social and environmental monitoring) for inclusion into the SEMP.
- Undertake an assessment of the identified impacts, assuming that proposed mitigation measures are implemented to determine a "residual" impact significance rating.

In addition to the general terms of reference provide above, the following additional tasks or investigations will be undertaken by the respective specialists.

7.1 Avifauna study

The specialist will also consider the following gaps or aspects in greater detail:

- Investigate the potential impacts of noise and light pollution on birds (especially breeding species such as Damara Tern and Cape Cormorant), and incorporate the findings of the noise specialist study;
- Further consult with local birders, the owner of Swakopmund Salt Works and any other relevant reports for the area;
- Incorporate the findings of the specialist studies in terms of the potential impacts of brine discharge on feeding marine birds;
- Address any further aspects arising from the public participation process; and
- Identify spatial constraints and limitations.

7.2 Heritage study

The specialist will also consider the following gaps or aspects in greater detail:

- Conducting a detailed investigation to identify all archaeological, cultural, and historic sites in the area; and
- Document (GPS coordinates and map) all sites, objects and structures identified within the vicinity of the project site.

7.3 Marine Ecology Study

In addition to the general specialist's Terms of Reference provided previously, the specialist will also consider the issues detailed in Section 6.4 as part of the Terms of Reference. The Marine ecologist will need to consider the findings of the hydrodynamic modelling and coastal dynamics study in order to determine potential impact significance ratings.

7.4 Wastewater discharge modelling and coastal dynamics

Note that assessment of impact significances will be largely undertaken in the marine ecology specialist's investigation and that this study serves mainly to support the marine ecologist's study.

In addition to the common Terms of Reference provided above, the specialist will also consider the following gaps or aspects in greater detail:

- The study will assess the potential impacts of the brine discharge infrastructure on the coastal dynamics, including both the impact of temporary facilities (such as excavations or berms) required to construct the permanent infrastructure, as well as the permanent infrastructure itself;
- The physical coastal dynamics that could potentially be impacted by the temporary and permanent infrastructure are likely to be the local wave regime and currents; and
- The physical coastal processes that could potentially be impacted at the site, or along the adjacent coastline, are likely to be the natural sediment transport patterns, leading to erosion or accretion of the beach on a short or long-term basis.

7.5 Noise study

The specialist will also consider the following gaps or aspects in greater detail:

- Cumulative day- and night-time noise levels to be assessed against IFC guidelines;
- The increase in day- and night-time noise levels above the baseline will be assessed against the IFC criteria and the South African Bureau of Standards' estimation of community reaction.
- The proposed desalination plant has the potential to generate noise pollution with the key sources needing to be identified, investigated and modelled further in the impact assessment phase. The sources may include:
  - Construction phase:
    - General construction (small plant), earthworks and associated equipment,
    - Construction traffic, and
    - Marine blasting and pile driving (if needed);
  - Operations phase:
    - High pressure pumps, energy recovery systems, air compressors,
    - Traffic (expected to be minimal).

The determination of the noise baseline noise will require further assessment and should be addressed during the impact assessment phase; a 24-hour road traffic noise profile for the C34 should be determined since it presents a major source of noise in the local study area[48]. To include this in the impact assessment the following is required:

- Diurnal hourly traffic profile (i.e. vehicles per hour),
- The average speed of vehicles, and
- The percentage heavy vehicles.

7.6 Socio-economic study

In addition to the common Terms of Reference provide above, the specialist will also consider the following gaps or aspects in greater detail:

- The under-utilised capacity of the Areva desalination plant;
- NamWater's ability to provide water to users when a considerable proportion of the total supply rests in the hands of private producers;
- NamWater's plans to build a desalination plant; and
- The likely future cost and pricing of water (and electricity) for other industrial and domestic users.

7.7 Visual Study

The specialist will also consider the following gaps or aspects in greater detail:

- To ensure that excessive visual intrusion does not take place to tourist related landscapes identified, the following locations should be utilised to assess the impacts to the site, regional and cumulative visual impacts associated with the proposed landscape modification:
  - KOP1 – C34 southbound views towards the proposed transmission line road crossing;
  - KOP2 – C34 southbound views to the proposed plant and substation;
  - KOP3 - C34 northbound views towards the proposed plant and substation; and
  - KOP4 – Swakopmund residential views towards the proposed transmission line.

7.8 Considering Cumulative Impacts in Erongo

Cumulative impacts are difficult to deal with on a project SEIA level, since they may occur outside of the geographical area of the particular project being assessed and thus require the collaboration of other institutions, and involve broader social, economic and biophysical considerations outside the scope of the specific project-level assessment. The fact that several other mining companies have been pursuing uranium interests in the Erongo Region emphasized the need for a holistic approach, by means of a strategic or sectoral level assessment. Such a Strategic Environmental Assessment (SEA) of the so-called "Central Namib Uranium Rush" (Uranium Rush) was recently undertaken by the South African Institute

[48] *SANS 10210 (2008), 'Calculating and predicting road traffic noise' will be used to determine the impact area of current traffic on the C34.*

for Environmental Assessment, commissioned by the Ministry of Mines and Energy of the Government of Namibia. This section provides a summary of the SEA sections applicable to cumulative impacts.

The SEA (SAIEA, 2010) provides a bird's eye view of cumulative environmental impacts in the Erongo region brought about as a result of the Uranium Rush (and other directly linked developments, and potential developments, such as desalination and chemical plants), and advises on how to avoid negative cumulative impacts and to enhance opportunities for positive impacts, within the uranium sector and between mining and other industries. It should be noted that for some aspects the available environment data was lacking, such as for biodiversity, and that attaining a level of comprehensive data would be an undertaking of many years. To wait for such a time before development could continue would be unreasonable, and the SEA therefore proceeded with information at hand. The SEA found that the cumulative impacts resulting from the Uranium Rush are not limited to the Erongo region, but are wide-ranging, affecting the southern African region as a whole, particularly the Namibian and South African economies.

As far as Rössing Uranium's proposed desalination plant is concerned, a number of impacts that are expected to emerge as having cumulative social and environmental implications on the receiving environment must be considered in the SEIA, and recommendations provided regarding their management. The recommendations provided below are applicable to the cumulative situation, i.e. to the Uranium Rush industries as a whole, and not specifically to Rössing Uranium. Hence only those recommendations specific to Rössing Uranium desalination plant will be investigated carried forward to the SEMP where relevant. Although specific references to the SEA were made under the impact discussions above, this summary is provided for ease of reference.

1. **IMPACTS ON TOWNS** ~ Impacts on four areas of the receiving environment of towns (including amongst others Arandis, Swakopmund and Walvis Bay) should be considered, namely the town's sense of place, incidents of crime, issues around property availability and effects on prices, and waste management (domestic, special and hazardous).
2. **MACRO ECONOMIC ENVIRONMENT ~** The focus under this section is the potential economic benefits that Namibia could derive from the Uranium Rush on its Gross Domestic Product (GDP), potential income to government, national employment effects, salaries and wages, and income distribution, including issues pertaining to mining industry rehabilitation funds.
3. **EDUCATION AND SKILLS ~** The Uranium Rush industries and developments are expected to result in a number of impacts on education and skills in the Erongo region and nationally. The primary issues, the cumulative impacts of which could be positive or negative, are an increased demand for skilled human resources, access to education for school-aged children and the quality of education.
4. **COMMUNITY HEALTH ~** Large-scale mining and associated activities always have health consequences, positive and negative, for workers and the community. Negative health impacts on workers are most commonly accidents, dust-related lung disease and metal toxicity, and positive impacts are related to better economic prospects but sometimes this comes with a separation from family. Negative health impacts on the public include new diseases and social problems carried by the influx of population but again, balanced against this, is the increased prosperity and health care brought by the mining industry.
5. **IMPACTS ON ROAD, RAIL, PORT AND AVIATION INFRASTRUCTURE ~** The ideal condition of transport infrastructure would be an adequate and well maintained state to

encourage economic development, public access and safety, without compromising biodiversity functioning.

6. **IMPACTS ON WATER SUPPLY, QUALITY AND BULK INFRASTRUCTURE ~** The preferable condition of environmental aspect:
    a. Supply: There should be an adequate and reliable supply of water at reasonable cost for all consumers.
    b. Bulk infrastructure: The water reticulation network should be optimally planned so as to minimise negative impacts.
    c. Quality: Water quality should not be compromised so as to cause it to be unusable for its current purposes.
7. **IMPACTS ON ENERGY SUPPLY AND BULK INFRASTRUCTURE ~** The preferable condition of environmental aspect should be:
    a. Supply: There should be an adequate and reliable supply of energy at reasonable cost for all consumers, when it is needed, and as far as possible without compromising the state of the environment. However, seen as part of this statement, demand side management should be effectively implemented to reduce pressure on grid electricity and alternative sources of energy should be promoted.
    b. Supply infrastructure: The electricity reticulation network and associated facilities such as substations should be optimally planned so as to minimise negative impacts.
8. **RECREATION AND TOURISM** ~ The tourism industry is of the utmost importance to the Namibian economy, providing over 18,000 direct jobs and earning NAD 1.6 million per annum revenue (3.7% of Gross Domestic Product). Tourism products offered in the central Namib include adventure, business, consumptive and eco-tourism. In line with MET's vision, "a mature, sustainable and responsible tourism industry that contributes significantly to the economic development of Namibia" is the ideal situation for the recreation and tourism industry. However, to achieve this, environmental conditions need to be conducive to such activities and an alluring, unique sense of place represents many other environmental aspects such as low noise levels, healthy and uncompromised biodiversity, and good services**.**
9. **BIODIVERSITY ~** The habitats in which plants and animals occur, the species which are most vulnerable due to endemicity or threatened status, the ecological processes which support life in the central Namib, and the areas of high biodiversity value, have been considered in terms of how these will be affected by the combined impacts expected from the Uranium Rush industries. Impacts on biodiversity will have a negative impact on tourism and recreation as well as a number of other significant secondary and tertiary impacts such as public health issues in the case of a predatory species controlling a disease vector such as mosquitoes. In developing, care should be taken that the ecological integrity and diversity of fauna and flora of the central Namib is not compromised by the Uranium Rush.
10. **ARCHAEOLOGICAL HERITAGE ~** The types of archaeological sites that are vulnerable to damage by mining activities include graves, rock shelters with evidence of occupation, scatters of stone artifacts, battlefields and historical mines. Archaeological heritage is differentiated into two types, i.e. sites and landscapes, the latter being a collection/group of related sites similar in particular characteristic(s) (generally referred to as sites in this section). The Erongo region has four National Monument sites (all rock art sites) but none affected by the Uranium Rush Scenario 2. Some sites are virtually invisible and therefore it is very difficult for mining activities to avoid damage if a specialist study is not undertaken and the sites identified. As a large part of the Erongo region is either currently under uranium exploration or mining licenses, or has renewals pending, detailed studies have been carried out for a large part of the area. These form

a good basis to identify archaeological landscapes that can be flagged as areas of differing archaeological significance (similar to tourism and biodiversity) where specific care would need to be taken in considering applications for mining activities. The preferable condition is for the Uranium Rush industries and all related activities, to have as little negative impact on archaeological resources as possible.

11. **AIR QUALITY ~** Cumulative impacts in relation to the existing air quality conditions in the central Namib with regards to dust, which includes the coarse particles called Total Suspended Particles (TSP), as well as the finer particles called PM 10. TSP is more nuisance-causing, while PM 10 particles are fine enough to be inhaled and potentially cause health problems. TSP and PM 10 were monitored at various receptor points in the Erongo region to monitor current levels. In general, TSP deposition through the Erongo region is slight, but PM 10 levels can be high, depending on meteorological conditions and human activities such as traffic movement. Particulate air concentrations in the Erongo region should not exceed the particulate threshold at which adverse health effects will be experienced. This threshold is the World Health Organisation's IT-3 guidelines for PM10, which correlates with the South African National Standards (SANS) that developed a limit based on conditions similar to the Namibian environment. Similarly, TSP levels (dust fallout) should not exceed the SANS limit for residential areas.
12. **INSTITUTIONS AND GOVERNANCE ~** Managing the Uranium Rush will be a considerable challenge for Namibian institutions, be they government, para-statal, regional and local authority, private sector or civil society. In combination with strong leadership, transparency and consistency in decision making will ensure that the Uranium Rush is a blessing and not a curse. The bottom line is governance.

7.9 Environmental Assessment Methodology

The following subsection comprises the methodology that will be adopted when assessing impacts in the SEIA phase, and the issues identified by the specialist components which need to be assessed in the SEIA. The overall outcome will be a robust and defendable process resulting in an SEIA Report, to achieve the following:

- Facilitate compliance with authority requirements, as well as the requirements of international best practice and international funding agencies;
- Inform the environmental authority's decision on the social and environmental acceptability of the proposed project; and
- Inform the proponent's understanding of the environmental implications of the project in question and highlight measures to ensure responsible development, including appropriate alternative technologies and mitigation measures.

The preferred, and any feasible alternative/s, will be taken through to the assessment phase for detailed study, to determine the associated impacts, and to look at ways to mitigate negative impacts and optimise positive impacts. The SEIA will be undertaken in terms of the standard accepted impact assessment methodology outlined below and will include the following components:

- An assessment of the full range of potential impacts identified during the Project Initiation and Scoping Phase[49], to include all impacts identified in the Terms of Reference for this study. This will include construction and operational impacts, as well as the decommissioning of old structures, and cumulative impacts. It will also address impacts both on and off site, as relevant (e.g. construction camps).
- Identification of potential mitigation measures to avoid negative impacts, or to reduce significance where avoidance is not possible.
- Release of an SEIA Report, with a section specific to each site (subject to acceptance of this approach by MET:DEA), for comment and eventual submission to the authorities, to include:
  - A detailed description of the process followed to date, with reference to the Baseline and Site Selection Reports, as well as the public process conducted as part of the current SEIA;
  - Supplementation of information contained in the previous Reports, as required;
  - Description of specialist findings and assessment ratings. The assessment will provide an evaluation of the positive and negative impacts both with and without the implementation of identified mitigation measures.
  - Recommendations regarding the full range of mitigation measures that could be used to ameliorate negative impacts and enhance positive impacts.
  - Detailed conclusions and recommendations. This section of the SEIA Report will integrate and summarise the key findings of the investigations (in both text and tabular formats), highlight the environmental implications associated with the various options, note cumulative and strategic impacts, assist the proponent in the determination of any preferred options and guide the proponent in the identification of the most appropriate mitigation measures.

Assessment of predicted significance of impacts for a proposed development is by its nature, inherently uncertain – social and environmental assessment is thus an imprecise science. To deal with such uncertainty in a comparable manner, standardised and internationally recognised methodology[50] has been developed. Such accepted methodology is applied in this study to assess the significance of the potential environmental impacts of the proposed development, outlined as follows:

Table 12: Assessment criteria for the evaluation of impacts

CRITERIA	CATEGORY	DESCRIPTION
Extent or spatial influence of impact	National	Greater than 100km of the impact site
	Regional	Within 100km of the impact site
	Local	On site or within 5km of the impact site
*Magnitude of impact (at the indicated	High	Social and/or natural functions and/ or processes are severely altered (i.e. function is severely hampered and processes are unlikely to function)
	Medium	Social and/or natural functions and/ or processes are notably altered (i.e. function is

[49] Based on specialist assessment, the scope of which is to be determined at the end of the Scoping Phase, in consultation with the project proponent and the lead project managers.

[50] As described, inter alia, in the South African Department of Environmental Affairs and Tourism's Integrated Environmental Management Information Series (Gov of SA, 2002).

spatial scale)		affected to a noticeable degree and processes struggle to function effectively)
	Low	Social and/or natural functions and/ or processes are slightly altered (i.e. while function is affected in a measurable way, processes are likely to function, albeit sub-optimally)
	Very Low	Social and/or natural functions and/ or processes are negligibly altered (i.e. function is slightly affected and processes are likely to function effectively)
	Zero	Social and/or natural functions and/ or processes remain unaltered
Duration of impact	Long Term	More than 5 years after construction
	Medium Term	Up to 5 years after construction
	Short term (construction period)	6 months

*NOTE: Where applicable, the magnitude of the impact has to be related to the relevant standard (threshold value specified and source referenced). The magnitude of impact is based on specialist knowledge of that particular field.

For each impact, the EXTENT (spatial scale), MAGNITUDE (size or degree scale) and DURATION (time scale) are described. These criteria are used to ascertain the SIGNIFICANCE of the impact, firstly in the case of no mitigation and then with the most effective mitigation measure(s) in place. The decision as to which combination of alternatives and mitigation measures to apply lies with Rössing Uranium as the proponent, and their acceptance and approval ultimately with the relevant environmental authority. The tables on the following pages show the scale used to assess these variables, and defines each of the rating categories.

The SIGNIFICANCE of an impact is derived by taking into account the temporal and spatial scales and magnitude. Such significance is also informed by the context of the impact, i.e. the character and identity of the receptor of the impact. The means of arriving at the different significance ratings is explained in the following table, developed by Ninham Shand (now part of Aurecon) in 1995 as a means of minimising subjectivity in such evaluations, i.e. to allow for replicability in the determination of significance.

Table 13: Definition of significance ratings

SIGNIFICANCE RATINGS	LEVEL OF CRITERIA REQUIRED
High	High magnitude with a regional extent and long term duration High magnitude with either a regional extent and medium term duration or a local extent and long term duration Medium magnitude with a regional extent and long term duration
Medium	High magnitude with a local extent and medium term duration High magnitude with a regional extent and construction period or a site specific extent and long term duration High magnitude with either a local extent and construction period duration or a site specific extent and medium term duration Medium magnitude with any combination of extent and duration except site specific and construction period or regional and long term Low magnitude with a regional extent and long term duration
Low	High magnitude with a site specific extent and construction period duration Medium magnitude with a site specific extent and construction period duration Low magnitude with any combination of extent and duration except site specific and construction period or regional and long term Very low magnitude with a regional extent and long term duration
Very low	Low magnitude with a site specific extent and construction period duration Very low magnitude with any combination of extent and duration except regional and long term
Neutral	Zero magnitude with any combination of extent and duration

Once the significance of an impact has been determined, the PROBABILITY of this impact occurring as well as the CONFIDENCE in the assessment of the impact has been determined using the rating systems outlined in the following two tables. It is important to note that the significance of an impact should always be considered in concert with the probability of that impact occurring.

Table 14: Definition of probability ratings

PROBABILITY RATINGS	CRITERIA
Definite	Estimated greater than 95% chance of the impact occurring.
Probable	Estimated 5 to 95% chance of the impact occurring.
Unlikely	Estimated less than 5% chance of the impact occurring.

Table 15: Definition of confidence ratings

CONFIDENCE RATINGS	CRITERIA
Certain	Wealth of information on and sound understanding of the environmental factors potentially influencing the impact.
Sure	Reasonable amount of useful information on and relatively sound understanding of the environmental factors potentially influencing the impact.
Unsure	Limited useful information on and understanding of the environmental factors potentially influencing this impact.

* The level of confidence in the prediction is based on specialist knowledge of that particular field and the reliability of data used to make the prediction.

Lastly, the REVERSIBILITY of the impact has been estimated using the rating system outlined in the following table.

Table 16: Definition of reversibility ratings

REVERSIBILITY RATINGS	CRITERIA
Irreversible	The activity will lead to an impact that is permanent.
Reversible	The impact is reversible, within a period of 5 years.

Despite attempts at providing a completely objective and impartial assessment of the environmental implications of development activities, environmental assessment processes can never escape the subjectivity inherent in attempting to define significance. The determination of the significance of an impact depends on both the context (spatial scale and temporal duration) and intensity of that impact. Since the rationalisation of context and intensity will ultimately be prejudiced by the observer, there can be no wholly objective measure by which to judge the components of significance, let alone how they are integrated into a single comparable measure.

This notwithstanding, in order to facilitate informed decision-making, SEIAs must endeavour to come to terms with the significance of the potential social and environmental impacts associated with particular development activities. Recognising this, Aurecon has attempted to address potential subjectivity in the current SEIA process as follows:

- Being explicit about the difficulty of being completely objective in the determination of significance, as outlined above.
- Developing an explicit methodology for assigning significance to impacts and outlining this methodology in detail. Having an explicit methodology not only forces the assessor to come to terms with the various facets contributing towards the determination of significance, thereby avoiding arbitrary assignment, but also provides the reader of the SEIA Report with a clear summary of how the assessor derived the assigned significance.

- Wherever possible, differentiating between the likely significance of potential environmental impacts as experienced by the various affected parties.
- Utilising a team approach and internal review of the assessment to facilitate a more rigorous and defendable system.

Although these measures may not totally eliminate subjectivity, they provide context within which to review the assessment of impacts.

Environmental Assessment Policy requires that, “as far as is practicable”, cumulative environmental impacts should be taken into account in all environmental assessment processes. SEIAs have traditionally, however, failed to come to terms with such impacts, largely as a result of the following considerations:

- Cumulative effects may be local, regional or global in scale and dealing with such impacts requires coordinated institutional arrangements; and
- Studies are typically carried out on specific developments, whereas cumulative impacts result from broader biophysical, social and economic considerations, which typically cannot be addressed at the project level.

8 PUBLIC PARTICIPATION

In terms of Section 21 of the EIA Regulations a call for open consultation with all interested and affected parties (I&APs) at defined stages of the EIA process are required. This entails participatory consultation with members of the public by providing an opportunity to comment on the proposed project. Public Participation has thus incorporated the requirements of Namibia's legislation, but also takes account of international guidelines, including SADC guidelines and the Namibian EIA Regulations. Public participation in this project has been undertaken to meet the specific requirements in accordance with the international best practice.

8.1 Initiation of the public participation process

The approach adopted for the initiation of the SEIA and associated public participation process (public participation process) was to identify and contact as many potential I&APs as possible through a number of activities which are listed in Table 17 below:

Table 17: Initiation of public participation process

DATE	DESCRIPTION
24 July – 5 August 2014	The existing Rössing Uranium I&AP database was updated prior to, and during, the project initiation phase (refer to Annexure C6)
9 July 2014	Site visit
17 July 2014	SLR and Ecoserve (Bird specialists) met with NACOMA to inform them about the proposed project and to discuss issues relating the Damara Tern breeding areas in the location of the Swakopmund Salt Works.
Early July 2014	A non-technical Background Information Document (Background Information Document) describing the project and SEIA process was compiled (refer to Annexure B1).
24 July & 1 August 2014	Rössing Uranium carried out an internal staff notification process regarding the project by issuing two different employee briefs (refer to Annexure B5).
24 July 2014	The Background Information Document was distributed electronically to all I&APs on the database. Hard copies of the Background Information Document were placed in the Swakopmund Library and the Uranium Institute (in Swakopmund).
24 July – 5 August 2014	Various key stakeholders were contacted telephonically during the course of the public participation process.
25 July 2014	Site notices were placed at the Seaside Hotel and Spar entrance at Mile 4 and on site (refer to Annexure B3).
24 and 31 July 2014 (National) 25 July and 1 August 2014 (Local)	Advertisements were placed in two (2) national newspapers (The Namibian and the Republikein) and one (1) local newspaper (Namib Times) (refer to Annexure B4). These advertisements were placed once a week for two consecutive weeks as per the regulatory requirement.
24 July – 5 August 2014	As part of the notification period all of the identified potential I&APs were invited to participate in the SEIA process via posting and/ or emailing their comments or filling in a comment sheet. I&APs were given 14 days within which to submit comment on the project. Comments received are included in a Comments and Response Report which is attached here as Annexure C9
July 2014	Various newspapers published articles on the project based on the contents of the Background Information Document and the media briefing/meeting.

8.2 Meetings

The following stakeholder engagement meetings were held during the initial I&AP notification period:

Table 18: Details of stakeholder engagement meetings

DATE	TIME	VENUE	DESCRIPTION
31 July 2014	8:00 AM	Rössing Uranium Corporate Office	Mineworkers' Union of Namibia (MUN)
31 July 2014	12:00 PM	Swakopmund Hotel & Entertainment Centre, Spitzkoppe Room	Media focus group
31 July 2014	15:00 PM	Swakopmund Hotel & Entertainment Centre, Spitzkoppe Room	Key stakeholder meeting. Representatives of the following were invited: • NamWater • Salt Works • Other mines • Regional Governor • Ministry of Fisheries and Marine Resources (MFMR) • Ministry of Environment and Tourism local office (MET) • Namibian Coast Conservation & Management Project (NACOMA) • Gecko Water • Swakop Matters • EarthLife • Swakopmund municipality • MWUG • Employees • BEC • Ministry Of Water Affairs and Forestry: Department of Water Affairs and Forestry (MAWF:DWAF) • Areva • Erongo desalination company
31 July 2014	18:00 PM	Swakopmund Hotel & Entertainment Centre, Spitzkoppe Room	Public meeting
7 August 2014	09:00 AM	Government Office Park, Ministry Of Water Affairs and Forestry	Meeting with representatives of the Ministry Of Water Affairs and Forestry (MAWF) Department of Water Environment
7 August 2014	11:00 AM	NamWater	Meeting with NamWater representatives
19 August	15:00 PM	Telephonic discussion	Ministry of Environment and Tourism: Department of Environmental Affairs (MET:DEA)

Similar project information was presented at all the meetings. A copy of the presentation is attached in Annexure B2. The minutes of these meetings are available for review in Annexure C.

8.3 Comment on the Draft Scoping Report

The second stage of the public participation process involves the review of the draft scoping report by registered I&APs. Registered I&APs were informed of the draft scoping report public comment period via an email dated 9 September 2014. A summary of the draft scoping report was also included in the email to the registered I&APs. I&APs will have until 7 October 2014 to submit comments or raise any issues or concerns they may have with regard to the proposed project or SEIA process.

In addition to the emailed Report Summary, I&APs were notified of availability of hard copies of the draft scoping report at the following locations:

- Swakopmund Public Library
- Arandis Public Library
- Walvis Bay Public Library
- National Library in Windhoek

CD's containing electronic copies of the Scoping Report and all of its supporting documents are available on request to SLR and/or Aurecon. The Scoping Report will be made available on the Aurecon and Rössing Uranium websites for download and details on how to access these will be included in correspondence to I&APs at the commencement of the public comment period.

8.4 Decision and Way Forward

On completion of the public comment period, the Scoping Report will be finalized, taking cognizance of further comments received/issues raised and then be submitted to MET:DEA for their review and decision regarding the approval of the Report and related Terms of Reference for SEIA.

All comments received on the Draft Scoping Report, together with the applicant's responses, will be included in the Comments and Response Report which will be made available to I&APs for information.

9 CONCLUSION

This section briefly concludes the report and touches on a few key procedural aspects going forward.

Rössing Uranium is proposing to construct and operate and new seawater desalination plant near the Swakopmund Salt Works north of Swakopmund as a means of reducing the overhead costs and improving the economic sustainability of the Rössing Uranium mining operation near Arandis. To allow this, Rössing Uranium must gain acceptance, in the form of an Environmental Clarence Certificate from MET:DEA as well as a number of permits and licenses as required by the prevailing water resources legislation, before commencing with such activities.

The project is currently at a conceptual planning stage and numerous design options are under consideration. These options will be screened and refined until a preferred project alterative is identified. The preferred alternative, along with any feasible alternatives, will be assessed in detail during the impact assessment phase to determine the potential significance of the impacts on the social and bio-physical environment. A number of specialists have been commissioned to conduct specialist studies on the key potential impacts. The specialist studies to be conducted include:

- Avifauna;
- Heritage;
- Marine discharge modelling and coastal dynamics;
- Marine ecology;
- Noise;
- Socio-economic; and
- Visual.

The Terms of Reference for these studies are not final and will be refined based on issues raised, during the Scoping Phase. This Draft Scoping Report will be made available to the public and stakeholders. The Draft Scoping Report will be finalised in light of feedback from I&APs and stakeholders, and will then be submitted to MET:DEA for consideration and decision making, before commencing with the SEIA Phase. The next stage in the SEIA process, namely the compilation of the Draft SEIA Report, will follow MET:DEA's approval of the finalised Scoping Report. All registered I&APs and stakeholders will be kept informed of progress throughout the assessment process.

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ANNEXURE A

CVs of the Environmental Assessment Practitioners

ANNEXURE A1

CV for Andries van der Merwe

ANNEXURE A2

CV for Patrick Killick

ANNEXURE A3

CV for Simon Charter

ANNEXURE A4

CV for Werner Petrick

ANNEXURE B

Public Awareness and Notifications

ANNEXURE B1

Background Information Document

ANNEXURE B2

Project meetings presentation

ANNEXURE B3

Site Notices

ANNEXURE B4

Newsprint Advertisements

ANNEXURE B5

RUL staff notifications

ANNEXURE C

Public Engagement and Response

ANNEXURE C1

Meeting Minutes with MUN

ANNEXURE C2

Meeting Minutes with Media Focus Group

ANNEXURE C3

Meeting Minutes with Swakopmund stakeholder groups

ANNEXURE C4

Meeting Minutes with Swakopmund public

ANNEXURE C5

Meeting Minutes with MAWF

ANNEXURE C6

Meeting Minutes with NamWater

ANNEXURE C7

Record of discussion with MET

ANNEXURE C8

I&AP Register

ANNEXURE C9

Comments and Responses Report