CNNC Rössing Uranium Working for Namibia

Rössing Uranium Limited

Environmental Management Plan

Effective Date:	**25 June 2021**	
Status:	**Revision**	
Version No:	**1.4**	
Document No:	**JE20/MMP/011**	
Custodian(s):	**Specialist Environment**	
Reviewed by:	**S Gaeseb**	**Original signed**
Authorised by:	**J Mwenze**	**Original Signed**

Executive Summary

When mining activities at Rössing commenced in the 1970s, no environmental assessment was required. Despite this the early operations took due cognisance of the sensitive environment in which the mine was established. Consequently, pro-active and responsible management measures were set as voluntary operational standards since the design and planning phases of the mine.

Built on the early commitment, all present operations at Rössing – from the planning to the decommissioning stages – are governed through applicable national legislative and regulatory frameworks and are managed through an integrated Health, Safety and Environment Management System (HSE MS). The HSE MS conforms to the International standards ISO 14001, ISO 45001 and ISO 9001, of which Rössing is certified to ISO 14001 since 2001. Based on an understanding of potential health, safety and environment hazards / aspects, the HSE MS allows Rössing to identify key aspects and impacts, guide operating procedures and attain to continual improvement in managing these. All potential impacts are listed on a risk register, coupled to mitigating and operational controls guided by the Rössing internal HSE Performance Standards. An audit programme evaluates the HSE MS periodically.

Ultimately, environmental management at Rössing aims at achieving the following:

- Assess environmental impacts of mining activities throughout the design and planning, construction, operational and decommissioning phases
- Develop, implement and manage monitoring systems to ensure maximizing of avoidance, mitigating and rehabilitation of adverse environmental impacts
- Comply with all environmental regulatory and legislative frameworks during all phases of the mine's operations through approved Environmental Management Plans
- Investigate and exploit measures to reduce usage of non-renewable resources
- Maximize positive environmental impacts
- Avoid, mitigate and rehabilitate adverse impacts
- Limit contamination through prevention measures (escapes into aquatic and atmospheric pathways), appropriate containment, recycling and removal measures
- Protect, conserve and enhance cultural, heritage and archaeological resources
- Keep communities informed and involved in decision making about mining activities
- Ensure the health and safety of employees, contractors and surrounding communities through agreed performance criteria
- Support and encourage awareness, training and responsibility of environmental management

This document contains a description of the current environmental management practice and plans at Rössing. The document is organized as five chapters with four appendices and references. Chapter 1 provides brief background information about Rössing; Chapter 2 describes the environment within which Rössing operates; Chapter 3 describes the current operational activities; Chapter 4 summarizes the Environmental Impact Assessments conducted over time and Chapter 5 describes the current management of environmental impacts at Rössing.

Table of content

List of Figures

List of Tables

1 BRIEF BACKGROUND INFORMATION

1.1 CONTACTS OF MINE

1.1.1 NAME

Rössing Uranium Limited

1.1.2 ADDRESS

Postal address: Private Bag 5005 Swakopmund Namibia

Registered address with the Ministry of Trade and Industry: 360 Sam Nujoma Drive, Klein Windhoek, Windhoek

1.1.3 TELEPHONE AND FAX NUMBERS

Telephone: +264 (64) 520 9111
Fax: +264 (64) 520 3017

1.2 MINE OWNER

1.2.1 RESPONSIBLE PERSON / MANAGER

CNNC is the majority shareholder of Rössing Uranium Limited and owns 69% of the shares. The Namibian state has a 3% shareholding, and a 51% majority vote when it comes to issues of national interest. The Iran Foreign Investments Company (IFIC) owns 15%. The Industrial Development Corporation (IDC) of South Africa owns 10% while local individuals own a combined 3% of Rössing shares. The minority shareholders have no rights to production take-off.

1.3 CONTACTS OF MINERAL RIGHTS HOLDER

1.3.1 NAME

Rössing Uranium Limited

1.3.1 ADDRESS

Private Bag 5005 Swakopmund

1.3.1 TELEPHONE AND FAX NUMBERS

Telephone: +264 (64) 520 9111
Fax: +264 (64) 520 3017

1.4 CONTACTS OF APPLICANT

1.4.1 NAME

Rössing Uranium Limited

Original application was done in 1959. In 1985 the Mining Grant M46/4/17 in the name of G P Louw (Pty) Ltd was consolidated with Rössing Uranium Limited's mining grant M46/4/5 to form Mining Grant M.46/4/28 and then converted to Mining Licence No. 28 in 2006.

1.4.2 ADDRESS

Postal address: Private Bag 5005 Swakopmund Namibia

Registered address with the Ministry of Trade and Industry: 360 Sam Nujoma Drive, Klein Windhoek, Windhoek

1.4.3 TELEPHONE AND FAX NUMBERS

Telephone: +264 (64) 520 9111
Fax: +264 (64) 520 3017

1.5 CONTACTS OF LAND OWNER

1.5.1 NAME

State-owned

1.6 LOCATION AND REGIONAL SETTING

Rössing Uranium Limited mines a large-scale low-grade uranium ore body in the Namib Desert, in the sparsely populated Erongo Region of Namibia (Figure 1.1).

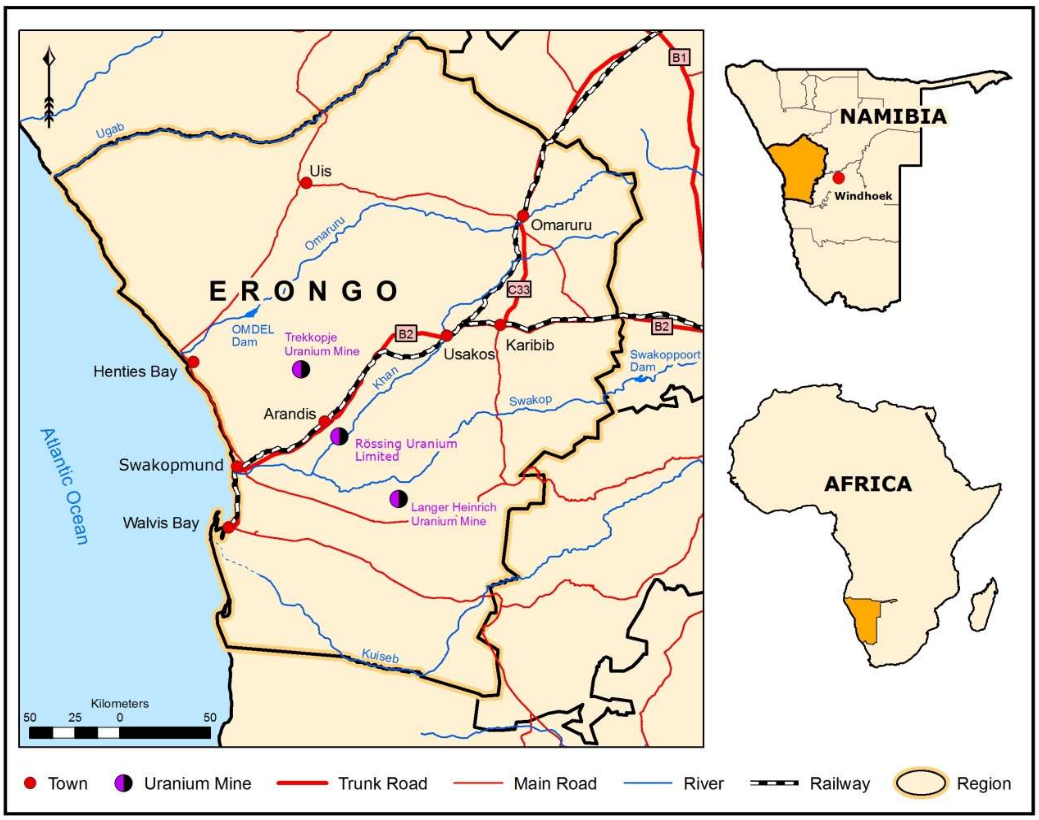


Figure 1.1: Location of Rössing Mine

1.6.1 DIRECTION AND DISTANCE TO NEIGHBOURS

Rössing is part of the Arandis Constituency, one of the seven political constituencies that make up the Erongo Region. A section of the northern boundary of Rössing's Accessory Works Area borders overlaps Arandis Townlands (Figure 1.2). Arandis is situated less than 10 km from the mine's main entrance gate.

The coastal town of Swakopmund is about 70 km away and Walvis Bay is located 30 km south of Swakopmund (Figure 1.1). To the east, the nearest town to Arandis is Usakos – about 80 km away.

The #Gaingu Conservancy is one of the immediate neighbours of the Mining Licence area. The largest part of communal and state land that forms part of this conservancy is totally uninhabited. The closest commercial farmland is about 15 km to the east of the Mining Licence area while the rural settlements of the conservancy are much further away from the mine – near Spitzkoppe (more than 60 km to the northeast).
An Exploration Prospecting Licence (EPL) 3138 is bordering Rössing's Mining Licence (ML 28) to the south and has been granted to Swakop Uranium. This EPL covers the Husab uranium deposit. To the east ML 28 is bordered and the Accessory Works Area of Rössing overlapped by EPL 3602, which is granted to Zhonghe Resources (Namibia) Development (Pty) Ltd., a Chinese exploration company exploring for uranium occurrences. EPL 3624 overlaps with Rössing's Accessory Works Area to the northwest and has been taken out by the Namibian company Creative Enterprises to explore for base and rare metals, industrial minerals, precious metals and dimension stone. Stone Africa operates two dimension stone quarries to the west of ML 28.

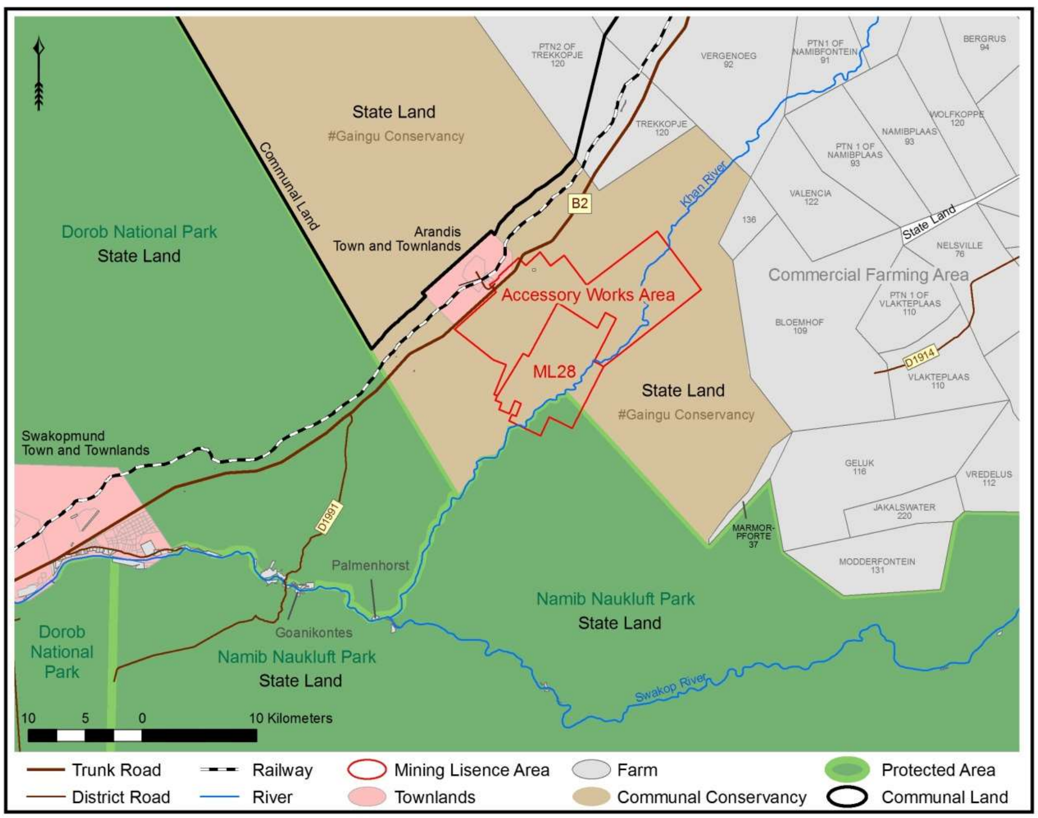


Figure 1.2: Rössing's Mining Licence and surrounding land

1.6.2 LAND TENURE AND USE OF IMMEDIATELY ADJACENT LAND

The Namibian state manages state land uses directly through the line ministries of the present government. The Ministry of Environment, Forestry and Tourism controls conservation areas, the Ministry of Works and Transport administers infrastructure on governmental land. Water management is mandated through the Ministry of Agriculture, Water and Land Reform which is also the custodian of surveyed and unsurveyed state land. Mining activities are regulated by the Ministry of Mines and Energy and the Ministry of Urban and Rural Development regulates the management of urban settlements.

Rössing Uranium Limited (RUL) operates on state land with a mining license issued by the Ministry of Mines and Energy (MME) under the Minerals (Prospecting and Mining) Act, 1992 (no. 33 of 1992). The current mining licence expired in May 2019 and as per the requirement, RUL submitted the renewal application a year prior the expiry date to MME. There have been a few challenges in getting the licence renewed, one such challenge was that MME would now renew the license for 10 years instead of the minimum 15 years as stipulated in the act. Due to this and other challenges, the renewal process was delayed as these issues had to be addressed through engagement. Ultimately, ML28 was in principal renewed for RUL in June 2021. However, official documentation to this regard was still awaited from MME at the time of this text.

Together, the current Mining Licence area and accessory works cover 13,003 ha, of which 91% is located on the northern bank of the Khan River (Figure 1.2), on relatively hilly terrain. By the end of 2020, the Rössing Mine complex covered 2,558ha. Thus, the total footprint of the mine is about 19% of the land under Rössing auspices, and consists of the open pit, waste rock dumps, the processing plant and tailings facility, offices, and infrastructure such as power lines, pipelines and roads

In the southwest about 720 ha of the Mining Licence area overlaps with the Namib-Naukluft Park on the southern bank of the Khan River. The Dorob National Park is a near neighbour with its eastern border about 10 km to the west of the Mining Licence area (Figure 1.2). The overlap with the Namib-Naukluft Park secures rights for Rössing to mine potential minable uranium occurrences in a thin stretch of land parallel to the river. The Mining Licence area is otherwise bordered by the #Gaingu Conservancy in the west and south-east. The rest is bordered by the accessory works area, which in turn is overlain by the #Gaingu Conservancy except for the northern part that borders, and partly overlaps, the town of Arandis and its Townlands. In 1997, the accessory works area was extended to include portions of the Khan River where an aquifer recharge scheme was planned by the mine. Although the construction of the scheme did not go ahead, the area was retained.

Arandis Airport is situated southwest of Arandis. A Rössing plane was operated from the airport until 2000, after which the airport infrastructure was sold to a private company.

1.6.3 RIVER CATCHMENT IN WHICH THE MINE IS SITUATED

Virtually the whole of the Central Namib Desert is drained by four river systems, from north to south the Omaruru, Khan, Swakop and Kuiseb rivers. The Omaruru, Swakop and Kuiseb rivers flow westwards to the Atlantic Ocean while the Khan forms a major branch of the Swakop River. Each of the rivers originates on the high interior plateau of Namibia.

Rössing is situated about 25 km upstream of the Khan / Swakop River confluence (Figure 1.3). The Khan River, which flows for a distance of about 15 km on the Accessory Works Area and about 10 km on the Mining Licence area, forms a major sub-catchment of approximately 8,200km² (of which only 6,000km² is considered to generate run-off[1]) of the larger Swakop River catchment. Both the Khan and Swakop rivers are classified as episodic ephemeral drainage lines, which mean that they only contain discharge for a brief period after sufficient downpours in their catchments on the higher interior.

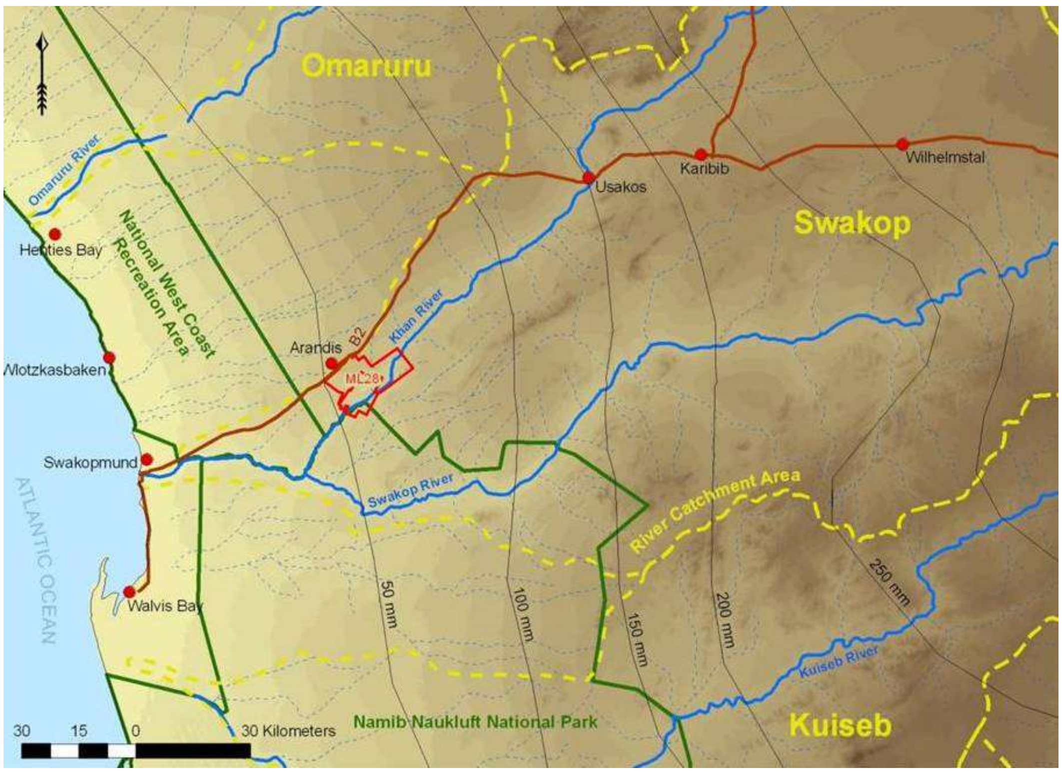


Figure 1.3: River drainage systems, average rainfall and topography

Surface floods in the Khan River below Dome gorge have been recorded on six occasions during a 26 year period (1966-1992). Further flood events occurred in 1995, 1997, 2000 and 2010/11. Recharge to the aquifer, as well as movement and deposition of alluvium and silt occurs during these high flow events. During the dry season the water flow down the rivers is sub-surface. Surface run-off partly infiltrates and recharges the groundwater in the alluvium or fractured bedrock, so that a continuous flow is maintained.

[1] Aurecon, (2011)

The Khan River originates in central Namibia, near Okahandja at an elevation of about 1,500 metres above mean sea level (mamsl) and joins the Swakop River 45 km from the mouth at Swakopmund. The sharp decrease in rainfall totals from east to west, combined with the erratic nature of run-off and the increase in evaporation potential from east to west, results in highly episodic functioning of central Namib rivers and give them distinct convex longitudinal profiles. The average gradient of the Khan between its origin and the point where it joins the Swakop River at an elevation of 190 mamsl is approximately 1:180. In the Rössing area the Khan River forms a deeply incised, steep-sided gorge. Three tributaries, from east to west Dome, Pinnacle and Panner Gorge, traverse the mine area and discharge into the Khan River.
The Khan River contains appreciable quantities of groundwater that sustains riparian vegetation in spite of its brackish quality. Rössing abstracts water from the Khan River for dust suppression in the open pit. The sediment fill of the tributaries is about 5-10 m thick, and can be very permeable in the lower stretches of the gorges.

No farming activity takes place and no people live along the Khan River downstream from Rössing.

In the second half of the 1990s the possibility to establish an aquifer recharge scheme in the Khan River was investigated by Rössing. Several in-depth technical studies were conducted and in the end it was decided not to develop this scheme.

1.6.4 SURFACE INFRASTRUCTURE AND SERVITUDES

A number of parastatal enterprises are mandated to provide infrastructure of national importance in Namibia: TransNamib (railways); NamPower (bulk electricity supply); NamWater (bulk water supply); Telecom (telecommunication) and Roads Authority (roads). In many cases the linear infrastructure provided by TransNamib, NamPower, Telecom, NamWater and Roads Authority are concentrated within developed ribbons, often parallel to a main road.

With regard to Rössing the railway line between Usakos and Swakopmund, the Telecom line and water pipelines are located within the narrow strip on both sides of the main road (B2) north of the Accessory Works Area. Near the turn-off to Arandis, the infrastructure branch-off from the main networks, to follow a corridor of linear infrastructure along a private roadway, which enters the Rössing Mining Licence area from the north (Figure 1.4.).

In short, existing service infrastructure connected to Rössing includes the following:

- A 6 km long double-lane tarred private roadway from the main Swakopmund–Usakos national road (B2)
- A full-gauge railway line linking the mine's service areas with the main Windhoek–Usakos–Swakopmund–Walvis Bay railway line from the Arandis siding
- A water supply pipeline and storage reservoirs; four (4) with capacity of 80 000m^3 and additional six (6) in construction to provide combined 60 000m^3 storage by 2022.
- A link to the NamPower 220 kV power line supplying electricity to Swakopmund and Walvis Bay and Telecommunication networks.

District road D1911 provides access from the B2 national road to Arandis, partly running over the Accessory Works Area. The private road that provides access to Rössing turns off from the D1911. A right-of-way servitude was surveyed in April 1994 over the Arandis Townlands to secure access to Rössing's railway line and private access road to the mine. This servitude was, however, not registered with the Registrar of Deeds.

The main road towards the mine leads to the main entrance gate. On site this road forms the spine of a network of various bitumen and gravel access and haulage roads and tracks with a total distance of more than 30 km.

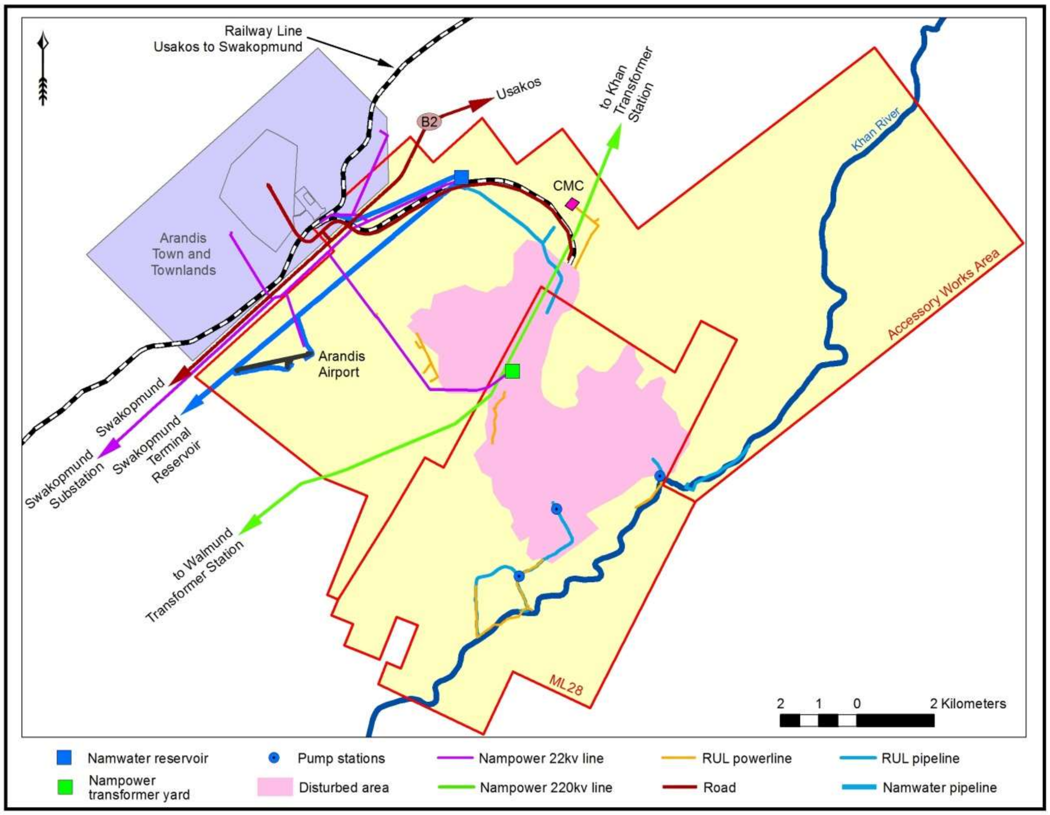


Figure 1.4: Lay-out of linear infrastructure at Rössing

The railway line is connected to four branched sidings. Main supplies brought in by rail include sulphuric acid, diesel, ammonia, manganese, and ammonium nitrate with drums of U_3O_8 product loaded into containers and railed to Walvis Bay for export.

Water for the central coastal region is provided by the parastatal bulk water supplier, NamWater, which sources fresh water from the Desalination plant at Wlotzkasbaken. NamWater distributes the water via a network of pump stations, reservoirs and pipelines to Henties Bay, Swakopmund and Walvis Bay, Langer Heinrich Uranium Mine, Husab Mine, Rössing, and Arandis.

Water to Rössing is supplied through a mounted pipeline with three booster pumping stations from a main water reservoir near Swakopmund. This 600-mm pipeline runs parallel to the B2 on its southern side. The pipeline's positioning allows secure and easy access for maintenance purposes. Fresh water is supplied to NamWater's Rössing terminal reservoir and additional six (6) reservoirs which Rossing is currently constructing - to be commissioned in 2022, these are all located south of the B2, close to the linear infrastructure corridor that enters the mining area from Arandis. The conduit system serving Rössing from the terminal reservoir has a capacity of 8,000 m^3 a day. Water to Arandis is also supplied from this reservoir with a pipeline.

Power to the mine is supplied from the national grid by NamPower, from the line between the Khan Transformer substation and Walmund transformer substation (close to Swakopmund) via a 220 kV overhead transmission line. A ring feed exists via the Kuiseb close to Walvis Bay, linking it to the Walmund Substation. NamPower's current supply capacity to Rössing consists of two 40 MVA transformers in parallel, with a declared maximum demand of 35 MVA, fed from the 220 kV supply.

Rössing is a large user of electricity and an agreement between Rössing and NamPower in this context exists since 1973. An addendum to this agreement was signed with NamPower in 1997. NamPower owns and operates all 220 kV equipment up to and including the 220/11 kV transformers and 11 kV metering.

For internal and external landline telecommunication, Rössing uses a grid of copper lines connected to Telecom in Arandis. Telecom operates the use and maintenance of a grid of landlines on-site, while the mobile telecommunications operator MTC has been contracted since 2002 to provide a base station with a mast, four global system for mobile communications antennas, one microwave antenna with a co-axial cable, and antenna brackets.

1.7 BACKGROUND ABOUT THE MINING OPERATION

During its early years, and after Namibia's independence, prospecting for uranium elsewhere in the Erongo Region was at a relatively low intensity. This has changed markedly over the past few years. Global concerns about the security of uranium supplies and sharp increases in uranium prices triggered renewed interest in uranium exploration in Namibia, and 2005 to 2007 saw a sudden scramble for prospecting rights in the central Namib. In 2007, when the State placed a moratorium on further uranium prospecting licences, 36 exploration licences for nuclear fuels had already been granted in the central Namib.

1.7.1 HISTORICAL OVERVIEW OF THE DEVELOPMENT OF THE MINE[2]

People have known about the presence of radioactive mineralisation in the Rössing area since the beginning of the 1900s. The first significant discovery of radioactive mineralisation was made in 1928, when prospector Captain Peter Louw and his wife

[2] The exploration history (Section 3.1 on p 43), the investigation of the Rössing deposit (Section 3.2 on p 44 – 45) and the project outline and schedule (Section 3.3 on p 45) is well documented in Ashton, *et al.,* (1991) and could be read in addition.

conducted an autoradiograph test on a supposed sample of pitchblende. Over the years they tried to interest major mining groups in investigating the potential of the area. Only in the late 1950s was the potential confirmed by the Anglo American Corporation of South Africa after intensive exploration. The company's geologists concluded, however, that the mineralisation was of an erratic occurrence and of a very low grade. The poor economic prospects for uranium at that time induced the company to abandon the search. It was only in the 1960s that a renewed interest in uranium motivated the Rio Tinto Zinc Corporation (RTZ) to reinvestigate the Rössing deposit intensively.

Rössing Uranium Limited (RUL) was formed in 1970 to develop the deposit. RTZ was its leading shareholder, with 41.35% of the equity; other shareholders included Rio Algom, the Industrial Development Corporation of South Africa, and Gencor. In 1972, Rössing awarded a management contract for the design, engineering, procurement and construction of the project to a joint venture of Arthur G McKee Western Knapp Engineering Division and Davy Powergas.

Mine development commenced in 1974 and commissioning of the plant and the initial production commenced in July 1976. The original production target was 2,500 short tons (2,268 t) of uranium oxide (U_3O_8) per year. Forward sales contracts were arranged to assure a market for the product. The United Kingdom Atomic Energy Authority was initially an important customer for Rössing's product, as was the French Total Compagnie Miniere et Nucleaire.

The objective was to reach full design capacity of 5,000 short tons (4,536 t) per year of uranium oxide during 1977. In 1979, the target production figure of 5,000 short tons (4,536 t) of uranium oxide was reached. The significance of weaknesses in the plant and the abrasiveness of the ore were not apparent during the pilot stage and the plant was extensively modified. The process plant – after a year of extensive modification in 1978 and total reconstruction of one of the two solvent extraction sections that was destroyed by fire in May 1978 – was operating effectively at the rated throughput of 40,000 t of ore per day.

Production between 1980 and 2004 fluctuated in response to the volumes required by the long-term sales contract portfolio. Contract prices were in turn influenced by market price and exchange rate fluctuations. The drop in the uranium price in the early 1990s necessitated a reduction in production to a minimum of 2,800 t per day in 1998. The drop in price also caused other significant changes at Rössing. Consequently, Rössing was forced to reduce production and withdraw from many external developmental initiatives.

The grim economic outlook of the 1990s was followed by regained flexibility to respond to changes in uranium price and exchange rates. Production was increased to above 3,000 t per day and, in July 2004, a study was completed into the feasibility of extending mining operations. The study indicated that profitability could be extended until the end of 2009. A second phase of mining with an additional 8 years of operation was foreseen, subject to a number of sales contracts being ratified and the parent company – that had since become simply Rio Tinto – approving the proposed expansions, including the replacement of mining equipment, a tailings extension, and plant upgrade. From the mid 2000s the grim economic outlook of the 1990s was finally something of the past. As a result of the upward trend in uranium prices on the international market, Rössing considered possible expansions to extend the Life of Mine plan beyond 2020.

1.7.2 CURRENT SHAREHOLDING

After acquiring shares from Rio Tinto in 2019, CNNC is the majority shareholder of Rössing Uranium Limited, holding 69% of the shares. The Namibian Government has a 3% shareholding, yet has the majority (51%) when it comes to voting on issues of national interest. The Industrial Development Corporation of South Africa owns 10%, while local individual shareholders own a combined 3% shareholding. The Iranian Foreign Investment Company owns 15%, a stake that was acquired during the set-up of the company in the early 1970s, prior to the revolution in Iran, i.e. when the Shah was still in power. In 2010, the United Nations (UN) Security Council passed Resolution 1929 (UNSCR 1929), which prohibits UN member countries – of which Namibia is one – from allowing Iran to acquire an interest in a commercial activity involving uranium mining or to obtain access to nuclear technology. The two shareholder representatives of the Iranian Foreign Investment Company have not attended Board meetings and have not received Board material since the beginning of 2010, in compliance with UNSCR 1929.

The minority shareholders have no uranium product off-take rights.

1.7.3 CURRENT SCALE OF OPERATION

In 2020, Rössing produced 5.5 million pounds U3O8. A total of 2.0 million pounds were shipped to western converters and sold to customers in North America, Asia (excluding China) and Europe, Middle East and Africa (EMEA). A total of 4.0 million pounds, including some production from the 2019 year, were shipped to China and sold to CNNC. Rössing continued to benefit from the contractual sales prices in its historical contract portfolio, as well as the beneficial CNNC off-take agreement, with an average sales price across the entire portfolio, well above the average spot price for the year.

1.7.4 CURRENT LIFE OF MINE

Piloting to start mining the SJ Pit started in 1974, and after commissioning in 1976, full production was reached in 1979. Originally prepared for closure in 2009, an increase in long-term uranium market prices in 2005 allowed the extension of the Life of Mine plan to 2016. As mine planning continues to adapt to changing internal and external conditions, the Life of Mine plan developed in 2015 foresees the end of mining activities in 2025.

The piloting of the expansion – known as *Phase 2* – started in the north-western part of the pit in 2006. The Phase 3 also reffred to as Phase 2B pushback on the southern side of the pit commenced in 2007 in mainly waste rock.

At the end of mining activities in 2025, the final depth of the open pit will be reached at Bench 36, about 30 mamsl.

2 DESCRIPTION OF THE ENVIRONMENT

2.1 GEOLOGY[3]

The Rössing uranium deposit lies within the central part of the late-Precambrian Damara orogenic belt that occupies an area of approximately 50 km wide and extends northeast for over 100 km in west-central Namibia.

The Damara lithology consists mainly of folded, steeply dipping meta-sediments (gneiss, schist, quartzite and marble) arranged in a northeast-southwest striking belt (Table 2.1).

Table 2.1: Stratigraphy and rock types at Rössing

Period	Formation	Lithology
Recent		Alluvium and scree
Damara System	Intrusives	Dolerite dykes
		Alaskite
		Red granite-gneiss
	Karibib Formation	Metasediments
	Chuos Formation	Meta-tillite
	Rössing Formation	Feldspathic quartzite
		Upper cordierite gneiss
		Upper marble
		Lower cordierite gneiss
		Lower marble
	Khan Formation	Amphibole schist
		Upper banded gneiss
		Mottled gneiss
		Amphibolite
		Lower banded gneiss
	Etusis Formation	Biotite gneiss
		Feldspathic quartzite

Several tectonic phases caused intensive folding, shearing and jointing of the Damara rocks, especially around the Rössing Dome, but open fractures are rare due to the predominantly compressive nature of the tectonic stress. The closed nature of the fractures causes the generally low hydraulic conductivity of the meta-sediments. Younger fractures were often intruded by post-Karoo dolerite dykes, which often act as barriers to groundwater flow. The youngest sediments in the area are the alluvial fills of the Khan River and its tributaries, as well as other quaternary deposits.

The geology of the mining area at Rössing is associated with a dome structure and occurs in pegmatitic granite known as alaskite, which intruded into the meta-sediments.

[3] The regional geological setting as well as the geological origin, local setting and structure and the mineralogy of uraniferous deposits is described by Ashton, *et al.,* (1991), Section 2.3 (p 9 – 14).

The Rössing ore body is unique in that it is the largest known deposit of uranium occurring in granite. The nature and grade of uranium ore is extremely variable and can be present as large masses or narrow inter-bands within the barren meta-sediments. All of the primary uranium mineralisation and the majority of the secondary uranium mineralisation occur within the alaskite. However, the alaskite is not uniformly uraniferous and much of it is unmineralised or of sub-economic grade.

Uraninite is the dominant ore mineral (55%); secondary uranium minerals constitute 40%, while the refractory mineral betafite makes up the remaining 5%. Ore grades at the mine are very low, averaging 0.035%. The uranium ore consists of 70-90% alaskite and is subdivided into four ore types according to the composition of the host rock.

2.2 CLIMATE[4]

The climate of the central Namib Desert is hyper-arid with an average precipitation of less than 50 mm per annum over the greatest part. Rainfall is episodic and highly erratic with a variation coefficient of more than 90%, which means that the average might be obtained from single showers, with years of minimal rainfall recordings in between. The effect of these enormous variations may extend over decades.

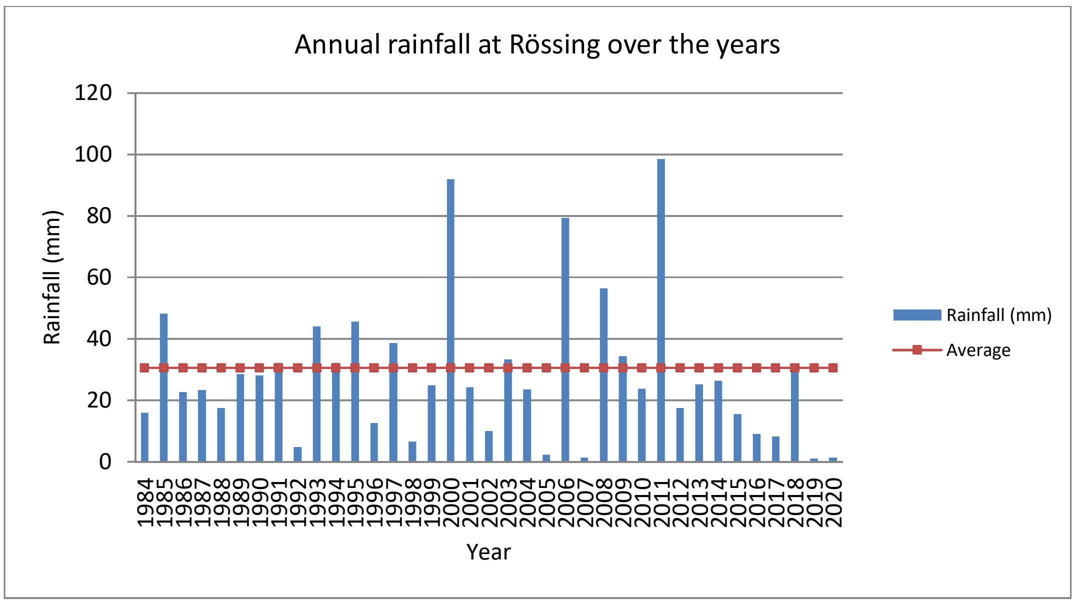


Figure 2.1: Variation in annual rainfall at Rössing

At Rössing rainfall measurements indicate an average annual rainfall of about 30 mm, but this figure is misleading because the totals vary widely below and above the mean (Figure 2.1). Much of the rainfall occurs as an episodic late summer thunderstorm of

[4] Although outdated, additional information about climatic aspects at Rössing is contained in Ashton, *et al.,* (1991), Section 2.2 (p 3 – 8).

high intensity and short duration with virtually no rainfall recorded in the winter months. Rainfall increases inland from Rössing (See also Figure 1.3).

Advection fog is a highly significant source of precipitation over the central Namib Desert, especially close to the coast, but its effect decreases rapidly the further it moves away from the coast. Fog occurs more often than rain over the coastal Namib. The frequency differs spatially and between seasons. Biota has adapted miraculously to utilize this form of precipitation and the fog is a significant source of moisture for some of the species, especially those that occur on higher terrain, also at Rössing. Besides providing precipitation, the fog can ameliorate the otherwise torrid temperatures of the Namib Desert up to 100 km inland.

Associated with the cold Benguela Current and the occurrence of fog is the presence of high humidity along the coast. Even when fog is absent, the humidity along the coast remains the highest in Namibia with night values of more than 80% not unusual. Further away from the coast the humidity drops sharply while temperatures rise steeply. Extending inland for a distance up to 60 km during many nights, the fog is densest at an elevation of between 300 and 600 m. This phenomenon creates a foggy and cool coastline, followed by a zone between 30 and 60 km inland from the coast where fog and high humidity is common during the morning, but disappears before noon when the temperatures rise. Rössing is thus located in a zone of extremes, experiencing great diurnal fluctuations in temperature and humidity.

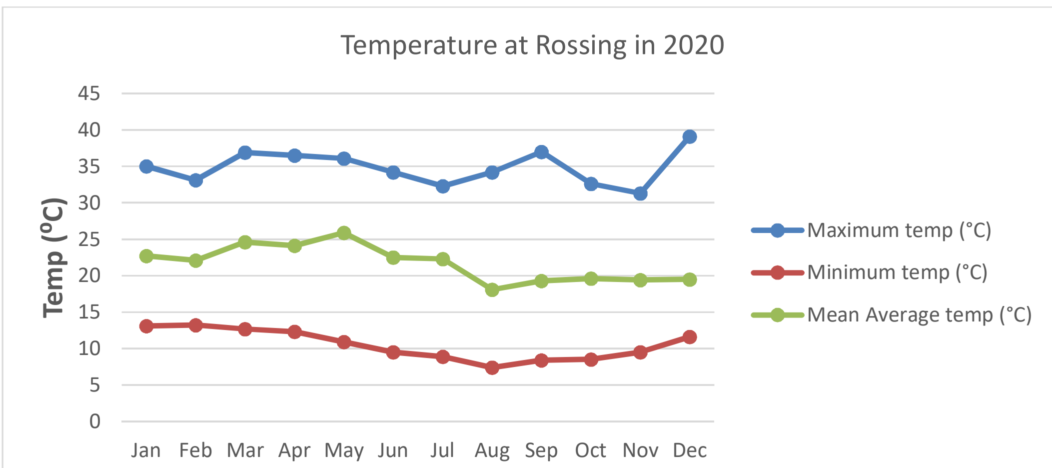


Figure 2.2: Temperature ranges at Rössing during 2020

2.3 TOPOGRAPHY

Generally the surface of the Namib Desert has a slow rise towards the escarpment, but does not exceed an altitude of more than 1,000 m above sea level (Figure 1.3). Consisting of broad gravel peneplains (open outwash plains) with a low relief, the central Namib Desert is also known as the Namib Desert Pavement.

At a mean altitude of 575 m above sea level, most of the Rössing tenement in the west, north and northeast consists of broad peneplains[5]. The flat terrain is traversed by shallow drainage lines and stormwater gullies that aim at the Khan River. Close to the Khan River the undulating plains change to an increasingly rugged terrain, which further increases towards the Swakop River, as illustrated in Figure 2.5.

Several dissected gorges coalesce as dry tributaries from both sides to the dry Khan River before its confluence with the Swakop River 25 km to the southwest of the mine property. The gorges are separated by steep-sided ridges, which give the terrain a hostile and impassable appearance.

The peneplains are also traversed by sporadic dykes and intrusions, mostly of a low altitude. A steep-sided ridge of dolerite hills stretches from southwest to northeast between Pinnacle Gorge and Dome Gorge, rising to a peak of 707 m above sea level. To the north and west of the ridge the landscape is less hilly and rugged, the plains more dominant and the gullies less pronounced. To the east and south the landscape is dominated by rolling hills, the plains are absent and the gullies clearly defined.

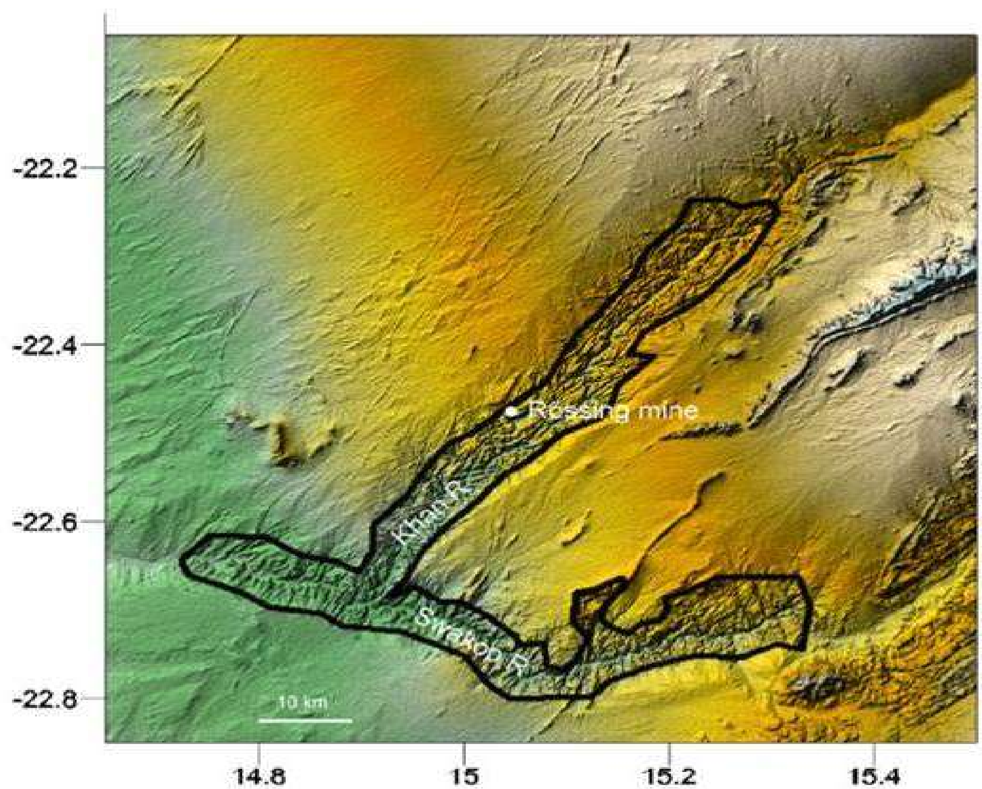


Figure 2.3: Satellite image showing the dissected terrain of the Khan and Swakop Rivers

On the southern side of the Khan River the rugged landscape dissipates abruptly giving way to the gravel plains of the Welwitschia Plains. These plains cover almost the entire

[5] The topography at Rössing is also described in Ashton, *et al.*, (1991), Section 2.1 (p 3).

area between the Khan and Swakop Rivers, down to their confluence, and are called like this because of the many Welwitschia plants that occur here.

Despite the low elevations over a large part of the tenement, sporadic flash floods of a high intensity have the potential to cause extensive erosion. This is even more pronounced in areas where topographic features have been impacted by mining (for example excavations in the sand borrow pits and steep slopes on the tailings facility and waste rock dumps) and waste disposal sites. Stabilisation of these features against water erosion is an important management aspect in maintaining the environmental and aesthetic integrity of the landscape.

2.4 SOILS

Soils in the vicinity of Rössing could be described as shallow (<25 cm), greyish or ochre leptosols and petric calcisols, with a large proportion of coarse fragments and occasional calcium carbonate or gypsum concretions[6]. Solid material is broken down first by physical weathering processes, after which chemical decomposition processes transform the fragments to progressively finer particles. The predominance of chemical weathering processes is accentuated by the dry climate and the occasional deposition of wind-blown salt of marine origin.

The soils are characterized by high soil pH-values. Hard surface and near-surface crusts, due to calcrete or limestone deposits, are common and these soils are known as "Schaumboden" or "foam soils"[7]. Sometimes the surface crusts are bound by an overlying layer of blue-green algae (cyanobacteria), like in the case of soils in lower Panner Gorge. The crusts reduce rainfall infiltration rates and enhance run-off.

Aeolian sand deposits of varying depth are found in sheltered areas in the upper gorges and are particular prominent on the leeward (wind protected) slopes of Rössing Mountain. These sands are a mixture of dark to light brown grit, quartz and feldspar fragments, and biotite flakes. Colluvium is present on the slopes of some hills. Thickness varies, but may reach a depth of up to about 1.5 m. The material consists of grey-brown silty sands with an open, angular pebble layer and the consistency varies from medium-dense to dense.

Despite the low elevations over a large part of the tenement, sporadic flash floods of a high intensity have the potential to cause extensive fluvial erosion. Fluvial erosion causes an accumulation of unconsolidated alluvium, mainly sand and gravel, in the drainage lines. These deposits up to a few meters thick fan the valley bottoms horizontally, in laminated layers of coarse sand mixed with angular gravel and sorted pebbles. The plains are also exposed to wind erosion, which constantly removes fine material and enhances the soilless appearance of the gravel plains.

The deepest soil is thus confined to the drainage lines, comprising of mainly infertile – almost sterile – alluvium, that vary in thickness. Moreover, topsoil is shallow, poorly developed, infertile and even absent over the largest part of the hill slopes and gravel plains of the mine tenement.

[6] Soils are also described in Ashton, *et al.,* (1991), Section 2.5 (p 15 – 19).
[7] Aurecon, (2011)

2.5 LAND CAPABILITY

Much of the Erongo Region is occupied by the Namib Desert, which runs parallel to Namibia's entire coastline. As the average annual rainfall increases and the altitude elevates to the escarpment in the east, the Namib Desert gradually transforms to the savannah-like landscapes of the interior. In general, land capability in the Erongo Region is marginal and land use is of a low intensity.

About two-thirds of the total area in Erongo is owned by the State. One third is under state conservation management, which includes protected areas such as the Namib-Naukluft Park and Dorob National Park, while the other third is made up of communal land, most of which is under communal conservation management[8] (Figure 1.2).

Much of the communal land is of very low agricultural potential and cannot support formal farming activities. As the agricultural potential increases towards the east, small-scale subsistence livestock farming is practised. On commercial farmland a mixture of livestock and game farming is practiced and some land owners secure additional income through tourism and professional hunting.

Although tourism is regarded as an important economic mainstay of Swakopmund, the town becomes increasingly important as a location of mining-support businesses. More than 60% of Rössing's workforce resides in Swakopmund. Walvis Bay, on the other hand, is Namibia's only deep-water harbour and the town is an important hub for the fishing, shipping, storage and transporting industries of Namibia. About 19% of the workforce at Rössing resides in Walvis Bay. In Arandis, where 21% of the workforce resides, economic activities are restricted to local supplies and retail.

Mining activities have affected Swakopmund where all of the corporate offices of the mining companies are located, and most of the employees also reside here. Arandis, to a lesser extent, is home to some of the employees and the town has witnessed some signs of development during the last few years.

2.6 LAND USE

Rössing's Mining Licence area encompassed the open pit, rock dumps and processing plant, whereas activities related to tailings disposal, sand mining, seepage control around the tailings facility, the Arandis Airport and other infrastructure including power lines, pipelines and roads are situated in the accessory works area.

Apart from Arandis, there is no active land use in the proximity of Rössing's Mining Licence area[9]. Around Rössing water is severely limited, meaning that agriculture is of marginal potential only, even along the ephemeral water sources of the Khan and Swakop River. The closest commercial farmland is about 15 km to the east, and the border of communal land is about 15 km to the north. Along the lower Swakop River, close to the coast, commercial farming is undertaken on several smallholdings. Production aims to supply the needs of Swakopmund and Walvis Bay and includes

[8] Rössing Land Use Management Plan, (2008)
[9] Rössing Land Use Management Plan, (2008)

asparagus, olive, mushroom and vegetable farming, as well as tourism- and leisure-oriented activities.

Both the Rössing mining license area and the Accessory Works Area lay within the #Gaingu Conservancy area (Figure 1.2). The #Gaingu Conservancy was registered in 2004. Not many people reside within the #Gaingu Conservancy area south of the main road. The abandoned Khan Mine is located on the unoccupied land of the #Gaingu Conservancy southwest of Rössing's operational area. Game migrates freely between the various parts of the conservancy, the proclaimed conservation areas and the properties of Rössing in response to pasture and water availability.

About 720 ha of the Mining Licence area overlaps with the Namib-Naukluft Park on the southern bank of the Khan River. The Dorob National Park, about 10 km to the west of the Mining Licence area, is a near neighbour of the mine. Both parks fall within Category 2 of the International Union for Conservation of Nature (IUCN).

With an overall size of almost 50,000 km^2 in surface cover, the Namib-Naukluft Park is Africa's largest game park. Originally established in 1907, the park is an amalgamation of three previous conservation areas, of which the boundaries were finalised in 1978. The Dorob Park was proclaimed in 2010 and incorporates the old National West Coast Tourist Recreational Area, which was proclaimed in 1968, as well as adjacent areas that were previously unprotected. Dorob Park links the coastal Skeleton Coast Park (north) with the Namib-Naukluft Park (central), which is connected to the Sperrgebiet (south) to ensure that the entire Namibian coast is protected.

2.7 VEGETATION

On the gravel plains at Rössing vegetation is dominated by sparsely scattered dwarf shrubs and ephemeral grasslands[10]. This is also the case for the undulating hills and mountains, but grass is less. Sparse riparian vegetation marks the drainage lines, in particular the Khan River.

In 2003 Rössing decided to assess the vulnerability of the area adjacent to the tailings facility when extensions were proposed. Dr Antje Burke, a Namibian specialist of arid ecology was consulted in this regard. The presence of *Adenia pechuelli* and *Lithops ruschiorum* was found and a follow-up study was recommended. Subsequently a plant red list[11] assessment was carried out by the National Botanical Research Institute (NBRI). More populations of *Lithops ruschiorum* were found in further work in the same area under a Rio Tinto – Kew Botanical Gardens Partnership[12].

In 2004 it was realized that biodiversity management at Rössing requires a systematic approach and a biodiversity assessment was commissioned in 2005[13]. The aim was to delineate ecologically homogenous units, with a specific emphasis on floral biodiversity, reconstruct pre-mining conditions and provide a biodiversity assessment of these mapped units. In this way the "biotope method" was adapted to the local conditions at

---

[10] Although outdated, more information about the vegetation at Rössing is also contained in Ashton, *et al.*, (1991), Section 2.8.1 (p 28 – 34).
[11] Red list status refers to the International Union for Conservation of Nature (IUCN) categorization of species under threat as *vulnerable*, *near threatened* or *threatened with extinction*.
[12] Loots, (2006)
[13] Burke, (2005a)

Rössing[14]. The methodology was developed and tested over two years[15] and applied to assess extensions of the mining lease in 2007[16] and south of the Khan River in 2009 for exploration work[17].

It was decided to use plant species as practical indicators for overall biodiversity management at Rössing for several reasons:

- Plants are the key component of most terrestrial ecosystems, providing food, shelter and habitat for many other living components of an ecosystem.
- Plants are the basis for all terrestrial food chains delivering primary production without which very little other biodiversity can thrive.
- Plant species in Namibia can be identified within a reasonable time frame (before the next season starts).
- The conservation status of individual plant species is known and has been assessed nationally and internationally.

Certainly this does not mean that other components of biodiversity are not important, and one cannot assume that all trends shown by plants will be the same for other biodiversity components (e.g. reptiles or insects), but on the current knowledge base plants prove a powerful proxy for biodiversity in most situations. There is no question that the diverse habitats encompassed in Rössing's licence area have resulted in very high plant species richness in this arid environment and make it an important sanctuary for the maintenance of biodiversity in the region. However, quantifying Rössing's contribution is difficult, as readily available and published information on plant species distributions in this area reflects a significant sampling bias, meaning that the plant inventory at Rössing now stands out as the most comprehensive in the central Namib Desert[18].

In addition to the key perennial plant species *Arthraerua leubnitziae* (pencil bush), *Aloe asperifolia* (Sand paper aloe) and *Zygophyllum stapffii* (Dollar bush) on the plains, and *Euphorbia virosa* (Milk bush) and various *Commiphora* species (Kanniedood[19]) on the hillsides, other common species include *Asclepias buchenaviana*, *Salsola tuberculata, Pelargonium otaviense, Adenolobus pechueli, Aizoanthemum membrumconnectens, Sarcocaulon marlothii*, *Trichocaulon pedicellatum, Euphorbia virosa* and *Hereroa puttkamerana.* A few tree species, *Acacia erioloba* (Camel thorn), *Acacia reficiens* (Red umbrella thorn) and *Parkinsonia africana* (Green-hair tree) dominate along the drainage lines while *Faidherbia albida* (Ana boom), *Tamarix usneoides* (Tamarisk) and thickets of *Salvadora persica* (Mustard tree) are more common along the Khan River. Two endemic plant species of particular importance to Rössing are the cryptic rock plant *Lithops ruschiorum* (Stone plant) and the larger succulent *Adenia pechueli*, or Elephant's foot.

Biological soil crusts, comprising lichens, micro-fungi, algae and blue-green algae (cyanobacteria) at Rössing are present in a somewhat reduced form compared to their

---

[14] Burke, (2005b)
[15] Burke, *et al*., (2008)
[16] Burke, (2007)
[17] Burke, (2009)
[18] Burke, (2011)
[19] The Afrikaans word *Kanniedood* literally means *cannot die*, which describes the appearance of these succulent-stemmed plants that only show signs of life after it has rained, remaining leafless for most of the year.

occurrence in other Namib Desert habitats. Lichens are largely absent, while hypolithic organisms are abundant[20].

The ephemeral flooding of the Khan River provides an important source of water to its riparian vegetation. In general vegetation relates strongly to the frequency, intensity and duration of flooding events. A few species dominate – Ana boom, Camel thorn, Tamarisk and thickets of Mustard tree. The relative more dense riparian vegetation provides food and shelter to many animal species and sustains important migration and dispersal routes as a result.

2.8 ANIMAL LIFE

While specialist work has, since 2004, increasingly focused on floral biodiversity, it was realized that faunal biodiversity at Rössing deserves more specialized investigation as well. From work done in the 1980s it was known that unnamed or undescribed taxa, and known only from a few localities, could be present at Rössing. Accordingly, eight invertebrate species were regarded as Critical, nine as Endangered and one as Vulnerable, using the IUCN categories. The list includes four spiders of critical conservation priority.

The Dome area was identified as particularly critical in terms of faunal biodiversity conservation because of single finds of species during the 1980s. In 2007, therefore, the Environmental Evaluation Association of Namibia (EEAN) was contracted to conduct a biodiversity survey. Unlike floral biodiversity, which requires spatial division at a fine resolution (biotope scale), faunal biodiversity at Rössing could be adequately described according to broad demarcations. EEAN argued that habitats at Rössing could broadly be divided into the following[21]:

- Rocky hillsides with loose surface rocks and no soil or soil that is very shallow, and having the least vegetation, relatively speaking
- Open plains with deeper soil and scattered bushes and shrubs. The plains are interrupted with rocky outcrops of varying dimension, and
- Ephemeral watercourses marked by having more bushes and scattered trees along their length than in other areas, and having a substrate that is usually sandy and unconsolidated.

The abundance and diversity of spiders is relatively lower than expected, and the numbers of solifuges is exceptionally low, in contrast to the central Namib which is known as a world hotspot of solifuge diversity. Fourteen scorpion species are known to inhabit the Rössing licence area, of which three are classified as threatened. A total of 271 species of ground-living insects are recorded from Rössing, and this excludes flying groups such as moths and lacewings. Of the 271 species, 20 are classified as threatened.

The Namib Desert is known for its reptile diversity, particularly of lizards and geckos. At Rössing 33 reptile species are expected to occur. Of these, one (a tortoise) is classified as threatened but it prefers moister habitat and its occurrence in the area is very marginal. The Namib chameleon (*Chamaeleo namaquensis*) is more common. Information about the endemic Husab Sand Lizard (*Pedioplanis husabensis*) is limited.

---

[20] EEAN, (2008)
[21] Ibid

Only small numbers of this species and relatively small areas of occurrence – rocky terrain along the lower Khan and Swakop Rivers – are recorded. By the precautionary principle the species is classified as threatened.

Three species of frogs are known to occur at Rössing, none of which are classified as threatened. The Namib Desert has relatively low avifauna species diversity, but does have a relatively high occurrence of endemics and near endemics[22]. From a local perspective the Khan River has the highest bird species diversity, indicating the importance of water availability and consequent supported plant life as well as the diversity of cliff habitats. Two species are classified as threatened.

According to EEAN the rocky hillsides, in particular those located in Lower Dome and along the Khan River are regarded as the most important habitats of the scarce invertebrates at Rössing. EEAN also concluded that it would be possible but unlikely, that the identified species would be extinct by a new mining development and that the apparently high level of endemism might be real or it might be from the sampling bias of earlier research[23].

Mammal diversity at Rössing is not very high, as is typical in the central Namib. Climatic variation is closely coupled with marked changes in the abundance of animal species[24]. Many of the animal species that occur around Rössing use a wide range of habitats, or may cross a wide range in the course of migrating from one habitat to another. Short-lived annuals dominate the plains after local showers of rainfall and provide a vital source of pasture to opportunistic grazers. Large mammal species occur occasionally because they are nomadic and use three main migration routes[25]. Watering points like the pools of the Khan River and the springs are particularly important in attracting animals and serve as orientation guides along migration routes. Common animal species include Klipspringer, Springbok, Ostrich, Kudu, Hartmann's zebra, dassie (Rock hyrax), Black-backed jackal, Baboon and rodents (particularly gerbils).

2.9 SURFACE WATER

Open surface water in the Namib Desert is a rarity and may occur only ephemerally during the rainy season. Flowing surface water on the Mining Licence area only occurs after heavy rainfall. Run-off in the drainage lines is an episodic, brief event and peaks and periods of run-off vary widely. At Rössing[26] average flow rates of the Khan River recorded over three decades vary between 2 m^3/s and 100 m^3/s, indicating the formidable (but highly infrequent) transportation potential of the river.

The many drainage lines that originate on the higher elevations to the north of Rössing form part of the Panner, Pinnacle, Boulder and Dome Gorge drainage systems. These smaller drainage lines function even more episodically than the Khan River, many of them are dry for decades before they may carry torrent flash floods for brief periods.

---

[22] Stacey, (2006)
[23] Brett, (2009)
[24] Although outdated, more information about animal life at Rössing is also contained in Ashton, *et al.*, (1991), Section 2.8.2 (p 34 – 40).
[25] Campbell, (1998)
[26] Although outdated, aspects relevant to the hydrology and surface water quality at Rössing is described in Ashton, *et al.*, (1991), Section 2.6 (p 19 – 23).

The local drainage patterns in the vicinity of the Rössing mine site are particularly well defined by lithological and structural features, generally directed towards the Khan River. The regional flow pattern shows a gradient from northeast to southwest in accordance with the local topography. Flow in the alluvial aquifers follows the course of the dry riverbeds, which are aligned roughly north-south.

The watershed of Pinnacle Gorge is characterised by an intensely dissected drainage, reflecting the local fracture density. Pinnacle Gorge has its catchment to the southern part of the tailings facility and flows along the south western side of the open pit. The Panner Gorge watershed area, to the west of the tailings facility, is characterised by a strong linear dendritic pattern reflecting structural and lithologic controls in the underlying strata. Panner Gorge is orientated in a southerly direction and drains to the west of the mine. The drainage lines of Dome Gorge flow in a south easterly direction and captures run-off east of the tailings facility. The drainage lines of Boulder Gorge contain the run-off from the mine plant and the watercourse to the east of the plant.

Due to the alluvium the tributaries of the Khan River contain subsurface water flow for most of the year. Permeability of the alluvium is high – as much as 10^{-3} m/sec, resulting in subsurface flows between 4 and 8 m per day. The alluvium has also a high storage capacity with the water table being within 2 to 3 m of the surface. In the Khan River alluvial deposits may reach a depth of several meters, where they act as an important subsurface aquifer. The aquifer is recharged fairly frequently by run-off from its headwaters in the interior. Recharge rates depend on factors such as flood size, flood frequency, silt load, and local surface conditions.

Seasonal springs and small pools may occasionally form in the Khan River and in the gorges that drain into the Khan River. Pools relate to bands of impervious rock that traverse the river bed beneath the alluvium, forcing the subsurface water to the surface. Ephemeral springs may last for a short period after local rainfalls. Their flows are insignificant and persist for short periods after local rainfalls only. Many of them are saline, but provide important sources of drinking water for animals, despite their salinity.

Insignificant occurrences of permanent natural surface water can be found at small springs in the vicinity of the mine. These occurrences vary from areas of wet soil to small puddles. The water is normally very saline, but the springs are frequently used by wildlife for drinking. Only one natural perennial spring occurs in the Rössing area and is located in a side-arm of Panner Gorge.

2.10 GROUNDWATER[27]

Local geological formations show extensive patterns of folding, jointing and cracking, trending predominantly in a northwest-southeast or north-northwest-south-southeast direction at Rössing. This direction is perpendicular to the strike of the regional fold structures, which influences the geo-hydrology strongly. Consequently, groundwater flows and rainfall seepage at Rössing is mainly along the fractures and thus focused towards the gorges that drain into the Khan River (Figure 2.6).

[27] Aspects relevant to the geohydrology and groundwater quality at Rössing are also described in Ashton, *et al.*, (1991), Section 2.7 (p 23 – 26).

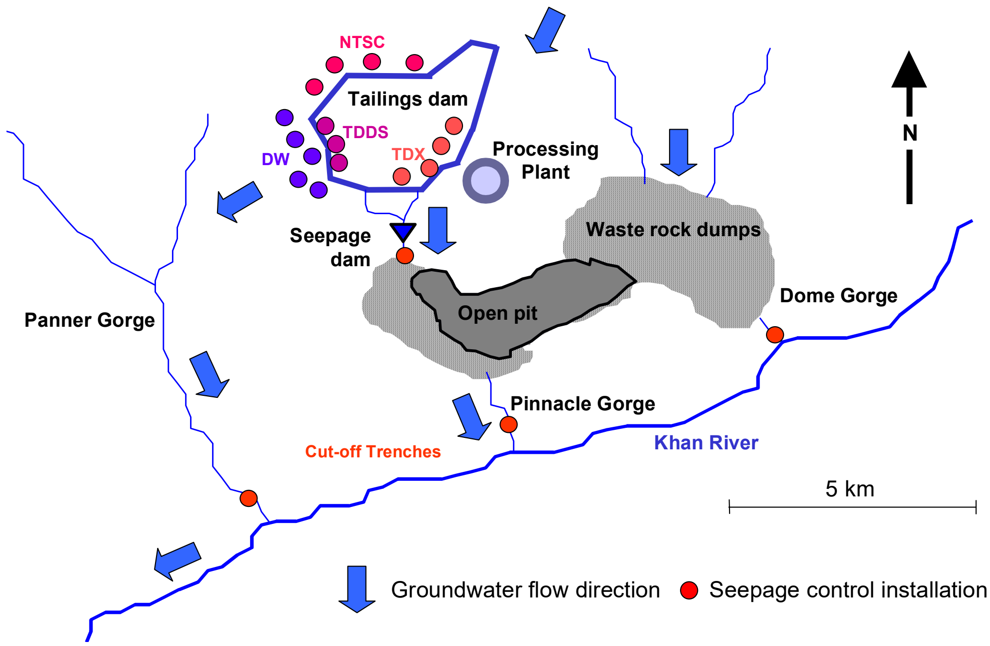


Figure 2.4: General groundwater flow directions and control at Rössing

In general, fracturing in the gneiss-like rocks is highly developed, with joint planes exhibiting well-defined blocks and rectangular patterns. In the schistose rocks, fracture density is more intensive. Many of the fracture zones in the latter type of rock intersect valley walls; this causes groundwater to be collected in the fractures; thus providing potential pathways for seepage flow. In the bedrock, groundwater flow is mainly along fractures.

Superimposed on the natural groundwater system are sources and sinks created by mining. The open pit, more than 300 m deep presently, cross-cuts the hydrogeological connection between the existing processing plant situated above the Boulder Gorge fracture system and the Khan River receiving environment (Figure 2.6). It acts as a cut-off trench thus, and enables the interception and subsequent evaporation of potentially contaminated water moving downstream from the plant area. Furthermore, it creates a cone of groundwater table depression that cuts off groundwater flow through bedrock and alluvial channels. Around the open pit hydrogeological parameters of storage and permeability are very low; permeability of the bedrock ranges between 1×10^{-8} cm/s and 4×10^{-6} cm/s; porosity is less than 0.01 m per day. The amphibole schist horizon and the SJ Fault are two thin but substantial features of higher permeability (0.2 m per day compared to 0.005 m per day of the surrounding rocks) that cut the pit longitudinally. They connect the void to the bounding fracture systems of the Pinnacle Gorge to the west and Dome Gorge to the east. The two horizons cause a redirection of groundwater flow towards the pit void cone of depression, away from the Khan River. Thus, these features act as natural drains for potential fracture flow of tailings seepage water from underneath the gorges into the pit, passively assisting long-term seepage control.

The current elevation of the bottom of the pit is substantially lower than the level of the Khan River – 3 km to the south, and the regional water table – about 20 m below ground. The Khan River is also separated from the pit by a low-permeability rock mass and the possibility of water from the Khan River entering the pit void is significantly reduced this way.

The natural groundwater quality in the vicinity of Rössing is very saline with Total Dissolved Solids (TDS) concentrations of 20 000-40 000 mg/L on the desert plains in the north-west. The water quality improves gradually to TDS <10 000 mg/L in a south-easterly direction towards the Khan river. The tailings facility creates an anomaly of more saline water (20 000-40 000 mg/L) in an area of naturally intermediate salinity (10 000-20 000 mg/L). The tailings solution itself is highly saline (>40 000 mg/L), but it is reused in the process and not allowed to interact with the environment.

Table 2.2: Typical Khan River quality (in 2020) compared with Namibian stock-water guidelines

Determinant	Stock-watering standard	Khan River borehole (BH 1.6A)
Conductivity (mS/m)	3500	872
Sodium (mg/ℓ)	2000	888
Calcium (mg/ℓ)	1000	562
Magnesium (mg/ℓ)	500	251
Chloride (mg/ℓ)	3000	3050
Sulfate (mg/ℓ)	700	621
Nitrate (as N mg/ℓ)	400	<0.5
Fluoride (mg/ℓ)	6	5.6

Groundwater quality data for the Khan and Swakop rivers indicate a variable composition that improves after floodwater recharge, but generally deteriorates with distance downstream.

Khan groundwater in the vicinity of the mine is brackish with an average TDS concentration around 5000 mg/L. The lower courses of the Khan and Swakop rivers contain brackish to saline groundwater that is not suitable for human consumption.

The only groundwater potentially suitable for agricultural use near Rössing is found in the Khan River. This water is brackish and only suitable for livestock watering[28]. Table 2.2 shows typical selected analyses of Khan River water abstracted from boreholes in the river bed, compared with Namibian guidelines for stock watering.

As a result of the high salinity of the water in the Khan River the only beneficial uses of the water are for industrial purpose, such as for dust suppression. Despite its salinity, the very hardy natural vegetation along the river depends on this water and abstraction is closely coupled to monitoring of the water table. Current groundwater use of the Khan River is limited to environmental use downstream of the mine and there is no danger of an adverse effect on the primary use potential of this resource.

[28] SRK, (2010)

2.11 AIR QUALITY[29]

The arid climate at Rössing is typified by daily temperature ranges that often exceed 20°C, an average annual rainfall of around 30 mm and evaporation potential is about 4,896 m3/day. Under these conditions air quality is prone to airborne dust and other impurities, a situation which is enhanced by atmospheric movements. Average daily wind speed is 4.35 m/s with the highest maximum wind speed over a one-hour period recorded at 17.20 m/s. These velocities usually occur during the winter and gusts of up to 34.90 m/s have been known to occur. The mean maximum gust is 26.17 m/s. Predominant winds are southwest in direction, or alternatively, east to northeast.

Potential for the transport of dust and other impurities via atmospheric pathways towards inhabited areas is dependent on the direction of receptor points relative to wind direction. Table 2.3 summarizes localities relevant to wind direction at Rössing.

Table 2.3: Geographical position of localities relative to wind direction

Locality	Distance	Direction	Relative to wind direction
Arandis Town	5 km	Northwest	Does not lie in the direction of E, NE, or SW winds
Arandis Airport	6 km	West	Lies in the direction of E wind
Swakopmund small holdings	50 km	Southwest	Lies in the direction of NE wind at a distance
Swakopmund Town	60 km	Southwest	Lies in the direction of NE wind at a distance
Walvis Bay	75 km	South-southwest	Lies in the direction of NE wind at a distance
Henties Bay	88 km	Northwest	Does not lie in the direction of E, NE, or SW winds

Occasionally during winter, wind blows from the interior, mainly from the east or the east-northeast. These sometime high-velocity winds (average of 11.9 m/s with peaks exceeding 34.2 m/s) are accompanied by marked increases in temperature and sharp decreases in humidity, which causes the anomaly that the west of Namibia frequently experience the highest temperatures, lowest humidity figures and strongest wind during winter. These winds, known as *Bergwinds*, can carry large quantities of dust and can prevail from a few hours to a few days.

Generally deposited dust is not a health hazard, but because it is visible it is the cause of most complaints. While dust is in suspension, particulates with a diameter of less than 10μm might be inhaled, causing lung function disorders. If the dust contains silica, lead or radio-nuclides for example, it can present an additional health risk in the form of silicosis, lead poisoning or irradiation respectively. The degree of hazard is determined by the dust concentrations and the period of exposure. It is not only human health that can be adversely affected by dust: The fall-out of heavy metals onto soil and the foliage of plants also results in an adverse impact on the environment. The metal is either taken

[29] Additional information is contained in the Rössing Dust Management Plan, (2012)

up directly from the dust deposits on the foliage, or it is taken up by plants and concentrated in the leaves of the plants. This can result in the bio-accumulation of heavy metals and radio-nuclides in the food chain, with severe adverse impacts in some cases.

It is important to distinguish between total dust, which includes all fractions, and inhalable dust, i.e. particles with a diameter of less than 10μm (PM10). The sources of dust are divided into two: particulates and fugitive dust. Particulate dust is derived from controlled sources such as emissions and other point sources. Fugitive emissions refer to those air pollutants that enter the atmosphere without first passing through a stack or duct designed to direct or control their flow. Fugitive dust sources therefore can be considered as uncontrolled, or non-point sources which are mobilised by the forces of the wind or machinery acting on exposed materials. Examples of fugitive dust sources at Rössing are the tailings dam, the crushing circuit and the open pit. Furthermore, dust sources are classified as localised (from blasting, loading trucks, crushing ore or transfer by conveyor); diffused (from waste rock dumps or areas of disturbed ground) or linear (from roads, for example).

While most of the dust generated in the pit at Rössing is of a fugitive nature, blasting activities can be considered as a point source of particulates, from where dust is dispersed into the surroundings of the mine. The exact size of the blasting plume is unknown at present, but it is unlikely to increase in size because as the pit deepens, the effects of blast dust will become less. The dust plumes from the smaller blasts tend to disperse along the length of the pit and the dust settles on the benches and roads within the pit, only to be remobilised again by wind action and vehicles.

From the primary crushers coarse ore is loaded onto an open conveyor which feeds to the coarse ore stockpile. The ore on the conveyor is moist and therefore the potential for dust generation from the coarse ore conveyor is low. Once it is tipped onto the stockpile, the material dries out to and the fines becomes susceptible to wind action. There can be up to 20% fine particles (<45μm) by mass in the primary crusher feed, especially when weathered ore is being processed.

Of the eight (8) common air impurities identified, five (SO_2, CO, NO_x PM10 and dust deposition) are released at Rössing. However, only two are recognized as significant i.e. particulate matter smaller than 10 microns in diameter (PM10) and dust deposition, which are regularly monitored. Rössing conducts annual monitoring of SO_2, CO and NO_x that could be emitted as a result of the yellow cake roasting at the Final Product Recovery (FPR). Gas emissions sources include stacks, process fugitives and mobile equipment. Only the stack emissions gases from the final product recovery are currently quantified annually. In addition, greenhouse gas (GHG) emissions are estimated as carbon dioxide equivalent (CO_2-e) on a monthly basis, deduced from fuel consumption, electricity usage and explosives used for blasting.

Noise and vibration arising from exploration and operations, including mining, mineral processing, materials handling, infrastructure and on-site transport may have significant impacts on employees, communities and the surrounding environment. Noise, ground vibrations and air blasts can have an adverse impact on the general living conditions of species and / or lifestyle of its neighbours and need to be monitored in order to mitigate adverse impacts. For this purpose spot-checks, specific surveys and investigations and regular risk assessments need to be conducted. Air blast and ground vibration are monitored to provide information for geo-technical purposes as well, specifically to assess stability of man-made landforms.

2.12 SITES OF ARCHAEOLOGICAL AND CULTURAL INTEREST[30]

An assessment conducted in 2007 documented a total of 49 archaeological and historical sites at Rössing, mainly outside the mining operational areas, meaning that it is unlikely that important archaeological and historical sites were destroyed in the course of mining activity. Although there is some evidence of upper Pleistocene occupation, most of the archaeological sites date to within the last 5,000 years. Historical sites relate to the narrow gauge railway that operated between Khan Mine and Arandis siding until about 1918.

Many of the archaeological sites were confined to Panner Gorge and date between 2800 BC and AD 380. The third millennium BC, in climatic terms the mid-Holocene, was a period of above average rainfall in the Namib. This cluster of sites relate to the high quality chert for stone artefact manufacture and the strategic use of Panner Gorge as a hunting area. The chert artefacts mainly came from the prominent dolerite dyke striking in a SW-NE direction in the northwest corner of the mine tenement (Figure 2.7). Fragments of ostrich eggshell were also found at some sites in this cluster.

A second cluster of sites relates to grass seed digging activities in well-drained soils derived from weathered granite, estimated to post-date AD 1000. These sites occur mainly in the northern and north-eastern parts of the mine tenement (Figure 2.7) and relate to the seed-digging activities that still exist among Damara-speaking Namibians today. The seed digging sites are concentrated around a number of low-lying granite outcrops associated with shallow depressions, which may contain water after rain, in between. Two shelters and some coarse-tempered pottery as well as a pestle were found in this area, indicating that the possible ephemeral water supplies were used as base camps during the seed digging activities.

Thus, the Rössing tenement is not an area of outstanding archaeological importance and does not have the dense site clusters which are characteristic of some parts of the escarpment and ephemeral river systems of the Namib. The areas of highest heritage value lie outside the main focus of mining activity and the mining area and related high disturbance locations have a rather low heritage value. The sites also show a low vulnerability potential to disturbance. In general the archaeological and historical sites are mainly of a low individual significance.

[30] Further information is contained in a specialist report conducted for Rössing by Quaternary Research Services, (2007)

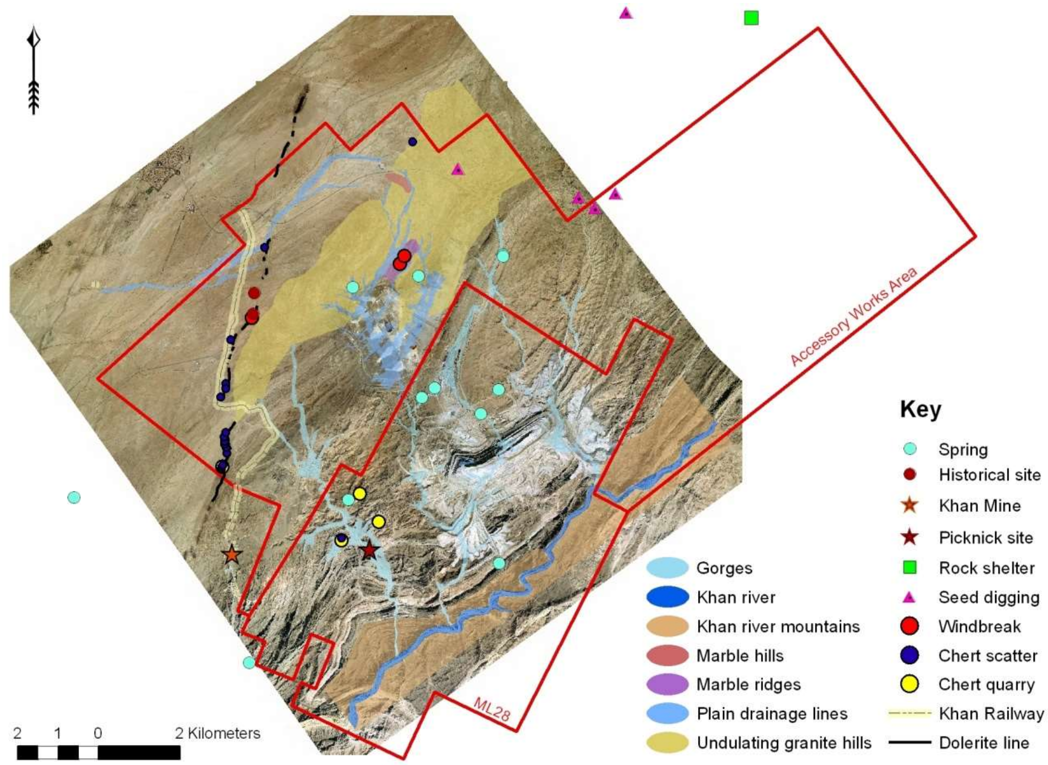


Figure 2.5: Archaeological and sensitive sites at Rössing

2.13 SENSITIVE LANDSCAPES[31]

Sensitive landscapes encompass a wide variety of site-specific points of interest as well as zonal areas, ranging from critical habitats or habitats occupied by threatened or endangered species to areas of historical (legacy), cultural and heritage importance. Sometimes the boundaries are well defined and the features clearly discernible (e.g. national parks), but sometimes the boundaries are uncertain, varying or vague (e.g. habitats). Sensitive features may also be located on adjoining land or include undefined aspects of a perceived value such as an ecosystem, landscape aesthetics or sense of place.

The Khan River and its associated rugged flanks are particularly scenic and have touristic potential. Places of archaeological and historical importance such as the former Khan Mine and the remnants of the old German railway line built in the early 1900s are part of this landscape (see also Figure 2.7). The naturalness, remoteness and cultural-historical importance of these landscapes are collectively known as their *sense of place*. Rössing highly respects sense of place and believes that maintaining this natural sense of place throughout the mine's life will result in a positive legacy after closure.

[31] Additional information is contained in the Rössing Land Use Management Plan, (2008)

Access to the Khan River and its associated mountains is limited. Its northern bank is part of the Rössing Mining Licence and its southern bank is part of the Namib-Naukluft Park. Along the Khan River and within the gorges several ephemeral springs occur, mostly after local rainfalls. From all the studies done by Rössing and others, these parts have shown biodiversity of high significance, especially within the wider landscape context. Several scarce plant species occur here; many animal species, especially invertebrates, are confined to the rocky hillsides; and the availability of water in the drainage lines create important ecological corridors, providing water, food, shelter and migration routes. Although vulnerable, because the river is relative inaccessible, the Khan River and its associated mountains enjoy implicit protection. In combination, the inaccessibility of hilly and mountainous terrains, the tourism potential and the conservation status of the zone south of the Khan River qualifies the area clearly as a sensitive landscape that needs protection and wise management.

2.14 VISUAL ASPECTS

At Rössing the visual impacts of man-made landforms such as the tailings facility and the waste rock dumps can have an adverse effect on the landscape aesthetics. Moreover, the appearance of man-made landforms has a definite cumulative impact, often centred on visual contrast, which needs to be understood and managed. In addition to visual contrast, visual absorption capacity needs to be considered when determining impact significance. This refers to the capacity of the receiving environment to absorb the visual intrusion and typically relates to colour, shape, form and texture.

Objectives of minimising the visual impacts of the final heights and shapes of man-made landforms thus need to be set, requiring maintaining the characteristics and attractiveness of the surrounding, wider landscape. Although the design of mitigation measures and the evaluation of options need to take the visual aspects of surrounding landforms into consideration, the ultimate goal is to maintain or create a sense of place that is characteristic of the environment and valued.

Sense of place at Rössing has already been significantly impacted due to the long period the mine has been operating. To the contrary, the landscape character of some surrounding areas such as parts of the Khan River and the Welwitchia Plains remain intact due to the stark skylines constituted by the rugged terrain.

Higher levels of visual intrusion as a result of the vertical rise of the tailings facility are possible. Height of the tailings beyond 680 mamsl can have higher levels of contrast created by massing and scale. Waste rock dump heights have reached levels that are about the same elevation as the surrounding topography and visual impacts of these man-made landforms are restricted to a small number of viewing points outside the Mining Licence and accessory works areas.

2.15 REGIONAL SOCIO-ECONOMIC STRUCTURE[32]

The Erongo Region, located in west-central Namibia and measuring nearly 64,000 km^2 in size, is sparsely populated. Just over 150,000 people, or about 7% of Namibia's total population, live in the region. More than 80% of these people live in the urban areas. Three of the region's eight towns are located along the coast and includes the major towns of Walvis Bay and Swakopmund with the latter as the capital of the region. In addition to mining-support businesses, tourism is regarded as an important economic activity for Swakopmund while Namibia's only deep-water harbour is located at Walvis Bay, which makes the town an important hub for the fishing, shipping, storage and transporting industries. Mining and Agricultural are key drivers for the micro and macro economy with agriculture limited to stock farming and mostly located in the more arable eastern parts of the region and operating mines delving for uranium, gold granite, marble, semi-precious stones and salt.

Erongo has a well-developed infrastructure, second to the Khomas Region. Mining, fishing, tourism, transportation and storage comprise the principal economic activities in Erongo, with most of these taking place in the western and coastal parts of the region.

Namibia's next census is scheduled to take place on August 29th, 2021.

Based on the National Census of 2011, the Region's population was pegged at 150,000 (from 107,000 in 2001). In the ten year period from 2001 Erongo's population grew by 40%, the highest in the country. Much of this occurred in the three constituencies of Arandis, Swakopmund, and Walvis Bay, which had a combined growth of 50%. The high growth figures are suggestive of high in-migration to the region and specifically to Walvis Bay, Swakopmund and Arandis. Based on the 2001 census, only 43% of the region's population were born in Erongo, indicative of high migratory tendencies. This confirms Erongo as a labour-receiving region, and could further explain the dramatic rise in population size. This fact is underlined by a high concentration of a working age population of between 15–59 years (66%), the second highest in the country after the Khomas Region. Erongo has nearly 45,000 households with an average household size of 2.6, the lowest in the country. Nationally, there are over 465,000 households with average size of 4.4.

The Namibian population was projected at 2.6 million in 2019[33]. In 2020 the Erongo region had 119, 784 registered voters. The 2011 census had the following key findings: At 97%, Erongo has the highest number of literate persons in the country aged 15 and above. Country-wide literacy rate is pegged at 88%. Erongo also has a very low percentage of non-literate persons between the ages of 15 and 24 at 1.4%, compared to the country average of 5% and urban average of 2%. About 72% of the region's population aged 15 and above are estimated to have attained secondary education – the highest level in the country. Also, half of the unemployed in the region have up to junior secondary education and about 25% have obtained senior secondary education. The region is also estimated to have the second highest proportion (7.4%) of individuals with tertiary qualifications.

---

[32] Additional information relevant to this section is contained in the Rössing Closure Management Plan, (2011), updated from the preliminary results of the 2011 Population and Housing Census by the National Planning Commission, (2012).
[33] Namibia Statistics Agency, 2021

There are more than 60 schools in the region, which are made up of 33 primary schools, 6 combined and 16 senior secondary schools and additional 10 schools that are run privately. There are 21 public health facilities in the region comprising 4 public hospitals, 2 health centres and 15 clinics. Privately operated facilities also exist, but mainly cater for individuals with medical insurance and the wealthy.
The residents' high dependence on wages and salaries as the main source of income for 76% of households is consistent with most urbanised centres in the country, and second only to the Khomas Region. While unemployment remains a significant challenge in Erongo, with 22.6% of the labour force estimated to be jobless, this figure is lower than the rest of the country. Poverty levels are on the lower side of the scale, with only 5.1% of all households in Erongo being considered poor, the lowest in the country. Households in the region spend about 17% on food and beverages (2nd lowest in the country), 23% on housing (3rd highest), 20% on transport and communication (2nd highest) and other unspecified items.

Housing conditions and tenure seem to follow patterns that can be observed in all of Namibia's urbanised centres. That is, over 55% of households live in detached or semi-detached houses, with a significant proportion – nearly 35% – living in improvised housing units or shacks. Tenure levels are spread across rented and owner-occupied dwellings. Erongo has the highest proportion of households in rented dwellings compared with the rest of the country, with 26% of households renting their homes. Once again, this seems to confirm the view of the region as a labour-receiving area.

2.16 INTERESTED AND AFFECTED PARTIES

The following stakeholder groups were identified as key interested and affected parties consulted in engagement processes, related to Environmental Impact Assessments, at Rössing:

- The Namibian State, specifically the following ministries:
    - Mines and Energy,
    - Health and Social Services,
    - Labour and Social Welfare,
    - Environment, Forestry and Tourism,
    - Agriculture, Water and Land Reform,
    - Education,
    - Urban And Rural Development, and
    - Ministry of Finance
- Regional and local authorities:
    - Erongo Regional Council,
    - Swakopmund Municipality,
    - Walvis Bay Municipality, and
    - Arandis Town Council;
- Parastatal service providers
    - NamPort;
    - NamWater;
    - NamPower;
    - TransNamib;
    - Roads Authority;
- Other service providers
- The !Oe#Gan Traditional Authority;

- Other uranium mines in the Erongo Region;
- Rössing Uranium;
- The Rössing Foundation;
- Organised labour;
- The media;
- The farming community, both small-scale and commercial;
- Economic sectors which may be affected by mineral exploitation, e.g. tourism;
- Community groups and social institutions in Swakopmund, Walvis Bay and Arandis.

3 DESCRIPTION OF THE CURRENT OPERATION

Although the extent of linear infrastructure at Rössing is comparable with that of a small Namibian town, it does not cover a large surface area. Including the linear infrastructure, the total surface area of land disturbance at Rössing according to man-made landforms, i.e. the direct footprint, is about 2,558 in 2020 ha. This area represents about 20 % of the total land of 13,003 ha under Rössing auspices. The footprint did not increase substantially over time.

To portray the footprint better, the production and extraction process at Rössing is briefly described below. It is followed by a description of the main components of the mining activities that caused the direct footprint, followed by a brief description of components of the socio-economic footprint of the company.

3.1 PRODUCTION PROCESS

The current mining sequence is a conventional drill, blast and load operation on a large scale. Mining is done by blasting, loading and hauling from the main open pit, referred to as the *SJ Pit*, before the uranium-bearing rock is processed to produce uranium oxide.

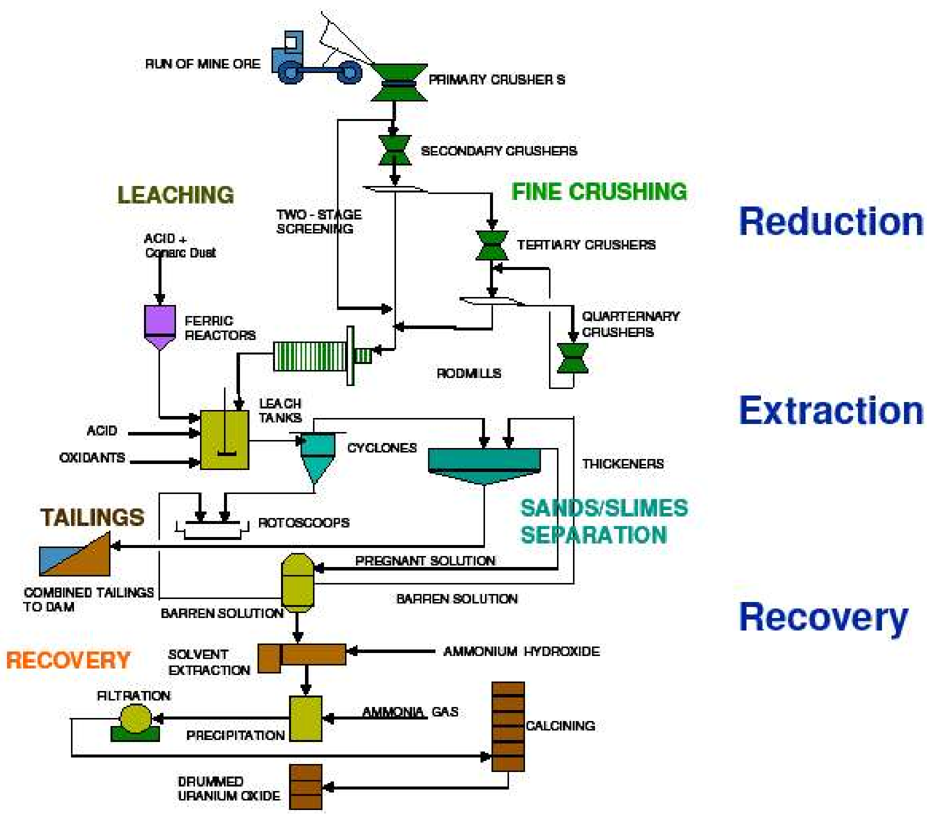


Figure 3.1: A simplified flow diagram of the production process at Rössing

The run of mine material from the open pit is fed through primary and secondary crushers to the processing plant. The metallurgical process is a conventional acid leach with ion exchange solution concentration and solvent extraction purification, followed by the precipitation of ammonium diuranate and roasting to produce uranium oxide. The final product, U_3O_8 concentrate, is of a low radiation level and loaded into steel drums, containerised and dispatched via Walvis Bay for export to conversion and enrichment facilities in other parts of the world, to be processed as nuclear fuel for use in power plants. Figure 3.1 simplifies the production process at Rössing as a flow diagram.

The stages of processing and extraction are described in more detail in the following sections[34].

3.1.1 MINING

Ore is extracted from the hard rock by blasting. The explosive used is a mixture of 60% Emulsion (E6000HR) and 40% Ammonium Nitrate Prills (Expan 200), this explosive mixture is well known as High Energy Fuel (HEF) 260. Blasting takes place on average once a week, using approximately 200 tonnes of explosives per blast. A total of 10 000 tonnes of explosives is consumed per year.

3.1.2 CRUSHING

Ore from the open pit is delivered in 140 and 180 tonne haul trucks to the primary crushers, where two gyratory crushers reduce the ore to less than 160 mm in size. A conveyor belts transports the crushed ore to a coarse ore stockpile with a live capacity of some 80,000 tonnes (see Figure 3.2).

Coarse ore is withdrawn from the stockpile by vibrating pan feeders, feeding directly onto a coarse ore reclaim conveyor. This conveyor discharges the ore to a pre-screening plant where all fines are removed and the coarse material returned to the surge bin ahead of the secondary crushers. The ore is further processed through secondary, tertiary and quaternary stages of crushing and screening, delivering a final product of less than 19 mm in size to the fine ore stockpile. The crushing circuit is equipped with an adequate system of dust extraction and collection into covered lugger bins. There are, in total, ten collection systems that provide extraction points from the reclaim tunnel to the fine ore storage bin.

[34] See Section 3.4 (open pit mining operations, p 46 – 53), Section 3.5 (processing operations, p 53 – 59), Section 3.6 (waste disposal, p 59 – 72) in Ashton, *et al.*, (1991). Recent information relevant to this section was also obtained from Rössing's Radiation Management Plan (2012)

Figure 3.2: The coarse ore stock pile at Rössing

3.1.3 MILLING AND LEACHING

The final stage of size reduction employs four Marcy rodmills operating in parallel. This milling stage comprises two modules that can be operated independently. Each module consists of two rodmills which feed into six leach tanks respectively. Grinding in the rodmills is a wet process, with feed water that can be any one or a combination of fresh water, return dam solution from the tailings impoundment and seepage water from the seepage dam. The final particle size leaving the rodmills is 1.1 mm in diameter on average.

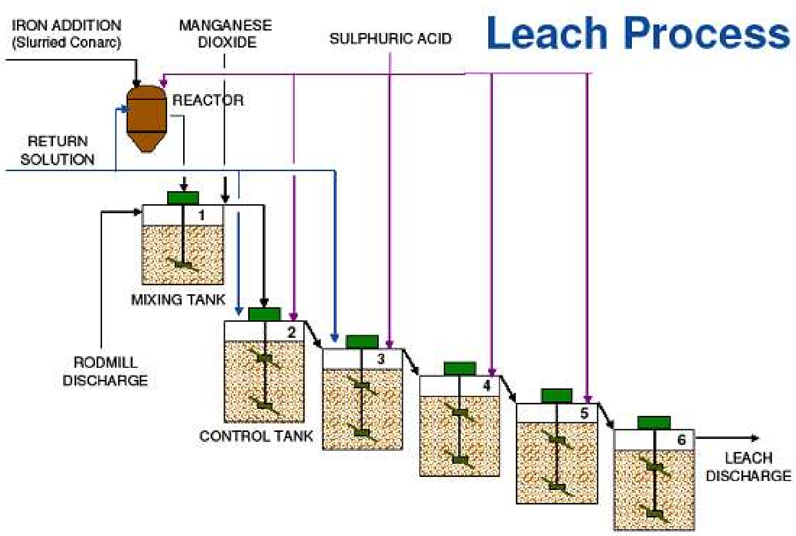


Figure 3.3: The leach process at Rössing

The resulting slurry is pumped from the rodmills to the leaching section where it is mixed with sulphuric acid, ferric iron and manganese dioxide in a series of six leach tanks (see

Figure 3.3). The first tank in the series (290 m^3 capacity) is considerably smaller than the other five (1,450 m^3 capacity), thus ensuring adequate mixing of reagents and leach feed.

The steel leaching tanks are rubber-lined and mechanically agitated. Retention time in the leaching section is 8−9 hours at a temperature of 35°C, with uranium extraction of 85−90%. Gases and fumes generated during the leaching process are captured on top of the leach tanks by means of scrubbing units. The reagents used for leaching are:

- Ferric iron to oxidise the uranium from a tetravalent to a soluble hexavalent state. Ferric iron is obtained by reacting iron oxide with 93% sulphuric acid in special Rössing designed reactor vessels. Iron oxide (haematite) is brought in by truck in 1 m^3 mega bags.
- 93% sulphuric acid for extraction. Sulphuric acid is imported through the harbour in Walvis Bay, railed to site and stored in large acid tanks prior to being delivered to the leach tanks.
- Manganese dioxide to oxidise ferric iron to ferric. Manganese dioxide ore is delivered to the harbour in Walvis Bay by ship and then railed to site and stored in a storage bunker. It is transported by front end loader to a crushing, grinding and thickening plant adjacent to the leach modules where a finely ground slurry is produced and delivered to the leach tanks as part of the extraction process.

3.1.4 THE SANDS / SLIMES SPLIT

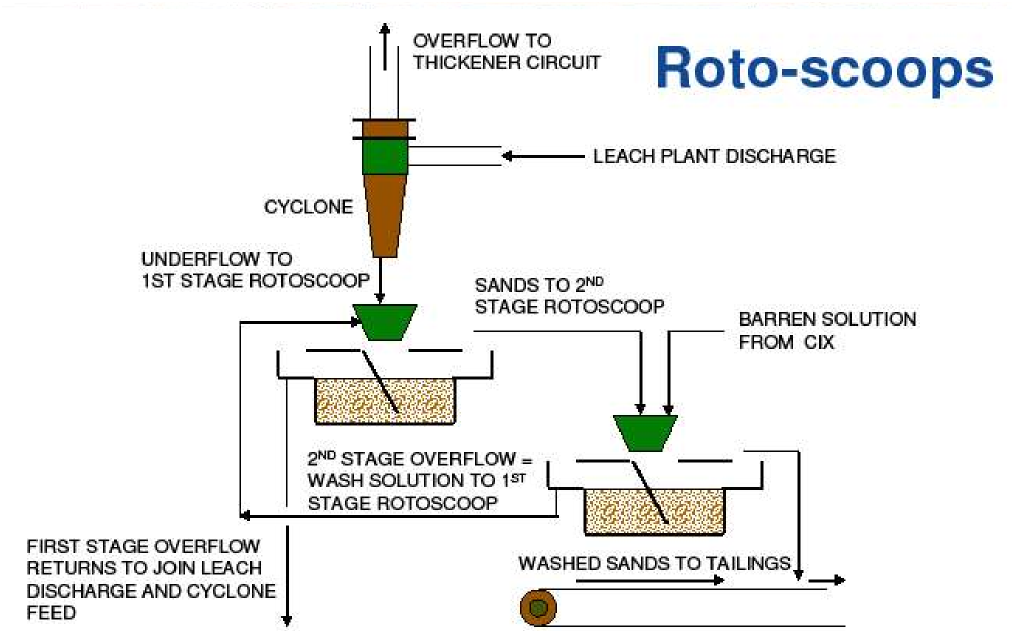


Figure 3.4: Washing circuits

Pulp leaving the final leach tanks flows into a ten-way motorised pulp distributor and thence to 10 hydro cyclones. A sand/slime split occurs here with the slime fraction (cyclone overflow) directed to a counter current decantation (CCD) thickener circuit (see Figure 3.4). The coarse sand fraction (cyclone underflow) reports to one of ten primary rotoscoops. There are 20 rotoscoops in each module arranged as 10 discrete pairs, a primary and secondary unit each, providing a two stage sands washing circuit. Barren solution from the continuous ion exchange plant is used as the wash medium on all second stage units. Washed sands are removed from the second stage rotoscoops by a conventional conveyor belt.

3.1.5 THE SLIMES WASHING – CCD THICKENERS

Slimes (cyclone overflow) washing is carried out using a five stage CCD thickener circuit (see Figure 3.5). The first stage consists of four identical thickeners with the slimes fraction distributed equally to two of them. The third and fourth thickeners are used as clarifiers. First stage thickener underflows are re-combined and progressively pumped through four further stages of thickening and re-pulping, thus five washing stages are achieved. Continuous ion exchange (CIX) barren solution is introduced into the fifth washing stage. This runs counter current to the slime flow, and provides the wash medium taking up the uranium. First stage thickener overflow, called "pregnant solution", contains uranium (uranyl sulphate), at a concentration of 0.180 g/L.

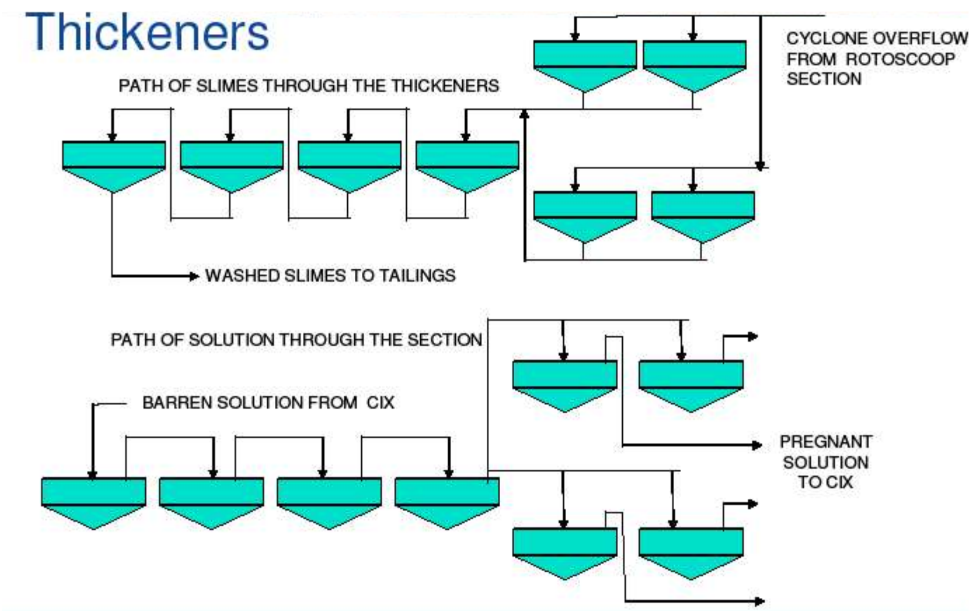


Figure 3.5: CCD Thickeners

3.1.6 TAILINGS DISPOSAL

The slimes from the fifth thickening stage are pumped to the tailings facility to the mixing and tailings pumping station at Paddy X via a pipeline, while sands and the coarse material from the second stage rotoscoops are sent to the station via the sands conveyor. The slimes and sands are re-combined prior to disposal. The solids settle out while the effluent (return dam solution) is pumped back to the processing plant for re-use at the rodmills.

3.1.7 CONTINUOUS ION EXCHANGE

First stage CCD thickener overflow (pregnant solution) is pumped to a pregnant solution storage tank situated near the CIX plant (see Figure 3.6). Tank discharge is by four pumps, each delivering to one line of the CIX contactors. The Rössing CIX plant is built on the Porter system, which uses the upward flow of pregnant solution to fluidise a bed of ionic resin beads in a series of six contactor chambers per line. The flow of pregnant solution is counter current to the resin movement. There are four lines of CIX contactors with six chambers in each line. Resin transfer from one contactor to the next is carried out by air lifter units of which there are six per contactor. Loaded resin from contactor 1 in each line is transferred to the elution columns. Three elution columns per line of contactors are provided; these take the form of fibreglass lined mild steel pressure vessels. Sulphuric acid (at 10% concentration) is passed through the resin bed, stripping the uranium from the resin beads during its passage. Stripped resin is then returned to the contactor line and the uranium rich concentrated eluate is pumped to solvent extraction. The eluate has a uranium concentration of 4 – 5 g/L.

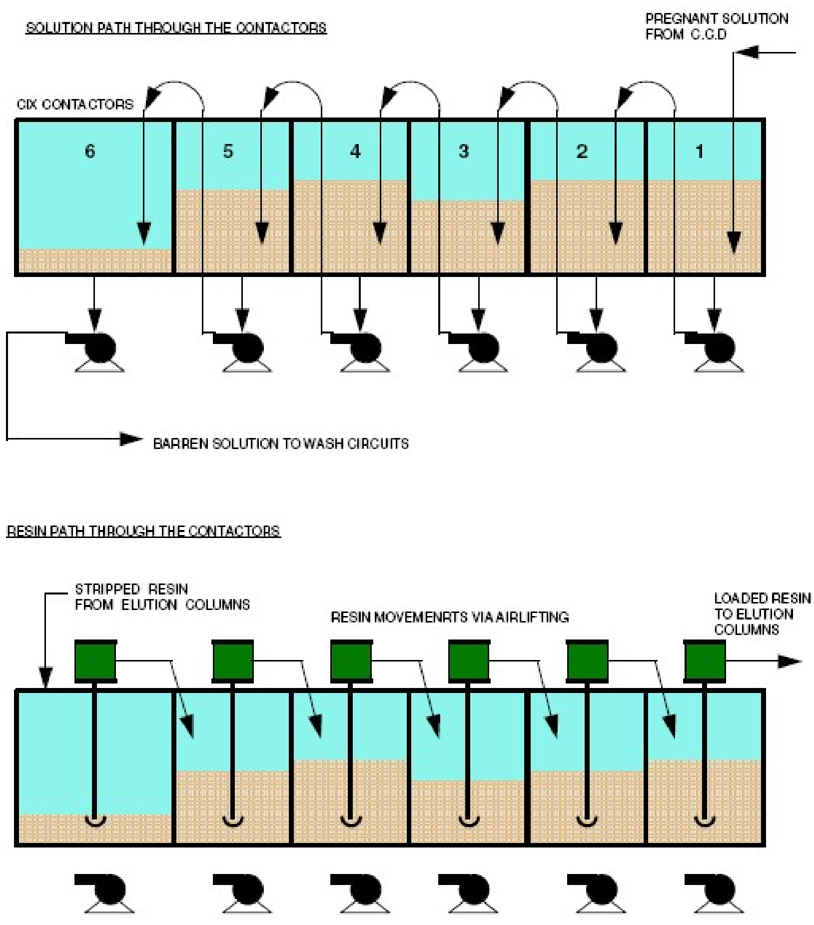


Figure 3.6: Continuous Ion Exchange (CIX)

3.1.8 SOLVENT EXTRACTION

Concentrated eluate containing 4 to 5 g/L uranium is pumped to solvent extraction as the aqueous phase of the extraction process (see Figure 3.7). The organic phase is Shellsol, containing alamine 336 and isodecanol. Extraction, i.e. transfer of uranium from the aqueous to the organic phase, is carried out in five stages of counter current contact using Davy Powergas mixer settler units. The loaded solvent is then passed through a two unit clean water scrubbing stage prior to a four unit stripping stage where the loaded solvent (organic) is mixed with a 7% ammonium sulphate (aqueous) solution under pH control with aqueous ammonium hydroxide. Uranium is stripped into an aqueous phase and is pumped to the final product recovery plant as OK liquor (concentrated uranium diuranate solution) containing 8 to 20 g/L uranium. The stripped solvent returns to the extract mixer settlers to repeat the process as described above.

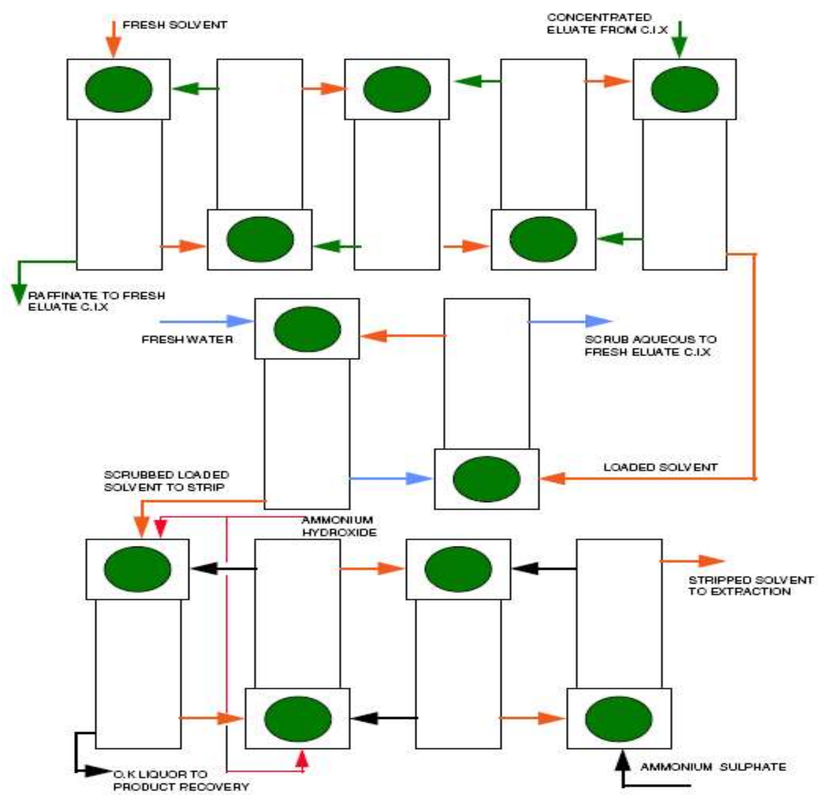


Figure 3.7: Solvent extraction

Strict fire protection procedures are in force at the Solvent Extraction (SX) plant. These include:

- Restricting access to area;
- Annual induction for all personnel who enter the SX area for any reason;
- Prohibition of matches, cigarette lighters or any other combustible material within the designated area.
- Regulation of hand tool types such that the possibility of creating a spark is minimised.

- A comprehensive fire protection system attached to and serving all mechanical equipment and storage tanks. This system comprises fixed water sprays on the outside of all mixer settler units and storage tanks.

Mixer settler units are also equipped with an internal foam injection system. The system is activated manually on receiving a signal from sensing devices located inside and outside the various items of equipment. Automatic initiation of the systems will activate the water sprays only.

3.1.9 FINAL PRODUCT RECOVERY

OK liquor, the chemical solution containing uranium trioxide, is pumped to the FPR building from the SX plant. The first stage of final recovery is the precipitation of ammonium diuranate (yellowcake) from the OK liquor. This is carried out in an agitated precipitation tank. Gaseous ammonia is added to raise and maintain the pH of 7.3. Precipitation tank discharge gravitates to a yellowcake thickener. Thickener overflow (ammonium sulphate) is returned to the SX strip mixer settlers while underflow material is pumped to a two stage washing section. Washing is carried out by two drum filters in series equipped with overhead water sprays. Filter cake from each stage of washing is re-pulped with process water. Re-pulped second stage filter cake is fed into one of the two multi-hearth calcining furnaces. Each furnace has six hearths and is heated to 700°C on the final hearth. The yellowcake feed is calcined to uranium oxide and is discharged via a hammer mill to an automatic drum filling plant. Final product at ± 98.5% U_3O_8 is dispatched in sealed drums, each drum automatically washed and dried and weighing ± 450 kg.

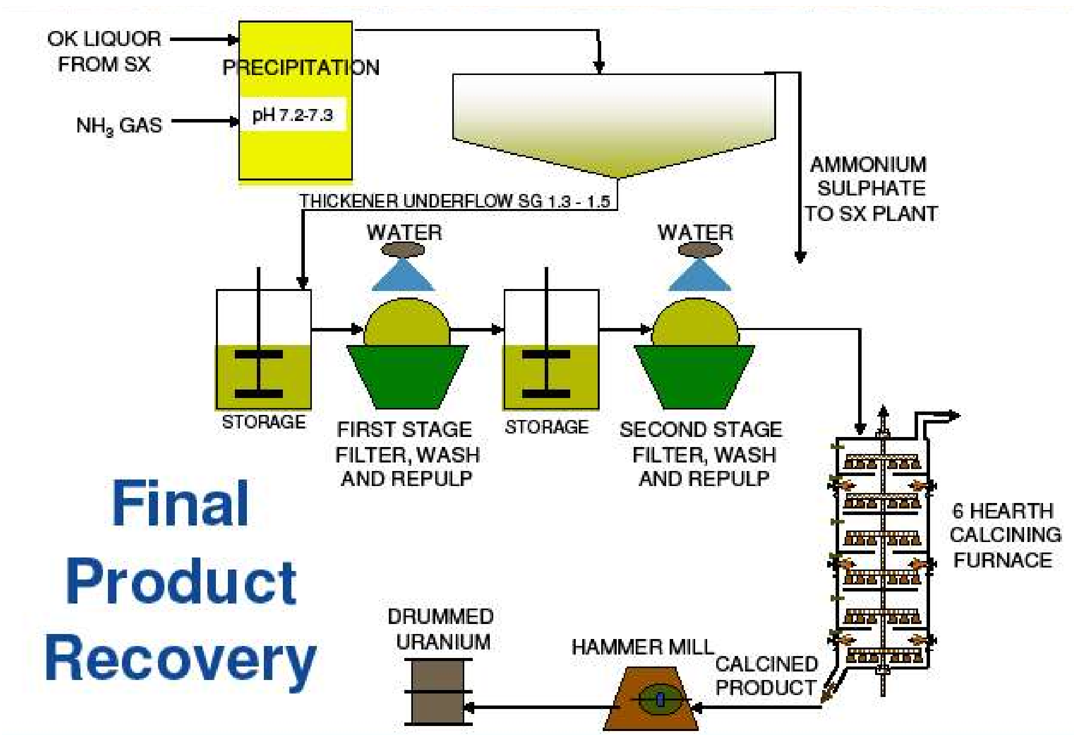


Figure 3.8: Processes of the Final Product Recovery

Gases and calcine particulates generated and emitted from the process are prevented from entering the atmosphere by means of an extraction and dust collection system and two wet venturi type scrubbers.

A summary of the processes at the FPR is shown in Figure 3.8.

3.2 COMPONENTS OF THE CURRENT LAND FOOTPRINT

As a large-scale open pit operation, the majority of Rössing's land footprint comprises of huge man-made landforms which include the open pit, the waste rock dumps, the tailings facility and the processing plant, offices and administrative buildings. These man-made landforms are clearly visible from air (see Figure 3.9) and in combination with the linear infrastructure on site, account for almost 90% of Rössing's current land footprint. The linear infrastructure and man-made landforms are described below.

Figure 3.9: Aerial view of Rössing

3.2.1 LINEAR INFRASTRUCTURE

Linear infrastructure at Rössing is connected to buildings for workshops, laboratories, medical, personnel and administrative use, gardens, security facilities, a landfill site, parking lots, domestic and industrial waste demarcated areas and storage facilities for fuel, consumables, explosives and chemicals. Linear infrastructure connections to Rössing are indicated in Figure 1.4.

3.2.1.1 Road and rail infrastructure

The D1911 district road branches off from the B2 national road between Swakopmund and Usakos to connect Arandis with the national road network. A 6 km-long double-lane tarred road from the Arandis turn-off provides access to the mine. This latter road consists of the short D1905 and the private road section.

On-site, the infrastructure consists of a main tarred road with a network of various tarred and gravel access and haulage roads and tracks, with a total distance of around 30 km. From the B2, uncontrolled access to the site is possible on the gravel track via the Arandis Airport to the Khan River and, hence, the Welwitschia Plains in the Namib-Naukluft Park. This track is partly situated on the mine accessory works area.

A full-gauge railway line link connects the mine site to the main TransNamib railway line between Swakopmund and Usakos from the Arandis siding. On-site, the railway line has four branched sidings.

3.2.1.2 Water infrastructure

NamWater's Rössing terminal reservoir is connected to the mine with a 600-mm pipeline. The water infrastructure on site exists furthermore of a network of water supply pipelines and storage reservoirs, a series of borehole pumping stations in and along the Khan River and a network of monitoring boreholes scattered over the mining tenement as well as an extensive system of sewerage and effluent pipes that drains to an activated sludge treatment plant near the open pit. In 2020, Rössing's Investment Committee approved a capital project for the construction of six (6) additional water reservoirs to collective capacity of 60 000m^3. The Project is envisage to commence in 2021, with commissioning scheduled in Q1, 2022.

As a result of the drive that began in the late 1980s to reduce water consumption at Rössing, today about 60% of plant solution utilised at the mine is recycled by means of a closed water system. An extensive water infrastructure network exists on site.

The Department of Water Affairs (DWA) of the Ministry of Agriculture, Water and Land Reform permits Rössing to extract brackish water from the Khan River aquifer for industrial use. Power lines and pipelines connect the abstraction system to the mine's water distribution network. Water from the Khan is mainly used for the suppression of dust in the open pit.

3.2.1.3 Power infrastructure

Power is supplied from the national grid by NamPower. Rössing itself has a switching substation, from where power is distributed to the mine, to Arandis, to the NamWater booster stations along the pipeline, and to the Arandis Airport. At Rössing the 220 kV power supply is stepped down to 11 kV into a network of overhead and underground cables. The power line supplying power to the external sites partly runs along the southern slope of the tailings facility.

Rössing's main 11 kV substation distributes power to the various areas via overhead and underground cabling. Furthermore, equipment is fed from 6.6 kV, 3.3 kV or 550 V lines, which are stepped down by transformers at various substations.

Trolley assist technology is utilised in the open pit to increase the energy efficiency of haul trucks. The haul trucks can be operated by diesel fuel or electricity. Overhead lines are erected on haul truck runs which are economically viable, upon which haul trucks engage trolley assist mode in order to operate on electrical power. Shovels in the open pit use power via portable 6.6kV transformers.

3.2.1.4 Telecommunication infrastructure

A total of 624 landlines exist on-site. Rössing also makes use of a 20 Mbps Telecom Metro ethernet network to enable information technology (IT) network functioning on-site and at the Corporate Offices in Swakopmund.

On-site, the IT network consists of a fibre-optic backbone connecting four distribution points to two data centres. The fibre-optic cable is mostly trenched across the mine site, but several aerial fibre cable lines also exist. From the distribution points, fibre-optic cables branch out to the relevant buildings.

3.2.2 THE OPEN PIT[35]

The open pit at Rössing is the longest-running and one of the largest open pits in uranium mining in the world (see Figure 3.10), measuring about 3,200 m by 1,500 m. The depth from the pit rim, 555 m mamsl, to the currently lowest operating bench (165 mamsl) is approximately 390 m, about 150 m below the level of the Khan River alluvial aquifer situated 3 km to the south.The pit is roughly rectangular in shape with the longest axis oriented approximately east–west, cross-cutting a north-easterly trending ridge which is bounded to the southwest by Pinnacle Gorge and the northwest by Dome Gorge.The area disturbed by the pit void and its margins is approximately 450 ha and it is expected that the final footprint of the pit would be about 470 ha in 2021, after all the extensions.

The pit void is mined by a conventional truck-and-shovel operation, with mining being conducted in 15 m benches. Pit ramps are 40 m wide and established at a maximum 10% gradient. The central benches of the pit are generally in excellent condition – a result of good pre-split blasting techniques. The upper and lower benches are in poorer condition as a result of over-blasting, potentially affecting the stability of the pit rim. Nevertheless, the rocks making up the pit walls, despite being heavily jointed, have high strength values. There is also little seismic activity in the area. Sudden rockfalls and failures are thus rare.

Production at Rössing between 1980 and 2004 fluctuated in response to the volumes required by the long-term sales contract portfolio. Development of the open pit fluctuated accordingly. Mining had reached Bench 20 in 2004, when a decision had to be taken whether to close the mine in 2009 or extend operations to 2016. During 2005, RUL Board approvals were obtained for extending the life of the mine, by introducing the concepts

[35] Additional information relevant to this section is contained in the Rössing Closure Management Plan (2011)

of mining two separate pushbacks, named Phase 2 and Phase 3. The Phase 1 extension was completed in 2010, when mining in the centre of the pit was stopped at Bench 29 because of limited mining space and rockfall hazards. The piloting of Phase 2 mining started in the north-western part of the pit in 2006 while the Phase 3 push-back on the southern side of the pit commenced in 2007. The final depth of the open pit, within the context of the currently approved Life-of-Mine plan, will be reached in 2026 at Bench 34, approximately 60 metres above mean sea-level (amsl).

Figure 3.10: The pit void at Rössing, looking northeast from the current viewpoint.

Mining activities in the lower part of the pit have been abandoned towards the end of 2010 and have been refocused on the higher lying benches of the next set of push-backs, located in the south, west and northwest of the existing excavation. As the new pit walls cut their way through severely folded geological domains, constant monitoring and assessment of pit limits and haul roads is taking place, in order to ensure that potential high wall failures won't put the business at risk.

Infrastructure in the pit consists of a trolley-assist with power cables and transformers, installed in 1986, as well as water distribution pipelines. Radiometric scanners are used to measure the grade of truckload material in order to direct allocation to the crusher or at the low-grade stockpiles and waste rock disposal areas. As the new ramps are starting to evolve, the existing trolley-assist infrastructure is being relocated. As such, trolley 13 has very recently been commissioned and will be the waste conduit for the next four years to the eastern stockpiles. Furthermore, Trolley 12 is in the process of being commissioned and will be the main ore conduit from the pit to the primary crushers and stockpiles, until end of the current mine life.
Due to the inaccessibility of the Khan Mountains and the steep slopes of the waste rock dumps, access to the pit void from the south, south-east and east is restricted, and can

be regarded as impossible. Access from the west is restricted and the only permitted access is from the north, by coming from the main entrance of the mine.

Mining of the small satellite pit known as *SK4*, and situated 1,200 m to the east of the SJ Pit, commenced in 2010 and was completed in 2011. The 97.5 m-deep SK4 Pit void has a final volume of 164,000 m³, a footprint of 4.03 ha, and a depth of 442.5 m above mean sea level at the bottom of the pit.

Public access to the open pit from the northern directions is only possible through the main entrance of the mine. Otherwise the surrounding waste rock dumps and rugged terrains on the southern, eastern and south-eastern sides limit wildlife, and human, access to the open pit. From the west human access is not permitted.

The open pit cross-cuts the hydrogeological connection between the existing processing plant situated above the Boulder Gorge fracture system and the Khan River receiving environment. In this way the pit acts as a cut-off trench, and enables the interception and subsequent evaporation of water moving downstream from the plant area. A pit lake at the bottom of the pit is absent. The elevation of the bottom of the pit, furthermore, is substantially below the level of the Khan River – 3 km to the south – and the regional water table is about 20 m below ground. The direction of groundwater flow is towards the water table depression around the pit, and not away from the pit into the surroundings. The Khan River, in turn, is separated from the pit by a low-permeability rock mass, significantly reducing the possibility of water from the Khan entering the pit void.

3.2.3 THE WASTE ROCK DUMPS[36]

The total footprint of the waste rock dumps in 2020 is about 755.2 ha. Approximately 991.7 million tonnes of waste rock were mined and disposed. The stockpiles have a combined footprint of more than 120 ha. The rock dumps' footprint increased in both the western and eastern areas of the open pit, with waste dump 2 increasing to 1.4 ha and waste dump 7 to 3.0 ha. In general, rock disposal sites are established as close to the major mining areas as possible (Figure 3.11). The current waste rock dumps and low-grade stockpiles consist of a mix of the abundant rock types in varying and random proportions. No deliberate efforts are made to segregate specific rocks when dumping, but minimising haul distances from the respective mining phases dictate that waste rock from the different formations are segregated. Typically, as mining deepens the pit, the dumps grow in height rather than width in terms of footprint area.

Waste and low-grade stockpile areas are mostly located around the western, southern and eastern margins of the pit void, in the former valleys of dry drainage lines that drain towards the Khan River. Dumps extend up to 2 km away from the pit.

The waste rock dumps and low-grade stockpiles consist of mineral waste and low- or high-grade, high calcium-carbonate-content (high-calc) material that is generally resistant to weathering. The waste material varies in size from large boulders more than 1 m in diameter, to gravel-sized particles and fine sand. The following cut-off grades are used to classify the material transferred to the rock dumps:

---

[36] Additional information relevant to this section is contained in the Rössing Closure Management Plan, (2011)

- Waste rock: <0.118 kg/t U_3O_8
- Low-calc material: >0.118 < 0.169 kg/t U_3O_8, at low-calc index values, and
- High-calc material: >0.194 kg/t U_3O_8, at high-calc index values.

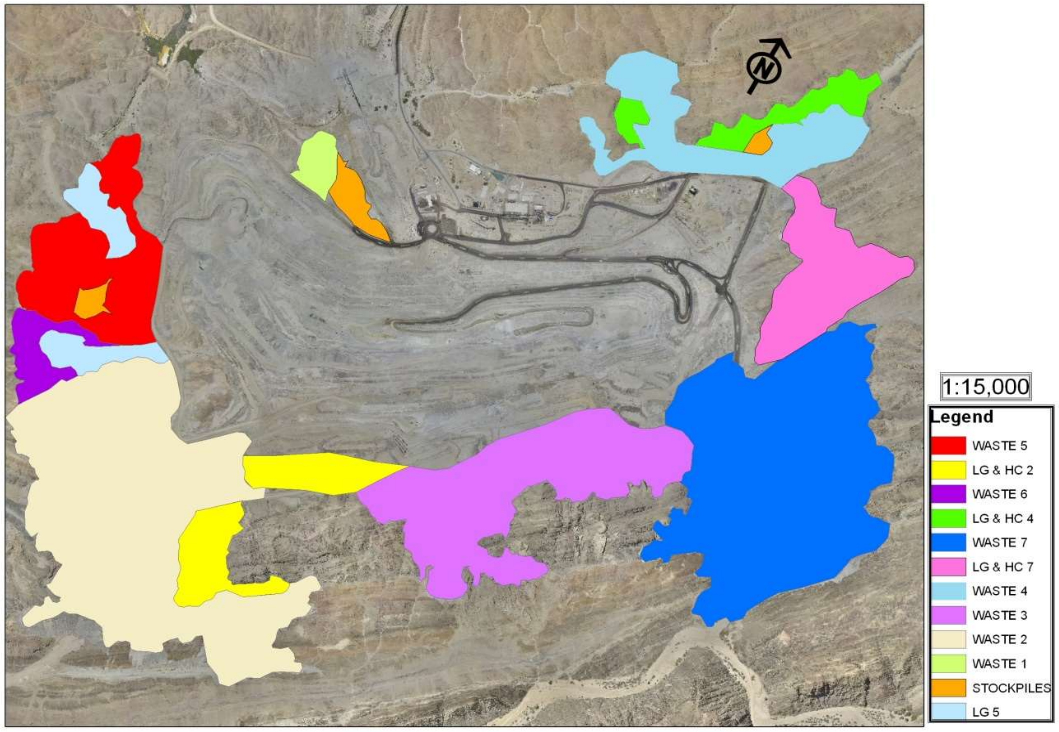


Figure 3.11: The location of waste rock dumps at Rössing

Dump heights have reached levels between 520 and 575 mamsl. This is at about the same elevation as the surrounding topography and, at this stage visual impacts of these man-made landforms are restricted to a small number of viewing points outside the Mining Licence and accessory works areas. Due to the sheer magnitude of the waste material to be dumped and stockpiled, it is inevitable that new land would be disturbed. About 90 ha would be eventually disturbed in addition to the current dumps, meaning that the total footprint of the waste rock dumps and stockpiles would be more than 830 ha.

Secondary aquifers underlying the rock dumps consist of rock of different geological formations weathered on structural features like fractures and joints. Water moves slowly through these secondary features, following the down-gradient direction, with velocities and volumes of flow being much smaller than in the sand of the dry drainage lines, but showing a wide range of variability depending on rock type.

Positioning of the waste rock dumps has already permanently altered some of the surface drainage patterns that join the Khan River. The flow of surface water is directed either through or beneath the waste rock dumps, with the potential to increase the levels of heavy metals, salts and radio-nuclides in groundwater. Primary and secondary aquifers play an important role in transmitting groundwater to the Khan River. Groundwater flow is for this reason adequately monitored and controlled.

Since waste rock contains low or sub-economic concentrations of radioactive minerals, radioactive emanations have been determined. Radon exhalation rates average around 0.74 Bq/cm^2s, ranging between 0.01 Bq/cm^2s and 3.97 Bq/cm^2s.

On occasion, foreign materials have been placed within the waste rock dumps. For example, high-grade ore from underground workings, which are contaminated by metal pieces, was stockpiled on the Waste Rock Dump 4 footprint. Over time, non-mineral waste was also placed on the waste rock dumps. The latter type of waste included contaminated waste from the FPR facility and the burnt-down SX facility, scrap metal, grease, vanadium pentoxide drums, tyres, and bags of jarosite. The placement of this form of waste on the waste rock dumps has been terminated as a practice, and over the years, the non-mineral waste has been covered with thick layers of waste rock.

3.2.4 THE TAILINGS FACILITY[37]

The tailings facility is the largest component of the combined Rössing footprint, covering a footprint of about 742 ha and containing more than 360 million tonnes of tailings. It rises to an elevation of about 670 mamsl, more or less 100 m above the surrounding surface. Only the Olympic Dam Impoundment in Australia – with an area of 720 ha – has a comparable size. These two impoundments are at least twice as big as other similar facilities at uranium mines, but Rössing has by far the largest tailings facility that is located in an arid landscape. The location and layout is shown in Figure 3.12.

All tailings from the uranium extraction process are conveyed and pumped to the facility situated to the north-west of the plant and separated from it by a north-east trending ridge and hills. Due to the low uranium content of the ore, the tailings consist of virtually the entire mass of input ore plus waste process liquids. The tailings material is coarse, by industry standards.

Originally designed as an upstream ring deposition facility, it was operated as an open surface tailings dam until the early 1980s. In this design, deposition was confined to a catchment, protected by a surface seepage collection dam situated in the main channel about 1,000 m downstream of the depositions. From 1976 to 1984, the process plant was operated on freshwater. Water pumped to the tailings dam as part of the tailings slurry, as well as all process plant run-off from the plant drainage sump known as the *snake pit*, was left on the dam to evaporate. By 1984 pumps were used to distribute the tailings around the crest of the tailings dam. It became clear that water savings measures became necessary and it was decided to change the circuit within the processing plant, to recover water stored on the tailings facility and to reduce the wetted surface of the facility. As part of these measures a paddock operation over the entire tailings facility was introduced in 1984. It proved so successful in saving water that the decision was taken to implement the paddock operation throughout the tailings facility.

[37] Additional information relevant to this section is contained in the Rössing Closure Management Plan, (2011)

Figure 3.12: Location and lay-out of the tailings facility at Rössing

In 2000, a number of pump stations were decommissioned, a conveyor installed to transport sands to the top of the tailings facility and two new pump stations had been commissioned. During 2008 and 2010, a number of studies were carried out to investigate the feasibility of alternative tailings deposition methodologies, including dry-stacking and high-density tailings deposition, using various footprint extension options. The preferred option was to continue with conventional slurry deposits in paddocks on the entire footprint of the existing facility.

A biodiversity study to assess the footprint impact of proposed extensions in 2005 indicated that, in the west, the tailings facility borders an important zone of *lithops* – not only a Red Listed plant species but also an endemic to Namibia. Since the study area is covered by about a quarter of the entire population, a decision was taken not to expand the tailings facility horizontally, but vertically.

To accommodate the maximum volume of tailings vertically, it is assumed that all existing but currently dormant paddocks, as well as paddocks to be re-established on existing tailings materials, will be brought back into service as part of routine operations, using the normal equipment. For this phase a new starter embankment, a seepage recovery sump and a seepage collection trench and sump are to be provided.

The 300 million tons of coarse and fine tailings material contain radioactive minerals and have a specific activity of roughly 50 Bq/g. Radon emanations between 0.11 and 2.21 Bq/m^2/s with a mean of 1.6 Bq/m^2/s are characteristic. Four radioactive release pathways are discernible: from radon, airborne radio-nuclides in dust, water-borne radio-nuclides, and direct radiation.

Tailings material is also susceptible to wind erosion. Windblown tailings have been accumulated to the southwest of the facility over the years and heavy wind storms in the past have dispersed tailings to a distance of up to 8 km west of the facility.

Surface seepage from the tailings impoundment occurs through the filter drain in the embankment and the foundation materials. An extensive seepage control programme and monitoring system has been established to contain sub-surface seepage in Pinnacle and Panner Gorges.

A designated part of the tailings facility is used for disposal of contaminated waste, but it is covered by layers of tailings material.

3.2.5 THE PLANT, OFFICES AND ADMINISTRATIVE BUILDINGS[38]

The processing plant at Rössing covers a surface area of 195 ha and encompasses the primary crusher, the coarse ore stockpile and conveyer system; the secondary crushing plant; the fine crushing plant; the uranium extraction section, which includes the rod mills, the leaching section, sands washing, ten counter-current decantation thickeners; the tailings handling systems; CIX plant; the SX plant; the FPR plant; and the engineering workshops and offices.

The plant also includes the former pyrite stockpile area, the former acid plant area, the acid unloading facilities, the acid pipeline, and the acid storage tanks. Buildings are mostly of concrete and concrete block construction. The tanks for storing diesel and process solvent are underground, while those for acid and ammonia storage are above ground.

The area comprising the processing plant is delineated in Figure 3.13. Elongated in shape, the south-eastern boundary of this area is the corridor formed by the main mine road and railway line, and in the north-west by the elevated slopes of a north-east-trending ridge, the Berning Range, which forms a natural buffer zone against the tailings facility. The total processing plant area is approximately 195 ha in size. The layout of the plant has remained virtually unchanged since the beginning of production in 1976 although some changes to facilities and infrastructure were made over the years.

With the height of the tailings facility rising continuously at the time, it became impractical to pump the tailings slurry from the level of the plant to the high level of the tailings facility. For this reason, an overland conveyor was commissioned in 2000 to transport tailings sand to a new mixing station on the dam and the pump system in the processing plant area altered accordingly.

A pre-screening plant was added prior to 2000 as a way to save on ore-crushing costs. A pilot ore-sorting plant was constructed during 2000, and was operated from 2001 to 2007. It was then closed down because the operations were no longer considered feasible due to continuously high maintenance requirements. Slimes, mixed with the sands, were pumped to the dam.

---

[38] Additional information relevant to this section is contained in the Rössing Closure Management Plan, (2011)

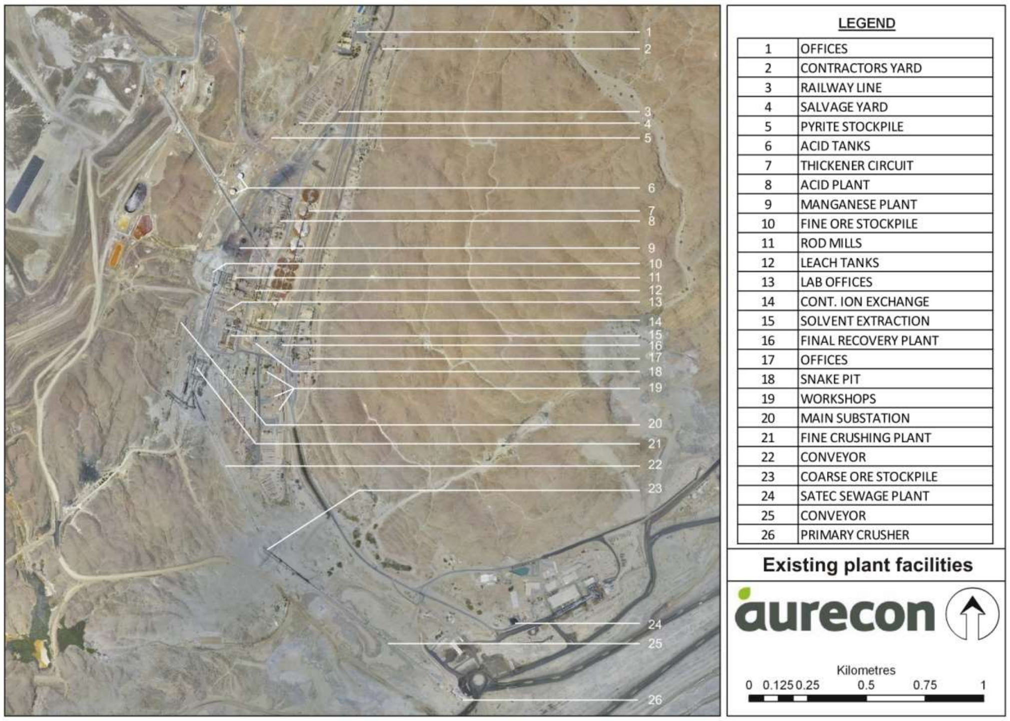


Figure 3.13: Lay-out of the processing plant at Rössing

In 2010 the former acid plant was demolished as part of the mine-wide progressive rehabilitation programme. The area was cleared of rubble but not decontaminated, because of the potential future use of the land as part of the processing plant. In order to provide more acid storage on-site, a third acid storage tank was built in 2010 and taken into service in 2011. A new set of emergency generators was built in 2010.

In the original area that became the processing plant, the top soil was originally thin, sandy and unconsolidated. Although the area had a low elevation, bedrock was exposed at a number of places. Fill materials from various sources have been used to make up the ground levels over most of the processing plant area. Tailings have been used as fill in some instances. Parts of the plant area were initially uncovered, but were later paved with concrete. Most of the roads in the area are tar-sealed.

The entire area where the processing plant is located dips gently towards the east, and surface drainage aims towards Boulder Gorge situated on the eastern side of the administrative buildings and offices, along the main road that runs from the main gate towards the pit. In turn, this drainage line aims towards the Khan River, but is intersected by the open pit. In the southern part of the processing plant area, run-off is divided between the Boulder and Pinnacle Gorges.

Underneath the surface of the processing plant bedrock fractures provide the pathway for water-borne contamination from some parts of the plant. A number of potentially hazardous chemicals and materials are present on the surface and in the subsurface at the site. These residues have accumulated over many years, and may be concentrated or diffused where they occur. Most of these contaminated sites have been verified to identify management requirements. The list of potential residues is summarised in Table 3.1.

A removal programme for asbestos has been in place for some years. The last significant quantity of asbestos was removed from the demolished acid plant area in 2011. It is company policy not to use chemicals containing polychlorinated biphenyl (PCB). None have been identified in inspections since an exchange campaign was put in place in the late 1980s.

Table 3.1: Potential hazardous chemicals and materials present in the processing plant area

Chemical/material	Location
Uranium concentrate	FPR/Laboratories
Uranium-containing aqueous solutions	Laboratories/Plant (rod mills to FPR)/Tailings facility
Resin	CIX/Fibreglass workshop
Uranium-bearing organic solutions	SX
Sulphuric acid	Acid tanks/Leaching plant/CIX/SX
Pyrite	Former acid plant
Manganese	Leaching/Manganese plants
Caustic soda	CIX
Sodium hydroxide	SX
Isodecanol	SX/Tailings facility
Alamine	SX/Tailings facility
Shellsol	SX/Tailings facility
Flocculants	Thickener area
Ammonia	Ammonia tanks/SX/FPR
Explosive chemicals, e.g. ammonium nitrate	HEF plant/Ammonium nitrate store
Laboratory chemicals	Laboratories/Leaching plant/CIX
Compressed gases, e.g. oxygen and acetylene	Workshops/Compressor room and plant
Degreasers, descalers, etc.	Workshops and plant
Cleaning chemicals	Plant, offices, workshops
Other chemicals such as paints and adhesives	Paint shop, plant, rubber lining workshop
Soil stabilisers	Open pit and tailings facility
Water treatment chemicals	Acid plant, CIX, SX and Satec plants
Petrol and diesel	Workshops and service stations

The mine's progressive rehabilitation programme was implemented in 1995. Within the ambit of this programme, a number of smaller buildings, redundant plant sections and waste sites were rehabilitated over a three-year period. The programme was resuscitated in 2010 upon the demolition of the acid plant and, in 2011, saw the removal of redundant infrastructure and a number of salvaging and waste site clean-up projects. Since 2011 all historical waste disposal sites are identified and assessed in terms of remediation requirements.

3.2.6 EXPLORATION ACTIVITIES

Exploration activities at Rössing re-commenced during the mid-2000s in response to improvements in uranium prices and demand. Prior to this, there were numerous exploration campaigns between 1955 and 1978, following discovery of uranium mineralisation in the Rössing area in 1928. During the mid-2000s exploration program, a number of areas on the mining lease were targeted for drilling to verify and potentially upscale the extent of uranium mineralisation identified from previous exploration programs, and for assessing potentially new deposits from a 2005 airborne radiometric survey. Work involved geological mapping and exploration drilling by percussion and diamond core drilling to establish three-dimensional pictures of the occurring ore bodies. Land disturbance during exploration is inevitable, because the drill platforms and access tracks can only be shifted in a limited way.

Specific archaeological and vegetation surveys have been carried out to identify areas of sensitivity and vulnerability. The findings of these surveys were incorporated into a social and environmental management plan that were part of the exploration programs, signed off by the national authority and internally within Rössing Uranium. Transport of samples for assay and final storage at Rössing's sample storage facilities and transport of mineral waste generated during the drilling process to be disposed at the contaminated waste storage facility on the tailings facility was officially permitted.

Exploration area rehabilitation at Rössing generally includes the removal of drilling samples and all waste material types from the drilling sites, clearing of spillages, raking of vehicle or rig tracks, and covering of open drill holes with concrete cones or wooden blocks. For example, drilling in the SH area was completed in 2007 and the area was rehabilitated, inclusive of sample and waste removal, some restoration of the chert quarry and road areas. The exploration work in the Z19/Z20 anomalies were conducted between 2010 and 2012. Since these anomalies are located inside the Namib-Naukluft Park (NNP), an environmental management plan (EMP) for exploration was developed. Approval was obtained from the Department of Parks and Wildlife Management of the Ministry of Environment, Forestry and Tourism (MEFT) and had a special emphasis on the rehabilitation part of the plan. Following completion of the Z19/Z20 exploration activities, a rehabilitation contractor experienced in working in the NNP was contracted to implement the rehabilitation commitments which were signed off by the MEFT in mid-2012 after completion.

Rössing has not undertaken any exploration activities after 2012.

3.3 COMPONENTS OF THE SOCIO-ECONOMIC FOOTPRINT

Rössing is Namibia's first uranium mine, and the only one for about three decades. As an employer and contributor to various levels of the economy, the mine played a significant social and economic role in the Erongo Region since the 1970s, and has since become well integrated into the socio-economic fabric of the region and of Namibia. When operations commenced at Rössing, it triggered multiple developments in the Erongo Region and among the communities in the immediate vicinity of the mine. A great number of people were drawn from inside and outside Namibia into the Erongo Region and significantly enriched its social fabric. An increasing need for housing employees saw the establishment of the town of Arandis, while an obvious socio-economic influence on Swakopmund arose with the need to accommodate the majority of Rössing employees, besides seeing the development of a range of related supporting services, facilities and infrastructure.

Rössing always aims to ensure that its contribution to social, economic and environmental improvements in the Erongo Region in particular and to Namibia in general will be sustainable over time, an aspiration that is based on a firm stakeholder engagement approach. Given the socio-economic context of Namibia as a developing country, stakeholders recognized Rössing as a major employer and an indirect contributor to various levels of the economy. Rössing contributes significantly to Namibia's revenue from taxes on income and profits. More than 60% of Rössing's procurement spending is allocated to Namibian registered suppliers. Rössing's exports also contribute a significant amount to foreign exchange for the country.

To comprehend Rössing's socio-economic footprint, it is important to understand the characteristics of its workforce. Rössing's influence on the socio-economic fabric of Namibia and the Erongo Region is manifested in many ways, but mostly in the hosting communities and through the Rössing Foundation.

3.3.1 THE WORKFORCE[39]

At the end of 2020, the staff complement of Rössing totalled about 955 permanent employees, of which 98.8% were Namibians, 1.2 % were Non-Namibians. Female representation among employees is about 18.8%.

The current average age of the workforce is standing at 40. In both Arandis & Swakopmund, average age of the employees is 41, while Walvis Bay seems to attract younger employees with average age of 39 year.

Most of the employees (around 60%) reside in Swakopmund, while about 21% reside in Arandis and about 19% in Walvis Bay. More employees appear to prefer residing in Swakopmund, with numbers increasing in Walvis Bay as well. A probable explanation is that they perceive the two larger towns as being acceptable place to settle, start a family and establish personal social networks. In contrast to Arandis, the group of relatively younger employees that prefer Walvis Bay and Swakopmund as places of residence will probably continue to prefer those two towns as their home towns over the next few years – and even when they are not employed by Rössing. With access to the support systems that these two larger towns offer, e.g. good schools, medical services, a diverse range of shops and financial facilities, and recreation and entertainment options, these employees may even find it difficult to relocate to any other place in Namibia except Windhoek for the same range of conveniences. Similarly, many employees stay on in Swakopmund or Walvis Bay after retirement.

Primary benefits of Rössing employees include a salary, medical aid contribution, retirement provision, cash in lieu, housing, and risk cover (death, accidental and disability). Medical coverage is likely to be beyond the reach of most employees when they are not employed by Rössing, meaning that employees may depend on the State's provision of health care when not working for Rössing. For those employees with chronic medical conditions other than HIV/AIDS, the termination of medical aid may result in having to rely on State facilities for chronic care. State facilities began providing anti-retroviral treatment (ART) in 2004.

[39] Information relevant to this section was obtained from the Rössing Closure Management Plan, (2011)

Financial support was provided to four bursary recipients for undergraduate studies on a fulltime basis. During 2020, a total of 26 full-time employees were awarded financial assistance through the correspondence studies scheme to obtain a formal tertiary qualification. A total of 35 dependents of the mine's employees received financial assistance through an educational assistance programme to provide the children of permanent Rössing employees and pensioners an opportunity to further their education at an accredited institution or at a vocational training centre. Vocational education and training levy Rössing has participated in the Vocational Education and Training Levy submission since inception and has paid N$7.4 million for the 2020 training-levy cycle. A total of 48 vocational trainees completed their job attachment as part of their tertiary curriculum, whereby they were exposed to on-the-job learning within their various disciplines. Further opportunities to support vocational trainees will continue during 2021. We further invested in technical training and our total training cost amounted to N$20.6 million for 2020, representing 2.6 % of the company's salary cost.

3.3.2 THE HOSTING COMMUNITIES[40]

Information gathered in 2011 concerned with the multiplier impacts of the uranium sector estimated that about three jobs are created downstream for every two direct jobs[41]. As at 2021, Rössing employs + 1000 employees and an equal amount of contractors.

Rössing has a Namibia procurement spend of just over 2 billion Namibian dollars. This compared to 370 million spent in South Africa and 227 million spent internationally[42].
The range of services and goods supplied by these various vendors varies widely with some providing unique services for the mining environment, while others perform mainstream activities such as general repairs, construction, security, and transportation. Most of these service suppliers are located in the Erongo Region.
Swakopmund and Walvis Bay account for over 90% of all suppliers. Swakopmund is by far the main base of suppliers, with nearly double the number of those based in Walvis Bay.

Arandis was established in the late 1970s as a resettlement town for Rössing's largely semi-skilled employees. Later, in 1994, Arandis was handed over to the State and proclaimed as an independent town. The Updated Baseline study that was conducted in 2017/18 showed that Arandis is 43% dependent on the mine for its income.

The Rössing Foundation's which accounts for a significant amount of Rössing's social spending, closed their head office in Arandis as part of the mine's divestment plans moving towards closure in 2019. The Arandis Sustainable Development Project (ASDP), a public-private partnership arrangement between the Arandis Town Council, Rössing mine, Rössing Foundation and various stakeholders, has served as the main platform for engagement with the Arandis Town Council since 2006. The ASDP offered opportunities to partner on the town's socio-economic development.
Direct engagement from the Mine in Arandis Town on the ASDP was closed-out in 2021, with the sign-off on the Roofing Project which was initiated in 2018.
For the Arandis Roofing Project, an aerial assessment was done showing that 831 roofs were in need of attention. Of these, the project scope was limited to roofs classified as Critical and Significant which brought h focus down to 464 roofs. At close-out of the

[40] Information relevant to this section was obtained from the Rössing Closure Management Plan, (2011)

project in 2021, a total of 465 structures had their roofs replaced. These included houses, government administration buildings and the three schools.

The current slump in the uranium price, the 2013 retrenchments at Rössing and the subsequent lowered focus of the ASDP highlighted the need to diversify the economy in Arandis in addressing the ever present need for self sustainability. New employment opportunities did however present itself through the opening of other mines – albeit short lived. In the years 2016 – 2019 the town saw an upsurge in residential developments, retail shops opening, banks opening full branches and in 2019 with the Roads Authority opening a registering office in Arandis.
In the years 2018 - 2020 a Gipson factory and a Charcoal factory opened its doors in the town. There is also an operational solar plant which sells electricity into the national grid. Coleman Transport is also in process of opening a Truck staging area in the town. Other development include the planned Traffic Management Centre which has an operations centre as at 2020 with an adjacent fuel station which will also serve as a truck port currently under construction.

The economic scourge experienced as a result of the decreased activities during lockdown as part of the Covid-19 Regulations and the concomitant forecasted closure of Rössing in 2020 had a run-up of contractors having to downscale on services rendered to Rössing which saw some downscaling on their employee numbers.
With Arandis sitting at 43% dependency on Rössing[41], the local economy contracted with banks closing, the fuel station having intermittent supplies of fuel, and – due to online banking having a stronger uptake in 2020 – two banks that had full operational branches in Arandis opted to only keep the automated teller machines to service their clients.
Arandis' population is projected at 8, 000 people – this from the immunization campaign that was held in 2012 by the Ministry of Health and Social Services. The Baseline study of 2017/18 did not follow the same house by house count as the 2005 report but population numbers were also estimated between 8 500 – 9000. This number varies as there are now two vocational school in Arandis which sees the town having a fluctuating population based on when these schools are open and closed.

Swakopmund is one of Namibia's older towns, and is the country's second largest coastal town. More than 700 single dwelling houses were built for Rössing in the Vineta and Tamariskia suburbs of Swakopmund in the 1970s. Since 1993 - 2019, the majority of these houses have been sold to employees. As at June 2021, Rössing own one house in Arandis, two in Swakopmund and a compliment of 26 flats.
In addition to the residential property, Rössing has a transport centre as well as an office block in Swakopmund. In Walvis Bay Rössing owns an acid tank farm in the harbour area and in Arandis it owns residential realty. In Windhoek Rössing owns offices.

The infrastructure and improvements at Arandis Airport no longer belong to Rössing, although the airport is located within the works accessory area of the mine. Rössing was also instrumental in building the Cottage Hospital in Swakopmund. In its early years, Rössing invested noticeably in sports facilities for its staff complement by way of the Rössing Golf Club as well as the Rössing Country Club. The Country Club, about 15 km outside Swakopmund, was sold in 1992; the Golf Club, about 7 km outside Swakopmund, was sold in 1995.

[41] Socio-Economic Baseline study, 2017/18

Swakopmund residents derive their livelihood mainly from wages and salaries, which account for 73% of the town's population's income. The town is home to the majority of Rössing's employees, as well as most of its contractors. Based on household size, it is estimated that about 15% of the livelihoods in the town is directly related to Rössing. The town is mainly seen as a tourism resort, with a significant number of tourist-related activities being offered. Apart from Windhoek, it attracts the largest share of both local and foreign visitors each year, particularly during summer.

Swakopmund has undergone some significant changes over the past few years. The town has always been considered a vibrant tourist destination and takes great pride in that, it has increasingly become associated with mining and, lately, some industrial activity. Prospects for jobs in the mining sector have seen an unprecedented growth in the population of the town, which jumped from 26,000 in the 2001 census to the estimated present 45,000. The town has also witnessed some significant growth in the number of established businesses, which have doubled between 2005 and 2010, inclusive of new operational and prospective mining companies. These developments could translate into the assumption that the town become increasingly less dependent on Rössing.

Although Walvis Bay accounts for Rössing's third largest share of local expenditure, the town's key economic activities include fishing and fish processing, marine engineering, transport and storage. Historically, fishing and its related activities have always been the mainstay of the Walvis Bay economy. However, the sector's dependence on exports and the cyclical nature of its products due to their seasonality as well as their susceptibility to unpredictable oceanic conditions have often proved to be a source of major uncertainty to the town's residents. Thus, the emergence of the port as a major economic activity has sustained business development to some degree and has fixed the town as Namibia's transportation and industrial hub. Because the town offers a diverse portfolio of economic activities, Walvis Bay – when compared to Swakopmund and Arandis – is the least dependent on Rössing.

3.3.3 THE RÖSSING FOUNDATION[42]

The Rössing Foundation was established in 1978 through a Trust Deed to serve as the social development arm of Rössing Uranium Limited, with the mission to develop identified communities "to achieve self-reliance through education, training, innovation and enterprise development".

At inception, the Foundation focused on practical skills development and education aimed at addressing the shortcomings of the colonial dispensation. The Foundation's operational head office was based in Windhoek where many programmes such English for teachers, information and communications technology (ICT), vocational training that included automotive, welding, library services, commercial subjects, craft programme as well as outreach programme for teachers and agriculture training were run. In addition, more projects and programmes occurred in northern Namibia. This northern focus tied in with community development needs in the country, and fulfilled part of Rössing's mission to "Work for Namibia". Notable examples of the skills development and education drive included basic skills such as reading and needlework, as well as support in the sectors of agriculture, natural resource management, business development,

[42] Information relevant to this section was obtained from the Rössing Closure Management Plan, (2011)

health, commercial craft development, information and communications technology (ICT). Further courses such as maritime training, Craft and needlework and were also offered in Gibeon and Luderitz, southern Namibia.

A change in Namibia's political landscape in the years before independence saw a shift to mainstream educational activities focused on the youth, such as the teaching of mathematics, science, English and ICT. The new focus intended to prepare students for entry into tertiary education. In 2001, the Rössing Foundation established a one-person office in Arandis, increasing its presence there after 2004. The move in 2004 marked the establishment of the Rössing Foundation Erongo Region Office, with the mandate to expand its activities in the Region, while focusing specifically on developing Arandis into a self-sustaining town. The main objective of the latter strategy was to aid and assist in transferring skills to and building capacity in institutions within the town, particularly the Town Council and improving the leadership capability of councillors.

Consequently, the Foundation became a founding member of the Arandis Sustainable Development Project, which aims at ensuring that Arandis becomes self-sustaining and less dependent on Rössing. In addition to the Arandis Sustainable Development and the Foundation's education projects, other support activities were directed at a farming/agriculture project in the Topnaar community, small-scale miners, the development of small- and medium-scale enterprises (SME s), and community-based natural resource management.

Current projects managed and operated by the Foundation include education, enterprise development, agriculture, natural resource management and conservation, and community development programmes. The Rössing Foundation being a semi-independent organisation, executes certain corporate social investment work on behalf of the benefactor, Rössing Uranium Limited. The Rössing Foundation is governed by board of trustees, drawn from Rössing's executive management, appointed members from State and civil society.

Rössing remains the Foundation's sole benefactor. The Foundation's dependency on Rössing for its upkeep meant having its operations and success directly linked to the fluctuation in the company's fortunes. The effect of this dependency was demonstrated during the company's lean years, when poor uranium market conditions impacted Rössing's profitability. As the mine contemplated closure, it became apparent that the Foundation would not be in a position to continue operations without a secure source of funding. This prompted a series of reorganising efforts that led to the termination of projects and cuts in the human resource component. A decision was also made to establish an endowment fund that would ensure the Foundation's operations continued beyond mine closure. Furthermore, a review was conducted on the operations of the Rössing Foundation in 2010 by taking into account national policies such as Vision 2030 and evolving national legislation to reposition itself as a community development non-governmental organisation, funded by Rössing.

Over the years, the Rössing Foundation has developed a reputation as a strong development partner in Namibia, and in the Erongo Region in particular. Being an organisation that executes certain corporate social investment work on behalf of Rössing, the Foundation is closely associated with Rössing and its corporate reputation. Rössing has a social obligation to its neighbouring communities in the Erongo Region, and this obligation is interpreted and implemented by the Rössing Foundation to a large extent. The Foundation had a particular role to see that Arandis became and Swakopmund and Walvis Bay remain characterised as being independent, self-sustaining communities with diversified and active local economies, and that the opportunities for education and training, business, and community development that have been created are sustained by means of joint community, state and Rössing initiatives.

The Foundation is still operating education programmes focusing on English, Mathematics and all Science subjects through its English, Mathematics and Science Centres in Swakopmund, Arandis and Ondangwa. In addition, the Foundation launched a National Mobile Outreach Programme to assist rural schools, that otherwise would not be able to benefit from the state of the art education programme offered at the Rössing Foundation Centres.

Other programme that continue to be offered and supported by the Foundation include agriculture, community based natural management, the introduction of the national planetarium programme to schools in partnership with a university from the Netherland.

4 DESCRIPTION OF ENVIRONMENTAL IMPACT ASSESSMENTS AT RÖSSING

Rössing has a long history in proactive management and over its 42 years of existence various environmental strategies were applied. Wherever possible Rössing prevented, or otherwise minimise, mitigate and remediate, adverse impacts of operations on the environment. Compliance with all environmental laws, regulations and standards is the foundation on which environmental performance is build.

4.1 FROM PRE-MINING AND CONSTRUCTION TO NAMIBIA'S INDEPENDENCE

During the late 1960s, the Rio Tinto Zinc Corporation (RTZ) acquired the exploration rights to the Rössing deposit and reinvestigated the resource intensively. This included airborne and ground radiometric surveys, detailed topographical and geological mapping, drilling, bulk sampling and metallurgical testing in a 100 t per day pilot plant to determine the feasibility of establishing a mine. A period of exploration, which included the construction of exploration camps and development of basic infrastructure, followed.

Actual development of the mine commenced in 1974 when the open pit was started. The plant was commissioned thereafter. By 1976 the first uranium from the new mine was produced with the intention to reach full capacity by 1977. However, certain design weaknesses in the plant emerged, and the ore proved to be highly abrasive. The SX-part of the plant was also destroyed by fire in 1978. As a result a great deal of the plant was extensively modified and one of the two solvent extraction sections totally reconstructed. Full production was reached in 1979 and in 1980 most of the construction work was completed.

Although no environmental assessment was required at the time of construction, the early mine operations commenced with due cognisance of the sensitive environment in which Rössing is situated. Since 1974 several investigations into specific aspects were conducted and documented. The initial investigations focused on changes of dust levels, water use, seepage and groundwater flows. An air quality monitoring program was established to address the early air quality concerns, and although no pre-operational radiation safety assessment was carried out, due care and attention was given to possible influences of radioactivity on both the human and the environment as from the late 1970s. At the end of the 1970's, the Environmental Department at Rössing was set up – something that was not mandated by law and considered as a unnecessary expense by many other mines.

Initial work on the environmental transfer of radio-nuclide discharges through the air and groundwater pathways started in 1979. In September 1982, Rössing contracted consultants to conduct the initial radon exhalation measurements on the tailings impoundment and other areas of the mine. A further study on the reclamation of the Rössing Tailings Impoundment was completed in 1984. One of the conclusions was that radon exhalation from this source could be reduced by applying a specified thickness of alluvium or waste rock[43].

Focus on water and seepage remained strong during the 1980s, but the focus increasingly included air quality and employee health. Investigations with a biodiversity focus were conducted since the second half of the 1980s, but investigations and reports with an integrative approach were still rare.

Early commitment with regard to responsible environmental management was shown with the transplanting of *Aloe dichotoma* (quiver trees) from the area that was to become the open pit to the national botanical gardens in Windhoek. In the 1980s this commitment was strengthened when Rössing supported the former State Museum in an ambitious program to catalogue key elements of biodiversity on site. Monitoring of vegetation in the Khan River to examine the impacts of water extraction by the mine started in the early 1980s and became routine monitoring in 1988. It has been carried out ever since and contributed to the Tree Atlas of Namibia published in 2005[44].

Three important studies on radioactivity at Rössing were conducted by the Atomic Energy Corporation of South Africa between 1988 and 1990: Doses in the open pit was assessed and adaptation of the monitoring programme was suggested[45]; environmental radon concentrations were measured and a dispersion modelling was carried out[46]; and radon exhalation rates from identified sources were identified[47]. These studies assisted to model environmental radon concentrations associated with mining activities at Rössing[48] and to estimate the average radiation dose to the people of Arandis from radioactivity originating from natural and mining-related sources[49].

4.2 OPERATING IN INDEPENDENT NAMIBIA – THE FIRST 20 YEARS

Since Namibia gained independence from South Africa in 1990, a new legislative environment began to evolve. Shortly after independence, Namibia's Green Plan was drafted. Rooted in Article 91 (c) and Article 95 (l) of the Namibian constitution, the Green

[43] The bulk of the consultancy work at Rössing between 1979 and 1984 was done by Dames and Moore. See Ashton, *et al.*, (1991).
[44] Curtis and Mannheimer, (2005)
[45] De Beer and Leuschner, (1988)
[46] Grundling and Leuschner, (1988)
[47] Strydom *et al.*, (1989)
[48] Grundling and Leuschner, (1990)
[49] De Beer, (1990)

Plan was developed on a framework to promote sustainable development and described and identified actions to address the main environmental challenges facing Namibia. Following the Green Plan a lengthy, but pioneering stakeholder engagement process began to establish Namibia's 12-point Plan for Integrated and Sustainable Environmental Management and the Environmental Assessment Policy of Namibia. The latter was approved by the cabinet of the Namibian government in 1994.

Soon after independence, and before the Environmental Assessment Policy was approved, Rössing reiterated that one of its up-front, recorded goals (embedded in the business plan) is environmental improvement. The proactive pursuit of this philosophy moved Rössing management beyond the compliance focus to a focus of continual improvement in environmental performance.

In this spirit Rössing committed itself to responsible environmental management in an independent Namibia by conducting an Environmental Impact Statement, completed in 1991[50]. A first of its kind, the purpose of the project was to provide a scientific base of the possible pre-mining environmental conditions describing location, topography, geological and mineral reserves, radioactivity, soils, hydrology and surface water quality, geo-hydrology and groundwater quality, ecological and biodiversity features, demographics, socio-economy, patterns of land use and communications and infrastructure.

The study comprehensively describes the mining operations of then, including waste disposal, dust and radiation control measures, workforce and environmental health and safety and interpolate from adjacent and similar, but undisturbed areas to set a reference document against which the impacts of both current and future developments, as well as the effectiveness of environmental protection and reclamation measures, could be assessed. Possible impacts as a result of projected future mining operations are assessed, and decommissioning plans are also proposed, but an Environmental Management Plan was not included.

Closure Planning at Rössing began in 1991 to accommodate anticipated operational changes for the remaining life of the mine, as well as the vision for closure. In support of the continuous planning process, several social and technical closure studies were done and have been updated. Since 1991 various studies were conducted to increase the knowledge base regarding mine closure.

In search for a long term solution for water supply to Rössing, an impoundment of the Khan River was suggested and investigated during the second half of the 1990s. The idea was to create an aquifer recharge scheme whereby a portion of the occasional floodwaters in the river would be captured, silt to settle out and then channel clear water into the downstream alluvial aquifer. Several technical and design investigations were made and assessment of the potential environmental impacts of the proposed aquifer recharge scheme was conducted during 1997[51].

The final document contains comprehensive information about water supply along the coast of Namibia; extensive baseline information about the Khan and Swakop Rivers; describes the methodology to evaluate the magnitude and importance of impacts

---

[50] Ashton, *et al.*, (1991)
[51] CSIR, (1997)

associated with the proposed project; describes the main findings and lists the key issues and concerns; assesses the identified and possible impacts of the proposed project and summarizes recommendations and monitoring requirements. The report also contains consideration of mitigatory actions and finally concludes that there are no “fatal flaws” which would prevent the proposed project from proceeding. Despite this conclusion, the report recognizes the importance of negative public discernment about perceived undesirable detrimental effects of the project. Finally the report made firm recommendations about the removal of invasive plant species along the two rivers; monitoring of water tables and sharing of this information with the public; improved recharge and irrigation methods and the long term need for routine monitoring of sand, sand mining and the dynamics of sandy beaches north of the Swakop River mouth.

Although the project did not go ahead, the assessment of potential impacts was one of the most comprehensive conducted in Namibia at the time. The final documented report contains extensive baseline and technical information about water management as well as a number of specialist reports organized as appendices. Even though the assessment did not include an Environmental Management Plan, the final report contains a summary of impacts, mitigatory actions and further recommendations. As such the final report is still regarded as an important reference document to many of the more recent studies, assessments and investigations conducted at Rössing.

In 1997 an assessment of the radiological impacts associated with the use of Rössing tailings for maintenance of haulage roads in and around the open pit was conducted by the Atomic Energy Corporation of South Africa[52]. Before, Rössing was using alluvial sand from nearby drainage lines for cover of the roads inside and around the open pit. Due to a possible long term adverse impacts on the drainage lines and groundwater, the replacement of the alluvium with Rössing tailings material was contemplated. It was concluded that the average airborne activity concentration from and gamma dose rate on haulage roads should decrease or stay similar to the levels determined.

A similar study was conducted to assess the impacts of using seepage water for dust suppression in the open pit[53]. Rössing was using water from the open pit sump, from seepage collection trenches in the Pinnacle and Panner Gorges and from an aquifer in the Khan River for dust suppression in the open pit. Due to a reduction in the water available from the Khan River aquifer, the need arose to find an alternative – seepage water from the tailings facility. Possible radiological impacts from this source were assessed and the conclusion was that it is unlikely to cause any significant increase in radiation doses because of limited increase in radioactivity concentrations and a small fraction of seepage water involved[54].

A wildlife survey was carried out in 1998 to determine wildlife migration routes and the influence of fences (specifically around the tailings facility) on wildlife. Two reports and a map of migration corridors of wildlife as well as watering points were produced[55]. BirdLife International was instrumental in carrying out a number of bird surveys at Rössing to update the inventory produced during the 1980s[56].

---

52 De Beer, (1997a)
53 De Beer, 1997(b)
54 Rössing’s Radiation Management Plan, (2012)
55 Campbell, (1998)
56 Stacey, (2006)

Since its inception the Environment Department at Rössing was responsible to ensure that environmental impacts of operations are controlled and managed. In 1996 the International Organization for Standardization (ISO) published standard 14001 Environmental Management Systems (EMS) – Requirements with Guidance for Use and Rössing immediately started to develop its EMS in line with this international standard. Rössing was awarded certification the first time in February 2001 and became the second Namibian land-based mining operation to achieve certification. When ISO14001:2004 was published, Rössing incorporated the change into the existing EMS and received certification to ISO14001:2004 in early 2006.

Until the late 1990s Rössing produced acid for the extraction process in the metallurgic plant. Initially the acid plant used pyrite ore that was obtained from the Otjihase Mine near Windhoek, but after the closure of Otjihase in 1997, the pyrite ore was substituted with sulphur to produce sulphuric acid. From time to time acid stocks were supplemented by importing sulphuric acid from overseas, via the port of Walvis Bay. The imported acid was pumped to storage tanks on shore and then railed to the mine where it was stored for further use. In 2000 the acid plant was mothballed because it became more economical to import acid than to produce it on-site. The decision was taken to import the entire acid requirements via Walvis Bay and to expand the storage facilities thus. The new arrangement also implied more frequent and larger quantities of acid to be railed to Rössing.

Due to the nature and scale of the proposed expansions and the potential hazards sulphuric acid pose to human health and the environment in the event of a spillage, a team of specialists was commissioned to conduct an environmental impact assessment of the envisaged expansion to the importation, storage and transfer of acid to Rössing and evaluation of alternative processes, recommendation of best options, mitigation measures and management plans for the preferred options. It was made clear that the assessment should exclude responsibilities of non-Rössing organizations (such as aspects related to transport). The terms of reference included also formal communication with regulatory authorities and interested and affected parties[57].

The final report has been preceded by a comprehensive scoping report. The scoping report was used to answer the majority of concerns and issues raised by stakeholders and highlighted those concerns that were addressed through the actual impact assessment. The information compiled for assessing potential impacts is documented in the final report, issues of concern were listed and grouped into a logical sequence to provide the scope and scale of concerns as well as appropriate mitigatory measures that could enhance positive benefits and minimize potential adverse effects. Criteria to evaluate the impacts include anticipated scale, duration, severity, certainty and significance. Moreover, the assessment process brought issues to the fore in an open debate, improved public awareness about Rössing’s operational practices, enabled wide and constructive stakeholder engagement and underlined the importance of maintaining a high “state of readiness” to deal with possible disaster events such as sulphuric acid spills. Organized as appendices the report contains also a specialist study on acid handling; design specifications on storage facilities; transport logistics and scheduling; handling, training and emergency responses; medical preparedness; and public awareness about sulphuric acid.

[57] Ashton, *et al.*, (2000)

Radiation remains a challenging priority at Rössing and in 2001 the company invited Rio Tinto Technical Services to conduct a study on post-closure radiological exposures and mitigation options, in particular to evaluate the tailings facility cover options, by calculating doses for the various options of the 1997 Closure Plan. In the study, post closure doses were estimated to be well below the dose limit for members of the public, both during and after decommissioning. All doses in the Rössing environment for the offsite maximally exposed persons were found to be less than 0.25 mSv/a. It was concluded that radiation from Rössing, and the tailings facility in particular, would not have a significant radiological impact at Arandis[58].

A number of radiation-related studies followed during the 2000s: On radon exhalation values, radon sources and dose attributable to radon at receptor locations surrounding Rössing[59]; assessment of airborne and deposited dust levels[60]; and background radon concentrations for determining pre-mining conditions[61]; a screening assessment of the post-closure radiological impacts of Rössing[62]; post-closure public dose assessment for proposed expansions at Rössing[63]; an investigation into the possible increase in external radiation doses at the FPR[64]; atmospheric dispersion calculations to assess radiological impacts of radon and long-lived radioactive dust at selected locations to assess current, extension and post-closure scenarios[65]; and a dose assessment to compare current radiological impacts of the mine on members of the public compared to the life-of-mine-extensions and after mine closure[66].

The sustainability assessment for Rössing in 2003 included an environmental impact assessment conducted, which considers social, environmental and biophysical impacts of proposed mine extensions. The assessment aims to ensure appropriate remedial action where needed, and to identify actions that will create positive socio-economic outcomes for stakeholders beyond the physical and time dimensions of the present mine[67]. The proposed changes to the mine are described, which included a pushback of the then existing open pit to the west (referred to as Phase II) and a subsequent pushback of the pit to the south (referred to as Phase III).

The study includes a public stakeholder participation programme, and assesses socio-economic impacts on the towns of Arandis, Swakopmund and the Erongo Region elsewhere, and on- and off-site biophysical impacts. The environmental assessment showed that there are no environmental impacts that cannot be addressed or minimised and the highest environmental risk is associated with the expansion of the tailings facility. Assessment of the radiation levels indicated to remain well below occupational and public dose limits. Some of the proposed operational changes indicated possible improved environmental performance, such as reduced water usage, reduced dust emissions and reduced groundwater pollution.

---

[58] Isaack, (2001)
[59] Everett, (2001)
[60] PARC Scientific and EnviroSolutions, (2001)
[61] EnviroSolutions, (2002)
[62] De Beer, Ramlakan and Schneeweiss, (2002)
[63] De Beer and Ramlakan, (2003)
[64] Abrahams and Anderson, (2004)
[65] Strydom, (2006)
[66] De Beer and Liebenberg, (2008)
[67] Rössing Closure Management Plan, (2005)

The first complete closure management plan for Rössing, according to the Rio Tinto Closure Standard, was conducted in 2005. The plan covered two closure alternatives: closure in 2009 or 2016. The plan was the first to document detailed discussions of

- Impact and risk identification;
- Stakeholder consultation;
- The development of a vision for closure;
- The development of closure objectives and targets;
- A description of preferred mitigation alternatives;
- An identification of knowledge gaps and further work required;
- An estimation of closure cost and accounting provision.

The expansion activities proposed in the mid 2000s required authorisation and clearance and consequently a multiphase Social and Environmental Impact Assessment (SEIA) has been commissioned by Rössing for the proposed expansion project in accordance with these requirements, as well as the internal standards and guidelines prescribed by Rio Tinto[68].

The entire extent of the envisaged expansion of the Rössing comprised a number of components, dealt with in two phases. Phase 1 of the SEIA process entails a sulphuric acid manufacturing plant; associated sulphur storage on the mine; transport of sulphur from the port of Walvis Bay; a radiometric ore sorter plant and the mining of an ore body known as SK4. Phase 2a entails the sulphur handling facility in the port of Walvis Bay whereas Phase 2b entails the extension of the current mining activities in the existing SJ open pit; increased waste rock disposal capacity; establishment of a new crushing plant; increased tailings disposal capacity; establishing of an acid heap leaching facility; establishing of a ripios disposal area and additional plant associated with the above.

The assessment of the proposed expansions entails an outline of legal and policy frameworks regarding the environment within which Rössing operates; a description of the proposed expansion project components, their alternatives and potential impacts; a description of the public participation process; a description of the methodology; and, most importantly, an assessment of the significance and possible mitigation of the potential impacts that were identified, and management recommendations.

The proposed expansions were announced in the media in 2007, followed by public and key stakeholder meetings with a wide array of interest groups and organisations. Public meetings were again held in early 2008 in Arandis, Swakopmund and Walvis Bay. The purpose of this series of meetings was the release of the Phase 1 Draft SEIA Report, as well as the introduction of the Phase 2 Scoping Report of the SEIA process.

An SEIA for the construction of a sulphur handling facility in the port of Walvis Bay was completed in 2009. In the interest of time and to allow for an earlier clearance, it was decided to separate the sulphur handling component in the port from the remainder of Phase 2 of the SEIA process, meaning that this component was subjected to an individual SEIA process (referred to as the Phase 2a process).

Phase 1 of the SEIA process has been approved by the Directorate of Environmental Affairs at the Ministry of Environment and Tourism by 2008 and Phase 2a in 2009.

[68] Ninham Shand, (2008) and Aurecon, (2011a)

A number of specialist studies have been undertaken to properly understand the most significant impacts of the further proposed developments and to ensure an acceptable level of confidence in the assessment of such impacts. Impacts were evaluated according to a tabulated rating system, where each impact is described according to its extent (spatial scale), magnitude (size or degree scale) and duration (time scale), with and without mitigation. After mitigation, no risks remain that are high or critical.

Engagement with the public and stakeholders interested in, or affected by, the proposed development formed an integral component of the assessment process. Public and stakeholders have had several opportunities at various stages throughout the SEIA process to gain more knowledge about the proposed components, to provide input and to voice any issues of concern. The general low attendance of public meetings and the lack of comments on the draft Phase 2 Scoping Report caused concern that the public was not accessing information about the expansion project, and that the concerns and recommendations were not being articulated and recorded. It was hoped that a new approach would reach a broader audience than before and result in a better and more detailed understanding. This would, in turn, lead to more comprehensive input. Difficulties in engaging with marginalised groups were also identified as a need to be addressed. A decision was therefore taken to change the format of the public participation process for Phase 2b of the SEIA process, by moving away from large open house public meetings to specific focus groups based on stakeholder categories.

During August 2010 focus group meetings were held with the interest groups, preceded by a tour of the mine and a visit to the site of the proposed expansion project components. This contextualised the discussions at the meetings, and facilitated more informed and in-depth questions and comments. Meetings focused on issues which had been identified as of interest to each particular group and presentations and specialist attendance were arranged to match.

The new format proved to be extremely productive. All focus groups were involved in the consultation process, and the inclusion of marginalised groups was particularly successful. Participants freely voiced their concerns, questions and recommendations, captured and included in the final assessment. Participants also showed great interest in the technical details of the proposed new acid heap leaching process.

A key component of any thorough SEIA is the consideration of alternatives (strategic or project level; site, arrangement of facilities and layout; technology or process) during assessment. A two year process of refining the decision criteria and technical information was used to inform the decision on the preferred layout with the following main objectives:

- Minimise the physical footprint of the proposed expansion
- Optimise the use of areas where the sustainable development impacts are minimised
- Find the best practical site for each of the facilities
- Make the best use of newly impacted sites, and
- Ensure that the expansion follows a strategic Life of Mine approach.

Key decisions had to be taken about facility locations and overall site layout during the ‘order of magnitude’ stage. Two workshops were held to identify the most appropriate areas for new processing and waste disposal facilities by using multi-criteria decision making methodologies. The land use database (developed in 2008) was an essential tool in the subsequent process used to identify the most appropriate layout. Rössing determined a list of criteria comprising four main categories for land use optimisation during the assessment. The objective was to ensure that proposed extensions are in line with a sustainable development approach, which emphasises economic viability, environmental sustainability, and social acceptability. Criteria were sorted as technical, environmental, socio-economic and strategic categories.

The series of documents that support Phase 2b of the SEIA process, and culminate in the final SEIA Report, comprise:

- A Public Information Document (PID) released in August 2007
- A Scoping Report released in April 2008
- A Background Information Document (BID) released in October 2008
- A summary of specialist study findings released in August 2010 and
- The eventual SEIA Phase 2 Report (3 volumes)

The final SEIA Report provide a wide range of sufficient and reliable information to make an informed decision on whether or not the proposed components of Rössing's expansions were acceptable from a social and environmental perspective. Outcomes include confirmation of the social and environmental acceptability of preferred or indicated sites; identification or confirmation of the environmentally preferred process and technology alternatives; identification of possible mitigation measures to reduce the significance of potential impacts; and documentation of the identified mitigation measures in a Social and Environmental Management Plan (SEMP). The SEMP has been developed to guide the design, construction, operational and closure phases of the proposed expansions. The final SEIA report was submitted to the Directorate of Environmental Affairs by the end of 2011 and approved in 2012.

Exploration activities at Rössing commenced during the mid-2000s, causing a number of areas on the mining lease to be drilled in search of new uranium ore bodies. Rössing has decided to proactively follow best practice to manage these activities. Specific archaeological and vegetation surveys have been carried out to identify areas of sensitivity and vulnerability. The findings of these surveys were incorporated into a social and environmental management plan that became part of the exploration program rolled out in the Z-area since 2010, signed off by the national authority and internally within Rio Tinto.[69] Part of this management plan is to rehabilitate the areas disturbed by exploration activities.

4.3 STRATEGIC ASSESSMENTS

Ideally, cumulative environmental impacts should be taken into account in all environmental assessment processes. Environmental impact assessments have traditionally, however, failed to come to terms with cumulative impacts, largely as a result of the following reasons:

- Cumulative effects may be local, regional or global in scale and dealing with such impacts requires co-ordinated institutional arrangements; and

[69] Aurecon, (2011b).

- Environmental assessments 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.

In 2009, an initiative was launched to provide a guiding framework for sustainable uranium mining development specific to the Erongo Region, including aspects of mine closures and early planning for desired post-closure conditions. Consequently, the Southern African Institute for Environmental Assessment (SAIEA) was contracted by the Ministry of Mines and Energy to undertake a strategic environmental assessment (SEA) of the so-called uranium rush in the central Namib[70].
The SEA was expected to provide direction to the uranium industry, government and other stakeholders in the central Namib. Exploration for and mining of uranium is a collection of projects, each being conducted by individual companies that are not related to each other and, in many cases, undertaken in isolation of each other. However, they collectively combine to produce potentially cumulative impacts including the loss of a sense of place; the over-abstraction and pollution of groundwater; short- and long-term exposure to radiation by workers and the public; stress on physical and social infrastructure; and opportunity costs on other, more sustainable industries. But the uranium rush could also offer substantial opportunities for synergies, and the industry could stimulate critically needed development.

One of the objectives of the SEA was to outline a Strategic Environmental Management Plan. The latter offers a set of environmental quality objectives, expressed as a set of desired future environmental conditions elicited through a stakeholder consultation process. The Plan sets targets as regards how best to achieve the desired objectives, suggests indicators that could be used to map progress towards those targets, and lists the parties responsible for the Plan’s implementation.

Implementation of the Plan is the most critical part of the SEA and the extent to which it is implemented will determine its ultimate success in guiding the uranium rush towards a sustainable future. The planning for closure is addressed in a number of environmental quality objectives contained in the Plan, and provides specific guidance for the Erongo Region in this respect. Recognising the opportunities and constraints presented by the uranium rush, the Chamber of Mines of Namibia established the Uranium Stewardship Council as a ‘spokesperson’ for the Namibian uranium industry, both nationally and internationally[71].

In 2008, a significant milestone was achieved when the Namibian Stock Exchange (NSX) agreed that uranium exploration and mining companies could not be listed on the NSX unless they were members of good standing with the Uranium Stewardship Council. All Council members are bound by the Chamber’s Constitution that commits them to upholding the Namibian uranium ‘brand’, and ensuring the highest standards in environmental and radiation safety management.

[70] Rössing Closure Management Plan, (2011)
[71] Chamber of Mines of Namibia, (2009)

5 IMPACT MANAGEMENT AT RÖSSING

5.1 THE IMPACT MANAGEMENT SYSTEM IN EFFECT AT RÖSSING

All operational activities at Rössing are managed to ensure that the impact on both the biophysical and socio-economic environment are reduced to acceptable limits. This management is implemented in a number of ways, at all stages of mine operations, namely planning, construction, operation and decommissioning of facilities. For this purpose Rössing implemented an integrated Health, Safety and Environment Management System (HSE MS) in 2008.

The management system is a tool designed to assist in achieving Rössing's goals, including its legal obligations. This systematic approach to management performance promotes the efficient use of resources and offers the prospect of financial gains to the company – generating a win-win outcome in terms of environmental and business performance.

Health	**Safety**	**Environment**
H1 – General principles H2 - Fitness for duty H3 - Noise, vibration and manual handling H4 - Hazardous substances management H5 - Airborne contaminants H6 – Radiation H7 - Carcinogenic substances H8 - Travel and remote health	**C1** – Isolation **C2** – Electrical safety **C3** – Vehicles and driving **C4** – Working at heights **C5** – Confined spaces **C6** – Cranes and lifting equipment	**E1** - Air quality, noise control and Greenhouse gases (GHG) **E2** - Hazardous materials and non-mineral waste control and minimisation **E3** - Biodiversity, rehabilitation and Land use management **E4** - Mineral waste, acidic and other impacted drainage control **E5** - Water usage and quality management

Figure 5.1: The Rio Tinto HSE Performance Standards

In addition to the HSE MS Rössing developed internal Health, Safety and Environmental Performance Standards. The intent of the standards is to gain commitment of employees on an annual basis to improvement in impact management performance. Figure 5.1 displays the new set of standards that was introduced in 2019 and being successfully audited for compliance on annual basis.

The International Standard for environmental management systems, ISO 14001, through its design encourages continual improvement. ISO 14001 is embedded in the HSE MS at Rössing. The system not only helps to ensure that major health, safety and environmental risks and liabilities are identified and managed, it also establishes a framework for tracking, evaluating and communicating the performance in these aspects. Adoption of ISO 14001 therefore implies a constant commitment to improving Rössing's environmental monitoring and environmental performance efficiency.

Figure 5.2 provides an overview of the integrated HSE MS in effect at Rössing. The structure of the management system follows the layout of common international standards such as ISO 14001, (Environment); ISO 45001; ISO 9001 (Quality). The system is based on the principles of continuous improvement and adopts the methodology of Plan, Do, Check and Review.

Figure 5.2: Overview of the HSE management system in effect at Rössing

The use of a formalised, integrative HSE MS is essential in allowing Rössing to optimise, coordinate and manage the various operations, personnel, plant and equipment and their interactions in a manner that demonstrates consistent application of best practice in environmental management. Matters of planning, implementation and operation, checking and corrective action, and management review, are embodied in the system. This approach assists in identification of key environmental aspects and serves to guide Rössing in continued formulation of suitable Standard Operating Procedures (SOPs) and in attaining continual improvement objectives. Through the system Rössing can efficiently detect and minimise the potential adverse impacts of its activities on the receiving environment.

Codes of Practice have been developed as part of the HSE MS design to ensure a process of continual improvement in the HSE management and performance. The HSE MS Code of Practice (JA05/COP/003) provides a set of management steps, focussing on the organisation's achievement of its HSE goals that form part of the wider management of the organisation's operations. The Code of Practice considers all aspects of Rössing's operations in order to manage any potential HSE impacts and it contains references to the HSE MS procedures.

The HSE MS is furthermore divided into seventeen elements. Each element sets out to achieve a specific objective that enables the business to best identify and manage its various HSE threats and opportunities. Many of the elements are inter-related. The four core elements of the HSE MS are:

- The Environmental Policy
- The Legal and other requirements register
- The HSE risk register
- HSE improvement plan/s

5.1.1 PLANNING

5.1.1.1 HSE Policy

The HSE Policy is the overarching and guiding document that informs the manner in which Rössing conducts its business activities and manages impacts on the environment and the health and safety of its employees and on the public at large.

Rössing's Managing Director (MD) is accountable to the Rössing Board for all HSE matters and the MD is the custodian of the HSE Policy.

5.1.1.2 Legal and other requirements

The management of all identified HSE hazards / aspects must comply with the relevant Namibian legal requirements and relevant standards and guidelines to ensure that good international practices are applied to the HSE MS. The term "other requirements" refers to non-regulatory requirements to which Rössing has voluntarily subscribed, and / or Rio Tinto has formally committed Rössing to meet. A Legal Register that contains all applicable legal and other legislative requirements is maintained and annually updated.

Appendix 1 summarizes some of the legal requirements relevant to Rössing's operations.

5.1.1.3 Hazard identification and risk management

The policy and goals of the HSE MS are based on an understanding of all the HSE hazards / aspects of operations, products or services related to Rössing. This means that every hazard / aspect in which operational activities may affect health, safety and the environment must be investigated so that the most important HSE impacts (HSE hazards / aspects with significant impact) are identified.

A description of the potential or known HSE impact as a result of each identified HSE hazard / aspect is listed on the HSE risk register. Where mitigating measures are already in place to reduce the severity of any potential impact to the health, safety and environment, these measures are also described. The HSE hazards / aspects that potentially result from any particular input or output are classified according to their impact category, for example: Employee health; employee safety; pollution to air, water or soils; fauna and flora; hazardous and non-hazardous wastes; radioactive material, etc.

Appendix 2 summarizes environmental impacts according to their spheric dimension, hazard, outcome, operational phase, risk management control mechanisms and way that the impact is managed.

5.1.1.3.1 Risk assessment framework

In accordance with the HSE MS, the Rössing risk management framework is based on a three-tiered model (Figure 5.3) that allows the appropriate level of risk assessment to be selected to match the nature, context and scale of the hazard being considered.

Figure 5.3: The three-tier risk assessment model

5.1.1.3.2 Qualitative risk matrix

The HSE Risk Matrix (Table 5.1) and associated Consequence (Table 5.2) and Likelihood (Table 5.3) descriptors are used to assess risk levels.

Table 5.1: Qualitative risk matrix

Consequence / Likelihood	1-Minor	2-Medium	3-Serious	4-Major	5-Catastrophic
A-Almost certain	Moderate	High	Critical	Critical	Critical
B-Likely	Moderate	High	High	Critical	Critical
C-Possible	Low	Moderate	High	Critical	Critical
D-Unlikely	Low	Low	Moderate	High	Critical
E-Rare	Low	Low	Moderate	High	High

Rating	Class	Risk management response
Critical	*Class IV*	*Risks that significantly exceed the risk acceptance threshold and need urgent and immediate attention.*
High	*Class III*	*Risks that exceed the risk acceptance threshold and require proactive management. Includes risks for which proactive actions have been taken, but further risk reduction is impracticable. However active monitoring is required and the latter requires the signoff by Business Unit senior management.*
Moderate	*Class II*	*Risks that lie on the risk acceptance threshold and require active monitoring. The implementation of additional measures could be used to reduce the risk further.*
Low	*Class I*	*Risks that are below the risk acceptance threshold and do not require active management. Certain risks could require additional monitoring.*

Table 5.2: Descriptors for the consequence of an impact occurring

Consequence	MINOR	MEDIUM	SERIOUS	MAJOR	CATASTROPHIC
Non-Economic (Social and Environmental)					
HEALTH	Reversible health effects of little concern, requiring first aid treatment at most. Can include minor irritations of eyes, throat, nose and or skin, or minor unaccustomed muscular discomfort.	Reversible health effects of concern that would typically result in medical treatment. Can include temperature effects; travel effects; stress; and sunburn.	Severe, reversible health effects of concern that would typically result in a lost time illness. Can include acute / short-term effects associated with extreme temperature effects; or musculo-skeletal effects; vibration effects; nervous system effects; some infectious diseases; and non falciparum malaria.	Single fatality or irreversible health effects or disabling illness. Can include effects of suspected carcinogens, mutagens, teratogens and reproductive toxicants, progressive chronic conditions and/or acute / short-term high-risk effects	Multiple fatalities or serious disabling illness to multiple people. Can include effects of known human carcinogens, mutagens, teratogens and reproductive toxicants, and life-threatening respiratory sensitization and falciparum malaria
SAFETY	Low level short term subjective inconvenience or symptoms. Typically a first aid and no medical treatment.	Reversible injuries requiring treatment, but does not lead to restricted duties. Typically a medical treatment.	Reversible injury or moderate irreversible damage or impairment to one or more persons. Typically a lost time injury.	Single fatality and/or severe irreversible damage or severe impairment to one or more persons.	Multiple fatalities or permanent damage to multiple people.
ENVIRONMENT (on site)	Near-source confined and promptly reversible impact (Typically a shift)	Near-source confined and short-term reversible impact (Typically a week)	Near-source confined and medium-term recovery impact (Typically a month)	Impact that is unconfined and requiring long-term recovery, leaving residual damage (Typically years)	Impact that is widespread-unconfined and requiring long-term recovery, leaving major residual damage (Typically years)
ENVIRONMENT (off site)	Not applicable	Near-source confined and promptly reversible impact (Typically a shift)	Near-source confined and short-term reversible impact (Typically a week)	Near-source confined and medium-term recovery impact (Typically a month)	Impact that is unconfined and requiring long-term recovery, leaving residual damage (Typically years)

Table 5.3: Descriptors for the likelihood of an impact occurring

Likelihood	Likelihood description	Frequency	Substance Exposure
ALMOST CERTAIN	Recurring event during the life-time of an operation/project.	Occurs more than twice per year.	Frequent (daily) exposure at > 10 x OEL.
LIKELY	Event that may occur frequently during the life-time of an operation/ project.	Typically occurs once or twice per year.	Frequent (daily) exposure at > OEL.
POSSIBLE	Event that may occur during the life-time of an operation/project.	Typically occurs in 1-10 years.	Frequent (daily) exposure at > 50% of OEL. Infrequent exposure at > OEL.
UNLIKELY	Event that is unlikely to occur during the life-time of an operation/project.	Typically occurs in 10-100 years.	Frequent (daily) exposure at > 10% of OEL. Infrequent exposure at > 50% of OEL.
RARE	Event that is very unlikely to occur very during the life-time of an operation/project.	Greater than 100 year event.	Frequent (daily) exposure at < 10% of OEL. Infrequent exposure at > 10% of OEL.

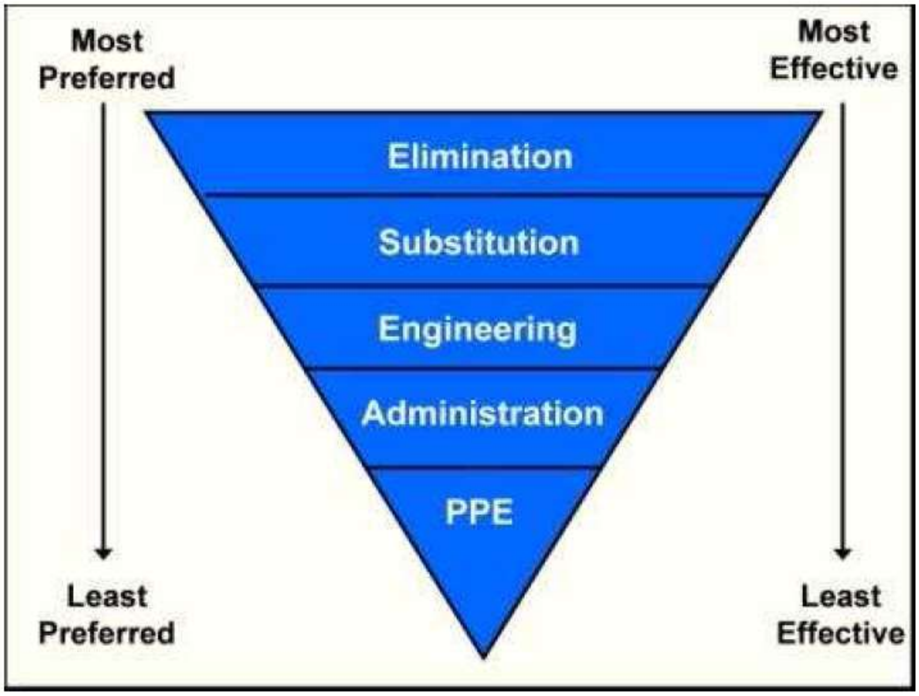


Figure 5.4: Hierarchy of controls

The potential impact resulting from each identified HSE hazard / aspect is prioritised into a HSE impact, as follows:

- Critical priority impact, and particularly all risks identified with a 'major' or 'catastrophic' consequence significantly exceed the risk acceptance threshold and require urgent and immediate action.
- A high priority impact is a risk that exceeds the risk acceptance threshold and requires proactive managements. This includes risks for which proactive actions have been taken, but further risk reduction is impracticable. Active monitoring is required.
- A moderate priority impact is a risk that lies on the risk acceptance threshold and require active monitoring. The implementation of additional measures could be used to reduce the risk further.
- A low priority impact is a risk that is below the risk acceptance threshold and do not require active management and requires only periodic review to test its status.

This HSE risk register is updated by Rössing employees and HSE advisors annually.

5.1.1.3.3 Hierarchy of controls

Operational controls are measures undertaken to mitigate risk and these are classified in accordance with HSE MS hierarchy, and preference given as follows (ordered from most to least effective): Elimination, Substitution, Engineering Controls, Administrative Controls and Personal Protective Equipment (PPE) (Figure 5.4).

5.1.1.4 HSE management improvement planning

HSE improvement plans are the cornerstone of the Rössing's HSE MS. An improvement plan describes the activities or tasks to achieve the set HSE objectives and targets in terms of timetables, resources, responsibilities and reporting frequencies for the various tasks and actions required.

Information for the HSE annual policy and policy strategies review, which is used to revise objectives and targets, is based on the following:

- Results of HSE MS audits
- Feedback from annual reviews
- Relevant incidents or emergencies
- HSE performance – monthly monitoring reports from the Health, Safety and Environmental Sections
- Legal compliance and new requirements
- Results of benchmarking to ensure that Rössing operates its HSE programmes in line with international trends, as defined by Rio Tinto
- Decommissioning requirements

HSE management improvement plans are set for each high and critical priority hazard / aspect, while monitoring programmes are set for medium and serious priority hazards / aspects to ensure that these remain well managed. There is ongoing monitoring of moderate and low priority hazards / aspects to ensure they remain well managed and do not become high priority hazards / aspects.

The results of the improvement plans are reviewed annually. During the operational review process, new activities, processes and HSE hazards / aspects are identified and incorporated into the database. New hazards / aspects are prioritised and programmed where required.

The following methodology is used to set up the improvement plans:

- The mine is subdivided into work areas with responsibilities
- Activities pertinent to each work area are identified and HSE hazards / aspects arising from each activity are identified
- A description of the impact resulting from each hazard / aspect is noted for each hazard / aspect, together with a priority ranking (Low, Moderate, High and Critical)
- Actions are identified for each high and critical priority HSE hazard / aspect to minimise the impact of that hazard / aspect on health, safety and / or the environment.
- A programme of implementation for each action is developed for incorporation into the HSE risk database, to include the following data:
    - Objective to achieve
    - The target for improvement (measurable outcomes)
    - A list of actions, to indicate the person responsible, the completion date and / or the frequency of monitoring and
    - Monitoring of progress, in accordance with the required reporting frequency

5.1.2 IMPLEMENTATION AND OPERATION

5.1.2.1 Organizational resources, accountabilities and responsibilities

The objective of this element is to ensure HSE responsibilities are allocated and accountability for the maintenance and continual improvement of HSE management is established at every level of the business.

The various appointments and their associated roles and responsibilities are central to the adoption and implementation of an efficient HSE MS.
General Managers are responsible for ensuring that the HSE Policy is implemented, that annual targets are met and that the necessary reporting procedures and structures are in place.

The HSE Manager is custodian of the HSE MS and is responsible for the implementation of health, safety and environmental strategies. The implementation of the operational HSE MS in each work area is the responsibility of the individual departmental managers. They work according to the guidelines maintained by the HSE Manager.

The HSE superintendents are the appointed management representatives of the HSE MS. As such they are responsible for the overall implementation of Rössing's HSE MS and so must co-ordinate implementation efforts throughout all departments. They liaise closely with the departmental managers, superintendents and the HSE specialists to ensure the programme is correctly managed and maintained, and facilitate and co-ordinate specialist HSE projects, should it be required. They are also responsible for reporting on the performance of the HSE MS to senior management for review.

The sectional superintendents are responsible for all HSE hazards / aspects in his / her work area and for ensuring that the objectives and targets as stipulated for each HSE hazard / aspect in his / her area are met within target dates stipulated in the relevant HSE improvement plans.

The HSE advisors are responsible for monitoring the hazards / aspects and impacts of Rössing's operations to the HSE Department. They assist departmental managers and superintendents with the implementation of the HSE MS in their respective work areas. The HSE advisors facilitate the internal communication on HSE issues within Rössing, collate and interpret monitoring results, set up and update the HSE improvement plans, based on annual HSE MS reviews as aligned with the operational HSE MS, and identify training requirements.

The HSE officers are responsible for the monitoring of those aspects within the department that are stipulated in the monitoring programme.

5.1.2.2 Training, competency and awareness

All Rössing employees and contractors have a responsibility to work in accordance with the foundations of the HSE MS. They should also possess the necessary knowledge and competence to carry out delegated tasks in compliance with the HSE MS, especially those activities that have the potential to have significant impacts. Accordingly training requirements for the various departments and work areas are undertaken.

A generic HSE induction training course is delivered to all new employees or contract workers, which deals with overarching health, safety, and environmental issues at

Rössing. Task-specific training can take place in the various departments and sections on an ad hoc basis. Records of all training courses are kept on the HSE MS register.

HSE advisors raise awareness and train employees about HSE hazards / aspects, as relevant to the employee's particular work area. Follow-up awareness training is scheduled where internal audits show HSE awareness is lacking. Records of HSE training and awareness programmes are maintained in the dedicated HSE folder on the Rössing Intranet.

5.1.2.3 Supplier and contractor management

5.1.2.3.1 Suppliers

The Rössing HSE MS includes procedures to ensure that the procurement of equipment, materials, chemicals and services (including labour) fall within the acceptable HSE risk to the operation, as follows:

- Potential suppliers of products or services are assessed on their ability to meet HSE requirements, appropriate to the assessed risk to the operation
- Suppliers must provide Material Safety Data Sheets (MSDS) to Rössing as far as possible, prior to the delivery of such products
- Equipment, materials and chemicals are received, stored and dispatched to and within the operation in accordance with HSE requirements and
- A Procurement Standard is in place to control any liability regarding the disposal of surplus, used materials, chemicals, equipment, and hazardous waste.

5.1.2.3.2 Contractors

Contractors are categorised and managed according to identified HSE risks, as assessed for each contract. Where risks are identified as unacceptable, agreements are made for the contractor to manage these risks, according to the Rössing HSE standards and procedures. Each contractor must designate an on-site works manager and contract owner responsible implementing the HSE MS in relation to that contract. All contractor personnel are given appropriate orientation and induction training, including emergency response procedures, by the Rössing HSE trainers, prior to commencing work.

5.1.2.4 Documentation and document control

A procedure for document control is in place for the HSE MS to ensure that appropriate procedures are available as required, implemented and maintained. The HSE Compliance Section is responsible for the distribution, control, storage and collection of all such documents and records, which includes process information, organograms of responsible personnel, internal standards and operational procedures. All HSE controlled documents are managed and disseminated via the HSE portal of the Rössing intranet. Systems and compliance audits are undertaken to verify the document control procedure.

5.1.2.5 Communication and consultation

Successful management of HSE hazards / aspects of concern are largely based on the effective communication of HSE monitoring results. The HSE MS ensures sound and effective communication and reporting structures so that hazards / aspects of concern are reported correctly, accurately and to the correct personnel. This allows for an appropriate response and the continual improvement of each of these aspects. The communication process in place also allows for changing requirements to be internalised and acted on, by way of the annual review process and by changes to the HSE policy and the HSE MS, as relevant.

5.1.2.6 Operational control

Operational controls are essential for the management of HSE risks associated with Rössing's work activities. This is achieved through the Rio Tinto Performance Standards (Figure 5.1), as well as other mandated or necessary risk treatment processes to control the risk to *as low as reasonably achievable* (ALARA). Procedural documents for specific operations and activities are developed on which management and mitigation measures are based. Performance against the operational procedures is monitored and non-conformances are reported so that area owners can rectify non-conformances by means of corrective actions.

Appendix 3 tabularises all procedures in operation at December 2019.

5.1.2.7 Management of change

Change is regarded as any alteration to the facilities, equipment, procedures or operating conditions outside the intent of current established parameters. The HSE MS includes a Management of Change procedure. The goal is to ensure that proposed temporary or permanent changes will not result in increased risk to health, safety, environment, financial systems and operations processes.

The Management of Change procedure requires that:

- all affected personnel are notified of any intended or actual change that poses a potential risk
- all affected personnel are fully aware of any possible dangers associated with the proposed and actual changes
- all affected personnel are informed of how to handle any adverse situations that may arise and
- required paper work is completed to record any temporary or permanent change.

The change owner, as the individual assigned to implement the change, is responsible for ensuring that a change is co-ordinated and all affected personnel are fully informed. Change is then implemented throughout the relevant area and line managers as appropriate, with required documentation to record measures for auditing purposes.

5.1.2.8 Business resilience and recovery

Through the Business Resilience and Recovery Programme (BRRP) Rössing ensures that the appropriate level of resources (plans, procedures, facilities, equipment and trained personnel) are available for an effective response to control and recover from disaster and emergency situations.

Rössing has procedures in place for responding to emergencies and unexpected and uncontrollable situations. Business resilience and recovery procedures are developed on an ongoing basis, based on a comprehensive risk assessment of the operations. Emergency procedures are practised regularly across the mine, as initiated by the Fire and Emergency Response Section.

5.1.3 CHECKING AND CORRECTIVE ACTION

5.1.3.1 Measuring and monitoring

HSE monitoring programmes are implemented to track workplace occupational hygiene and environmental performance. Monitoring of HSE hazards / aspects is undertaken by the HSE advisors, who have the following responsibilities:

- Collect and maintain all HSE records
- Develop techniques and procedures for monitoring
- Define standards
- Determine monitoring equipment, instrument control and calibration and
- Communicate results of all monitoring to HSE Superintendents, who reports performance on a monthly basis
- Compile monthly, quarterly and annual Health, Safety, Environment and Communities reports.

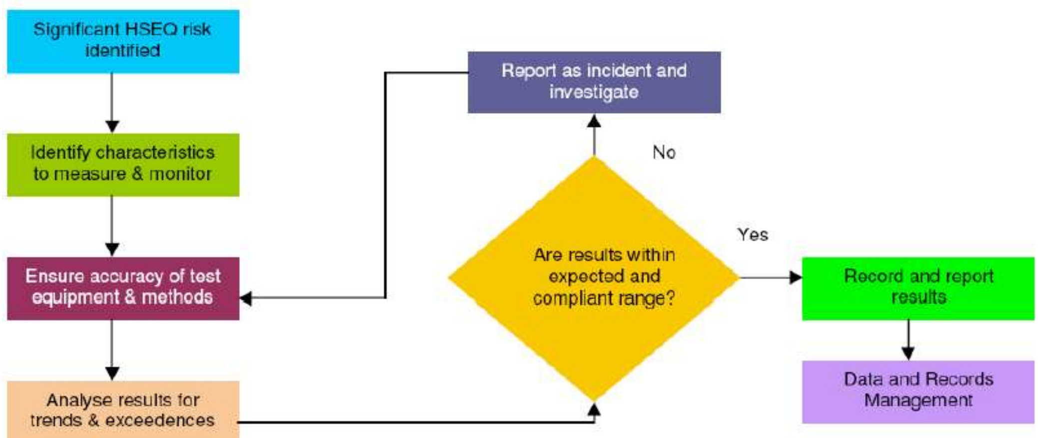


Figure 5.5: HSE monitoring work flow

Results from monitoring (Figure 5.5) are analysed on a regular basis to:

- Outline trends and potential exceedances of operating criteria (e.g. legal exposure, emission standards)
- Assess control designs and their success
- Identify the needs for corrective actions and improvement opportunities
- Reflect the level of achievement of objectives and targets, and
- Record, report and investigate exceedances.

5.1.3.2 Non-conformances, incidents and action management

The departmental managers are responsible for non-compliance reporting and investigation, allocation of resources for corrective action, and for ensuring the success of the corrective actions. Action is required when one of the following occurs:

- An HSE incident is reported;
- Monitoring (or auditing) has identified negative impacts;
- Non-compliance with Rössing standards and / or legal requirements occurs;
- Deviations from objectives and targets occur, and

- A complaint is received from a member of the public concerning any HSE hazard / aspect.

While HSE advisors can assist and facilitate implementation of corrective and/or preventive actions to minimise or prevent any HSE impact, the responsibility for the investigation and remedial actions rest with line management.

Reporting on HSE issues is integrated with existing reporting on operational issues, at monthly intervals. The HSE advisors attend departmental meetings to report on any non-conformance and corrective actions that were carried out or which are still outstanding.

5.1.3.3 Data and records management

Data relating to HSE management monitoring surveys conducted around the mine by the HSE advisors are stored in the HSE system. HSE records include:

- Collected HSE monitoring data
- Instrument calibration certificates
- Audit findings reports, and
- Corrective actions stemming from HSE incidents and non-conformances

Audit findings, HSE incidents, HSE non-conformance reports, as well as any other relevant correspondence (e-mails, photographs etc.) are stored either electronically or as hardcopies in the HSE filing system. The HSE improvement plans are documented in the electronic support system Business Solution and actions stipulated under an HSE improvement plan in the Business Solution as a result of an HSE incident are cross-referenced to the incident number or audit report number.

5.1.3.4 Performance assessment and auditing

The Rössing Audit Programme which allows for periodic evaluation has the following objectives:

- Determine / verify compliance with Namibian and other relevant international legislative frameworks
- Determine / verify compliance with HSE policies and standards
- Identify HSE hazards / risks
- Minimise potential liabilities by identifying areas where corrective action is required
- Assess the HSE MS, and
- Assess HSE performance against predetermined goals and targets.

HSE audits, as well as internal system compliance and technical audits are conducted according to prescribed procedures. The audit finding reports are stored in the relevant HSE sections. The HSE Manager ensures that audits occur within a year cycle and that all audit findings detailed in the audit reports are addressed. The HSE advisors sign off audit findings once audit deviations noted in the relevant audit report are satisfactorily addressed.

Rossing appointed global certification provider audits against ISO 14001, ISO 45001 and the HSE MS standard and issues certificates relevant to the defined scope of Rössing's business or management system.

Rössing has received ISO14001 certification the first time in February 2001. Appendix 4 provides a summary of the various assurance approaches followed at Rössing.

5.1.4 REVIEW

5.1.4.1 Management review

The objective of the management review is to ensure the effectiveness of the HSE MS through evaluating the need for changes and establish actions to improve the system, audits and resources.

The management review is undertaken annually to ensure the effectiveness of the system and evaluates the need for changes and establishes actions to improve the system.

5.2 HSE MANAGEMENT PROGRAMMES

Because of their complexity, the management of some HSE aspects requires a multi-dimensional, multi-year approach. The risks and liabilities of these aspects cross-cut over many terrains, involving many departments and operational activities, and require strategic and specialized management programmes. Examples include radioactivity, air quality, water, biodiversity, rehabilitation, mineral waste and non-mineral waste management. These management programmes are discussed below.

5.2.1 MANAGEMENT OF RADIATION[72]

5.2.1.1 Sources of radiation in uranium mining

The mining and processing of ores containing uranium and thorium can give rise to exposure to ionising radiation in various forms to both employees and to members of the general public living in the vicinity of the mine. In order to control the exposure to ionising radiation, all aspects of radiation protection and monitoring need to be addressed.

Radiation levels at Rössing are low compared with some other uranium mining operations in the world. This is due to the low-grade ore, and to a lesser extent due to the favourable uranium: thorium ratio of the ore; the ratio of uranium to thorium in the ore is about 6 to 1. Rössing ore contains an average of 360 g/t of uranium and environmental radioactivity is therefore low. The total radioactivity per gram of ore is typically 60 Bq, originating from uranium and thorium and their radioactive decay products. Uranium is extracted from the ore using an open-pit mining, crushing, milling and metallurgical extraction process.

After milling, the radioactivity is concentrated by the metallurgical extraction process. Radioactivity levels along the production process range from 60 Bq/g in the ore to 380 Bq/g in OK liquor. The majority of the radioactivity entering the processing plant

[72] Information relevant to this section was obtained from the Rössing Closure Management Plan (2011) and Rössing Radiation Management Plan (2012)

ultimately ends up in Rössing's commercial product – U_3O_8 – at levels of about 21,000 Bq/g. The remaining radioactivity from the ore, which is associated with the rest of the daughter radio-nuclides in the uranium decay chain and those in the thorium series, is deposited to the tailings impoundment, along with other mineral waste. The radioactivity level in the tailings is typically 50 Bq/g.

The processing of bulk uranium containing materials also leads to the formation of radioactive scale on equipment within vessels and pipes. The radioactivity level of this scale can reach up to 40,000 Bq/g. Radioactivity from the above materials and process chemicals can lead to exposure to workers, and/or the contamination of the soil, air or water in the vicinity, and will require remedial measures during operation and at closure. Radioactivity also occurs in dust generated by the mining and milling process which is dispersed by wind. Finally, the extraction and size reduction of ore results in an increase of radon concentrations in the environment, both within the borders of the mine site and beyond.

Most of the radiation occurring at the Rössing mine originates from the uranium, actinium and thorium decay chains. Because of the low ore grades, radiation levels in most areas of the mine are low, except for the areas in the plant where concentration of uranium takes place. Figure 5.6 shows mining related sources of radioactivity in purple colour.

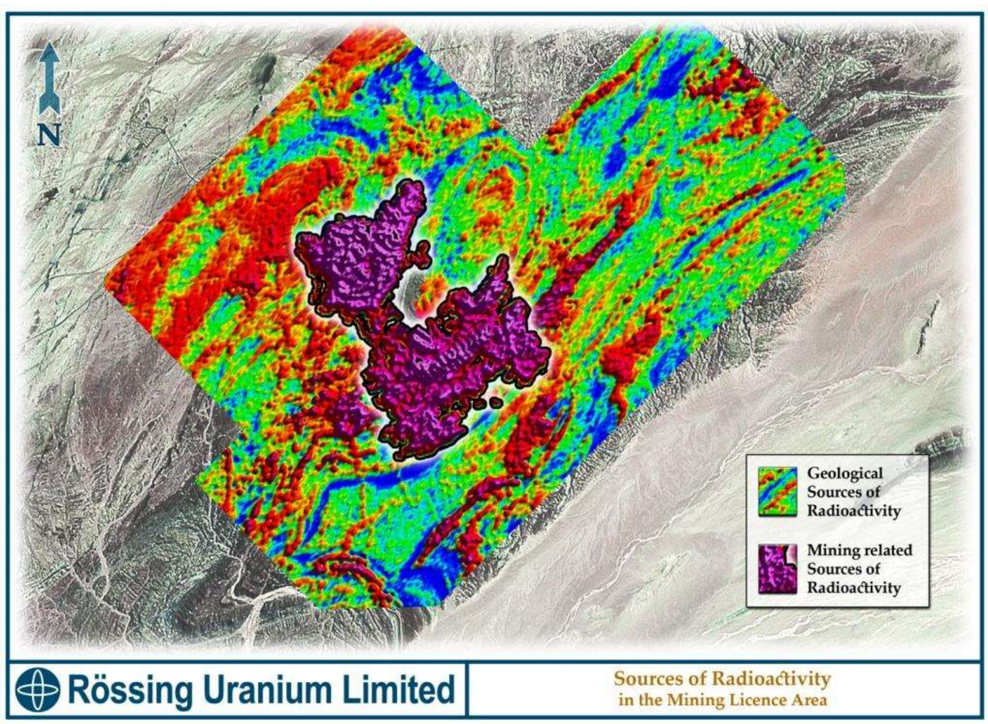


Figure 5.6: Sources of radioactivity at Rössing

Radioactivity in excess of the natural background radiation specific to the area enters the environment through the redistribution of rock materials by mining out the open pit, placing material on rock dumps and placing tailings into the tailings repository.

Long-lived radioactive dust comprises the inhalable portion of dust containing the long-lived radio-nuclides of the uranium, thorium and actinium decay chains. Sources at Rössing include

- The open pit and mining and blasting activities therein (ore dust)
- Dust roads, especially when covered with tailings sand (ore or tailings dust)
- The rock dumps, coarse ore and fine ore crusher dust plumes (ore dust)
- Areas of coarse and medium grained tailings on the tailings facility, the tailings dust plume, areas of silt and precipitated salts on the tailings facility and areas of seepage precipitate between the toe of the tailings facility and the seepage dam (tailings dust)
- Stack emissions from the FPR, if not adequately controlled, and the FPR area itself (uranium dust)

Radon-222 is a radioactive gas which is a member of the uranium decay chain. Sources of radon at Rössing include

- Ore body (open pit)
- Ore stockpiles (coarse ore stockpile, fine ore stockpile)
- Waste dumps and low grade ore stockpiles
- Tailings area
- Empty tanks and pipes with radon scales (jarosite)
- Crushing circuit

Since 1989, Rössing has measured radon exhalation rates from various radon sources. A comprehensive data set of radon flux measurements has been developed. The radon sources measured include:

- The open pit shell;
- The waste rock and low grade ore stockpiles;
- The crushing circuit, including the coarse and fine ore stockpiles;
- The tailings impoundment;
- Contaminated areas around the plant; and
- Background locations in the surrounding environment, including localized areas containing enhanced natural radioactivity levels.

Measured radon concentrations across the mine site range from background (50 Bq/m^3) to 350 Bq/m^3 in some areas of the pit and tailings.

5.2.1.2 Radiation exposure pathways

The path followed by radio-nuclides from their source via air, soil, water, and food, to humans, animals, or the environment is called the exposure pathway. The exposure of humans to radiation can occur directly from the outside (external), or internally through ingestion or inhalation. The most relevant pathways for the exposure to ionising radiation as a result of mining activities are as follows:

- Direct exposure to external gamma radiation
- Atmospheric pathway: The inhalation of dust containing radio-nuclides
- Atmospheric pathway: The inhalation of radon and radon progeny
- Aquatic pathway: Radioactivity can enter the environment via the aquatic pathway, in the form of seepage water that contains dissolved radio-nuclide salts. Seepage emanates from the tailings facility as surface water flow and groundwater flow in fractured rock aquifers and alluvial aquifers. If uncontrolled, the seepage could enter the Khan River and reach downstream users in the

lower Swakop River. Active seepage control measures are in place to prevent this from happening.

- Ingestion: Radio-nuclides can be ingested directly, or swallowed after inhalation of dust.

5.2.1.3 Legal requirements

In terms of the Atomic Energy and Radiation Act, 2005 (No. 5 of 2005) in Namibia, regulation of radiation exposure falls under the jurisdiction of the National Radiation Protection Authority (NRPA). The NRPA is currently situated within the Ministry of Health and Social Services, but it may eventually be an independent body. In addition, the Atomic Energy Board advises the Minister and the NRPA on radiation protection matters. The Act is implemented in the form of the *Regulations for Protection against Ionising Radiation and for the Safety of Radiation Sources*, which were gazetted in November 2011. The NRPA was established in 2009. Since then, mines have been required to compile and implement a Radiation Management Plan according to guidelines supplied by the NRPA. The Radiation Management Plan is approved by the NRPA and compliance with the Regulations is audited annually. In addition, each operation is mandated to report its uranium exports, transport of radioactive materials, disposal of radioactive waste and worker exposures to the NRPA on a six-monthly basis. Furthermore, the transport, storage and/or possession of radioactive materials, as defined in the Regulations, are subject to regulatory control from the NRPA.

The national radiation protection legislation is based on the internationally accepted principles recommended by the International Commission on Radiological Protection (ICRP), which are implemented in the form of Regulations by the International Atomic Energy Agency (IAEA). The ICRP guidelines include the principles of optimisation[73], limitation[74] and justification[75], which form the basis for the discipline of radiation protection. The Rio Tinto Health Standard B5, which deals with radiation protection, sets additional goals for optimising radiation protection in the workplace and for the public.

In addition to national legislation, Rössing follows the IAEA approach to radiation protection, which aims to reduce exposure to maximally exposed members of the public (‘critical groups’) to below the recommended and internationally accepted International Commission on Radiological Protection (ICRP) public dose limit and constraint. The public dose limit is set at 1 mSv per annum, with all exposures kept ALARA. In addition, the public dose constraint is used to ensure that exposure from all operations in the area combined, and to any specific critical group, is limited to a total of 1 mSv per annum. A reasonable starting point, therefore, is a public dose constraint of 0.3 mSv per annum, which would assume the unlikely situation of three operations contributing radiation exposures to a common critical group. A public dose assessment performed in 2020 has demonstrated that public exposure from the mine’s radioactive emissions is well below applicable limits, i.e. below both the public dose limit (1 mSv per annum) and also below the public dose constraint (set at 0.3 mSv per annum).[76]

[73] Radiation doses and risks should be kept as low as reasonably achievable (ALARA), economic and social factors being taken into account.
[74] The exposure of individuals should be subject to dose or risk limits, above which the radiation risk would be deemed unacceptable.
[75] No practice involving exposure to radiation should be adopted unless it produces a net benefit to those exposed or to society generally.
[76] Aurecon, (2011)

5.2.1.4 Radiation Management Plan

The objective of Rössing's Radiation Management Plan (JK20/MMP/001) is to ensure that exposures to ionising radiation will not give rise to unacceptable levels of risk, and that the sources of such exposures are identified, quantified, controlled and minimised.

The plan describes the occupational radiation protection programme, details the public exposure monitoring programme, the waste management programme and emergency preparedness and response programme, and provides a product transport plan. It also gives a comprehensive summary of the risk-assessments done, including all impact assessments, public dose assessments and closure management plans.

5.2.1.5 Occupational Radiation Protection

Measures for limiting and mitigating occupational radiation exposures include

- Radioprotection zoning (areas with a potential exposure exceeding 5 mSv are zoned controlled radiation areas, are fenced and access restricted, and workers in this area are monitored continuously)
- Occupancy limitation (in areas with a dose rate potentially exceeding 10 µSv per hour, occupancy limitation is applied to limit the maximum daily dose to below 80 µSv).
- Ventilation (ventilation is an effective measure to reduce the concentration of radon decay products in air, hence reducing the potential internal exposure from radon decay products)
- Dust or fume control measures (dust control measures include wetting or stabilisation of roads, covering of dust generating processes such as crushing and ore storage areas)
- Personal hygiene facilities (clean change rooms and lunch areas are provided, care is taken to avoid contamination of areas outside the mine by laundering contaminated clothing on site)
- Contamination control (items leaving site undergo a comprehensive contamination inspection routine before they are cleared to leave site. This prevents contaminated materials, such as scrap and tools, from leaving site and contributing to the spread of contamination)
- Administrative controls (safe work procedures)
- Training (awareness raising and skills improvement initiatives are offered to employees and to identified public stakeholders such as police officers, teachers, municipal workers, journalists, emergency responders and many more)
- Personal protection (PPE, in particular respiratory protection where needed) together with clean shaven policy.
- Emergency plan and drills

The effectiveness of employee radiation protection controls are monitored by way of personal and area radiation monitoring programmes:

- Continuous personal sampling of external radiation for all radiation workers. Thermo luminescent dosimeters (TLD) are used for this purpose. The wearing period is 12 weeks and TLD's are analysed and serviced by the South African Bureau of Standards (SABS).
- Random personal sampling of external radiation for all exposure groups. Electronic personal dosimeters are used for this purpose. Two models are presently in use, the Thermo Scientific EPD-G and the Tracerco PED.

- Random personal sampling of internal exposure from radon progeny. The SARAD DosemanPro is used for this purpose, a highly effective and user friendly direct-reading progeny measuring device.
- Random personal sampling of internal exposure from the inhalation of radioactive dust. The SARAD MyRIAM is used for this purpose, a direct reading instrument which uses in internal pump to collect dust on a filter, which is subsequently analysed for its radioactive content. A dose can be read directly from the instrument.
- Monthly urine bioassays are taken for all designated radiation workers to exclude any potential internal contamination or workers with uranium.
- Monthly pregnancy testing in female plant workers ensures timely removal of pregnant employees from areas with annual radiation exposures exceeding 1 mSv per annum.
- Air quality on site is monitored by using high-volume samplers and PM10 air samplers. Dust samples are regularly submitted for radionuclide analysis.
- Air quality in the FPR area is monitored continuously by using an Trolex Air XD Real-time Dust Monitor with real time reporting to the Central Processing Control (CPC) room.
- Comprehensive radiation clearance procedures for tools and equipment ensure any cross-contamination between contaminated and uncontaminated areas occurs on site.

5.2.1.6 Public Radiation Protection

The public dose limit is 1 mSv per annum. However, the maximum public dose assessed is significantly below this, at a maximum of less than 0.3 mSv per annum and down to very low exposures. It is therefore not possible to directly measure public exposure by issuing dosimeters to members of a critical group, as the measurement signal (the dose due to mining activities) will be swamped by the much larger measurement noise (natural background radiation, at approximately 2 mSv per annum).

The public dose assessment therefore builds on the principle of (see Figure 5.7)

1. Identification of radiation source
2. Identification of exposure pathway
3. Identification of critical group for this exposure pathway
4. Assessment of maximum exposure from identified source to identified critical group along pathway
5. Combination of all relevant pathways for each critical group

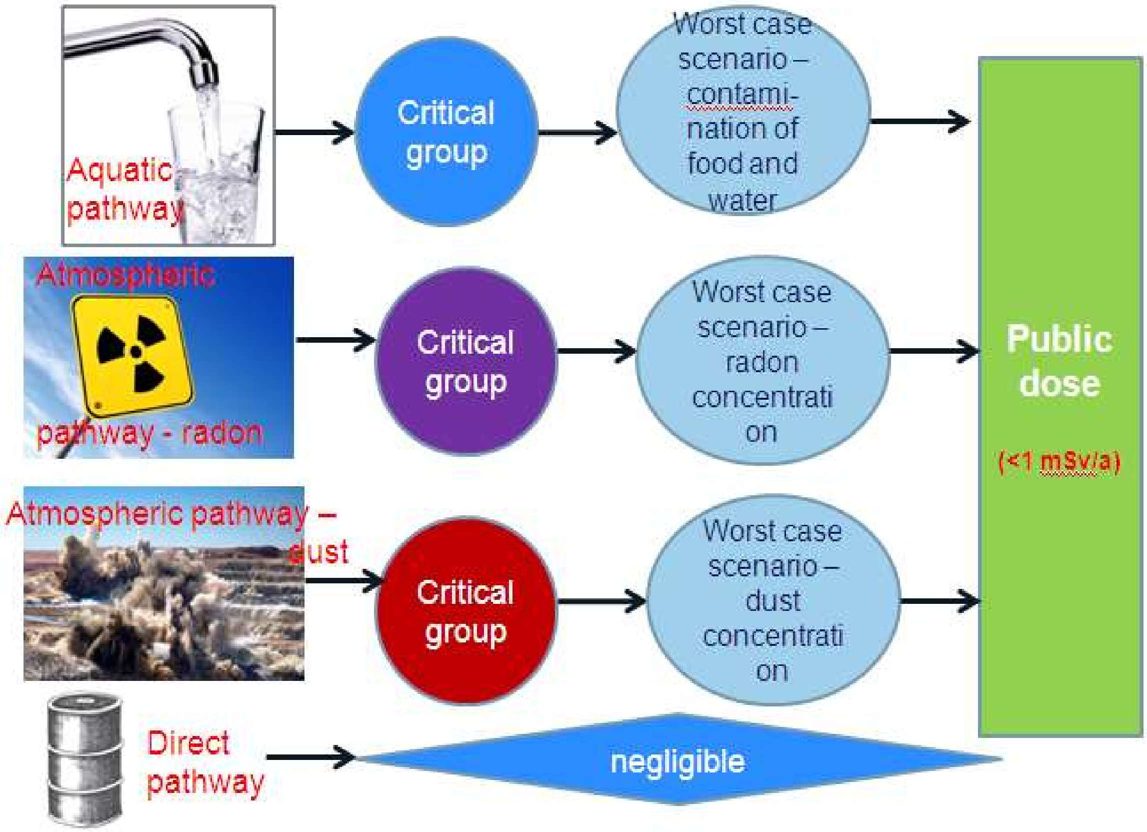


Figure 5.7: Exposure pathways and critical groups for public dose assessments

5.2.1.6.1 Aquatic pathway

Pollution of groundwater can occur through

- Dissolution and leaching into groundwater of radionuclides in tailings, ore and waste dumps
- Underground migration of seepage from tailings
- Deposit of radioactive materials on soil surfaces and subsequent dissolution in groundwater.

Radionuclides in groundwater can lead to the uptake of radioactive material through direct water consumption, or through the consumption of crops which have been irrigated with the groundwater, or by the ingestion of animal products from animals using the groundwater as drinking water. Assuming a groundwater concentration of radionuclides, the following processes are relevant:

- Irrigation of crops, subsequent crop ingestion by humans
- Irrigation of crops, ingestion of crops by animals, subsequent ingestion of animal products by humans
- Water ingestion by humans
- Irrigation of soil, soil uptake by humans and animals
- Irrigation of soil, direct irradiation of humans from soil.

A part of the tailings solution discharged to the tailings dam infiltrates into the tailings pile and either remains entrained around the particles or percolates through and emerges at the toe of the dam. The toe seepage is mostly collected in trenches, pumped to Lake Geoff. Overflow from the trenches is channelled on surface to the seepage dam from where it is recycled. Water that seeps into the bedrock under the dam is recovered by a collection of seepage control systems. Seepage recovered is re-entered into the plant process as a water saving measure. Monitoring of seepage control installations on the tailings facility is carried out daily.

Water quality is monitored by using a collection of monitoring boreholes located around the site and in the Khan aquifer, the aspect is discussed in section 5.2.3.

5.2.1.6.2 Atmospheric pathway – radon

For an assessment of public dose as a result of radon emissions from mine sites, the following information is required:

- Radon exhalation rates at various sources
- Meteorological data (wind speeds and directions)
- Local topology in the area surrounding the radon exhalation

Detailed atmospheric dispersion modelling is required to fully evaluate the distribution of radon from its sources to areas of concern, such as towns and villages, and also for impacts of dust containing long-lived radioactive nuclides.

The modelling exercise is supplemented with an extensive radon measuring programme, covering a 16 by 16 km grid across the mine site. This grid covers both areas affected by mining and background and hence serves as a confirmation and check of the radon dispersion models.

5.2.1.6.3 Atmospheric pathway – dust

For an assessment of the dose to humans resulting from fugitive dust, the following factors have to be considered:

- Sources of dust
- Chemical composition and particle size distribution of dust
- Radionuclide content of dust
- Meteorological conditions
- Age distribution of critical groups
- Rate of uptake of radionuclides by different crops from deposited dust
- Percentage of use of own grown crops versus crops imported from elsewhere
- Percentage of animals and animal products consumed versus animal products imported
- Percentage of milk and milk products produced by own cattle, versus imported products

Dust collected at the locations for critical groups is analysed for radionuclide concentration, in Bq/g. Dust samples are sent regularly to an accredited laboratory for an analysis of the radionuclide content in the inhalable portion of the dust.

5.2.1.7 Records

All records relevant to the employee and public exposure monitoring programme are kept indefinitely, in a format that allows the presentation of yearly statistical information about the monitoring processes.

5.2.1.8 Industrial radiation sources

All sealed radioactive sources (industrial gauges) are not in use and are stored in the radiation store. Safety and security of sealed sources is detailed in the Radiation Management Plan, and all sources on site are licensed by the Radiation Protection Authority and inspected by the latter annually.

5.2.1.9 Emergency preparedness and response

Actions taken in an event of a uranium oxide spill are detailed as part of Rössing's BRRP procedure. Valid emergency information sheets accompany the consignment throughout the duration of the voyage which provides correct emergency actions to the relevant parties. Formal and legal regulations are in place in the countries through which Rössing's product containers are transported and clearly address responsibilities and accountabilities regarding emergency response and clean-up. A drill on the action to be taken during an emergency is practiced at least once a year.

5.2.1.10 Transport

Rössing's final product, U_3O_8 is listed as a Class 7 hazardous material, with a United Nations hazardous material number of 2912 (radioactive material, low specific activity LSA-1 non-fissile or fissile excepted). The hazardous properties of U_3O_8 are relatively low compared to other radioactive materials and most hazardous materials in general. Transportation of U_3O_8 is governed by the IAEA Regulations for the Safe Transport of Radioactive Material[77] as well as national and international standards and regulations. These standards and regulations stipulate the responsibilities of shippers and carriers. In many jurisdictions, carriers must be licensed to carry nuclear material.

U_3O_8 is packed in drums steel drums and sealed. All cleaning, marking, labelling and monitoring of product drums and containers are done following the IAEA Regulations for the Safe Transport of Radioactive Material[78]. Employees working with the drums and close to the drums during packing, cleaning and monitoring, are monitored for external radiation dose.

Uranium ore samples are sometimes transported to laboratories off site, either within Namibia or across its borders.

Ore samples containing uranium, with an activity of 1 Bq/g (from uranium alone when ore grade is > 40 ppm), or with a total activity of 1,000 Bq or more, may only be transported if permitted by the National Nuclear Regulatory Authority. Packaging and disposal of ore is furthermore accompanied by required documents and subjected to internal control measures.

5.2.2 MANAGEMENT OF AIR QUALITY

Air quality management at Rössing is guided by an Air Quality Management Plan (JE20/MMP/004). All air emissions are listed in an inventory (JE65/STD/002) and all air quality standards applied at Rössing are documented (JE65/STD/001).

The current air quality monitoring program is based on the original one established during the pioneering years at Rössing. In the meantime the E12 (Air Quality Protection) guides the current operations. Concerns about air quality – then and now – are based

[77] IAEA, (2005)
[78] Ibid

on two uncertainties: The relationship between air quality and employees' health; and concerns about impacts on the ambient environment[79].

Measurements are taken in order to ensure that exposure levels of employees do not exceed prescribed occupational limits and to ensure that existing and newly introduced controls efficiently detect differentiations as a result of process changes. Informed risk-based decisions, related to the level of control, are introduced for the various exposure levels thus, and the objective is to optimise performance in terms of emission reduction and control measures.

Since its inception meteorological data is collected at Rössing in order to characterise the ambient environment and to determine the dilution and dispersion of atmospheric contaminants. There are four weather stations that are in operation, located at Point Bill, Hill Jim (open pit) and the tailings facility on site, and in Arandis at the valve house.
The Rössing air quality hazard assessment was initially conducted during a series of workshops in March 1993. During the workshops the nature of the airborne emissions, the mechanisms that result in the release of the airborne contaminants and the control systems to limit these releases were identified.

An air quality risk assessment for Rössing was conducted in 1998. It was identified that SO_2 (from the former acid plant), total dust and lodged silica from tailing dust were the air-borne contaminants with the most significant impacts. A study, which assessed hazards, exposure, pathway, intake and toxicity, was completed in 1998[80]. The study also applied the background and philosophy of risk in setting environmental control thresholds for use at Rössing. More recently an air emission risk screening was conducted and the risks at Rössing were classified as low. Although air quality risks are thus characterized, there is a need to update the risks to reflect current operations.

Rössing's documented dust inventory is based on the air quality risk assessment of 1998. Models such as the US-EPA recommended Fugitive Dust Model, AirDos EPA, Industrial Source Complex Long Term Model and Industrial Source Complex Short Term Model were used in the past to determine fugitive dust inventory sources at Rössing according to area, type and dust generating activity. The inventory was amended with calculated PM10 and Total Particulate Matter (TPM) emissions from the Air Quality Impact Assessment conducted in 2007 as part of the proposed Rössing expansions. Fugitive dust emissions were quantified during this assessment using the most recently United States Environmental Protection Agency's approved regulatory model, the AERMET/AERMOD suite of models.

It is acknowledged that the operations at Rössing can result in the generation of dust, and in combination with natural occurring background dust levels, dust can have adverse impacts on the surroundings. The Rössing Dust Management Plan intends to provide a consistent approach for dust management at the mine, with the aim to continuously

[79] The ambient environment, which may be adversely affected by radiation, dust and gases emanating from Rössing and its related activities, is defined as general public, visitors to Rössing, the residents of Arandis and the fauna and flora surrounding the mine. It is not only human health that can be adversely affected by impurities in the air: the fall-out of heavy metals onto soil and foliage of plants also results in adverse impacts. The metals are either taken up directly from the deposits on the foliage, or it is taken up by plants and concentrated in the leaves of the plants. This can result in the bio-accumulation of heavy metals and radio-nuclides in the food chain, with severe adverse impacts in some cases. On the other hand, greenhouse gases have a knock-on effect on (global) atmospheric processes.
[80] Metago Environmental Engineers, (1998)

reduce levels of fugitive dust. Specifically, the plan contains information about dust inventories, risk assessment measures and practices to minimize the generation of dust, monitoring, plumes, performance criteria, communication and reporting.

Detailed sources of dust and particulate emissions at Rössing are identified and documented. The main sources and activities that contribute to dust emissions are drilling and blasting; loading and hauling; transfer, crushing, conveying and storage of ore; operations (including vehicle movement) and exposure to wind[81]. Currently comprehensive air quality monitoring activities take place at various locations on the mine site. Monitoring includes measuring PM10 dust, for example (Dust fallout sampling procedures JE50/PIN/003; PM10 monitoring JE50/PIN/007; Multi-vertical dust sampling JE50/PIN/006). The network of monitoring sites is currently extended.

The impact of the fugitive dust emissions on the quality of the air is determined from dust fall out depositions measurements (including multi-vertical samplers) and monthly estimates. Multi-vertical dust samplers at the edge of the tailings facility collect dust and sand particles that are blown westwards off the tailings facility. Readings from the multi-vertical sampler around the tailings facility during Bergwind conditions is estimated annually. The PM10 dust sampler is situated at four (4) places around the mine, at the Arandis residential area, mine Boundary on the South westerly side of the mine, Tailings west and at the Contractor Management Centre (CMC). PM10 dust samplers are used to determine the level of dust in the air. The primary concern is to test to see how much dust under 10 microns in size is airborne, as dust particles this size or smaller can cause damage to human health.

Rössing is using the ambient air quality standards based on Schedule 2 of the South African National Environmental Management Act: Air Quality Act (Act No.39 of 2004), as a reference to set criteria. In keeping with the current best practise, Rössing will also adopt the new South African ambient air quality standards as provided by the South African Government Notice (No.32816 Vol. 534). Details are set (see Table 5.4 and 5.5).

Table 5.4: Particulate matter (PM10)

Type	24 hours average	Annual average	Comment
Ambient air concentration	75 μg/m^3	40 μg/m^3	Frequency of exceedance for a 24-hrs average not more than 4 times

For fall-out dust depositions, Rössing adopted the South African method of evaluation as given in Table 5.6. The1,200 mg/m²/day threshold level is used as an action level and in the event that on-site dust fall-out exceeds this threshold, the specific causes of high dust fall-out should be investigated and remedial steps taken. In Arandis a 600 mg/m²/ day will trigger an investigation and remedial steps.

Dust at Rössing is managed in various ways. Water is used to suppress dust on gravel roads. In addition, ligno-sulphonate, a chemical binder, is sprayed onto some road surfaces. A mobile road sweeper is used on tarred surfaces to remove dust and air-borne debris. At the crushers dust control entails preventative maintenance and frequent

[81] Aurecon, (2011)

wash downs. Engineering controls such as dust extractors (at the crushers), scrubbers and baghouses (at FPR) are also in place.

Table 5.5: Dust fall-out range

Restriction Area	**Dust Fall Rate (D) ($mg/m^2/day$, 30-day average**	**Permitted frequency of exceeding Dust Fall Rate**
RESIDENTIAL	D<600	Two within a year, not sequential months
INDUSTRIAL	600<D<1200	Two within a year, not sequential months

Dust fall-out is monitored and recorded internally - monthly on site and annually to CNNC - to reduce dust through innovative controls. The impacts of blast dust are reduced by considering wind direction, prior to blast events, in order to limit dispersal and deposition. In addition, the blast areas are soaked with water before blasting. At the tailings facility, windrows are created to break prevalent air flow over the paddies. Table 5.6 shows some of the dust control measures that are applied at Rössing.

Dried-out tailings and seepage deposits may represent a major source of wind-blown dust. As a remediation option for fugitive dust from the tailings facility after mine closure, covering the entire tailings facility by a layer of rock is presented. Seepage areas, which also present a dust hazard after drying up, can be covered with rocks after mine closure too.

It was observed that biological soil crusts at Rössing are present in a somewhat reduced form compared to their occurrence in nearby habitats[82]. The suggestion is that the reduced form of biological soil crusts found at Rössing may be the result of fine layers of dust coating rocks and stones reducing the natural flow of condensed moisture to the hypolithic environment, resulting in a drier microclimate non-conducive to biological soil crust formation. A reduction in biological soil crusts could reduce the productivity of the desert habitats - biological soil crusts are known to be very active in fixing and remobilising carbon and nitrogen in desert soils[83]. Further research and monitoring is required to fully understand the likelihood and consequence of the impact of dust on the formation of biological soil crusts.

[82] EEAN, (2008)
[83] Belnap, (2001); Evans and Lange,(2001)

Table 5.6: Dust control measures at Rössing

Source	Dust control measures
Open pit	
Haul and other roads	Spray with seepage water Spray with ligno-sulphonate Dust-A-Side Restricted speed limit (40 km/h)
Muck piles	Spray with water
Waste rock dumps	
Tops	Spray with water
Blasting	
Large blast	Wet drilling Consider wind direction
Small blast	Wet drilling
Plant	
Primary crusher	Spray at tipping point and dust collectors
Coarse ore stockpile	Spray at tipping point
Conveyors	Partially covered
Fine crushing	Regular wash-downs Dust collectors
Tailings facility	
Paddocks	Wind-breaks, e.g. wind rows
Roads	Spray with seepage water Spray with lingo-sulphonate Regular maintenance (road grading) Restricted speed limit (40km/h)
Mine-wide	
Roads	Road sweeper, Restricted speed limit (60 km/h)

It was also observed that the abundance and diversity of solifuges is exceptionally low at Rössing and the abundance and diversity of spiders is relatively lower than expected[84]. The Central Namib is a global hotspot of solifuge diversity so this paucity of solifuges and arachnids is likely to have a causal link. Dust attributable to operations at Rössing may reduce the availability of shelter and refuge for invertebrates. Coupled with dust related reduction in plant productivity, the reduced form of biological soil crusts and a reduction in moisture in the hypolithic environment, dust generation attributable to Rössing may have an impact on solifuge and arachnid mortality outside of the area of direct disturbance.

Invertebrate data collected from Rössing is restricted in terms of comparisons and identifying landscape-based patterns and some taxa are known only from one specimen trapped during survey work by the State Museum in the 1980s. To fully understand the likelihood and consequence of the impact of dust on solifuges and arachnids, quantified research and monitoring is required to a) establish a baseline of invertebrate abundance and diversity and b) fully understand the impact that dust has on invertebrate mortality.

[84] EEAN, (2008)

Efforts to stabilise global atmospheric concentrations of greenhouse gas (GHG) at lower levels is a priority, as a result, Rössing measures GHG emissions too which requires Rössing to:

- Develop and maintain detailed knowledge of energy use, GHG emissions and saving / abatement opportunities at its operations;
- Identify and assess GHG related risks and opportunities for the business;
- Develop a plan and targets that drive improvements in energy efficiency and GHG emissions.
- Implement programmes that maintain energy efficiency and GHG emission reductions

Current measuring of impacts that can contribute to climate change includes the monitoring of GHG emissions and the monitoring of energy use at Rössing.

The intensity of emissions is reported per unit of product target, according to an operation procedure (JE65/PRC/001). Sources of GHG emissions include electricity and fuel consumption transport of reagents and uranium, blasting (explosives), waste (sewage, rubbish disposal and landfill) extraction and processing.

GHG emissions intensity per unit of product target, the so called Tier 1 target, is reported monthly and annually. The Tier 2 target is an internal target that calculates energy use per unit of "*work done*". To calculate the GHG equivalent of the amount of energy used, the total energy consumed is converted to CO_2 per tonne of U_3O_8 produced. The figures are used to drive energy efficiency and emission reductions on site, and are reported monthly and annually.

Electricity at Rössing is supplied by NamPower. It is a mix of 58% hydro (from the Ruacana plant in Namibia) and 42% Eskom (mainly from coal power stations in South Africa) power. Taking into consideration the electricity makeup, factors were developed for conversion of electricity to energy and GHG and these are 3.6 (GJ/MWH) and 0.529 (t CO_2-e/MWH) respectively. These factors need to be verified from time to time. Sub-metering of electricity is done on all working areas at Rössing in order to calculate the contribution of each component to the total energy consumption. The electrical feed to the various working areas are monitored by an online monitoring system which is used as inputs to an energy efficiency analysis and to track improvements.

Fuel, mainly diesel, is consumed by drilling, hauling, blasting and support equipment and vehicles. Diesel is also used for roasting purposes in the FPR. Default factors used in conversion of diesel to energy and greenhouse gas and these are 0.0382 (GJ/L) and 0.00269 (t CO_2-e/L). For petrol these figures are 0.0345 (GJ/L) and 0.00227 (t CO_2-e/L).

For the conversion of explosives, the default factor is 0.1778 (t CO_2-e/t explosives). For sodium carbonate it is 0.434 (t CO_2-e/t), but at Rössing the factor becomes 0.434 * 0.05 = 0.0217 tonne of CO_2 for every tonne of Na_2CO_3 (as only 5% of the carbonate is used up). The factor used for conversion of ore processed to GHG is 0.0022 (t CO_2-e/t ore milled). GHG emissions (CO_2-e) from domestic waste dumped at the landfill are determined using the methodology provided by Rio Tinto specifically for Rössing's landfill site.

The transport of uranium to converters and the transport of major reagents from suppliers to the mine are also reported annually only.

Constant improvement in GHG management is guided by the documented plan (JE20/MMP/003). Accordingly targets to reduce energy consumption and emissions are set and reporting of performance against these targets are done monthly and annually (Monitoring and reporting procedures JE65/PRC/001). Energy efficiency initiatives have been identified of which some are implemented already.

Annual stack emissions monitoring are done at FPR to assess the efficiency of the stack filters. Chlorine detectors with an alarm system, for safety purposes, are in place at the sewage plant. Outcomes on several specialist studies (e.g. Volatile Organic Compounds) were done at various areas and indicated that the risk at Rössing is low.

Noise and vibration is monitored at Rössing through a network of various points and studies. Information is used to assess compliance and to address concerns, as well as to provide feedback to the Geotechnical Section, which utilized the information in investigating the impact of blast vibrations on the stability of the pit. The management of noise and vibration is guided by the Standard E12 (Air Quality Protection) on which the Noise and Vibration Management Plan (JE20/MMP/008) is based. Environmental noise is monitored according to a procedure (JE65/STD/003). Noise is monitored and monthly reported to minimize noise to threshold levels and to identify exceedances. Engineering solutions and continuous business improvements attempt to mitigate the impacts of noise. Regular inspections and audits are conducted. Best practices are shared.

In conclusion, improvements of the air quality management practice at Rössing aim at

- a refined understanding of Rössing's dust pollution footprint, as expressed by the current dust plume in correlation to the wind regime
- a better understanding of the correlation between blasting and its impacts – dust, noise and vibration
- a review of the existing sources of emissions from mining operations
- characterising ambient air quality
- a better comprehension of the impacts of air quality on biodiversity
- review of control measures to recommend additional measures if needed, and mitigation to manage air quality better.

5.2.3 MANAGEMENT OF WATER

Water management at Rössing is guided by a formal water strategy, Water Management Plan and a Rössing specific-specific environmental standard on water usage and quality management. The Standard covers all activities connected to water abstraction, dewatering, transport, storage, usage (potable and process), and direct / indirect discharge, involving surface water (including run-off), impounded water and groundwater. The intent of the Standard is to ensure efficient, safe and sustainable use and protection of water resources and ecosystems. An understanding of water resources, their spatial and temporal interrelationships, ownership and the needs of key catchment stakeholders is thus required to provide the basis for the development of an integrated and strategic approach to water management that promotes the maintenance or improvement of water quality, upstream and downstream, minimisation of fresh water use and the maximisation of reuse and recycling.

Water supply at Rössing dates back to the late 1960s when two wells in the Khan River were permitted to provide water to exploration activities. In 1971 a third borehole was drilled to serve the pilot plant. More boreholes were drilled between 1973 and 1976, some of which were washed away in the 1985-flood and had to be re-drilled in 1986. In

1993 two more boreholes were drilled. Power lines and pipelines connect the abstraction system to the mine's water distribution network.

In December 2004, The Water Resource Management Act, 2004 (Act No. 24 of 2004) was gazetted and enforced. Subsequently in 2013, the Water Resources Management Act 11 of 2013 was gazetted however this act has since not been enforced. In addition, The South African Water Act No 54 of 1956 is still referred in some instances.

The government agency controlling Rössing's water management programmes is the Department of Water Affairs (DWA) in the Ministry of Agriculture, Water and Land Reform.

From the early years of Rössing's existence the DWA permitted Rössing to extract 870,000 m^3 per annum (2,384 m^3 a day) of brackish water from the Khan River aquifer for industrial use, mainly to suppress dust in the open pit. Power lines and pipelines of Rössing connect the abstraction system to the mine's water distribution network. As a proactive measure to concerns about a dropping water table, the DWA granted Rössing permission to extract water on the condition that vegetation along the river is monitored. Since 1988, the monitoring results have been submitted to the DWA to provide basis for revising water abstraction rates, should abstraction be identified to have an impact on vegetation. As of 1995, the sustainable yield of the Khan River aquifer has been determined every year after the rainy season and the extraction target set accordingly. Volumes and water levels are monitored monthly and used to update the water reserve estimation according to a documented operational procedure, JA50/OWM/WBP/001.

Hydrogeological studies indicated that, as a result of abstraction, the water table would be lowered to 10 metres below the surface but groundwater reserves at a depth of 10-20 metres below surface would still be available to sustain vegetation and dependent biodiversity. Monitoring results have shown that water levels measured upstream of the aquifer have a natural range of variation extending from approximately 1-10 m below the surface.

Extraction of brackish water from the Khan aquifer was voluntarily suspended between 31 December 2009 and 3 August 2011 in line with a drive to promote water savings. The monitoring and measuring of the vegetation and water levels in the river continued during the same time[85]. Abstraction of water resumed because of an increase in the need to suppress dust in the open pit as a result of the present extensions. The current rate of 600 m^3 a day is a target that Rössing set internally and is below the safe allowable abstraction. Rössing continues to adhere to another permit condition which is the monitoring of the ground water and the biannual vegetation in the Khan aquifer as described in procedures JE65/OWM/002 R8.

About 40 million cubic meters of effluent is contained in the tailings facility at Rössing. This is a potential source of contamination that needs to be controlled. By law Rössing is obliged to ensure that no seepage from the tailings facility flows into the Khan River and other downstream receiving environments and to prevent residual contamination by metals, salts or radio-nuclides. Thus, impacts on water quality will fall within the range of natural variability for the receiving environment. Subsequently, water management at Rössing puts a strong emphasis on the tailings facility, and is regulated by various

[85] Rössing Closure Management Plan, (2011)

operational manuals and standard operational procedures that form part of the overall Water Management Plan (JA10/MMP/001).

Most of the surface seepage from the tailings facility flows down Pinnacle Gorge and is contained in the seepage dam below the facility. Two cut-off trenches further downstream were constructed during in the early 1980s by digging ditches across the riverbed into the weathered bedrock and removing any loose material. One or two concrete wells were placed in the deepest parts of the trenches before the latter were backfilled with permeable sand and gravel. The wells are installed with electrical submersible pumps which are operated by a fully automated system & monitored live on the Central Processing Control (CPC).

The purpose of the trenches is to remove groundwater flowing in the alluvium and thus cut-off the major flow paths of potentially contaminated water towards the Khan River (see Figure 5.8). A groundwater flow model of the tailings facility exists[86], which assists in the assessment of ongoing operations at the tailings facility and the consequent predictions of impacts of various long-term options. There is no diversion of storm water around the tailings facility in place. Due to the low rainfall in the area, there is minimal possibility of storm water damming up.

The buffering capacity of the rock types that surround the tailings facility, as well as the tailings sand itself, significantly inhibits the leaching of contaminants from the facility. However, small volumes of water from the tailings facility infiltrate into underlying bedrock where fractures allow some movement of groundwater from the western side of the dam towards Panner Gorge. Seepage of these contaminants into the alluvial aquifers of the Pinnacle, Panner and Dome Gorges is curbed by cut-off trenches and dewatering boreholes which are arranged in a double line on and along the western side of the tailings facility, in addition to the surface seepage collection dam in Pinnacle Gorge (Figure 5.8). Geophysical surveys were carried out to ensure that boreholes were placed on all major fractures. A cut-off trench is placed across the lower Panner Gorge to prevent inflow to the Khan River.

[86] Aquaterra, (2005)

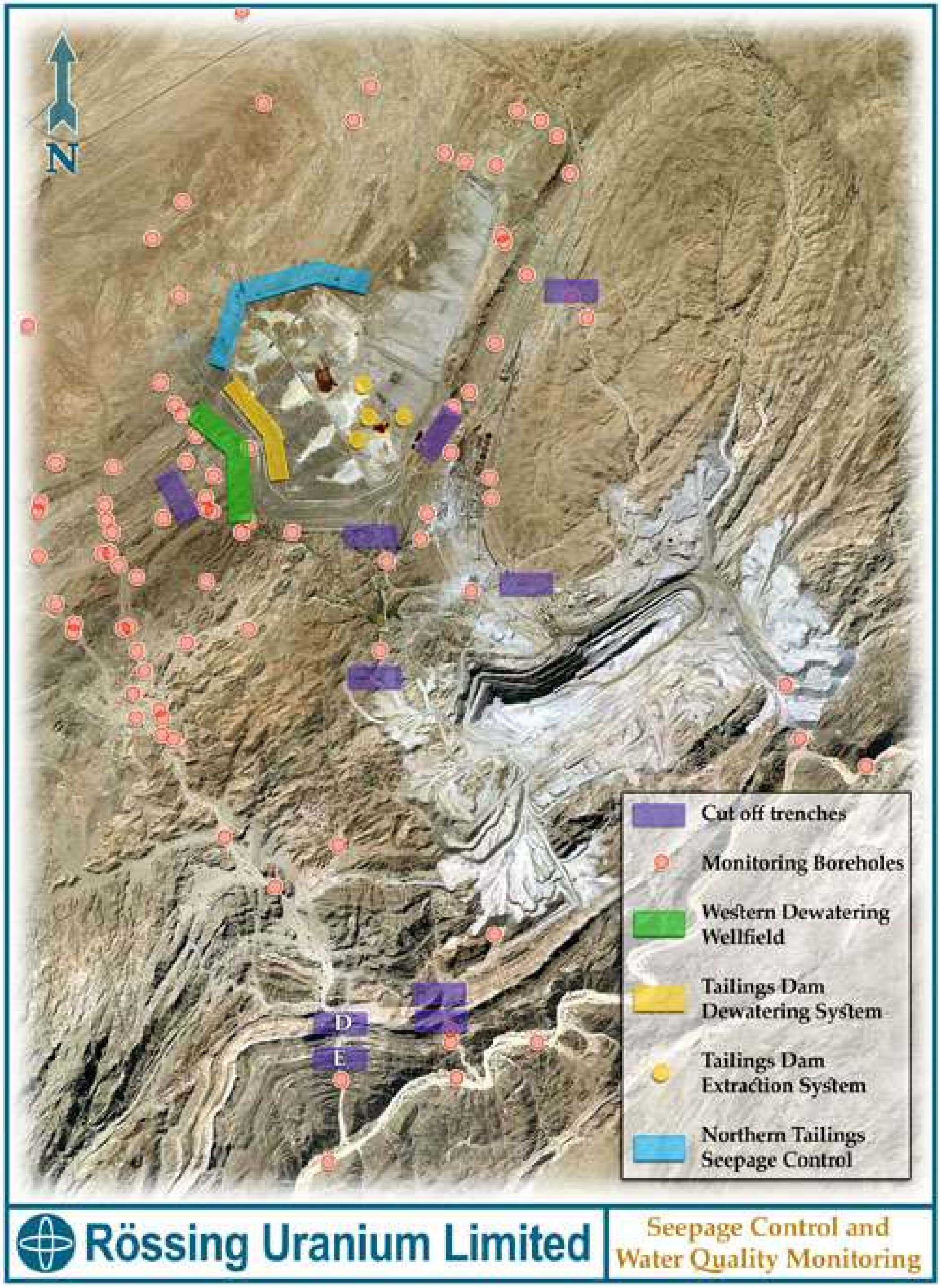


Figure 5.8: Water monitoring and seepage control at Rössing

Many former dewatering wells are currently not in operation because their yield has declined to less than 1 m^3/day, a capital project was submitted to the investment committee requesting for funds for drilling additional 20 boreholes in the area. If

approved, this project will be realised in 2021/2022 and contribute increased dewatering in the area.
The efficiency of the measures to control contamination of the Khan River is confirmed with regular borehole water monitoring in Pinnacle and Panner Gorges. The tailings facility is continuously monitored over 24 hours, generally completing a circuit every 2 hours. Groundwater flows and water quality are monitored at various other points and the seepage control installations are monitored daily. Monitoring includes checks on the available capacity at each operational open end as well as the water levels and shift log sheets are completed for evaluation. Flow meter readings are taken once per week and entered in a dedicated database to compile water balances and other reports. Water samples from the boreholes is analysed for radio-nuclide concentration, in Bq/L. Of the roughly 150 monitoring boreholes, monitoring is done against a schedule agreed upon between the mine & MAWLR under the Waste Water and Effluent Disposal Exemption Permit 674. Water samples are sent to accredited laboratories for analysis as per the agreed upon schedule.

Water storage in the tailings facility is minimised through a system of abstraction boreholes on and around the tailings facility. Away from the tailings facility the de-watering system exists of trenches and boreholes located in Pinnacle, Dome and Panner Gorges. The trenches and boreholes are pumped continuously to lower the water table and to reduce the advancement of groundwater contamination into the Khan aquifer. Detailed operational procedures include the Operation and monitoring of the seepage control systems (JA50/OWM/SCP/002); Water quality monitoring (JE65/OWM/004); Water quality management (JE50/MSP/001); Water recycling and re-use (JE50/OWM/003); Seepage recycling on the tailings dam (JE65/OWM/006) and Treatment of TDX boreholes (JA50/OWM/WSM/004). AutoCAD drawings of the seepage control systems and monitoring sites are annually updated (Water Control Plan 1002A) and filed at the Survey section. The location of the trenches and well fields can be seen in Figure 5.8.

Rössing uses steel pipelines of various diameters for the freshwater reticulation system. There are four main separate pipeline systems: 1) domestic water supply, 2) process water feed to the plant, 3) supply to the crushers and open pit and 4) supply to the fire tank and lakes. The purpose of having separate pipelines for domestic and process fresh water is to reduce the risk of potable water contamination. Drawings of the reticulation systems for fresh and recycled water are filed at the Engineering Drawing Offices. Pipes are colour-coded to indicate the type of solution.

The current water management system ensures that practically all process effluent is recycled, either directly from the paddy pond or from the seepage dam and seepage control systems. Only a small volume of seepage reaches the underlying bedrock and dissipates into fractured bedrock whose permeability is too low for effective dewatering. Hydrogeological modelling has shown this volume to be in the order of 150 m^3 per day. It is included in the site water balance as “seepage loss”.

The environmental impact of seepage is reduced by chemical reactions inside the tailings facility, which remove most of the acid and chemicals contained in the tailings solution. Tailings contain an average of 0.5% carbonate, which neutralizes sulfuric acid to gypsum and carbon dioxide. Other chemical reactions lead to the precipitation of iron hydroxides and co-precipitation of heavy metals and radionuclides. For instance, the TDS concentration of tailings solution is above 30 000 mg/L, but the seepage emanating from the facility is below 20 000 mg/L TDS.

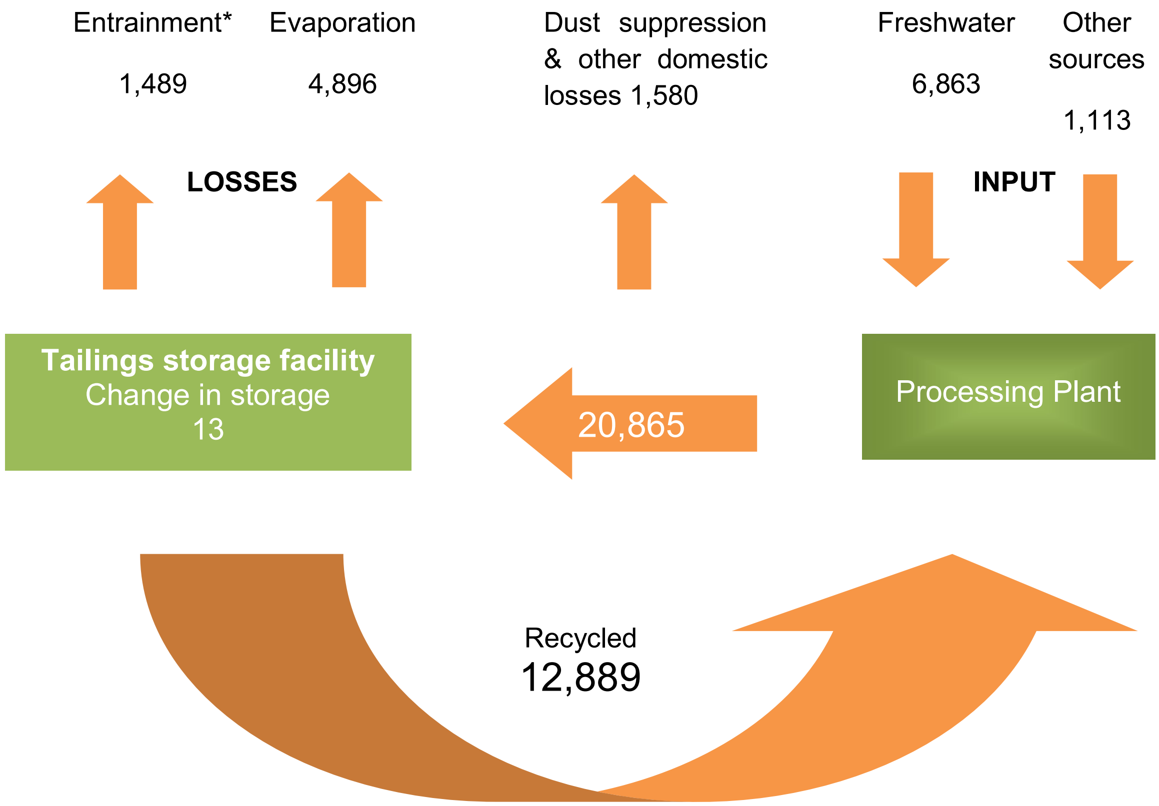


Figure 5.9: Schematic water balance for Rössing in cubic meters per day, 2020

Seepage is mainly characterized by increased sulfate, nitrate and magnesium concentrations, while chloride and sodium predominate in natural groundwater. The "seepage plume" around the tailings facility is defined at Rössing by the 3000 mg/L sulfate contour, while natural groundwater usually contains less than 2900 mg/L sulfate. The objective of water quality management in the mining area is to prevent as far as possible any expansion of the seepage plume beyond the area it occupied in 1999. Monitoring results since 2000 confirm that the plume did not spread outwards, but rather retreated in some places.

The Rössing water circuit is closed under normal operating conditions and no effluent is discharged. The water input balances the losses, so that the required volume of re-circulating process solution can be maintained. Water input to the mine (Figure 5.9) includes fresh water supplied by NamWater, brackish Khan River groundwater and recycled water from the seepage control systems, as well as moisture in ore and water in sulfuric acid.

Water losses occur due to evaporation from open water, e.g. tailings pools, lakes, tanks, wash-down and from entrainment of solution that will remain adsorbed to the tailings material. Other losses include water sprayed for dust suppression in the open pit, garden irrigation and seepage that bypasses the seepage control system. Evaporation loss is estimated at 4,896 m^3 per day.

In 2020, Rössing used a total of 2,511,966 m^3 of fresh water. The ratio of fresh water versus total water use was 0.382; meaning that 61.8% of the total water usage was obtained from reclamation. In essence fresh water is needed to counter evaporative losses and for drinking (household) purposes. Water input balances the losses (mainly through evaporation), so that the required volume of re-circulating process solution can be maintained. The Water Balance Procedure (JA50/OWM/WBP/001) and Fresh Water Supply Management (JA50/OWM/WSM/001) regulate operational activities.

Table 5.5: Water management procedures relevant to the effluence disposal exemption permit

Paragraph of permit	Subject	Procedure	Responsible section at Rössing
1.2.ii), 1.8.2	Seepage control systems	JE50/SOP/002	Water Management
1.2.i),ii) 1.6.2 1.9.1.6	Water recycling	JE50/OWM/003	Water Management
1.7.6	Fresh water supply management	JE50/MSP/002	Water Management
1.9.1.2	Waste rock dumping	MIN/WRD/001	Mine Planning
1.9.1.5	Disposal of hydrocarbons	JE50/WMP/002 ENV/WMP/003	Environmental Management
1.9.1.5	Disposal of chemicals	JE50/WMP/001	Environmental Management
1.7.3, 1.7.4, 1.7.9, 1.8.2	Water quality monitoring	JE65/OWM/004	Water Management
1.2.i),iii),iv) 1.4, 1.8.2	Monitoring of sewage plants	JE65/OWM/003	Water Management
1.7.1 1.7.2	Supervision of flow meters	JE50/MSP/001 JE50/MSP/002 JE50/SOP/002	Water Management
1.7.9	Monitor acid neutralization	JE65/OWM/004	Water Management

Rössing has standard operating procedures for water quality management and several related procedures to ensure compliance with the permit conditions. These are listed in Table 5.9 with reference to paragraph numbers in effluence disposal exemption permit.

There are currently no state regulations specifying water quality requirements for industrial water in Namibia. For this reason Rössing is using its own water quality criteria, formalised as JE65/OWM/004 (Water quality monitoring) and JE50/MSP/001 (Water quality management) with the Water quality monitoring schedule agreed upon with MAWLR in 2018. To supplement the monitoring of water quality, the monitoring of several other aspects are documented as operational procedures. See Table 5.10.

Table 5.6: Water monitoring procedures at Rössing

Water aspect monitored	Procedure
Water quality (including fresh water, seepage, hydrocarbons)	JE65/OWM/004
Water levels	JE65/OWM/004
Seepage control systems	JE50/SOP/002
Fresh water supply	JE50/MSP/002
Water recycling	JE50/OWM/003
Seepage recycling on the tailings facility	JE65/OWM/006
Sewage water quality	JE50/OWM/003
Septic tanks	JE50/SOP/004
Khan river vegetation	JE65/OWM/002

Water is a scarce resource in the Namib Desert, where Rössing is located and as a management measure, Rössing continuously aims to reduce its water consumption per tonne of U_3O_8.

Two major permits of the DWA have been issued to Rössing – the industrial and domestic effluent disposal exemption permit (current number 674) and the abstraction permit 10200 for the Khan River well field. The objectives of the industrial and domestic effluent disposal exemption permit as stated by the DWA are to regulate the disposal of effluents produced by the mine and to prevent the spread of groundwater pollution from effluent or waste disposal sites into the receiving environment.

5.2.4 MANAGEMENT OF BIODIVERSITY AND REHABILITATION[87]

In 2004 Rio Tinto launched its Biodiversity Strategy at the International Union for the Conservation of Nature (IUCN) World Congress in Bangkok. The strategy outlines the goal to have a 'Net Positive Impact' (NPI) on biodiversity on losses (impacts) and gains (offsets and restoration) by minimising the impacts of its businesses and contributing to biodiversity conservation to ensure that a region ultimately benefits as a result of its presence. By 2015, every site listed as High or Very High under the Global Biodiversity Values Assessment will have planned, costed, and commenced implementation of its NPI strategy. Rössing is listed as Very High.

[87] Smit, (2012)

Rössing's Environment Standard 3 – Biodiversity, rehabilitation and Land use management 36) prescribes the implementation of an overall land management direction for each site. Accordingly, concepts such as avoidance and mitigation are well embedded in decisions with land use implications. In addition to the Environment Standard 3, Rio Tinto's Biodiversity Strategy recommends that a business should develop a biodiversity action plan (BAP) to manage biodiversity issues.

Rössing's BAP provides a mechanism to assess, prioritise and develop actions to address biodiversity risks and opportunities. Biodiversity management at Rössing is closely coupled to many other internal assurance processes such as community baseline assessments, Five Year Communities plans and SEIAs.
As custodian over ML 28, Rössing subscribes to minimising impacts of its operations and the maintenance and progression of biodiversity (through concrete as well as inferred conservation measures) on the land belonging to Rössing and in recognition and close cooperation with the neighbouring #Gaingu Conservancy, Namib-Naukluft and Dorob National Parks. Rössing is furthermore committed to enhance biodiversity protection by assessing and considering ecological values and land use aspects in investment, operational and closure initiatives.

Current biodiversity management at Rössing aims at achieving NPI before mine closure. The following outcomes need to be met:

- Continuous improvement of the biodiversity knowledge base
- Adverse impacts are constantly avoided and minimized
- Rehabilitation tasks are part of operational activities
- Additional conservation actions are supported to ensure sustainable landscape- and region-wide biodiversity benefits.
- Residual impacts are accurately calculated and compensatory offsets are implemented and are sustainable.

Biodiversity management activities at Rössing currently focus on the following:

- Monitoring, recording and reporting of biodiversity (including collection and identification) and making biodiversity information of Rössing and the central Namib more accessible
- Stakeholder engagement and awareness building, including the annual Birdwatching Day, the Coastal Environmental Week and Arbour Day
- Continuous updating, refinement and re-alignment of ongoing work identified in the BAP, and
- In cooperation with land use management and closure planning, investigate and plan rehabilitation at Rössing.

In 2011 it was decided to conduct an in-depth floral survey of under-collected biotopes at Rössing and a re-analysis of previously collected data plant data[88]. A total of 133 sample points was used and a total of 21 biotopes were identified at Rössing (Figure 5.10). Four biotopes were identified as Critical: the *Euphorbia virosa* belt (in which the open pit and waste rock dumps are located); the Khan River Mountains; the south-east gneiss hills and the undulating granite hills. Seven biotopes are rated as Rare and all others have a General rating.

[88] Burke, (2011)

Initially only two plant species occurring at Rössing are thought to be of particular concern. The charismatic 'elephant's foot' *Adenia pechuelli*, occurs in relatively high concentrations on rocky hillsides. Formerly classified as near-threatened, it is now realized that the plant has a wide distribution in the Namib Desert and escarpment of Namibia and was down-listed in 2009 as a result. Thus, only *Lithops ruschiorum* remained as a species of concern from the earlier data. This *Lithops* species is believed to have a very restricted range in Namibia and is sought-after by collectors. Rössing possibly has the largest population of this plant in Namibia (around 25%). The species is the focus of continuous attention and research worldwide[89].

Following the 2011-survey, however, the number of recorded plant species in the Mining Licence area increased by over 100 species from 140 in 2005 to 253. A total of 68 plant species of conservation importance are now considered for the rating of biotopes.

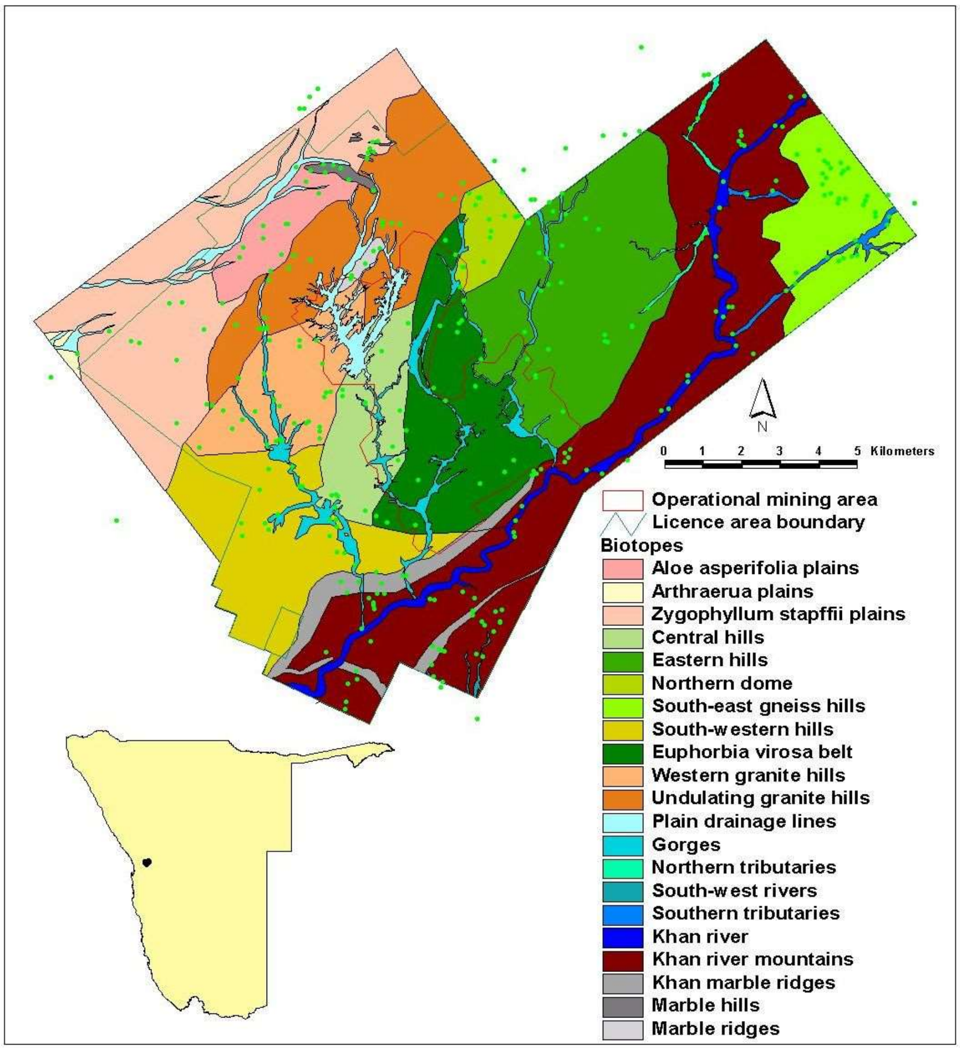


Figure 5.10: Biotopes at Rössing

[89] Loots, (2011)

Invertebrate monitoring is ongoing at Rössing. Specialist identification of some species is challenging due to limited taxonomic capacity globally. As a solution a network of specialists in Namibia, South Africa and elsewhere is requested to do the identification. Since 2010 invertebrate monitoring at Rössing focused specifically on representation within the wider landscape. Reasoning for this is to specifically collect and / or re-discover the eighteen invertebrate species within the Critical, Endangered or Vulnerable categories identified in the earlier surveys since the 1980s. Occurrence of some of the target species is presumably limited to rocky hillside habitats. To determine the habitat compatibility the positioning of the sites identified in the 1980s was correlated and amended accordingly.

Biodiversity at Rössing is well studied over more than three decades – in fact, some regard it as over-studied when compared to the surroundings, including the Namib-Naukluft Park[90]. From the knowledge based built up over the three decades, there emerged also a need for better understanding the bigger picture, the entire landscape, in particular connections, patterns and processes. Categorisation of biodiversity is further hampered by the low level of biodiversity sampling outside the boundaries of Rössing. As a worst-case example, some invertebrates are known only from one specimen trapped during field surveys undertaken in the 1980s[91].

Improved understanding of biodiversity at Rössing provides important insights into rehabilitation requirements. Because about 90% of the disturbed area at Rössing is in operational use, rehabilitation interventions are limited to demolishing redundant infrastructure and facilities, and stabilising and clean-up activities throughout the Life of Mine.

Efforts were made since the 1980s to promote human-induced revegetation of the tailings facility. The learning from this endeavour asks many questions in terms of kind of species, methodology, duration of intervention, etc. Irrigation also proved expensive and impractical under the arid conditions and shows a high failure risk. This experience convincingly indicated that biophysical conditions need to be rehabilitated to allow natural vegetation endemic to the Namib to re-establish itself in disturbed areas.

Demolition, clean up and partial remedial efforts have been in progress since 1995. A number of facilities and waste sites were rehabilitated until 1998. Financed from operational budgets, the total area in question measures about 90 ha. No restoration interventions have been made; instead passive, but supported restoration is preferred. Natural re-growth is evident in most formerly disturbed sites at Rössing, regardless of the age or type of disturbance. Establishment of the perennials *Arthraerua leubnitziae* (pencil bush) and *Zygophyllum stapffii* (dollar bush) on these terrains indicates that, even without intervention, the mine will not leave its entire footprint devoid of life into perpetuity.[92]

Since the mid-2000s a number of areas on the mining lease have been drilled in search for new uranium bodies. A contractor, Namib HydroSearch, was requested to rehabilitate these areas as the exploration program allowed it. Exploration is ongoing and rehabilitation of the disturbed areas as a result of exploration continues.

[90] Brett, (2009)
[91] EEAN, (2008)
[92] Burke, (2010)

The progressive rehabilitation programme was resuscitated in 2010 with the demolition of the acid plant and other redundant infrastructure. Currently, rehabilitation at Rössing entails several mechanical activities such as demolishing, remediation, geotechnical stability and protection against erosion, and providing a surface cap of topsoil.

Demanding climatic conditions, the scarcity of surface water, a high number of species adapted to aridity, and the lack of topsoil are some of the key biophysical determinants and are taken into account in the rehabilitation attempts at Rössing. Rehabilitation aims to initiate and accelerate natural recovery processes, a principle most appropriate to conditions in the Namib Desert where functioning of ecosystems at the landscape level requires special emphasis[93]. In order to facilitate natural recovery, the following base conditions have to be met:

- Suitable substrate needs to be available (stable, correct physical and chemical soil properties)
- Man-made landforms have to be suitable to support plant growth (no erosion and slope shapes and angles favouring seed and water catchment)
- The hydrological conditions need to be right to sustain natural processes
- Re-colonisation sources need to be nearby, and
- No pollution or other disturbances should interfere with the process of natural recovery.

Although rehabilitation is done as far as possible at Rössing, it is unlikely that all disturbed land will be rehabilitated. Backfilling the open pit, for example, is not a viable option. It is thus important to realize at an early stage that the residual impact area has to be calculated accurately and needs to be offset. Guidance from legislative and regulatory frameworks on biodiversity offsets and rehabilitation criteria in Namibia is limited. The sustainability of some offset opportunities is also questionable. The existence of exit plans and clarity with regard to relinquishment of land are some of the important prerequisites for Rössing.

Undoubtedly, the Namib Desert is one of the major attractions for visitors to Namibia. The part where Rössing is located is known for its scenic landscapes, picturesque vistas, solitude and uniquely adapted biotic life. Collectively refer to as *sense of place* these aspects of the Namib Desert are highly appreciated by many. Rössing highly respects *sense of place*. Rössing believes that maintaining this natural *sense of place* throughout the Life of Mine will result in a positive legacy after closure. This will be to the economic benefit of the region and to the enjoyment for the visiting tourist and the community member alike. Rehabilitation is a key initiative to achieve this vision.

5.2.5 MANAGEMENT OF NON-MINERAL WASTE

Namibian legislation is not particularly clear about the various types and definitions of waste, its management requirements and the agencies responsible. Currently at least eight ministerial bodies deal with waste management and pollution control in Namibia. Furthermore, there are no applicable national policies and standards in terms of waste management. The draft Pollution Control and Waste Management Bill is designed to address existing deficiencies and consolidate the legal framework while addressing related institutional fragmentation.

[93] Burke, (2005a)

In the absence of a clear legislative framework, Rössing uses international standards such as ISO 14001:2015 as well as the Rössing Uranium Environmental Performance Standard E4 (Mineral waste, acidic and other impacted drainage control) for conformances and compliance in waste management. Classification and disposal guidelines have been taken from the South African *Minimum requirements for the handling, classification and disposal of waste (2nd Edition)*[94]. Accordingly, Rössing defines non-mineral (solid) waste as a generic term that comprises rubble; garden, domestic, commercial and general dry industrial waste. It may also contain small quantities of hazardous substances dispersed within it, for example, batteries, and insecticides on domestic and commercial premises[95].

Waste products are thus divided into two classes. **General waste** is waste that does not pose a significant threat to public health or the environment if properly managed. Examples include domestic, commercial, certain industrial wastes and builder's rubble. Domestic waste is classified as general waste, even though it may contain hazardous components. This is because the quantities and qualities of hazardous substances in domestic waste are sufficiently small to be disregarded as a potential risk. General waste may be disposed of at any licensed landfill site. **Hazardous waste** is waste that has the potential, even in low concentrations, to have a significant adverse effect on public health and the environment because of its inherent toxicological, chemical and physical characteristics. Hazardous waste requires stringent control and management, to prevent harm or damage and hence liabilities. It may only be disposed of at a licensed hazardous waste landfill site. Under the precautionary principle, waste is regarded as hazardous where there is any doubt about the potential danger of the waste stream to man or the environment.

Throughout the whole operation various waste products are generated. Effective and responsible waste handling and disposal are key elements of any environmental management system. The waste stream at Rössing is characterized, an inventory was composed and a risk assessment was undertaken to put operational procedures to regulate the management of the various waste items in place. An over-arching non-mineral waste management plan is in place to ensure sound non-mineral waste management through minimization of waste generation and safe handling, treatment and disposal of waste. The plan addresses all non-mineral wastes generated at Rössing during the operational as well as the decommissioning phases. A database for historical waste dumps is also maintained and guidance for the remediation of these sites during operations exists.

Review of the waste management plan is conducted at least every four years. In short the objectives of the plan are:

---

[94] (South African) Department of Water Affairs and Forestry, (1998)

[95] The draft Pollution Control and Waste Management Bill refers to waste as '*an undesirable or superfluous by-product, emission, or residue of any process or activity that has been discarded, accumulated or been stored for the purpose of discarding or processing. Waste products may be gaseous, liquid, solid or any combination thereof. Waste may originate from domestic, commercial or industrial activities, and include sewage sludge, radioactive waste, building rubble, as well as mining, metallurgical and power generation waste*.

The bill defines hazardous waste as '*any pesticide, herbicide or other biocide, radioactive substance, chemical or other substance and any micro-organism or energy form that has properties that, either by themselves, or in combination with any other thing, make it hazardous to human health or safety, or to the environment, and includes any substance, micro-organism or energy form defined as a hazardous substance in (future) regulations'*

- Avoid waste generation – the use of substitutes or alternative processes reduces the volume of total wastes and hence management requirements
- Reduce waste generation – waste reduction reduce costs of further treatment and decrease the risk of pollution associated with disposal facilities
- Segregate waste – allows for different waste streams to be recycled, reused or disposed of correctly
- Re-use and recycle waste – reduces the volume of waste disposed of and has the potential to improve economic gain

Specific targets for waste management at Rössing are set annually and progress are monitored and reported monthly, six-monthly and annually. Effectiveness is measured against the following performance indicators:

- Number of non-conformances recorded.
- Increase in number of recycled/re-used waste.
- Reduction in waste generated.
- Incidents of pollution.

All procedures for segregation, temporary storage and eventual transportation of waste are written up and authorised. Area owners are held responsible for the classification of the waste generated in their area and the management of safe and responsible handling and disposal of waste from their areas. Sorting of waste material is carried out at source, prior to removal. Collecting points of waste are demarcated and the disposal bins color-coded. Bins are placed in such a way that it ensures free access, for disposal as well as removal. Used grease and oil are contained and dispatch to storage area as per procedure JE50/WMP/002.

Waste bins on site are regularly removed, emptied and replaced in such a way that they do not become overfilled. The waste is also weighed and a register is kept for reporting against targets. General waste is disposed at a licensed landfill and managed to comply with all legislative requirements (environmental, safety and health). Access to the landfill and other disposal sites are controlled. The landfill and external recycle sites are frequently inspected and audited on a two yearly cycle. Records of waste generated, stored and disposed of are filed and maintained. Groundwater in the vicinity of the landfill site is monitored, according to operational procedure.

In the work areas frequent inspections are done to ensure compliance with procedures and that the management system is working effectively. These inspections cover waste segregation, storage, general housekeeping, and management of hydrocarbon and chemicals. All non-conformances identified during inspections are communicated to area owners, and reported in order to investigate the causes of such non-conformances, to take corrective measures and to put measures in place to prevent similar future occurrences.

Disposal of recyclable items at the landfill site is restricted, as far as possible. Adequate resources are provided to ensure that salvageable waste material is collected and removed in such a way that the areas comply with all legislative requirements (environmental, safety and health). Radiation clearance is required before recyclable items as well as scrap metal are removed from site. All 5, 10, 20, 25l discarded plastic containers are holed and pressed before taken off site to prevent unauthorized use by third parties. Empty 210L drums are removed to a temporary storage yard from where it is removed in bulk. Access to the temporary storage yard is controlled.

Redundant material and equipment that could potentially be contaminated on the mine site includes items such as pumps, tanks, pipes, concrete surfaces, soil, resin and infrastructure found in the processing plant of the mine. Contaminated objects are segregated according to the criteria contained in a procedure (JK65/PRD/101-Monitoring and identification of contaminated items). Transport is conducted according to provisions contained in the procedure (JK65/PRD/007-Transport of contaminated items) and disposal is done in accordance of another procedure (JK65/PRD/003-Disposal of contaminated items). Disposal of contaminated material is on the tailings facility and the quantity and disposal location of contaminated waste is recorded. Access to the contaminated waste disposal site is controlled.

5.2.6 MANAGEMENT OF MINERAL WASTE

At Rössing mineral wastes are identified as waste rock and overburden, tailings and in the future heap leach waste (ripios). While Rössing managed the disposal of these waste streams throughout the Life of Mine, this was not always done through a formal waste management plan. A formal management plan for mineral waste is required by the Rössing Uranium Environmental Performance Standard E4 (Mineral waste, acidic and other impacted drainage control). The Standard sets the criteria against which Rössing is audited. It stipulates, inter alia, that waste disposal facilities should be located and designed to minimize environmental, health, safety and community impacts and risks. Facility location and design should be consistent with the long-term physical and chemical behaviour of the waste and must result in repositories that are physically and chemically safe and stable during operation and after closure.

Waste storage facilities are placed within permitted areas only. Considerations in the placement are:

- Preferentially placing waste within inactive open pits, underground workings or within existing disturbed areas
- Tying waste repositories into the surrounding topography to maintain regional drainage patterns and reduce visual impacts
- Avoiding placement on land with high biodiversity or ecosystem services values
- Avoiding placement in or near perennial surface water bodies or in large ephemeral drainage lines
- Avoiding placement of chemically reactive waste over important groundwater aquifers or recharge zones
- Avoiding placement in areas with significant archaeological or social value
- Avoiding placement in close proximity to local communities
- Preferentially placing chemically reactive wastes in drainage basins that already contain reactive waste (thereby avoiding placement in pristine drainages)
- Avoiding placement in areas with poor foundation conditions due to topography, underlying geology or hydrology.
- Balancing economic considerations such as haul profiles, potential resource sterilization, and pumping costs with environmental, social and closure considerations.

The Rössing Mineral Waste Management Plan (JE20MMP009) has been developed and prepared in accordance with the Rio Tinto Mineral Waste Management Guidance Notes, to comply with the standard as well as Namibian regulatory requirements. The intent of the plan is to ensure sound and effective mineral waste management by the minimization of waste generation and ensuring the safe handling, treatment and disposal of these wastes. The Mineral Waste Management Plan for Rössing was revised at the end of 2019.

The purpose of the plan is to provide a documented record of issues related to mineral waste and to manage all mineral waste produced at Rössing in such a manner that disposal facilities and sites must be physically, biologically and chemically safe. For the purpose of this document mineral waste entails mineralised waste rock and processed waste rock (tailings), and excludes the dormant landfill site (where only non-mineral waste is disposed), commodities imported to site i.e. hydrocarbons, and sewage farms.

Waste rock dumps are typically coarse, angular fragments of very strong rock material that is resistant to mechanical disintegration and chemical decomposition, with the exceptions of amphibole schist and biotite schist. Both these are “minor” rocks in terms of volumes, and are furthermore mostly processed as ore. Typically thus, the Rössing dumps are of pervious, frictional material placed on competent, but steeply sloping foundations.

The mineral composition of waste rock consists mostly of quartz, albite, microcline (both feldspars) and mica. Marbles layers add calcite or dolomite to the list, while weathered samples can contain chloritoid, kaolin or gypsum. Waste rock has higher CaO and MgO contents than ore, which is mainly due to the marble present. Tailings material has a very similar composition with predominant quartz, albite, microcline, mica and small amounts of calcite or gypsum. Precipitates at the tailings facility are composed of chloritoid, potassium and ammonium jarosite, ammonium aluminium sulphate, ammonium manganese sulphate hydrate, quartz, feldspars and some mica. Ore and tailings are quite similar, except for the higher sulphur concentration in tailings, which can be ascribed to sulphate minerals such as jarosite and gypsum in tailings.

An inventory of mineral waste at Rössing is kept. It reflects the tonnage per year, the cumulative tonnage, surface area, volume and the location of waste. Site maps are maintained. The spatial footprint of mineral waste is also maintained and annually reported. Identification of the primary hazards posed by mineral waste was done in 2007. Primary hazards associated with mineral waste, reflecting the potential impacts, at Rössing are:

- Radioactivity from waste rock, low grade storage facilities and tailings facility (radon emanation and radionuclides in dust)
- Although there is a possibility that asbestos and asbestiform can be found in dust from the pit and crushing plant because of metamorphosed magnesium carbonate (such as marble) and the presence of serpentine, none has been found when monitoring so far
- Uranium and its decay products can be released into seepage water (from the tailings facility)
- Acidic drainage is possible where mineral wastes are in contact with water
- Residual nitrate, from the use of blasting agents, can be solubilised from waste rock and migrate to underlying groundwater

Reshaping of the huge man-made landforms represented by the waste rock dumps and the tailings facility needs to be minimised at closure and to achieve this aim, dumping should progressively meet the final landform requirements. Additional work following closure (monitoring and maintenance) should be limited. With this in mind, Rössing follows a Waste Rock Disposal Planning and Design Strategy and in the case of the tailings facility an operating manual sets out the procedures to be followed in accordance with the engineering design. The following management objectives are emphasised:

- Geotechnical stability and access
- Radiation and radon emanation
- Surface drainage and rainwater leaching
- Rehabilitation and restoration requirements
- Visual appearance and aesthetics

Mineral waste facilities need to be geotechnically and erosionally safe and stable, not only during operation but also after closure. The waste rock dumps and tailings facility need to undergo a full geotechnical and geochemical review by an appropriately qualified independent engineering specialist at least once every two year. Information needs to be reviewed regularly and historical trends are examined so that the longer-term chemical behaviour can be assessed. Operation, safety and environmental aspects are periodically reviewed during an inspection by a suitably experienced and qualified engineer.

A good understanding of geotechnical factors governing mineral waste dump stability and the potential modes of failure at Rössing exist and directives for planning, design, construction and operation of these dumps are in place. Operational manuals regulate the management of the waste rock dumps as well as the tailings facility and comply with the Rio Tinto Management of Pit Slopes, Stockpiles, Spoils and Waste Dumps (Rio Tinto Safety Standard D3). The likelihood of injury to humans and wildlife is minimized through the design, construction and access control and through ensuring (geotechnical) stable conditions. In addition the facilities are made inaccessible for temporary and long-term use or habitation.

Inspections of the tailings facility are carried out at least annually, but ideally every 3-4 months. Consultants from Knight Piésold (KP) and AQ2 undertake annual reviews and produce a report to document the proceedings, findings and recommendations for improvement. Knight Piésold conducts an inspection of the dam as a major waste storage facility as required by Rössing Uranium every one-two years.

Radiation management at Rössing is regulated by the Radiation Management Plan (JK20/MMP/001). The radiation potential from mineral waste forms an integral part of the management plan, which aim to ensure that sources of ionising radiation are identified, quantified, controlled and minimised limited, and that exposures to these sources are limited. Dust management is regulated by several operational procedures, coordinated within the Rössing's Air Quality Management Plan (JE20/MMP/004).

The main source of potential groundwater pollution at Rössing is the tailings facility. Due to the acid-leaching process employed at Rössing the tailings solution is acidic and contains residual process chemicals, heavy metals and radio-nuclides. Another source of groundwater contamination is leaching of nitrate, sulphate and uranium from the waste rock deposits overlying the gorges.

To ensure that water quality parameters remain as close as possible to the range of natural variability and to allow optimal water use after closure implies that surface water, groundwater and the biophysical environment is protected against exposure to hazardous waterborne chemicals. The surfaces of mineral waste dump facilities are therefore inward sloped to ensure that surface drainage is not allowed outwards. Downstream cut-off trenches prevent contaminated water to enter the Khan River.

A key mineralogical hazard to be considered is acidic drainage from mineral wastes (Rio Tinto Environmental Standard E4). Column rainwater leach tests on samples from the various waste rock disposal areas and low-grade ore stockpiles at Rössing indicated a possibility of acid rock drainage (ARD) from certain minerals, particularly those contained in the pyritic quartzite unit. But this rock type is mostly found within the ore material and it is processed through the plant. Thus, there is very little chance of ARD being formed at the rock waste dumps, but only at the tailings facility.

The low sulphide content of coarser mineral wastes and the neutralisation capacity of the marble lower the potential to generate acid rock drainage in the waste rock dumps further. Finally, the potential of the Rössing waste rock dumps to generate acid rock drainage is minimal due to the arid climate (average annual rainfall around 30 mm and net evaporation potential of 4,896 m^3/day).

Investigations and risk assessments were carried out to understand the stability and seepage of the tailings facility in terms of layout, geometry and raised embankments with and without remedial measures (i.e. buttressing). Input data is obtained from previous studies and reports, seepage modelling, piezometer readings and seismic loading criteria. Outputs from the seepage models are applied as input parameters into slope stability assessments.

The probability of major incidents and excessive rainfall event (for example slope stability failure and overtopping) occurring at the tailings facility will be minimised as long as the procedures of the operating manual are followed. Monitoring systems are in place to give early warning of the preventable hazards. If, however, an emergency situation does arise, the emergency response plan as described in the operating manual is to be followed. In an event which is not covered by the established plans, the situation is to be managed by the BRRP. Although major incidents involving the waste dump storage facilities are not listed in the BRRP, this programme will be used in the event of any major incident to the rock waste dumps.

The waste rock dumps and the tailings facility will remain as man-made landforms at mine closure. Visual impacts of the final landforms are minimized in order to maintain the characteristics and attractiveness of the surrounding landscape. Deposition of mineral waste is thus scheduled in such a way that it complements the contours of the surrounding landscape. A state that allows passive revegetation and integration into functioning ecosystems is the preferred option.

5.3 THE DECOMMISSIONING PHASE

Any kind of development project has a lifetime. A mining project has a lifetime too, and the lifetime is normally limited to a few decades. As soon as mining becomes uneconomical, it is time to close a mine. Closure planning is an essential part of a mine’s life cycle: it is a way of ensuring that all impacts are managed until the end of a mine’s working life.

Closure planning is a continuous process at Rössing, and changes in operational circumstances, environmental conditions, legislative and regulatory frameworks, and stakeholder expectations were considered every time Closure Management plan is updated.

5.3.1 CLOSURE PLANNING: THE APPROACH

Closure planning at Rössing is driven by the Rössing Closure Standard and accompanying Guidance Notes, whilst also taking account of the guidance from the Chamber of Mines of Namibia and current draft on Mine Closure Framework being developed by Ministry OF Mines and Energy. Planning entails the development, maintenance and management of a process for eventual closure, which addresses all relevant aspects and impacts of closure in an integrated and multi-disciplinary way, and provides a fully scoped and accurate cost of closure to the company that is documented and auditable.

The Rössing Closure Standard and Guidance Notes are based on best industry practice and are compatible with the International Council for Mining and Metals' sustainable development principles. This Standard aligns the design, development, operation and closure of operations to ensure that adverse impacts on the human and natural environment are minimised and that a legacy remains which makes a positive contribution, i.e. that post-closure outcomes are optimised in terms of social, environmental and economic needs and expectations. Specifically, The Standard is intended to guide –

- improving the accuracy of closure cost estimates
- minimising the costs of closure
- the continued integration of closure planning into business plans
- the realisation of positive legacies for communities
- increased host community ownership for post-operational outcomes
- enhancement of Rössing's reputation, and
- Compliance with all applicable legal and other requirements.

The Guidance Note to the Rössing Closure Standard assists operations in meeting the requirements of the Standard with which operations are obliged to comply. There are also several other Rössing standards and guidance documents of relevance to closure planning. In summary, these documents contain guidelines on the following aspects:

- Planning for closure
  - The knowledge base
  - Closure strategy
  - Closure Management Plan and
  - Decommissioning Plan
- Implementation and operation
- Performance measurement
  - Cost estimating
  - Review and monitoring

Thorough and comprehensive definition of the scope of measures to be undertaken at closure is necessary in order to reach a realistic estimation of the costs, and to provide assurance to shareholders that adequate financial provision for closure has been made. Reporting of closure provisions to the corporate body is an annual event.

The Minerals Policy for Namibia (2003) requires a Final Mine Closure Plan to be prepared before a Mining Licence is granted and the Chamber of Mines of Namibia has recently published its draft framework for mine closure[96]. The latter is based on the

[96] Chamber of Mines of Namibia, (2009)

Australian Strategic Framework for Mine Closure with the aim of developing relevant and practical closure plans.

The 2005 Plan foresaw the potential closure of Rössing in 2009 or 2016, based on the prevailing business climate at the time. This situation has changed significantly since then, with closure now being planned for 2026, as proposed in the current Life of Mine Plan.

The latest full closure plan update was prepared in 2011 and has not been updated formally due to various reasons related to market conditions and negotiations leading to recent change in majority shareholder, however various technical updates on key aspects has been done separately and will be incorporated into the next updates.

5.3.2 CLOSURE PLANNING AT RÖSSING[97]

Closure plans, including costing and provision of financial sureties, are based on approved Life of Mine plans only. This means that at the stage when a new expansion plan is approved, provisions are set aside on a continuous basis until the full cost is provided before the end of Life of Mine, or project.

Closure strategies are developed during the financial and technical feasibility studies for projects. Increasing levels of closure detail are developed as the studies progress from an initial concept via the stages of order of magnitude, prefeasibility, feasibility and final design. If a project finally results in an activity that becomes part of Rössing's operations (and thus part of the Life of Mine plan), the scope of the Closure Plan for Rössing is adapted accordingly to include the additional activities.

Rössing's closure plans are guided by an aspirational vision for closure that is translated into objectives and targets. In order to achieve those, a closure strategy is developed by analysing impact mitigation alternatives using sustainable development criteria and choosing a preferred alternative for each aspect or facility. Implementation plans for these preferred alternatives are then developed and the necessary closure costs calculated. Closure cost calculations are updated annually. The present closure obligation for Rössing is calculated at N$1,601m.

A Rössing Rehabilitation Trust Fund was established and makes provision for closure expenditure that will be incurred by the mine, in order to comply with statutory obligations and the requirements of the Ministry of Mines and Energy as well as the Ministry of Environment and Tourism. Clause 15.2 of the Trust Fund Agreement stipulates: *The mining company shall before the end of its financial year concerned, pay to the Fund a contribution towards the estimated cost of implementing the measures so approved.* The agreement also stipulates the formula to be used to calculate the annual contribution. As at the end of 2020, the Rössing Rehabilitation Trust Fund had a cash balance of N$1,120m. The mine will make additional payments into the Fund on an annual basis in order to provide for the eventual total cost of closure.

The Closure Plan presents a defined closure strategy, an extensive knowledge base, and the costing and scheduling of activities that were developed for the 2026 closure scenario. Rössing Uranium Limited intends to implement mine closure according to the discussions and conclusions detailed in this Closure Plan, and will provide adequate

[97] Information for this section was obtained from the Rössing Closure Plan, (2011)

resources to achieve this goal. Should mine closure become inevitable unexpectedly, due to *force majeure*, the Closure Plan might have to be modified according to prevailing circumstances, but it will nonetheless guide the closure process according to the concepts it contains.

Under the current scenario backfilling of the open pit at Rössing is not considered as a viable option at the time when the mine closes. With this presumption in mind, current operations at the open pit are guided by the following management objectives:

- to minimise the likelihood of injury to humans and wildlife by means of appropriate design and constructing, access control and providing safe and stable conditions
- to manage radiological protection so that doses do not exceed allowable limits and prescribed constraints
- to minimise surveillance and maintenance needs at the time of mine closure through appropriate design of the pit void and associated control structures
- to maximise the beneficial use of the pit at the time of mine closure.

Being one of the largest open pits in uranium mining in the world, the open pit presently attracts many visitors to Rössing. This attraction might be retained and even encouraged at mine closure. Alternatively, the open pit could be used after closure as a safe and inaccessible disposal site for contaminated materials and as an acceptable storage option for the disposal of seepage and groundwater from elsewhere on the mine site and for disposing of contaminated material by external operators after closure. Final decisions with regard to the beneficial use of the open pit after closure will be made towards the actual closure date.

In summary closure measures are detailed and include

- No backfilling of the open pit with mineral waste; use of the open pit as evaporation area for reclaimed surface seepage as well as a containment area for contaminated infrastructure and demolition materials; and covering of waste in the pit with a 10 m-layer of waste rock to minimise the likelihood of scavenging for materials.
- Demolition of plant facilities where infrastructure is not suited to further beneficial use; removal of contaminated materials to onsite hazardous waste facility; and remediation of areas no further to be used.
- Covering tailings facility walls and beaches with rock to control erosion; access restriction to tailings facility with fencing and signage; control systems for groundwater management to continue for 30 years after closure; continued operation of seepage control system until seepage has stopped; removal of dust plumes from around tailings dam and disposal in tailings dam; visual blending of tailings into environment with rock coverings; and regular monitoring and maintenance of pumping system.

6 APPENDIX 1: LEGISLATIVE FRAMEWORK

Statutory requirements relevant to environmental management at Rössing, according to Rössing's Environmental and Health and Safety Legal Register, could be divided between International Conventions, Regional Agreements, Domestic Legislations and Domestic Policies. The information contained in the Legal Register cannot be construed as legal advice but provides a summary of relevant international, regional and domestic laws and policies applicable to Rössing's operations in Namibia.

6.1 STATUTORY REQUIREMENTS

6.1.1 INTERNATIONAL CONVENTIONS AND REGIONAL AGREEMENTS

After independence in 1990 South African legislation remained prominent in Namibia but in some sectors it has been replaced by new laws. Presently some sectors are still regulated by outdated acts, or new legislation has only emerged to draft form. In some instances Namibian legislation has been enacted to give effect to obligations contained in international agreements.

In terms of the Namibian Constitution (Article 144), *"... the general rules of public international law and international agreements binding upon Namibia under this Constitution shall form part of the law of Namibia."* In short this means that all international agreements to which Namibia is a party automatically form part of Namibian law.

A summary of the international and regional laws and policies relevant to Rössing's operations in Namibia are listed below:

- United Nations Convention on the Law of the Sea, 1982
- Convention on Biological Diversity, 1992
- Vienna Convention for the Protection of the Ozone Layer, 1985
- Montreal Protocol on Substances that Delete the Ozone Layer, 1987
- United Nations Framework Convention on Climate Change, 1992
- Kyoto Protocol on the Framework Convention on Climate Change, 1998
- International Maritime Dangerous Goods (IMDG) Code

- SADC Environmental Policy and Regulatory Framework for Mining (2001)
- SADC Protocol on Mining (1997)

6.1.1 DOMESTIC LEGISLATION AND POLICIES

The Namibian Constitution contains two clauses, articles 91(c) and 95(l) that are of particular relevance to sound environmental management practice. 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 State is committed to actively promote and maintaining the environmental welfare of Namibians by formulating and institutionalising policies that can realise sustainable development objectives. General principles for sustainable development and sound environmental management are part of acts such as the Environmental Management Act (No 7 of 2007).

The Environmental Management Act 2007 (Act No. 7 of 2007) was promulgated in December 2007 through Government Notice number 232 (GG 3966). The Act has three main purposes:

1. To make sure that people consider the impact of activities on the environment carefully and in good time.
2. To make sure that all interested or affected people have a chance to participate in environmental assessments.
3. To make sure that the findings of environmental assessments are considered before any decisions are made about activities that may affect the environment.

The Act came into operation in February 2012 through Government Notice No 28 (GG 4878). At the same time, regulations were promulgated that determine:

1. Listed activities that may not be undertaken without an Environmental Clearance Certificate (issued by the Environmental Commissioner).
2. The process to apply for the Environmental Clearance Certificate.
3. Environmental Impact Assessment regulations.

Listed activities that may not be undertaken without an Environmental Clearance Certificate are:

1. Energy generation, transmission and storage activities.
2. Waste management, treatment, handling and disposal activities.
3. Mining and quarrying activities.
4. Forestry activities.
5. Land use and development activities.
6. Tourism.
7. Agriculture and aquaculture activities.
8. Water resource developments.
9. Hazardous substance treatment, handling and storage.
10. Infrastructure.

Furthermore two definitions are of particular relevance:
Activity: “means any physical work that a proponent proposes to construct, operate, modify, decommission or abandon or an activity a proponent proposes to undertake”.

Construction: “means the building, erection or modification of a facility, structure or infrastructure that is necessary for the undertaking of an activity, including the modification, alteration, upgrading or decommissioning of such facility, structure or infrastructure”.

It is important to note that these regulations apply not only to new activities and construction, but also to the modification, alteration, upgrading and decommissioning of any existing facilities, structures or infrastructure.

As implied by the Act, an Environmental Management Plan must be submitted and approved by the relevant authorities. The Environmental Management Plan thus forms the foundation of environmental impact management, also at Rössing.

In terms of environmental management, the Namibian Constitution (Government of Namibia, 1990) and the Environmental Management Act (Act No 7 of 2007), the Environmental Assessment Policy (MET, 1994) and the Minerals Act (Act No 33 of 1992) provide particular guidance. In addition, a number of other pieces of legislation and policies are of relevance:

- Allied Health Professions Act 7 of 2004
- Atomic Energy and Radiation Protection Act 5 of 2005
- Atmospheric Pollution Prevention Ordinance 11 of 1976.
- Constitution of the Republic of Namibia 1 of 1990
- Electricity Act 4 of 2007
- Environmental Management Act 7 of 2007
- Explosives Act 26 of 1956
- Foreign Investment Act 27 of 1990
- Forest Act 12 of 2001
- Hazardous Substances Ordinance 14 of 1974
- Hospitals and Health Facilities Act 36 of 1994
- Labour Act 11 of 2007
- Marine Resources Act 27 of 2000 (and accompanying regulations Government Notice (GN) 241, Government Gazette (GG) 2657, 7/12/2001)
- Medicines and Related Substances Control Act 13 of 2003
- Minerals (Prospecting and Mining) Act 33 of 1992
- Mines, Works and Minerals Ordinance 20 of 1968: Regulations (GN143, GG2927 of 1 October 1968)
- Namibian Ports Authority Act 2 of 1994 and Port Regulations promulgated in terms of this section in GN 117 published in GG2549 of 5 June 2001
- National Heritage Act 27 of 2004
- Petroleum Products and Energy Act 13 of 1990 and regulations relating to the purchase, sale, supply, acquisition, usage, possession, disposal, storage, transportation, recovery and refinement of used mineral oil are published in GN 112 of 1991 (GG 281 of 21 October 1991) ("1991 regulations") and the petroleum product regulations are published in GN 155 of 2000 (GG 2357 of 23 June 2000) ("2000 regulations")
- Public Health Act 36 of 1919
- Road Traffic and Transport Act 22 of 1999
- Soil Conservation Act 76 of 1969 as amended in South Africa to March 1978
- Social Security Act 34 of 1994
- Water Act 54 of 1956

- Environmental Assessment Policy for Sustainable Development and Environmental Conservation, 1994
- National Environmental Health Policy, 2002
- Minerals Policy of Namibia, 2003
- General Environmental Assessment Guidelines for Mining (Onshore and Offshore) Sector of Namibia
- Policy for the Conservation of Biotic Diversity and Habitat Protection, 1994
- National Environmental Health Policy, 2002

7 APPENDIX 3: RÖSSING PROCEDURES

7.1 OPERATIONAL PROCEDURES RELEVANT TO THE HEALTH, SAFETY AND ENVIRONMENT MANAGEMENT SYSTEM

Code of Practice	
HSE Management System Code of Practice HSE	JA05/COP/003
Procedures	
Environmental audit schedule	JA80/SCH/001
Monitoring and Measurement	JA65/MSP/001
Communication and Reporting	JA45/MSP/002
Document Control Procedure	JA40/MSP/003
Record keeping	JA75/MSP/004
Updating and review of Legal and other requirements	JA10/MSP/005
Hazard identification, risk evaluation and risk management	JA15/MSP/006
External Communications/Complaints	JA45/MSP/007
Reporting and investigation of HSE incidents and/or non-conformances	JA70/MSP/010 & MSP/011 merged
Training, competency and awareness	JA30/MSP/013
HSE Auditor Register	JA80/REG/001
HSE Audit Schedule	JA80/SCH/001
HSE Purchasing Criteria	JA35/MSP/013
Management of Change	JA 55/MSP/001
Appendix 1 - Proposal Form guidelines	JA 55/MSP/001.APP01
Appendix 2 - Level 1 Change	JA 55/MSP/001.APP02
Appendix 3 - Request Proposal Form	JA 55/MSP/001.APP03
HSE Committee Meetings for Rossing	JA45/MSP/008
HSE & Product Quality & Quantity Audit and inspection procedure for Rossing	JA80/MSP/001
Vendor pre-Qualification	JA35/PRC/001
Purchasing of chemicals	JA50/PRC/001
Sustainable sand management	JA50/PRC/003
Major Maintenance of Acid tanks	JA50/PRC/002
PPE Procedure	JA50/PRC/004
Customer Audit Procedure	JA80/PRC/002

7.1.1 HEALTH, SAFETY AND ENVIRONMENT MANAGEMENT PLANS

Sustainable sand management	JA20/MMP/003
Product Stewardship Plan	JA20/MMP/004
Biodiversity	JA20/MMP/005
Tailings Dam Dust Management Plan	JA20/MMP/010
Radiation Management Plan	JK20/MMP/001
Non-Mineral Waste Management Plan	JE20/MMP/001
Hazardous Material and Contamination Control Management Plan	JE20/MMP/002
Greenhouse Gas Emissions Management Plan	JE20/MMP/003
Air Quality Management Plan	JE20/MMP/004
Biodiversity Action Plan	JE20/MMP/006
Noise and vibration management plan	JE20/MMP/008
Mineral waste management plan	JE20/MMP/009
Water Management Plan	JA10/MMP/001

7.1.2 HEALTH, SAFETY AND ENVIRONMENT POLICIES

HSE Policy	JA05/POL/001
RUL Smoking Policy	JK05/POL/001
PPE Policy	JA05/POL/002
Fatigue Management Policy	JA05/POL/003
Clean Shaven Policy	JK05/POL/003
RUL Alcohol & Drug Policy	JK05/POL/004
Occupational Exposure Limits applied at Rössing	JK50/STD/001
HSE Policy Strategies	JA10/STR/001
HIV & Aids Policy Agreement	
Golden Rules	JA05/CHK/COP003 App006
Mobile Phone Usage Policy	JH05/POL/001

7.2 OPERATIONAL PROCEDURES RELEVANT TO HEALTH

Codes of Practice	
Peer Educator Programme	JK45/COP/001
Occ. Hygiene Monitoring	JK65/COP/002
Control of Asbestos at work	JK65/COP/003
Respiratory Protection Programme	JK65/COP/004
Thermal Stress	JK65/COP/005
Protection Against Ionising Radiation	JK65/COP/006
Protection Against Ultra Violet Radiation	JK65/COP/007
Control of Substances Hazardous to Health	JK65/COP/008
Hearing Conservation	JK65/COP/009
Human Vibration Protection	JK65/COP/011
Procedures	
Maintenance work carried out on the CIX contactors	JK50/PCL/001
Aerotesting Procedure	JK65/PIN/001
Operating the Thermo Eberline Handecount	JK65/PIN/002
Instrument Procedure for the Automess 6150 AD4 Dose Rate Meter	JK65/PIN/003
Operating Instructions for the Electra and DP2R/4A Probe	JK65/PIN/004
Management of Health Instruments and equipment.doc	JK65/PIN/005
Personal Monitoring of LLRD using the Myriam Instrument	JK65/PIN/006
Personal monitoring of RDP using the DoseManPro instrument	JK65/PIN/007
Thermal Stress	JK65/PRC/001
Maintenance of Water Coolers and Emergency Units	JK50/PRC/002
Area Noise Survey	JK65/PRC/003
Personal Noise Survey	JK65/PRC/004
Alcohol & Drug Testing Procedure for Cottage	JK65/PRC/005
Alcohol & Drug Testing Procedure for Windhoek	JK65/PRC/006
Confined Space Clearances	JK65/PRC/007
Measurement of Whole Body Vibration	JK65/PRC/008
Measurement of Hand-arm Vibration	JK65/PRC/009
Particulate Monitoring Particulates, Mists, Fumes and Vapours	JK65/PRC/010
Diesel Particulate Monitoring	JK65/PRC/011
Alcohol & Drug Procedure	JK65/PRC/012
Wood dust Monitoring	JK65/PRC/013
Confine Space clearances	JK65/PRC/014
HIV & Aids Transfer Procedure	JK65/PRC/015

7.2.1 OPERATIONAL PROCEDURES RELEVANT TO RADIATION

Radiation Protection when working with Sealed Radiation Sources	JK50/PRD/001
Urinalysis Sampling Procedure	JK65/PRD/002
Disposal of Contaminated Items	JK65/PRD/003
Removal of Scrap	JK65/PRD/004
Removal of Equipment and Material from Site	JK65/PRD/005
Decontamination of Contaminated Items	JK65/PRD/006
Transport of Contaminated Items	JK65/PRD/007
Monitoring of Employees Exiting FPR During unavailability of Thermo Electron PCM-2 Portal Monitor	JK65/PRD/008
Uranium Oxide Spillage	JK60/PRD/009
Monitoring & Identification of Contaminated Items	JK65/PRD/010
Product Shipment Inspection & Monitoring	JK65/PRD/011
Baseline Monitoring of Empty Containers	JK65/PRD/012
Analysis of Smear Sample for Alpha Radiation with Handecount	JK65/PRD/013
Procedures for Maintenance Work Carried out on the CIX Contactors	JK50/PRD/014
Area Radiation Survey for Total Alpha and Beta Contamination	JK65/PRD/015
Area Survey for External Gamma Radiation	JK65/PRD/016
Area Radiation Contamination Survey using Smear Samples	JK65/PRD/017
Contact radiation monitoring (Beta/Gamma) in Final Product Recovery	JK65/PRD/018
The monitoring of Personal Radiation Dose	JK65/PRD/019
Personal External Dose Monitoring with a Dosicard	JK65/PRD/020
Monthly pregnancy test	JK65/PRD/021
Container Packing & Strapping Procedure	JK65/PRD/022
Personal monitoring of RDP using the DoseManPro instrument	JK65/PRD/023
Scales Calibration	JK65/PRD/024
Determination of transport requirements for transporting radioactive materials"?	JK65/PRD/025
Microwave testing	JK65/PRD/026
Guidelines on Equipment leaving site	JK65/PRD/027
Alpha Analysis of Smear Samples with the Hand-E-Count (new instrument	JK65/PRD/028
Low Frequency EMF workplace Analysis	JK65/PRD/029
	FPR10
Inspection of Drums	FPR11
Drum Information Stencilling	FPR12
Drum Packing and Handling of Containers	FPR13

7.3 OPERATIONAL PROCEDURES RELEVANT TO SAFETY

Codes of Practice	
Vehicles and Driving	JH50/COP/007
Off-site Vehicles and Driving Standard	Appendix A
Cranes and Lifting	JH50/COP/011
First Responder Training	JH50/COP/012
Storage of flammable and Explosive Material	JH50/COP/013
Aisles, Storage and Demarcating	JH50/COP/014
Stacking and Storage	JH50/COP/015
Colour Coding	JH50/COP/016
Barricading and Demarcation	JH50/COP/017
Machine Guarding	JH50/COP/018
Compressed Gas Cylinders/Pressure Vessels	JH5O/COP/019
Hand Tools	JH50/COP/020
Work, Yard and Back Areas	JH50/COP/021
Appointment of Responsible Persons	JH50/COP/023
Permit to Work Systems	JH50/COP/026
Working at Heights	JH50/COP/030
Personal Protective Equipment	JH50/COP/031
The role of an OHSE Representative	JH50/COP/032
Fire Training	JH50/COP/033
Electrical Safety	JH50/COP/035
Procedure for cutting a lock	JH50/COP/036
Procedures	
Tyre Management	JH50/PRC/001
Confined Space Procedure	JH50/PRC/002

7.4 OPERATIONAL PROCEDURES RELEVANT TO ENVIRONMENT

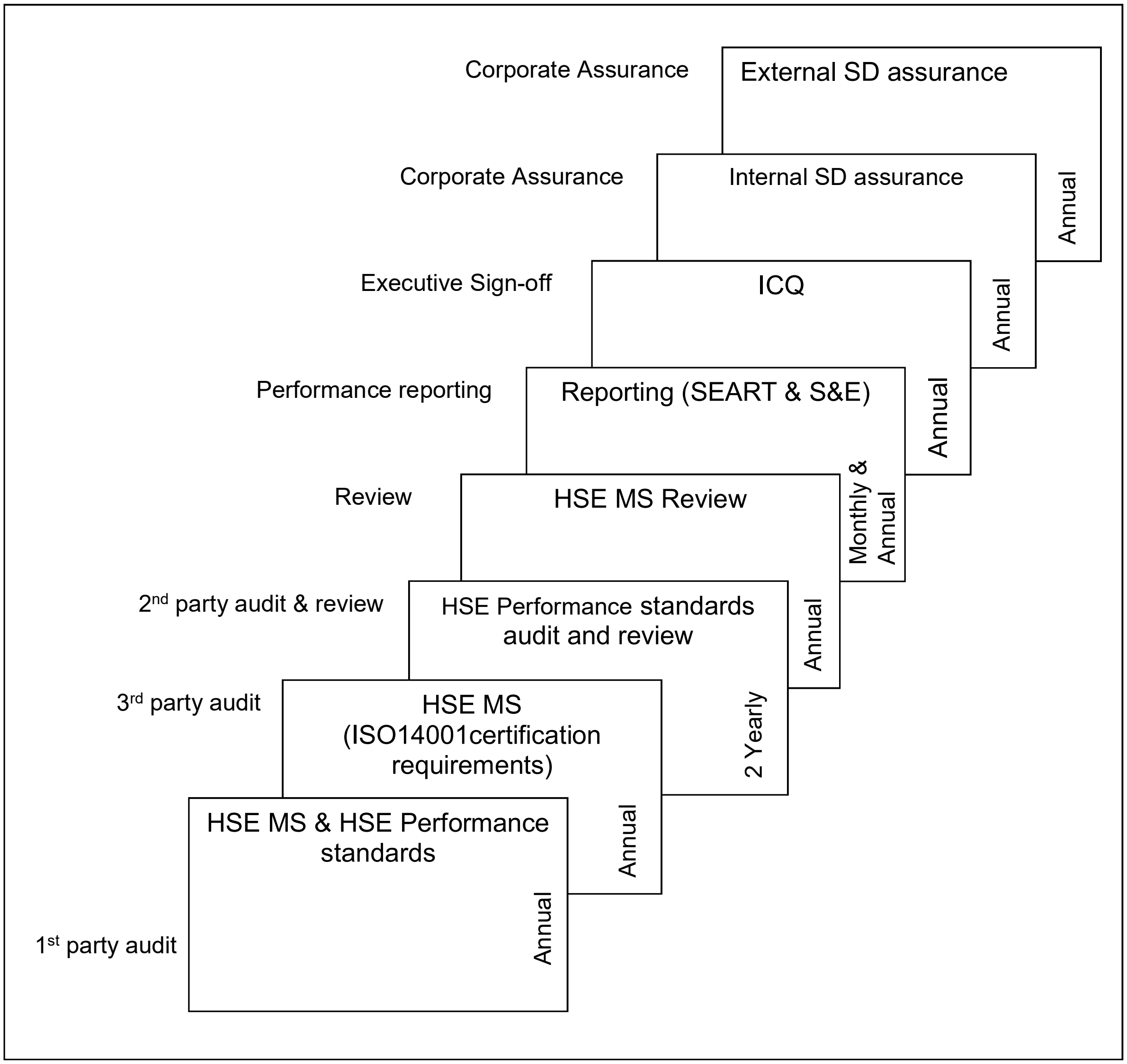
Procedures	
Non-Mineral Waste Management	JE50/WMP/001
Disposal/re-use of Hydrocarbons	JE50/WMP/002
Disposal of capacitors	JE50/WMP/003
Disposal practice for the Rössing Landfill Site	JE50/WMP/006
Procedure for action taken in the event of a diesel/oil spillage	JE50/WMP/010
Disposal of oil and diesel filters	JE50/WMP012
Bio-remediation of hydrocarbon contaminated soil and sludge	JE50/WMP/014
Disposal of Oil Trap Residue to the Oil Separation Plant	JE50/WMP/015
Purchasing of chemicals	JA50/PRC/001
Setting up of the Environmental Aspect Register	EMS/OPS/006
Air blast Ground Vibration Monitoring Programme	JE50/PRC/002
Inventory and Inspection of Chemicals in the lab	JE50/PRC/004
Determining of GHG procedure	JE65/PRC/001
Environmental Noise Monitoring Procedure	JE65/PRC/003
Land disturbance reporting	JE65/PRC/004
Biodiversity Monitoring and Information Management	JE65/PRC/005
Procedure for Storing, Transporting, Usage and Disposal of Hazardous Materials of Puma Energy (Namibia)	JE50/PRC/005
Instructions for Mercury Kit	JE50/PIN/001
Instruction for the ph fix Indicator strips	JE50/PIN/002
Dust Deposition Sampling	JE50/PIN/003
Downloading Data from the OSIRIS Dust Monitor at the Crushing Circuit	JE50/PIN/004
Operating Instructions for the spike pH5/6 meter (Analysing soil contamination)	JE50/PIN/005
Multi-Vertical Sampler	JE50/PIN/006
PM10	JE50/PIN/007
Operating Instructions for Total Petroleum Hydrocarbon (TPH) Test Kit	JE50/PIN/008
Procedure for Storing, Transporting, Usage and Disposal of Sodium Hydroxide	JE50/PRC/007
Procedure for Storing, Transporting, Usage and Disposal of Magnafloc	JE50/PRC/008
Procedure for Storing, Transporting, Usage and Disposal of Iron Oxide	JE50/PRC/009
Procedure for Storing, Transporting, Usage and Disposal of Manganese Dioxide	JE50/PRC/011

7.4.1 OPERATIONAL PROCEDURES RELEVANT TO WATER

Rössing water strategy.	JE05/STR/001
Standard Compliance (Rössing).	JE10/STD/001
Rössing Water Management Plan.	JA10/MMP/001
Khan river Vegetation Monitoring.	JE65/OWM/002
Bioremediation of Hydrocarbon Contaminated Soil and Sludge	JE50/WMP/014
Operation of oil separation plant.	JE50/SOP/001
Operation and monitoring of the Seepage Control systems.	JA50/OWM/SCP/002/
Monitoring of the sewage plant.	JE65/OWM/003
Operation of the sewage plant.	JE50/SOP/003
Procedure for the operation of septic tanks	JA50/ENV/OPS/003
Rössing water balance procedure.	JA50/OWM/WBP/001
Water Quality Monitoring.	JE65/OWM/004
Water Quality management.	JE50/MSP/001
Fresh water supply management.	JA50/OWM/WSM/001
Water recycling and reuse.	JE50/OWM/003
Weekly Determination of RDS and Seepage Evaporation Rates.	JE65/OWM/005
Seepage Recycling on the Tailings dam.	JE65/OWM/006
Treatment of TDX boreholes with Sodium hydroxide.	JA50/OWM/WSM/004
Freshwater Demand planning.	JE20/OWM/001

8 APPENDIX 4: SUMMARY OF AUDITS AND CERTIFICATION

The HSE assurance approach followed at Rössing.



9 REFERENCES

Abrahams A. and Anderson, F. (2004): Investigation into the Possible Increase in External Radiation Doses for 2004 at Final Product Recovery, Internal Memorandum, Rössing Uranium Ltd

Ashton P.J., C.A. Moore and P.H. McMillan (1991): An environmental impact statement for the Rössing Uranium Mine, Namibia. Published report for Rössing: CSIR, Division of Water Technology.

Ashton, P.J., L. Godfrey, R. Meyer and G. Dunn (2000): Environmental impact assessment of the proposal to expand the importation, storage and transfer of bulk sulphuric acid to Rössing Mine, Namibia: Environmental Impact Report. Published report for Rössing: CSIR, Division of Water, Environment and Forestry Technology (Report No. ENV-P-C-2000-030).

Atomic Energy Corporation of South Africa, (1988): An investigation of Rn-222 at Rössing Uranium Limited. A report for the period October 1987 to September 1988, Rössing Uranium Limited

Aquaterra Consulting (2005): Rössing groundwater model: Updated calibration. Unpublished report for Rössing: Aquaterra Consulting.

Aurecon (2011a): Social and Environmental Impact Assessment Phase 2b: Proposed expansion of Rössing Uranium Mine. Published report for Rössing: Aurecon.

Aurecon, (2011b): Social and Environmental Management Plan: Phase 2 Exploration drilling in the mine licence area within the Namib-Naukluft Park. Published report for Rössing: Aurecon.

Belnap, J. (2001): Factors influencing nitrogen fixation and nitrogen release in biological soil crusts. In: Belnap, J. and Lange, O.L. (eds): Biological soil crusts: structure, function and management. Springer Ecological Studies 150: 241-261.

Brett, R. (2009): Review of the biodiversity assessment at Rössing Uranium, Namibia. Unpublished report for Rössing: Fauna and Flora International and Rio Tinto partnership.

Burke, A. (2005a): Rössing's Biodiversity Strategy: Biotope mapping, reconstruction of the pre-mining situation and assessment of biodiversity value. Unpublished report for Rössing: EnviroScience.

Burke, A. (2005b): Biotope mapping, reconstruction of the pre-mining situation and assessment of biodiversity value. Unpublished report for Rössing: EnviroScience.

Burke, A. (2007): Biotope mapping for the Rössing Uranium mine expansion project in the eastern accessory works area. Unpublished report for Rössing: EnviroScience.

Burke, A., Kyläkorpi, L., Rydgren, B. and Schneeweiss, R. (2008): Testing a Scandinavian biodiversity assessment tool in an African desert environment, Environmental Management 42: 698-706.

Burke, A. (2009): Biotope assessment for Rössing’s license area, south of the Khan River. Unpublished report for Rössing: EnviroScience.

Burke, A. (2010): Input to the development of a restoration programme at Rössing Uranium. Unpublished report for Rössing: EnviroScience.

Burke, A. (2011): More of the same – or new patterns? Biotope assessment at Rössing Uranium during an exceptional season. Unpublished report for Rössing: EnviroScience.

Campbell, O. (1998): Wildlife follow-up survey – November 1998. Rössing Uranium Limited. Unpublished report.

Chamber of Mines of Namibia, (2009): Annual review. Windhoek, Chamber of Mines of Namibia.

CSIR, (1998): An assessment of the potential environmental impacts of the proposed aquifer recharge scheme on the Khan River, Namibia. CSIR, Division of Water, Environment and Forestry Technology (Report No. ENV/P/C – 97104.

Curtis, B.A. and Mannheimer, C.A. (2005): Tree atlas of Namibia. Windhoek: National Botanical Research Institute.

Dames and Moore (1981): Seepage and pollution control - Phase I. Unpublished report for Rössing: Dames and Moore.

Dames and Moore (1982): Seepage and pollution control - Phase II. Unpublished report for Rössing: Dames and Moore.

Dames and Moore (1983): TARGET – A mathematical model for Rössing Uranium Limited. Unpublished report for Rössing: Dames and Moore.

De Beer, G.P. and Leuschner, A.H. (1988): Assessment of the occupational dose from the various radiation sources in the open pit area at RUL. Unpublished report for Rössing: Atomic Energy Corporation of South Africa.

D Beer, G.P. (1990): Estimation of the Average Radiation Dose to the Population of Arandis from Radioactivity Originating from Natural as well as Mining Related Sources. Unpublished report for Rössing: Atomic Energy Corporation of South Africa.

De Beer, G.P. (1997a): An assessment of the radiological impact associated with the use of Rössing tailings for maintenance of haulage roads in and around the open pit. Unpublished report for Rössing: Atomic Energy Corporation of South Africa.

De Beer, G.P. (1997b): An assessment of the radiological impact associated with the use of seepage water from the Rössing tailings dam for dust suppression in the open pit. Unpublished report for Rössing: Atomic Energy Corporation of South Africa.

De Beer, G.P., Ramlakan, A.J. and Schneeweiss, R. (2002): An assessment of the post-closure radiological impact of Rössing Uranium Mine. Report GEA-1582. Unpublished report for Rössing: Nuclear Energy Corporation of South Africa, Pretoria.

De Beer, G. P. and Ramlaken, A. J. (2003): Post-closure public dose assessment for the Phase III expansion of the Rössing Uranium Mine. Report GEA-1617. Unpublished report for Rössing: Nuclear Energy Corporation of South Africa.

De Beer, G.P and Liebenberg, G.R., (2008): Dose assessment for a life-of-mine extension (LOME) of the Rössing Uranium Mine. Unpublished report for Rössing: Nuclear Energy Corporation of South Africa.

De Villiers, D. and De Beer, G.P. (2011): Report on the radiological public hazard assessment for the expansion of Rössing Uranium Mine in Namibia. Unpublished report for Rössing: Nuclear Energy Corporation of South Africa.

EEAN / Environmental Evaluation Associates of Namibia, (2008): Rössing Biodiversity Assessment. Unpublished report for Rössing: EEAN.

Evans, R.D. and Lange, O.L. (2001): Biological soil crusts and ecosystem nitrogen and carbon dynamics. In: Belnap, J. and Lange, O.L. (eds): Biological soil crusts: structure, function and management. Springer Ecological Studies 150: 263-279.

Everett, M. (2001): An assessment of the dose attributable to radon at a number of receptor locations surrounding Rössing Uranium Mine. Unpublished report for Rössing: EnviroSolutions.

EnviroSolutions, (2002): An assessment of the background radon concentrations for pre-mining conditions in the present mining grant area of Rössing Uranium Limited. Unpublished report for Rössing: EnviroSolutions.

Grundling, A. and Leuschner, A.H. (1988): An investigation of 222Rn concentrations at RUL. A report for the period October 1987 to September 1988. Unpublished report for Rössing: Atomic Energy Corporation of South Africa.

Grundling, A. and Leuschner, A.H. (1990): Modelling Environmental Radon Concentrations Associated with Mining Activities at Rössing Uranium Ltd. Unpublished report for Rössing: Atomic Energy Corporation of South Africa.

Isaack, J.B. (2001): Preliminary post closure radiological safety evaluation for Rössing Uranium Mine. Rio Tinto Technical Services: Unpublished report (Ref: GBJ016)

Loots, S (2006): Red list field assessments of *Lithops ruschiorum* and *Adenia pechuelii* in the Rössing Uranium Mine concession area. Unpublished report: National Botanical Research Institute.

Loots, S. 2011: National conservation assessment and management of two Namibian succulents with specific reference to the Rössing Uranium Mine. Published report for Rössing: National Botanical Research Institute.

National Planning Commission, (2012) Namibia 2011 Population and Housing Census Preliminary results. Windhoek, National Planning Commission.

Ninham Shand, (2008): Social and environmental impact assessment: proposed expansion project for Rössing Uranium Mine in Namibia: Phase 1 ~ acid plant, ore sorter and SK4 pit

Parc Scientific and EnviroSolutions, (2001): An assessment of the airborne and deposited dust levels attributable to dust sources at a number of receptor locations surrounding Rössing. Unpublished report for Rössing: PARC Scientific Pty Ltd.

Kinahan, J. (2007): Archaeological assessment of SK Area in ML 28. Unpublished report for Rössing: Quaternary Research Services
Rössing Foundation, (2009): The Rössing Foundation 1978 – 2008. Windhoek, The Rössing Foundation.

Rössing Uranium Limited, (2005): Rössing Closure Management Plan. Unpublished report: Rössing Uranium Limited.

Rössing Uranium Limited, (2008): Land Use Management Plan. Unpublished document: Rössing Uranium Limited.

Rössing Uranium Limited, (2011): Report to stakeholders. Published report: Rössing Uranium Limited.

Rössing Uranium Limited, (2011): Closure Management Plan. Unpublished report: Rössing Uranium Limited.

Rössing Uranium Limited, (2012): Dust Management Plan. Unpublished document: Rössing Uranium Limited.

Rössing Uranium Limited, (2012): Radiation Management Plan Unpublished document: Rössing Uranium Limited

SAEIA, (2010): Strategic Environmental Assessment for the central Namib uranium rush. Windhoek, Ministry of Mines and Energy

SIAPAC in Association with Golder Associates Africa (2003): Sustainability Assessment for the Life Extension of Rössing Uranium Mine

Simonis Storm Securities, (2010): The Namibian uranium industry: Economic impact and counter valuation. Published report: Simonis Storm Securities.

(South Africa) Department of Water Affairs and Forestry, (1998): Minimum requirements for the handling, classification and disposal of waste (2nd Edition) Pretoria.

Smit, P. (2011): Biodiversity and rehabilitation at Rössing. Unpublished document. Rössing Uranium Limited.

Stacey, J 2006: Rössing Uranium Limited. Rössing Mine Lease bird survey 2005-6. Unpublished report for Rössing: BirdLife International.

Steffen, Robertson and Kirsten Inc, (2010): Water specialist study for the Phase II SEIA for the Rössing mine expansion. Unpublished report for Rössing.

Strydom, R. Goede, P., Goosen, C., van Staden, M and Steyn, A. (1989): The measurement of radon exhalation rates from identified sources at RUL Unpublished report for Rössing: Atomic Energy Corporation of South Africa.

Strydom, R., (2006): Atmospheric dispersion modelling of radon and long-lived radioactive dust for current, life-of-mine extension and post closure mine operating scenarios. Unpublished report for Rössing: PARC Scientific Pty Ltd.

10 ABBREVIATIONS USED IN THIS DOCUMENT

ALARA	As Low As Reasonably Achievable
ART	Anti-retroviral treatment
ASDP	Arandis Sustainable Development Project
BAP	Biodiversity Action Plan
Bq	Becquerels
CaO	Calcium Oxide
CCD	Counter Current Decantation
CH_4	Methane
CIX	Continuous ion exchange
cm	Centimetre
CO	Carbon monoxide
CO_2-e	Carbon dioxide equivalent
DWA	Department of Water Affairs
EEAN	Environmental Evaluation Association of Namibia
EIA	Environmental Impact Assessment
EMS	Environmental Management System
EPL	Exploration Prospecting Licence
FPR	Final Product Recovery
g	gram
GHG	Greenhouse Gas
GJ	GigaJoule
HEF	High Energy Fuel
HIV/AIDS	Human Immunodeficiency Virus infection / Acquired Immunodeficiency Syndrome
HSE	Health, Safety and Environment
HSE MS	Health, Safety and Environment Management System
IAEA	International Atomic Energy Agency
ICRP	International Commission for Radiological Protection
IPCC	International Panel on Climate Change
ISO	International Organization for Standardization
IT	Information technology
IUCN	International Union for the Conservation of Nature
kg	kilogram
kV	kiloVolt
L	Litre
M	mega, one million
m	meter
m^3	cubic meter
mamsl	metres above mean sea level
mg:	milligram
MgO	Magnesium Oxide
ML	Mining Licence
mSv	milliSieverts, 10^{-3} Sv
µm	micrometre
MVA	MegaVolt Ampere
MWH	MegaWatt Hours
Na_2CO_3	Sodium carbonate
NBRI	National Botanical Research Institute
NECSA	Nuclear Energy Corporation of South Africa
NO_x	Nitrogen Oxide

NPI	Net Positive Impact
NSX	Namibian Stock Exchange
NRPA	National Radiation Protection Authority
OK liquor	The chemical solution containing uranium trioxide
PCB	Polychlorinated biphenyl
PM10	Particulate Matter < 10 μm
PPE	Personal Protective Equipment
ppm	Parts Per Million
RTZ	Rio Tinto Zinc Corporation
RUL	Rössing Uranium Limited
s	second
SAIEA	Southern African Institute for Environmental Assessment
SABS	South African Bureau of Standards
SEA	Strategic Environmental Assessment
SEIA	Social and Environmental Impact Assessment
SEMP	Social and Environmental Management Plan
SX	Solvent Extraction
SO_2	Sulphur Oxide
t	Tonne
TDS	Total Dissolved Solids
TLD	Thermo Luminescent Dosimeter
TPM	Total Particulate Matter
UN	United Nations
UNSCR	United Nations Security Council Resolution
U_3O_8	Uranium oxide
Yellow cake	Ammonium diuranate

11 CHANGES AND REVISION STATUS

Issue and Revision History				
First Issue	**Issue date**	**Prepared by**	**Approved by**	[redacted]
1.0	30/11/2012	Pierré Smit	Mpho Mothoa	
Version number	**Revision date**	**Revised by**	**Approved by**	**Reason for change**
1.1	29/02/2016	R. Schneeweiss	B. Uris	Periodic review
Version number	**Revision date**	**Revised by**	**Approved by**	**Reason for change**
1.2	01/03/2017	I Shaduka	J. Mwenze	Periodic review
1.3	25/04/2018	I Shaduka	J. Mwenze	Periodic review
1.4	25/06/2021	S Gaeseb	J. Mwenze	ECC application