Rio Tinto

Rössing Uranium Limited
Working for Namibia

Implementation of Radiation Management Plan

2013 Annual Report

The Rössing Mine

Uranium was discovered in the Namib Desert in 1928, but it was not until intensive exploration in the late 1950s that much interest was shown in the area. After discovering numerous uranium occurrences, Rio Tinto secured the rights to the low-grade Rössing deposits in 1966. Ten years later, Rössing Uranium, Namibia's first commercial uranium mine, began operating.

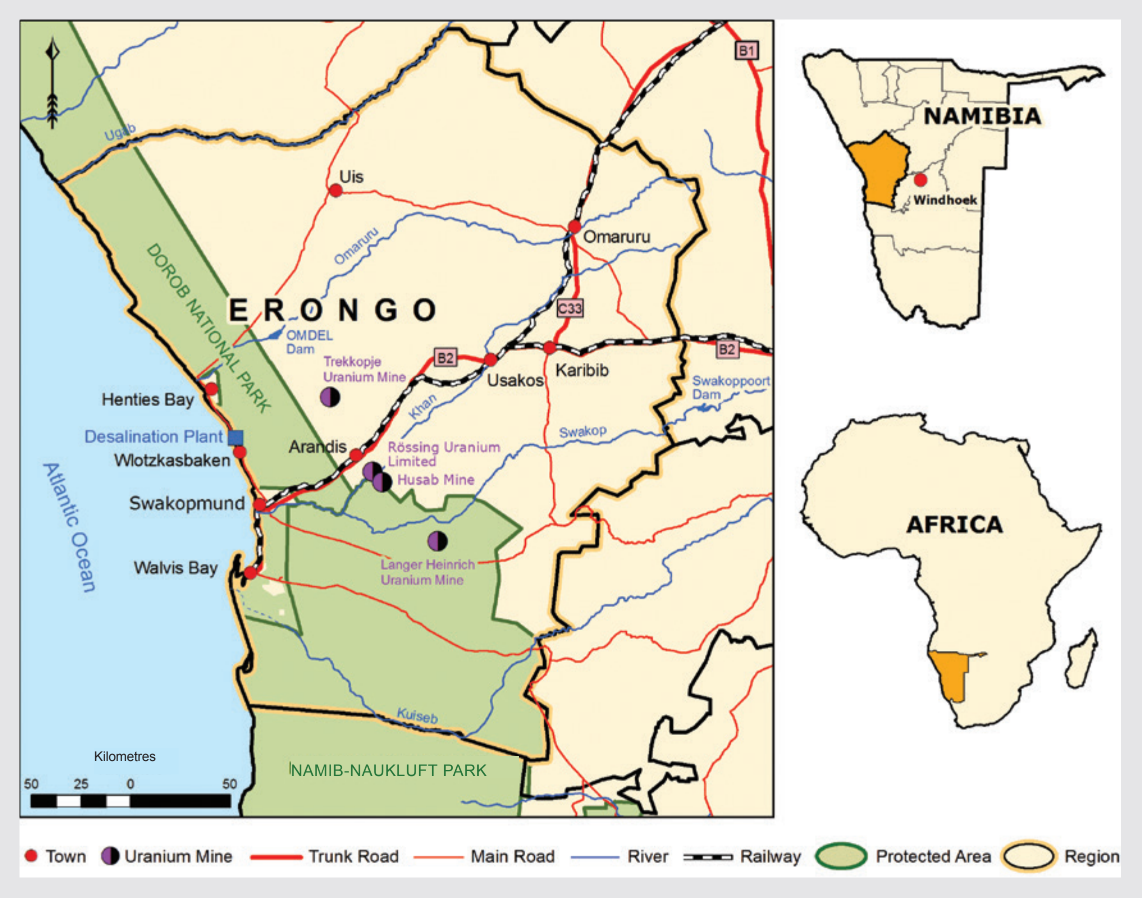
Today, Namibia has two significant uranium mines, which together provide for 6.96 per cent of the world's uranium oxide mining output; Rössing Uranium produces 3.4 per cent of the world's output. The mine has a nameplate capacity of 4,500 tonnes of uranium per year and, by the end of 2013, had supplied a total of 125,862 tonnes of uranium oxide to the world.

The mine is located 12 km from the town of Arandis, which lies 70 km inland from the coastal town of Swakopmund in Namibia's Erongo Region. Walvis Bay, Namibia's only deep-water harbour, is located 30 km south of Swakopmund.

The mining operation is in a semi-arid environment. Insolation at Rössing is high, and as a result, daytime ranges of temperatures are wide, especially during May and September, when the difference between minimum and maximum temperatures exceeds 20°C daily. The lowest temperatures are normally recorded during August, but frost is rare. The highest temperatures are recorded in the late summer, particularly March.

The mine site encompasses a mining licence and accessory works areas of about 180 km^2, of which 25 km^2 is used for mining, waste disposal and processing.

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. The open pit currently measures 3 km by 1.5 km, and is 390 m deep.



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JK85/RMP/001

HSE MS Element 4

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Acronyms and abbreviations

The following acronyms and abbreviations are used throughout the report:

µg/L	micrograms per litre
µg/m^3	micrograms per cubic metre, 10^{-6} g per cubic metre
µSv	Micro-Sievert, 10^{-6} Sv
Bq/m^3	Becquerel per cubic metre
GBq	Giga-Becquerel, 10^9 Bq
HR	Human Resources
kBq	Kilo-Becquerel, 1,000 Bq
LLRD	Long-lived radioactive dust
MBq	Mega-Becquerel, 10^6 Bq
mBq/L	milli-Becquerel per litre, 10^{-3} Bq per litre
mg/m^3	milligrams per cubic metre,10^{-3} g per cubic metre
mSv	milli-Sievert, 10^{-3} Sievert
mSv/a	mSv per annum
NRPA	National Radiation Protection Authority
NUI	Namibian Uranium Institute
ppm	parts per million
RMP	Radiation management plan
RSO	Radiation Safety Officer (statutory role)
SABS	South African Bureau of Standards
SEG	Similar exposure group
TLD	Thermo luminescent dosimeter
TSF	Tailings Storage Facility
UOC	Uranium oxide concentrate
XRF	X-ray fluorescence

1. Introduction

1.1 Background

In terms of Section 29(2) of the Atomic Energy Act,[1] it is required that every licence holder submits an annual report and data relating to radiation protection and safety, or any other matter concerned with the administration of the Act and the Regulations[2] pertaining to the Act.

From 2013, all operations have been requested to supplement the annual report and data with a narrative report, structured to replicate the framework of the Radiation Management Plan (RMP), and as outlined in the guidance document issued in 2014.[3]

This narrative report is therefore prepared in accordance with the above requirements, and supplements the annual data reported to the National Radiation Protection Authority (NRPA).

1.2 Rössing Uranium's operations in 2013

Rössing Uranium Limited (Rössing Uranium) underwent significant structural changes in 2013. Starting in April 2013, a structured retrenchment programme resulted in the termination of the contracts of close to 400 workers. As a result, work practices and roles in many areas had to be optimised or modified, leading to an overall rationalisation of roles and responsibilities.

Uranium production was particularly low in 2013, partly as a result of the aforementioned organisational restructuring but mostly as a result of the low ore grades mined. Low production tends to result in low average radiation exposures since these are directly related to the paucity of high grade ore being mined and processed.

As a result of the failure of a leach tank towards the end of 2013, the year concluded with a period of production shut down for maintenance and repairs. The leach tank failure did not result in any additional radiological risks as the material from the tank was collected in the collection sump designed for this purpose. It did, however, result in significant production shortfalls. Only a standby staff complement was kept on site during the shutdown period, which ended in mid-January 2014.

1.3 Rössing Uranium's Radiation Management Plan updates

Rössing Uranium's RMP was updated in March 2013 and again in November 2013. Changes made to the RMP included:

- Optimisations made to radiation safety procedures (see the summaries in sections 2.2 and 3.1 respectively)
- Updates on the exploration programme that was completed in 2013
- A summary of the newly-completed radon area survey across the site
- Updates on the classification of workers' similar exposure groups (SEGs).
- An update of the Rössing Uranium Transport Plan
- An update on the risk assessment of radiation workers, and
- The classification of workers into 'radiation workers' and non-classified occupationally-exposed workers.

The updated RMP was communicated to the NRPA and to Rössing Uranium's workers. The latest version of the RMP is always available to all workers via Rössing Uranium's intranet.

1.4 Rössing Uranium's radiation source inventory

Apart from the ore material mined at Rössing Uranium, the final product – uranium oxide – originating from this ore and being shipped to customers worldwide, and the radioactive mineral waste facilities (Tailings Storage Facility and Waste Rock Dumps), Rössing Uranium makes use of sealed sources for flow and density measurements; small calibration sources for onsite instrument calibrations; and X-ray fluorescence (XRF) machines for chemical analysis at the on-site laboratories.

At present, five sealed sources are being used in operations, with another nine sources stored in the Radiation Source Bunker for future use. All sealed sources are Cs-137 sources.

Two XRF machines are in use at the chemical laboratory and two calibration sources are kept at the Radiation Safety laboratory for calibration purposes.

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[1] Atomic Energy and Radiation Protection Act, 2005 (Act No. 5 of 2005)
[2] Radiation Protection and Waste Disposal Regulations (No. 221 of 2011)
[3] *Guide to Facilitate the Reporting by Licensees on the Implementation of the Radiation Management Plan* (RMP), Ministry of Health and Social Service, National Radiation Protection Authority, 2014

2. Organisational arrangements

2.1 Organisational restructuring

In 2013, Rössing Uranium underwent significant organisational restructuring, starting in April of that year.

This has led to the following changes in the Radiation Safety Section:

- A reduction in the number of Radiation Safety Advisors, from 2 to 0
- A reduction in the number of Radiation Protection Officers, from 4 to 2, and
- A change in the reporting structure of the Health, Safety and Environment (HSE) Department, from Operations to Organisational Resources.

The resulting organisational structure is shown in Figure 1.

Organisational restructuring in the Radiation Safety Section was completed at the end of April 2013. One of the remaining two Radiation Protection Officers resigned effective September 2013. Until the recruitment process for the vacant role has been completed, Ms Nelao Endjala is acting in this position[4].

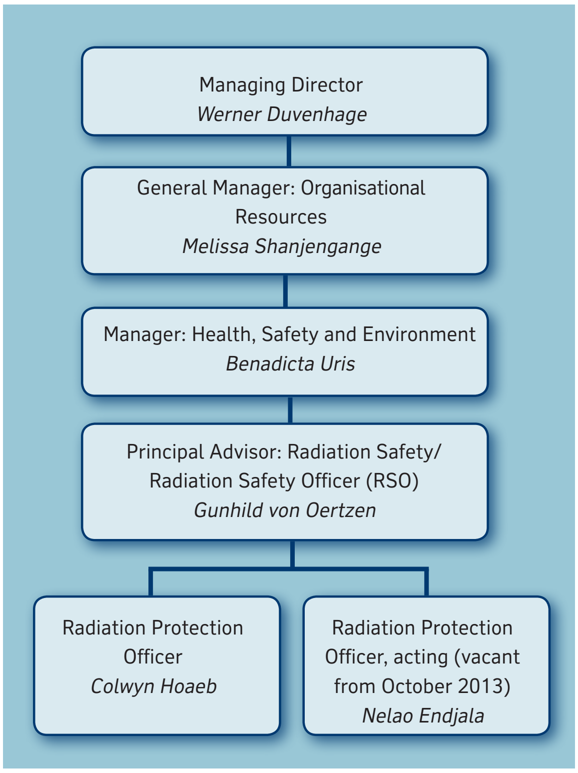

Figure 1: Organisational structure for the Radiation Safety Section

2.2 Changes in working arrangements

As a result of these organisational changes, significant restructuring of the Radiation Protection Programme was necessary. The changes made are summarised below:

- A comprehensive site-wide risk assessment of the classification and controls of all radiation workers (anyone who may potentially be exposed to a total dose of 5 mSv or more during one year of work) was made. The assessment included an investigation of the particular role of each radiation worker to link work attributes to roles rather than to specific persons, thus improving the protection of radiation workers and controlling their potential occupational exposure. The number of designated radiation workers (roughly 100 at present) has not changed significantly as a result of this process but the link between controls and roles has improved considerably: the attribute 'radiation worker' is now linked to a role within the mining operations rather than to an individual person. Organisational structures can therefore be more readily utilised to keep track of the persons occupying radiation worker roles. Radiation worker controls comprise:

  a) continuous monitoring of gamma doses by way of thermo-luminescent dosimeters (TLD)

  b) regular urine sampling to check for internal contamination, and

  c) monthly pregnancy testing for female radiation workers.

- A review of the contamination clearance procedure for items leaving the site was performed since the indiscriminate scanning of all items leaving the site is both unnecessary and time-consuming. The review resulted in amended clearance procedures that now only apply to items from the wet processing areas since these are the only items at risk of contamination.

[4] Ms Endjala was promoted to the role of Radiation Protection Officer in mid-February 2014, following the normal recruitment process for the position.

- The shipment procedure for the transport of uranium oxide to customers was optimised, including a comprehensive clearance procedure to ensure that no contamination arises in the port as a result of container storage. The new clearance procedure now only includes checks following the removal of containers from the port as these are sufficient to assess whether possible decontamination is required.
- The contamination controls for drums prior to packing into containers were optimised as these are time-consuming and lead to significant gamma exposures to employees during the packing process. Since contamination of drums is visible to the naked eye, instrument checks during the packing process have been replaced with visual checks. The risk of contamination is further reduced by ensuring that drums are thoroughly cleaned and dried, a process that continues to be a critical component of the contamination controls applied in the final product and drum-packing areas.
- Contaminated waste is disposed of in Rössing Uranium's contaminated waste storage area, ie the Tailings Storage Facility. Historically, detailed records were kept of the surface contamination levels of all contaminated waste that was disposed of; this labour-intensive process has now been rationalised and waste is now simply weighed before it is deposited. (All of the waste in the Tailings Storage Facility is regarded as low-level surface contaminated waste, which renders the collection of the details of the contamination of individual waste items unnecessary and irrelevant for the on-site control of contamination.)

2.3 Training

Radiation safety workers need regular opportunities to exchange information with their peers and update their professional qualifications. Rössing Uranium works in collaboration with the Namibian Uranium Institute (NUI) to upgrade the professional skills of all radiation safety workers in the industry, including those in other operations who work with radioactive materials or where workers may otherwise be exposed to radiation through their work. Rössing Uranium's designated Radiation Safety Officer (RSO), ie the Principal Advisor Radiation Safety, continues to provide expertise and advice to the training programmes offered via the NUI.

Both Radiation Protection Officers currently working in the Radiation Safety Section, Colwyn Hoaeb and Nelao Endjala, have completed modules I, II and III of the Radiation Safety Officer course, which is offered to radiation safety professionals at the NUI. In addition, Colwyn Hoaeb attended the first Winter School for radiation safety officers, which was offered at the NUI in 2013 and is intended to become an annual event.

3. Occupational exposure

3.1 Changes in the monitoring programme

The control and monitoring of occupational radiation exposure form significant components of the Radiation Protection Programme. Changes made to exposure control are summarised in Section 2.2 above. Changes made to the monitoring programme are as follows:

- Since 2013, all employees terminating their employment at Rössing Uranium have been issued with a dose report detailing their cumulative radiation exposure dose while working at Rössing. A list of termination dose records for 2013 was communicated to the NRPA but is included again in the reporting data spreadsheet. Cumulative dose records are based upon historical dose records for SEGs, for which average dose results exist for all years from 1996 onwards. For the years before 1996, an estimate of the dose was made based on averaging dose records in subsequent years. A statistical confidence level based on average results was attached to each record to indicate the range of dose records obtained in each group. For those workers who were registered as radiation workers and for whom records existed, the average deep dose results were replaced with accurate individual records as provided by the dosimetry service provider, the South African Bureau of Standards (SABS).
- From 2012, a dose record has been communicated to the NRPA for every worker at Rössing Uranium, contractors included. These dose records are based on individual deep dose records of all radiation workers and on random sampling by SEG for all other pathways and workers.

3.2 Monitoring results for 2013

There were 15 SEGs defined for mine workers in 2013, a category that excludes off-site workers since they do not receive an exposure dose. A total of 1,567 personal exposure dose samples were taken, ensuring statistical validity for each group and pathway.

Monitoring results were extrapolated to a full working year for each worker, based on the assumption that each worker works on site for 2,000 hours exactly. (This assumption is conservative, however, as the actual number of hours spent on site was significantly less than 2,000 in almost all cases.)

[5] *Personal Radiation Monitoring for Back Shifts* - RUL Report JK15/RPT/001, 2013.

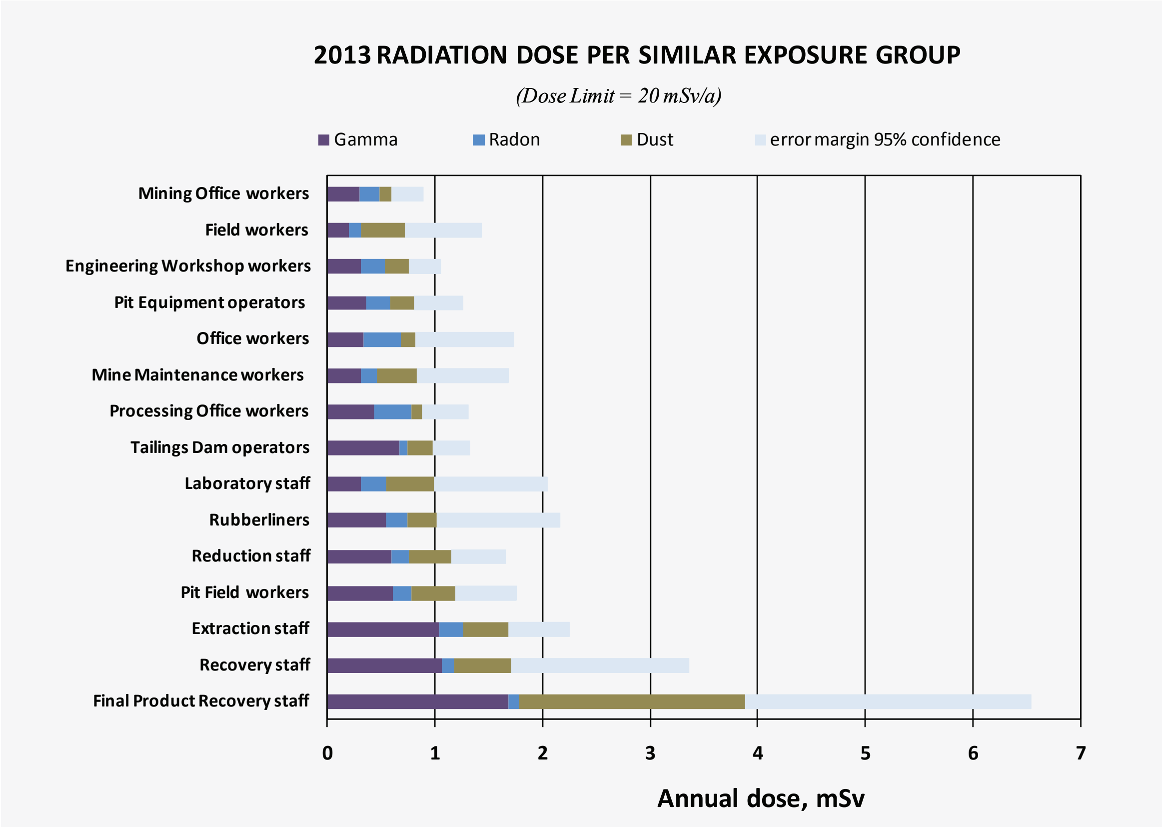

Figure 2: Summary of SEG monitoring programme, 2013

A report prepared in 2012 demonstrated that sampling during the day shift is representative of all shifts, or at least represents the most conservative (highest) dose for the SEG under consideration[5]. As a consequence, no samples were taken for afternoon and night shifts in 2013.

Monitoring results were communicated to employees after a sampling session in their work area was completed.

The results of the monitoring programme are summarised in Figure 2. The figure is based on random samples in all SEGs and for all pathways monitored. (TLD results for individuals are not used for this statistical summary.)

The mine-wide weighted average dose from all pathways for 2013 was 1.0 mSv/a per person, with a 95 per cent confidence level dose of 2.0 mSv/a.

Dose records for employees whose contracts were terminated and annual dose records for employees in 2013 are included in the reporting spreadsheet supplied with this report when submitted to the NRPA.

3.3 Radiation workers

The classification of workers follows the Rio Tinto Standard B5 (*Radiation*), which asserts that any person potentially exposed to a radiation dose of more the 5 mSv is a 'radiation worker'.

In 2013, the classification of the attribute 'radiation worker' was reviewed following a radiation risk assessment covering all working areas. The outcome of the risk assessment was summarised in procedure JK65/PRD/032 – *Radiation Worker Control Requirements at RUL*. Here, the outcome of the risk assessment for each role was used to classify these into 'radiation worker' and 'other' roles. A Human Resources (HR) process was also initiated to ensure that employees moving into, or out of, a 'radiation worker' role are recorded and as a result the required changes – such as registration or de-registration as TLD wearer – are now being implemented.

The period of use for TLDs for all radiation workers is 12 weeks, and the dosimetry service provider is the SABS.

Controls for radiation workers include:

- registration as a radiation worker, and wearing the TLD
- monthly urine sampling for detection of uranium in urine, and
- monthly pregnancy testing for all females under 50 years of age.

The following observations relating to radiation workers in 2013 can be made:

- A total of 54 radiation worker registrations were cancelled, either as a result of role changes, retrenchment, or resignation

[5] Personal Radiation Monitoring for Back Shifts - RUL Report JK15/RPT/001, 2013.

- A total of 18 workers were newly registered as radiation workers
- The maximum dose per 12-week period recorded for any TLD wearer was 2.81 mSv
- The maximum total dose for any TLD wearer in the year 2013 was 4.34 mSv
- Based on the SEG averages for the inhalation doses of radon and long-lived radioactive dust (LLRD), three workers exceeded the threshold of 5 mSv/a, at 5.74, 6.14 and 6.54 mSv/a respectively; all three were Final Product Recovery workers
- The average dose from all pathways for all radiation workers was 2.0 mSv, and
- The total number of radiation workers at the end of the year 2013 was 96.

A total of 1,023 urine samples were taken in 2013.[6] No sample exceeded either the warning level of 20 µg/L or the action level of 40 µg/L. A total of 27 exceeded the instrument detection limit of 5 µg/L, for which no further action is required.

A total of 335 pregnancy tests were conducted in 2013. One worker tested positive on pregnancy testing and was removed to a working area in which the expectation value for the annual dose is less than 1 mSv/a.

3.4 Radiation awareness training

It is a requirement for all Rössing Uranium workers that they attend radiation awareness training regularly.

Three training modules relating to radiation protection are provided at Rössing Uranium:

- Module 1, an introductory course of 90 minutes covering all the relevant information about radiation and radioactive material sufficient for first-time attendees
- Module 2, a 60-minute course about the biological effects of radiation, and radiation protection, and
- Module 3, a 60-minute refresher of modules 1 and 2 with additional information about the radiation protection of workers and the public.

In 2013, attendance was as follows:

- Module 1 – 384 attendees
- Module 2 – 291 attendees, and
- Module 3 – 144 attendees.

In addition to the scheduled training sessions mentioned above, individual sessions are offered on request, and are section specific.

At the end of 2013, compliance with the training requirements across site was 81 per cent for all workers.

4. Medical exposure

Not applicable.

5. Public exposure protection

5.1 Background

Public exposure protection is based on:

1. public dose risk assessment
2. public dose assessment
3. implementation of controls, and
4. environmental monitoring (confirming items 1 and 2, above).

The public dose risk assessment is outlined in the Rössing Uranium impact assessments and closure plans, as summarised in Rössing Uranium's RMP.

Various public dose assessments have been made and all are summarised in the RMP.

Controls relevant to radiation protection are, in brief:

- Dust suppression, dust minimisation, and engineering controls for processes generating dust (such as the crushing circuits), and
- Seepage control and seepage reclaim, as described in Rössing Uranium's RMP.

Monitoring programme activities relevant to radiation protection are, in brief:

- Dust monitoring at the mine site border and at Arandis (relating to the atmospheric pathway – LLRD)

[6] Urine samples were analysed at the Trace Element Analysis Laboratory (TEA Lab) in Swakopmund.

- Water sampling in monitoring boreholes and radionuclide analysis (relating to the aquatic pathway), and
- Intermittent surveys of radon concentrations (relating to the atmospheric pathway – radon).

The results of these monitoring programme activities are summarised below in sections 5.2 - 5.4.

5.2 Water quality

Boreholes on the mine site and beyond are monitored annually to confirm that seepage from the tailings area does not contaminate groundwater in the Khan River. A radionuclide analysis, performed by the South African Nuclear Energy Corporation SOC Limited (Necsa), is used to determine the characteristics of the water sampled whereby the ratio of concentrations of U-238 and U-234 in the water sampled is ascertained. A ratio U-234/U-238 of more than 1 indicates natural environmental sources, while a ratio of less than 1 indicates groundwater influenced by process solutions.

The water sampling results taken in 2013 are summarised in Table 1. The radionuclide ratios of all locations close to, or in, the Khan River were well above 1, indicating the absence of contamination downstream of the cut-off trenches.[7]

A map of the area with the relevant borehole monitoring results, as calculated from the August 2013 borehole analysis data, is shown in Figure 3.

Table 1: Radionuclide sampling analysis for monitoring boreholes, as of August 2013

Borehole code/ sample	U-234 concentration, mBq/L	U-238 concentration, mBq/L	Ratio U-234/U-238	Comment on location of borehole
G27121	411	456	0.90	
Control	4,960	5,470	0.91	Fresh uranium used for control
Tailings dam	137,000	149,000	0.92	Surface water
L9	27,400	29,400	0.93	
X2	1,180	1,260	0.94	
J	3,380	3,600	0.94	
L13	6,310	6,620	0.95	
X19	34,000	35,500	0.96	
Seepage dam	12,900	13,400	0.96	Surface water
X8	30,700	31,700	0.97	
N1A	12,600	13,000	0.97	
L19	30,200	31,100	0.97	
R 1	38,500	39,300	0.98	
X4A	4,450	4,460	1.00	
L1	276	271	1.02	Upstream of tailings
X21	248	219	1.13	
Trench H	29,900	29,600	1.01	
L18	314	280	1.12	
T1	127	112	1.13	Upstream of tailings
L8	9,390	7,990	1.18	Upstream trench C
L7	8,260	7,250	1.14	Upstream trench C
L6	6,790	5,790	1.17	Upstream trench C
Trench E	8,590	7,210	1.19	Barrier
Trench C	11,300	8,890	1.27	Barrier
1.6A	877	723	1.21	Khan River
DG1	7,540	5,930	1.27	Khan River
1.4	2,060	1,800	1.14	Khan River

[7] A list of all monitoring boreholes and their geographic coordinates is given in the RMP.

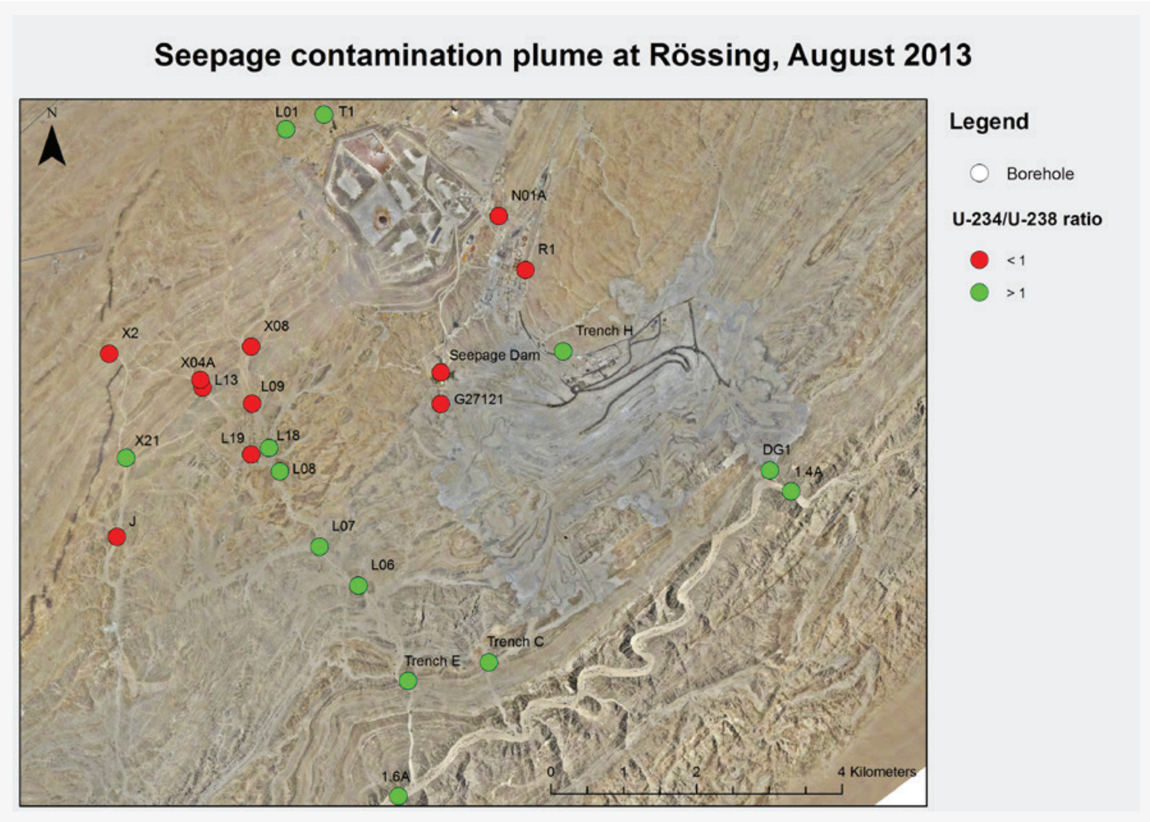

Figure 3: Seepage contamination plume at Rössing Uranium, August 2013

5.3. Dust monitoring

Fine inhalable particulate (PM10) dust is monitored continuously (at hourly intervals) at Arandis and at a location on the mine boundary to the south-west of the licence area. The location of the boundary station was chosen to coincide with the main wind direction during strong east wind events, mainly during the winter months. PM10 measurements are then combined with an analysis of a dust sample from each of the two locations to determine the radionuclide content of the dust. For a rough analysis it is sufficient to determine the content of uranium in the dust and to assume the dust to be predominantly ore dust. The International Atomic Energy Agency (IAEA) dust conversion coefficient used for determining LLRD doses from the inhalation of ore dust can then be used to estimate the public dose that is representative of the sampling location.

The 2013 measurement values for Arandis are displayed in graphical form in Figure 4.

It can be seen that there was considerable variation in the 2013 PM10 concentrations, which was mostly due to weather conditions since during east wind conditions (usually in May) the amount of dust is much higher than in less windy conditions.

The PM10 dust concentrations measured were compared to the World Health Organization (WHO) standard for the annual average of PM10 dust, ie 50 μg/m^3.

The 2013 concentration of uranium in dust at Arandis was determined to be 7 ppm.[8] Using this radionuclide content and the most conservative (highest) PM10 dust concentration at Arandis – ie the average value for May of 0.028 mg/m^3 – the resulting public adult dose from the inhalation of dust was estimated to be 34 μSv per annum (and based on the average for all months, the public dose was estimated to be 16 μSv per annum). Note that this conservative dose estimate:

- was based on the worst case assumption, ie using the highest month-average PM10 value; and
- included all natural sources of radioactivity in environmental dust and did not, therefore, only represent the public dose as a result of mining at Rössing Uranium.

This worst-case assumption estimate of the public dose – 34 μSv per annum (or 0.034 mSv per annum) – was significantly below the public dose limit of 1 mSv per annum and thus a more exact calculation was not regarded as necessary since this would only lead to an even lower public dose estimate.

[8] Using a composite dust sample collected at the Arandis PM10 dust sampler, and by doing a chemical analysis at the Rössing Uranium onsite laboratory to determine its uranium content.

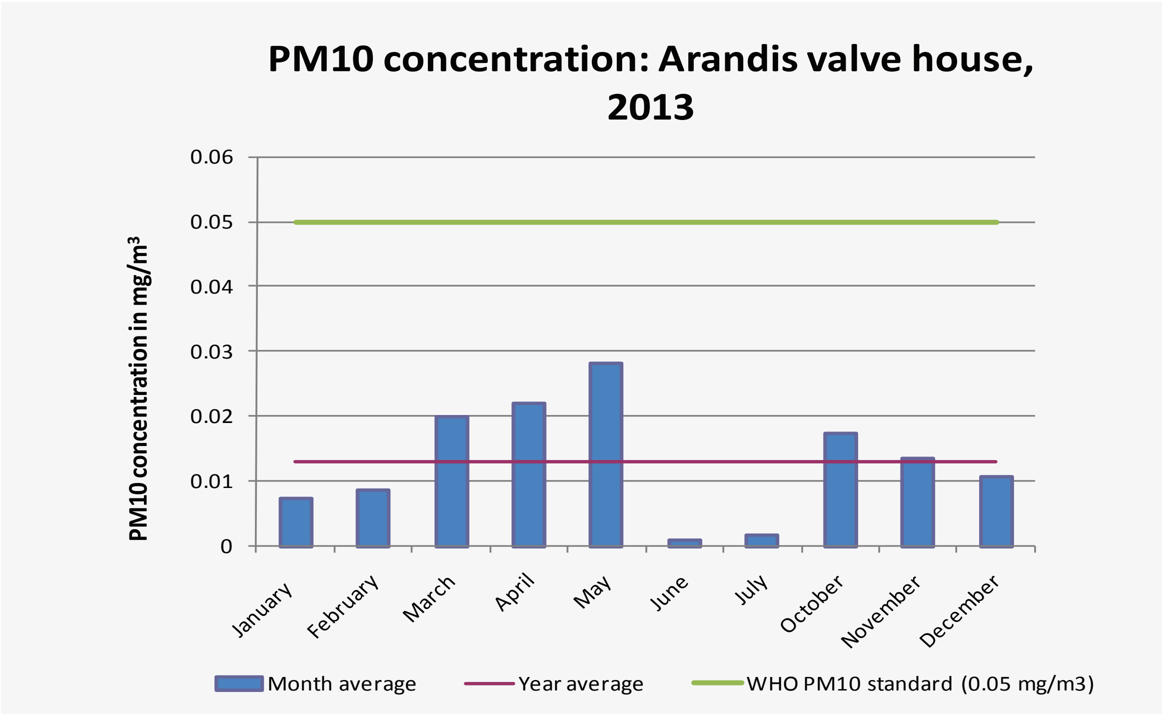

Figure 4: PM10 concentration at Arandis, 2013

At the south-western boundary of the site, PM10 concentrations were of a similar magnitude to those at Arandis, with roughly the same grade of uranium concentration in the dust (7 ppm). The resulting trends are summarised in Figure 5. The computed dose based on the maximum monthly average of PM10 was 36 μSv per annum, and was found to be 22 μSv per annum based on the average over all months in 2013 for which data were available. Note again that the former is a worst case dose estimate, as it contains all sources of dust inhalation, including natural background.

It is noteworthy that although the location of the PM10 monitoring station at the south-western mine boundary is directly downwind of the Tailings Storage Facility, the average dust concentration and worst case dose calculation were very similar to those for the town of Arandis, which is not in line with the prevailing wind direction. Again, because the maximum possible dose is significantly below the public dose limit, a more accurate calculation is not regarded as being necessary.

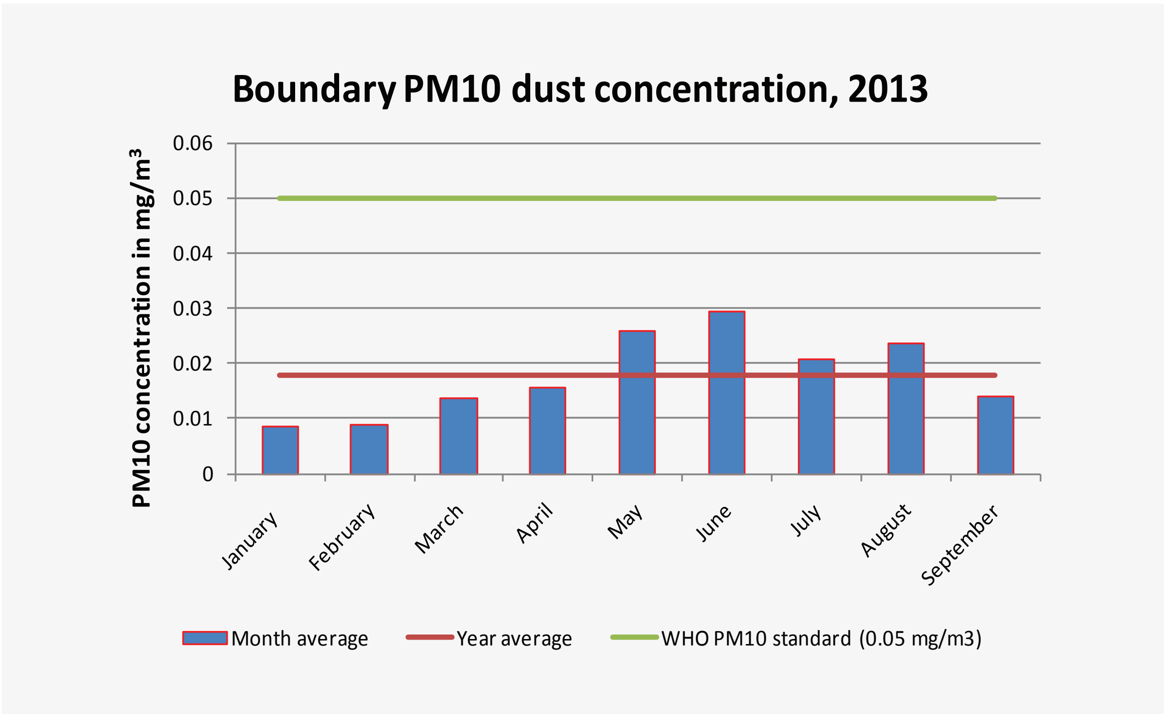

Figure 5: PM10 concentrations at the south-western mine boundary, 2013

5.4. Radon survey

In 2013, a three-year survey of radon concentrations at the mine site and adjacent background areas was completed. This survey was intended as a comparison with an earlier survey that was performed in 1987/88. [9]

In the 2013 survey, an area of 16 km by 16 km covering the mine site and surrounding background was selected. Grid points roughly 1 km apart were chosen at which radon monitoring cups from the radiation detection company PARC RGM were placed for periods of between three and six months. A total of five monitoring periods were completed. Of the roughly 100 monitoring points that were originally established in 1987, most were also used in the recent survey, as were a few indoor areas.

Survey sites were grouped into separate areas with different geographical locations and geological characters:

- The Arandis area: a flat area bordering the town of Arandis
- The dome area: the area in and around the geographical feature known as the 'dome'
- The area east of the 'dome'
- The Khan River area: all locations in the Khan River
- The Tailings Storage Facility (TSF) area
- The operations area, in which all buildings and the Processing Plant are located, and
- The open pit and waste rock dump area.

The detailed report[10] has already been submitted to the NRPA, but the findings are summarised in Table 2 for quick reference.

A three-dimensional representation of the measured radon concentrations is displayed in Figure 6, demonstrating the finding that the main impact on environmental radon concentrations was found in the area of the pit and the waste dump, and the TSF area.

The following was observed:

- The highest average outdoor concentration recorded at any location was 261 Bq/m^3, in the TSF
- The lowest average outdoor baseline concentration recorded at any location was 37 Bq/m^3, in the plains between Arandis and the mine
- The lowest individually recorded concentration in any term was 8 Bq/m^3, at a point to the west of the TSF, and
- The highest indoor concentration recorded in any term was 1,994 Bq/m^3, in the unventilated back room of the X-ray lab in the clinic building.

The representative values found in this survey will serve as input for future dose assessments and radon exhalation models.

Some rooms of the medical clinic, in particular those that are unventilated such as the X-ray room and sound room[11], were found to have average radon concentrations exceeding the 600 Bq/m^3 recommended as action level for work places. For this reason, the building was evacuated and the clinic relocated to premises in Arandis.

Table 2: Average radon concentrations measured during radon survey, 2011-2013

Area	Lowest average value (Bq/m^3)	Maximum average value (Bq/m^3)	Area average value (Bq/m^3)
Arandis (baseline)	26	71	54
East of the 'dome' (baseline)	53	96	66
Dome area (baseline)	48	113	68
Khan River (baseline)	46	68	57
Open pit and waste dump areas	113	213	159
Operations area	60	123	100
TSF area	96	261	178
Medical clinic (indoors)	318 (in ventilated offices)	1,381 (in unventilated treatment rooms)	n/a
Radiation Safety Laboratory (indoors)	n/a	n/a	336 (obtained over two measuring terms only)

[9] A. Grundling, A.H. Leuschner and A. Steyn: *An investigation of Rn-222 concentration at Rössing Uranium Limited. A report for the period October 1997 to September 1988.* Atomic Energy Corporation of South Africa, November 1988.
[10] G.U. von Oertzen and R. Schneeweiss: Baseline and Mining Related Radon Concentrations in the Rössing Mining Area, RUL, 2013.
[11] The sound room is a room used for performing audiograms and is hence windowless.

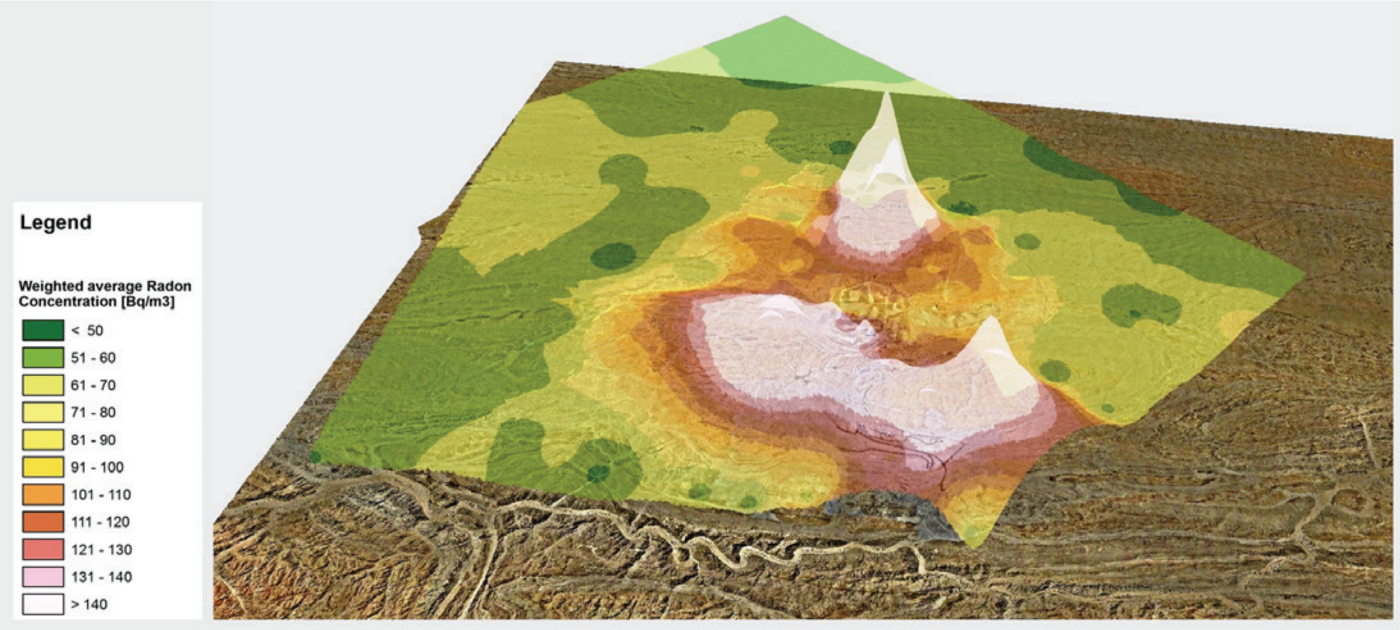

Figure 6: Three dimensional representation of radon concentrations at Rössing Uranium.

6. Safety and security of sources

6.1. Sealed source register

Two new sealed sources were purchased in 2013, bringing the total number of sources on site to 14.

One of the new sources has been installed in operation, while the second source is still awaiting installation and is kept in the Radiation Source Bunker.

A total of nine sources are kept in this bunker, two of which are now redundant and awaiting removal.

Sources on site are summarised in Table 3. The radionuclide of all sources is Cs-137 (a beta/gamma emitter), and the activity is given as on 14th February 2014.

Table 3: List of sealed sources at Rössing Uranium (radionuclide of all sources is Cs-137)

Name of manufacturer/ supplier	Serial number	Activity (GBq)	Location	Use	Comment
NTP Radio-isotopes	2725 GN	43.56	No. 1 Rock Box PC	Level	In operation – new source
	004/12	36.24	No. 2 Rock Box PC	Level	In operation
	2770	15.03	Lube Room PC	Level	In operation
	005/12	34.62	Lube Room PC	Level	In operation
	70682	0.17	Drum filling	Level	In operation
	2771	15.03	Radiation Source Bunker	Level	Redundant
	PA 304	0.30	Radiation Source Bunker	Density	Not in use
	PA 299	0.30	Radiation Source Bunker	Density	Not in use
	PA 301	0.30	Radiation Source Bunker	Density	Not in use
	PA 302	0.30	Radiation Source Bunker	Density	Not in use
	PA 298	0.30	Radiation Source Bunker	Density	Not in use
	PA 297	0.31	Radiation Source Bunker	Density	Not in use
	2772	15.03	Radiation Source Bunker	Level	Redundant
	4084 GN	43.39	Radiation Source Bunker	Level	New source

In addition to the sealed sources above, there are two calibration sources that are kept in the Radiation Safety Laboratory in a locked safe (see Table 4).

Table 4: List of calibration sources at Rössing Uranium

Nuclide	Type of source	Half-life (years)	Initial activity (kBq)	Date of manufacture	Time elapsed (years)
Cs-137	Beta	30	3	2011/12/13	2
Th-230	Alpha	75380	1	2011/12/16	2

6.2. Sealed source checks

Integrity checks of sealed sources in operation are performed monthly. Sealed sources in storage in the bunker are checked at six-monthly intervals only as there is no activity at the bunker.

6.3. X-ray generating equipment

The chemical laboratory makes use of two analytical x-ray units, as per its registration and licence, which expires in 2015.

7. Transport of radioactive material

7.1. Transport and export of uranium oxide concentrate

Thirteen shipments of uranium oxide were exported from Walvis Bay in 2013. The consignments are summarised in Table 5.

A total of 2,710,820.4 kg of uranium oxide concentrate (UOC) were exported, containing a total of 2,298,775.7 kg of natural uranium.

Table 5: List of UOC shipments from Rössing Uranium in 2013

Date of consignment	Country of final destination	Total weight of UOC in shipment (kg)
5 February 2013	France	87,182.319
13 February 2013	Canada	170,164.646
17 March 2013	France	72,214.984
8 April 2013	France	24,9314.306
23 April 2013	China	393,121.359
19 May 2013	US	248,890.401
19 September 2013	US	217,042.533
21 September 2013	China	303,317.978
21 October 2013	France	205,252.310
21 October 2013	Canada	106,852.438
16 November 2013	China	297,286.232
21 December 2013	France	252,746.423
21 December 2013	France	107,434.500

7.2. Transport of other source material

Ore and processing samples are sent to external laboratories for processing from time to time. Rössing Uranium holds separate annual authorisations for this purpose:

- Annual authorisation *TRM 113/13/02/T* for transports to Australian laboratories.
- Annual authorisation T*RM 113/13/01/T* for transports to South African laboratories.
- Annual authorisation *TRM 113/13/03/T* for transports to Swakopmund laboratories.

The sample transports undertaken under these authorisations are summarised in Table 6.

Table 6: Sample transports from Rössing Uranium to external laboratories in 2013

Date 2013	Weight of material	Material transported	Desti-nation	Purpose of consignment	Maximum activity
4 February	16 kg	Ore sample (10 kg), processing sample (sands, 3 kg), processing sample (slimes, 3 kg)	RTI, Australia	Metallurgical studies	60 kBq
5 February	12 kg	Ore samples (22 bottles), processing samples (6 bottles)	Set Point Labs, South Africa	Metallurgical studies	300 kBq
14 February	9 kg	Processing (liquor) samples	RTI, Australia	In vitro studies	10 kBq
2 April	18 kg	Liquor samples	RTI, Australia	In vitro studies	10 kBq
21 August	150 kg	Ore sample	RTI, Australia	Geochemical studies	400 MBq
31 October	8.3 kg	Ore samples	Set Point Labs, South Africa	In vitro studies	3 MBq
4 December	12.7 kg	Recycled Seepage (Liquor) samples	AQUA/VEOLIA Water, Windhoek	Quality comparison	5 kBq
12 December	9 kg	Ore sample (3 kg), processing sample (sands, 3 kg), processing sample (slimes, 3 kg)	RTI, Australia	Metallurgical studies	40 kBq

7.3. Radiation exposure of workers during transport

As described in the RMP, Rössing Uranium's UOC is transported by rail. As has been confirmed with individual dose monitoring via electronic dosimeter, the exposure dose to transport workers as a result of activities related to transporting UOC from the mine site to the port of Walvis Bay is negligible.

Those workers who accompany the transports to the port and supervise the handling of containers onto ships are designated 'radiation workers'. As such, their exposure to penetrating radiation is monitored continuously via TLD devices and additional monitoring is therefore not regarded as being necessary.

8. Emergency response and preparedness

Emergency response drills at Rössing Uranium are performed on a rotating basis, with a uranium spill or sealed source emergency drill among the other emergency response activities that are practised.

In 2013, there was no emergency response drill relating to radiation emergencies, as these do not take place annually. The emergency plans for uranium spills and sealed source emergencies were updated in February 2013 and the updated documents were attached to the revised RMP.

9. Disposal of radioactive waste

9.1. Disposal of redundant sealed sources

A total of 21 redundant sources were returned to South Africa in 2013 for disposal at the manufacturer. The list of returned sources is summarised in Table 7.

Table 7: Redundant sealed sources returned to supplier (South Africa)

Nuclide	Use	Serial number	Type of source	Half-life (years)	Initial activity (GBq)	Date purchased
Am-241	U-analyser	731	Alpha	432	1.70	78/06/01
Am-241	U-analyser	AMO 25	Alpha	432	1.70	78/07/01
Cs-137	Density	2581	Gamma	30	5.55	79/01/01
Cs-137	Density	0G27	Gamma	30	1.85	79/08/01
Cs-137	Density	0G97	Gamma	30	1.85	79/08/01
Ra-226	Calibration	94/570	Alpha	1601		unknown
Cs-137	Density	PC83	Gamma	30	0.74	83/06/01
Cs-137	Density	PC82	Gamma	30	0.74	83/06/01
Cs-137	Density	OG50	Gamma	30	3.70	84/04/01
Cs-137	Density	OG46	Gamma	30	3.70	84/05/01
Cs-137	Density	OG52	Gamma	30	3.70	84/05/01
Cs-137	Density	OG47	Gamma	30	3.70	84/05/01
Cs-137	Density	OG44	Gamma	30	3.70	84/05/01
Cs-137	Density	OG26	Gamma	30	3.70	84/05/01
Cs-137	Density	OG48	Gamma	30	3.70	84/05/01
Cs-137	Density	OG51	Gamma	30	3.70	84/05/01
Cs-137	Level	28263-8301724	Gamma	30	18.50	86/10/02
Am-241	U-analyser	QD9708	Alpha	432	1.70	95/03/01
Cd-109	U-analyser	EE956	Gamma	1.3	0.07	95/11/01
Cs-137	Density	PA 295	Gamma	30	0.394	05/07/01
Cs-137	Level	2773	Gamma	30	37.00	75/04/01

9.2. Disposal of contaminated waste

All discarded items that are contaminated with radioactive material are classified as 'contaminated waste' and are collected in white lugger bins and disposed of at the contaminated waste site (the TSF) once a week. Weights of disposed waste are recorded for each consignment.

In 2013, a total of 6,302 tonnes of contaminated waste were disposed of at the TSF. Contaminated waste is deposited in a trench and covered with tailings sand immediately after disposal to prevent the spread of contamination.

9.3. Mineral waste

The residues after ore processing (tailings), as well as the waste rock that it is not economic to process, are classified as 'mineral waste'.

In 2013, a total of 11,261,619 tonnes of tailings were deposited on the tailings dam (at the TSF), and a total of 25,332,432 tonnes of waste rock were disposed on the waste rock dumps surrounding the pit. This brings the cumulated amount of tailings deposited to date to 383,421,344 tonnes, and the cumulative amount of waste rock deposited to date to 729,081,689 tonnes.

10. Changes and revision status

First Issue	Issue date	Prepared by	
1.0	28 February 2014	G von Oertzen	
Version number	**Revision date**	**Revised by**	**Reason for change**
1.1	10 March 2014	G von Oertzen	Addition of Sections 1.3, 1.4, 2.3, 3.4, 5.1, 7.3 and 10, to provide more information.
1.2	30 August	G von Oertzen	Some additional text in aid of clarification of the report for public audiences. No information that was reported to the NRPA has been removed.

Please contact us for any feedback, comments, concerns or suggestions about this report. You can send us a text message to 081 616 3038 or e-mail to yourcontact@rossing.com.na.

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