Vaalputs National Radioactive Waste Disposal Facility

Public Information Document (PID)

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1 PURPOSE

The purpose of the Public Information Document (PID) is to provide members of the public with information regarding the application for authorisation to operate and manage the Vaalputs National Radioactive Waste Disposal Facility by the National Radioactive Waste Disposal Institute (NRWDI), which is legally enshrined by virtue of the National Radioactive Waste Disposal Institute Act (NRWDIA), (No. 53 of 2008) which became effective on the 1st December 2009.

2 INTRODUCTION

Most industries produce waste, some of which is radioactive. Radioactive waste is produced during the operational and decommissioning phases of facilities associated with the operation of nuclear reactors, production and use of radioactive materials in the fields of research, medicine, industry, agriculture, commerce, education and the extraction, processing and combustion of raw materials containing naturally occurring radioactive materials. More than 90% of the radioactive waste generated during these activities is classified as Low-level Waste (LLW), while the rest is made up of Intermediate Level Waste (ILW) and High-level Waste (HLW).

Due to the hazardous nature of radioactive waste, these wastes are disposed of in disposal facilities specifically designed to ensure that the waste is isolated from people and the environment until such time that the radioactivity has decayed to the extent that it poses no further hazard to people and the environment. Low-level Waste has been disposed at Vaalputs since November 1986. Results of environmental monitoring have shown that there has to date been no radiological impact on the environment or members of the public due to the waste disposal operations at Vaalputs.

The worker doses at Vaalputs are within regulatory limits. Radiation exposure of workers at Vaalputs are subject to control by the Operational Radiation Protection Programme. This programme ensures that control within the annual individual dose limit is achieved. In addition, the programme also serves to ensure that all doses are kept ALARA. Over the last 9 years, the maximum individual dose to radiation workers was 1.34 mSv/a, which is 14.9 times lower than the regulatory limit of 20 mSv/a.

Since commencement of its operations in 1986, Vaalputs was managed and operated by the South African Nuclear Energy Corporation (Necsa) under authorisation of Nuclear License 28 (NL28) which was replaced with Nuclear Installation License NIL-28 in December 2011.

The National Radioactive Waste Disposal Institute Act (NRWDIA), (No. 53 of 2008) was proclaimed by the President of the Republic of South Africa in Government Gazette no. 32764 and became effective on the 1st December 2009. The NRWDIA established NRWDI with the mandate to manage radioactive waste disposal on a national basis by executing the functions as per the Section 5 of the NRWDIA. NRWDI is listed as a Schedule 3A public entity in terms of the Public Finance Management Act (No. 1 of 1999) and is wholly owned by the State.

The NRWDI application to the NNR for management and operation of Vaalputs seeks to satisfy the provision of Section 5 of the NRWDIA and Section 8.2.2 of the Radioactive Waste Management Policy and Strategy.

2.1 History of compliance with the regulatory requirements

The Vaalputs repository has been in operation since 1986. All operations at the repository are performed in compliance with the requirements of the nuclear installation licence issued by the NNR in terms of the National Nuclear Regulator Act (Act No. 47 of 1999).

The safety performance of the repository system has been assessed by means of the Post-closure Radiological Safety Assessment and the safety information was consolidated in the Vaalputs safety assessment report. The assessment results showed that the radioactive waste disposal trenches provide safe isolation of the waste disposed of in the Vaalputs repository and that the long-term predicted radiation exposure to human beings and the environment are at levels considered to be acceptable as appraised against the applicable regulatory and international safety standards.

The international principle of ALARA (As Low As Reasonably Achievable) is applied to the repository operations, which would result in constantly striving for lower radiation exposure to personnel and the environment, all social and economic factors taken into account. Conventional operations comply with the requirements of the applicable regulations of the Occupational Health and Safety Act (No. 85 of 1993) as well as requirements of other applicable standards and regulations.

Annual audits on conventional safety, radiological safety, environmental surveillance, nuclear licence compliance and quality are conducted at the Vaalputs site. A comprehensive radiological environmental monitoring programme is implemented that covers a radius of 20 km from the disposal trenches. Monitoring results are reported to the NNR and compared to the pre-operational baseline environmental monitoring data. The annual monitoring results show that, since its inception, no environmental radiological impact could be detected as a result of the Vaalputs operations.

To accomplish the strategic goal of continuously improving, maintaining and further enhancing Vaalputs as a world class near surface disposal facility, concerted effort is applied in keeping abreast with international best practises in waste disposal operations. The Vaalputs nuclear and radiological safety as well as operational safety matters is communicated to local communities, surrounding farmers, local authorities and government bodies on a quarterly basis via the Vaalputs Public Safety Information Forum that was established in terms of the National Nuclear Regulator Act (No. 47 of 1999).

2.2 Similar Projects worldwide

There is vast experience in the disposal of Low-level waste globally. The disposal of Low-level waste in near-surface disposal trenches is a mature practice in a number of countries. This option implies that waste to be disposed contains short-lived radionuclides of low or medium specific activity with only very low amounts of long-lived radionuclides. The near surface disposal trenches are typically located above the groundwater table within a layer of low permeability material which has good retention characteristics for the radionuclides present in the waste. Protection of the environment is achieved through a combination of climatic characteristics, geological characteristics, waste conditioning, waste packaging requirements and the disposal site characteristics.

Examples of other countries that use near surface disposal facilities for low-level radioactive waste are:

- Spain which have been operating a near surface disposal facility for radioactive waste for since 1992;
- Czech Republic now operates three near surface waste disposal facilities, the first facility came into operation in 1964; and
- France operates two near surface disposal facilities, the disposal of radioactive waste into a near surface disposal facility started in 1969.

3 APPLICANT'S INFORMATION

Table 1: Applicant's information

The applicant's full name	National Radioactive Waste Disposal Institute
Physical Address	Elias Motsoaledi Street Extension (Church Street West) R104 Pelindaba Brits Magisterial District Madibeng Municipality North West Province 0240
Company registration number/incorporation number	N/A (NRWDI is a State Owned Entity (SOE) established by the National Radioactive Waste Disposal Institute Act (NRWDIA) (No 53 of 2008), which was proclaimed into operation on 1st December 2009 in Government Gazette No 32764)
Date of Incorporation	As per the NRWDI Act, No. 53 of 2008
Registered Address	Elias Motsoaledi Street Extension (Church Street West) R104 Pelindaba Brits Magisterial District Madibeng Municipality North West Province 0240 **Postal address:**

	Private Bag X1, Pretoria, 0001 Gauteng Province Republic of South Africa
The address of the facility	**Physical address:** Vaalputs National Radioactive Waste Disposal Facility Vaalputs farm (portion 1: Geelpan, portion 2: Garing) and Bokseputs (portion 1: Stofkloof) Kamiesberg Magisterial District Northern Cape Province **Postal address:** Private Bag X7 Springbok Northern Cape Province 0240
Details of any holding or subsidiary companies	Wholly owned by the State
Details of any foreign involvement or control of /nuclear installation by and foreign cooperation/government	None

4 PROJECT DESCRIPTION

The current disposal concept at Vaalputs uses near surface trenches up to 8 metres deep but above the groundwater table. The repository safety incorporates the Multiple Barrier System (MBS) approach and includes the Natural Barrier System (NBS) (i.e., the near field, geosphere and biosphere) and Engineered Barrier System (EBS) (i.e., the conditioned waste form, the waste container, the waste package and any other engineered enhancement).

The multiple barriers provide defence-in-depth assurance for preventing or controlling the release and subsequent migration of radionuclides from the waste to the biosphere, as to ensure (a) isolation of waste from the environment and (b) containment of radionuclides inside the disposal system.

Safety assessments, which incorporates the near field, geosphere and biosphere, have shown that the repository system:

- Provides a high level of operational and long-term safety.
- Demonstrates compliance with design standards.

- Ensures safety of current and future generations.
- Delays movement of radio nuclides toward the accessible environment.
- Can be safely closed once all operations have ceased, given that the necessary after care measures are taken within the institutional control period.

4.1 Process Overview

The disposal concept for LLW is near surface disposal consisting of trenches located in the region above the groundwater table as shown in Figure 1. Figure 2 shows that trenches are excavated in the surficial cover which is on average 30 m thick. The surficial cover generally consists of an overlying layer of topsoil (sand) approximately 0,5 m thick, a layer of indigenous calcrete 1 to 2 m thick and the clay material that extends down to the underlying granite layer. The sand, calcrete and clay material excavated from the trenches are kept separate in the stockpiling area and is later used to backfill and cap the trenches that have been filled with waste. Figure 3 shows how metal drums are placed in a disposal trench.

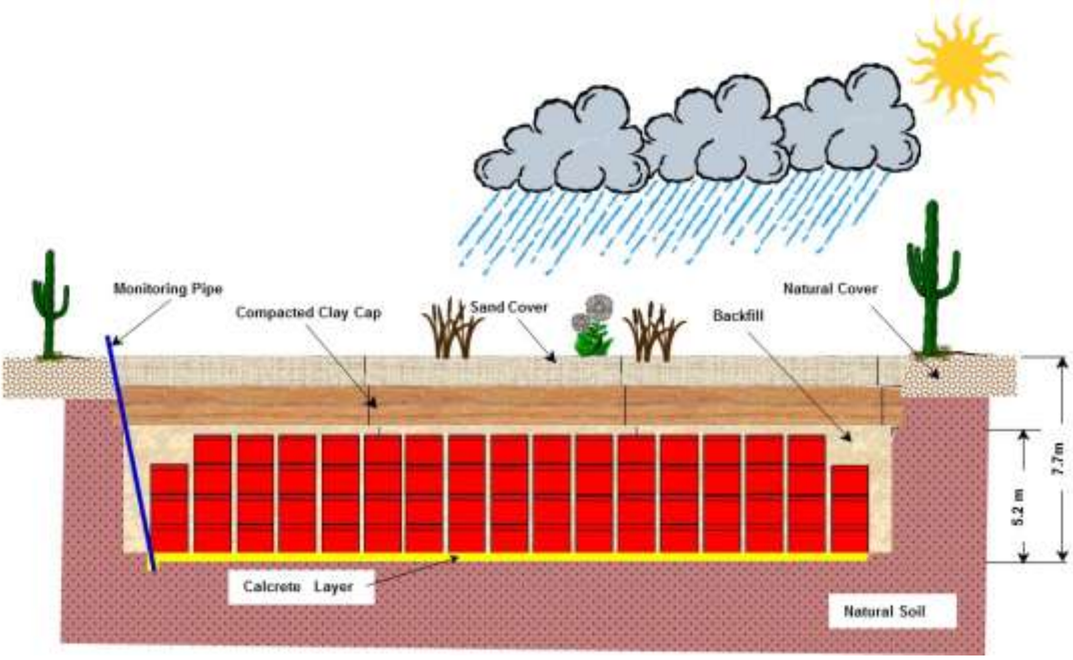

Figure 1: Graphical illustration of the Vaalputs near-surface disposal concept (not to scale)

Figure 2: LLW disposal trench at Vaalputs

Figure 3: LLW metal containers being emplaced in a disposal trench

4.2 Description of the process

The authorised activities for Vaalputs are:

- Receipt of Low-level Waste in approved waste packages.
- Temporary Storage of waste packages in the shielded storage area in the reception hall.
- Transfer of radioactive material and contaminated equipment to other facilities authorised to receive such material and equipment.
- Disposal of Low-level Waste packages in near surface trenches.

The waste disposal process is as follows:

- Waste generators that want to dispose radioactive waste at Vaalputs, must apply to the Chief Executive Officer of NRWDI for a disposal certificate in a prescribed format as stipulated in Section 23(1) of the NRWDIA. The Chief Executive Officer must assess the application for compliance with the radioactive waste acceptance and disposal criteria and may (subject to Board approval) either grant or refuse the application for a waste disposal certificate.
- For waste generators with an approved waste disposal certificate, pre-shipment inspections are done at the waste generator's site on a scheduled or ad-hoc basis.
- The required consignment documentation is forwarded to Vaalputs and compliance with the waste acceptance criteria is checked. The Vaalputs Manager verifies that the consignment documentation complies with the waste acceptance criteria before formally approving the waste shipments.
- The waste is despatched by the waste generator.
- On arrival at Vaalputs (see **Figure 4**), a receiving inspection is done to verify compliance with the waste acceptance criteria (see **Figure 5**).
- If the results of the verification tests show compliance with the waste acceptance criteria, the waste package consignment is transported to the appropriate trench for final disposal (see **Figure 6**)
- If the results of the tests are not complying with the waste acceptance criteria, a non-conformance is registered and the appropriate corrective action

implemented (e.g. returning non-conforming waste packages to the waste generator).

- Waste packages are stacked as close together as possible and back filled with material previously excavated from the trenches (see **Figure 7**).
- Waste packages are covered within one month (steel containers) or two months (concrete containers) after emplacement.
- Trenches are backfilled and capped using clay as soon as they are full (see **Figure 8**).
- Backfilling and capping operations are performed under radiation protection-supervision to assess and control radiation exposure to personnel.
- After a disposal trench had been backfilled and capped, it is rehabilitated (see Figure 9).

Figure 4: Arrival of Waste at Vaalputs

Figure 5: Receiving Inspection

Figure 6: Disposal into trench

Figure 7: Backfilling of waste packages

Figure 8: Capping of Disposal Trench

Figure 9: Rehabilitated Trench

4.3 Types of Radioactive Waste Disposed of

Vaalputs currently only receives solid or solidified Low-level Waste (LLW) from Koeberg Nuclear Power Station (KNPS) and the South African Nuclear Energy Corporation (Necsa). The KNPS waste consists essentially of compactable and non-compactable waste like redundant equipment, filters, ion-exchange resins, evaporator concentrate waste and contaminated paper gloves, plastic and coveralls in concrete and steel drums. The Necsa waste currently disposed of at Vaalputs consists of solidified Medium Active Concentrates (MAC) in steel drums and solidified NTP liquid waste in concrete drums. The current activity limits for Vaalputs are as described in the Vaalputs waste acceptance criteria and shown in Table 2 below. Any waste package that exceeds the indicated activity limits will not be approved for disposal.

Table 2: Activity limits

	NUCLIDE (/S)	ACTIVITY LIMITS
1	I-129 (site limit)	1.9 x 10^{11} Bq (1.9 x 10^{2} GBq)
2	Tc-99 (site limit)	1.18 x 10^{18} Bq (1.18 x 10^{9} GBq)
3	Long-lived alpha emitting nuclides	• ≤400 Bq/g average per consignment; • ≤4 000 Bq/g per waste package • Activity evenly distributed within the waste form.
4	Long-lived beta / gamma emitting nuclides	Factor 10 higher than (3) above
OR	Long-lived alpha, beta and gamma emitting nuclides in excess of activity limits as specified in 3 and 4 above.	Activity concentration levels that could result in inherent intrusion dose (the intrusion dose assuming the radioactive waste is spread on the surface) below 10 mSv per annum.
6	All other nuclides	The activity per waste package shall comply with the Low Specific Activity Material (LSA) or Surface Contaminated Object (SCO) transport limits as per the IAEA Safety Standards Series No. SSR-6, Regulations for the Safe Transport of Radioactive Material, IAEA, Vienna, 2012.

The total Vaalputs disposal inventory from Koeberg and Necsa for different types of waste packages is presented in the Table 3 below.

Table 3: Summary of the number of waste packages and total nuclide inventory for LLW received from KNPS and Necsa as at 31st December 2019.

Waste generator	**Waste package type**		**Total activity on 31 December 2019 (GBq)**
	Metal	**Concrete**	
Koeberg Nuclear Power Station	21 415	3 991	5.15 x 10^{04}
Necsa	6 154	420	1.75 x 10^{05}
TOTAL	**27569**	**8441**	**2.27 x 10^{05}**

4.4 Exposure to Radiation

An assessment on annual dose and mortality risk to the worker and member of the public during normal operations and accident conditions was conducted for the Vaalputs waste disposal facility. The dose from external radiation to members of the public during normal operations is zero, since the public is not allowed in the facility building and trenches when waste packages are received, inspected and disposed. The dose to workers from identified risks are outlined in the subsections below.

4.5 Normal Occupational Exposure (Planned exposure)

The nuclear authorisation for Vaalputs requires that all Vaalputs workers be subjected to a comprehensive medical surveillance program to ensure that they are, amongst other, fit to work in a radiation environment. Workers are continuously monitored for radiation dose through the use of Electronic Pocket Dosimetry (EPD) and thermo-luminescent dosimeters (TLDs). The regulatory dose limit for planned exposure for radiation workers is 20 mSv a year.

Workers are exposed to external radiation when carrying out the following activities:

- Conducting receiving inspections, quality checks, measuring dose rates, and taking smear samples to determine whether the containers conform to the Vaalputs WAC;
- Off-loading waste packages by crane at the trench; and
- When backfilling and capping trenches filled with waste packages.

Dose rate measurements on concrete and steel waste packages are recorded in the shipment data packs and the RPO survey data sheets. The dose rates from the waste packages are used in the dose calculations. The activity that gives higher radiation exposure to workers is capping of waste packages in the trenches with a calculated annual dose of 17.38 mSv/a which is still below the regulatory dose limit of 20 mSv/a.

The worker doses at Vaalputs are within regulatory limits. Radiation exposure of workers at Vaalputs are subject to control by the Operational Radiation Protection Programme. This programme ensures that control within the annual individual dose limit is achieved. In addition, the programme also serves to ensure that all doses are kept ALARA. Over the last 9 years, the maximum individual dose to radiation workers was 1.34 mSv/a, which is 14.9 times lower than the regulatory limit of 20 mSv/a.

4.6 Risk Analysis from Emergency exposure situations

Scenarios that may cause releases from the waste packages that are emplaced in the trenches have been identified, namely that waste packages may be dropped and rupture during crane lifting, and radioactivity released that may cause some risks to the workers.

For the worst-case scenario (i.e., two Necsa concrete waste packages drop due to a failure of lifting or rigging equipment and hit another two waste packages already emplaced in the trench) a total dose of 3.28 $x10^{-05}$mSv/a and a total mortality risk of 1.31 $x10^{-09}$ fatalities/a for workers was calculated. The exposure that would be received by a member of the public located at 1 km was calculated to be 3.20 $x10^{-05}$ mSv/a with a corresponding mortality risk of 7.51 $x10^{-14}$ fatalities/a.

The maximum annual mortality risk limit for an individual worker is set at 5×10^{-6} fatalities per year per site while the average annual risk limit for workers is 1×10^{-5} fatalities per year per site. The mortality risk limit for members of the public is set at 5×10^{-5} fatalities per year for an individual and an average of 1×10^{-8} fatalities per year per site for a population. The dose limits are set at 20 mSv per year for workers and 1 mSv per year for members of the public.

For the worst-case scenario described above, the potential exposure risk in terms of mortalities as well as in terms of radiation exposure to workers and members of the public, were well within regulatory limits.

5 PROPOSED DEVELOPMENT STAGES AND ESTIMATED TIMESCALES

Table 4 summarises the site development phases for Vaalputs. Given the current nuclear scenario in South Africa the operational lifetime of Vaalputs is estimated to be sixty years after which the site will be closed as it moves into an estimated three hundred years institutional control period. Any change in the current South African nuclear scenario or plant lifetime extension of existing nuclear power plants will necessarily imply that the site development phases for Vaalputs would need to be reviewed and adapted accordingly.

Table 4: Site development phases

DATE	TIME PERIOD (years)	SITE DEVELOPMENT PHASE	MILESTONES
1983 to 1986	3	Pre-operational Period	• Site selection • Disposal concept design • Safety report • Regulatory authorisation • Repository construction
1986 to 2046	60	Operational period	• Facility commissioning • Nuclear installation license • Waste disposal operations • Monitoring and surveillance • Post-closure safety assessment • Safety Assessment Report • Closure plan
2046 to 2050	4	Closure	• Final radiological survey • Detailed Safety Assessment • Site closure • Detailed decommissioning plan. • Decommissioning (Phases 1 and 2)
2050 to 2150	100	Institutional control period	Active control (e.g., post-closure monitoring, surveillance, corrective action)
2150 to 2350	200		• Passive control (e.g., land use control, markers, records) • Decommissioning (Phase 3) • Final safety assessment
Release of land			
2351 onwards		None	No controls over site (release of land from regulatory control)

6 SITE DESCRIPTION

Vaalputs is located in the District of Namaqualand, 110 km south east of Springbok in the Northern Cape Province and is 450 km from the KNPS, about 1400 km from Pelindaba. The Vaalputs facility is situated on adjoining portions of the farms Vaalputs (Portion 1, Geelpan and Portion 2, Garing) and Bokseputs (Portion 1, Stofkloof) as shown in Figure 10. The site is about 10 000 hectares in extent, of which the area currently set aside for waste disposal occupies approximately 350 hectares on the portion Geelpan surrounded by a 200 m exclusion zone.

VAALPUTS FACILITY LOCATION MAP

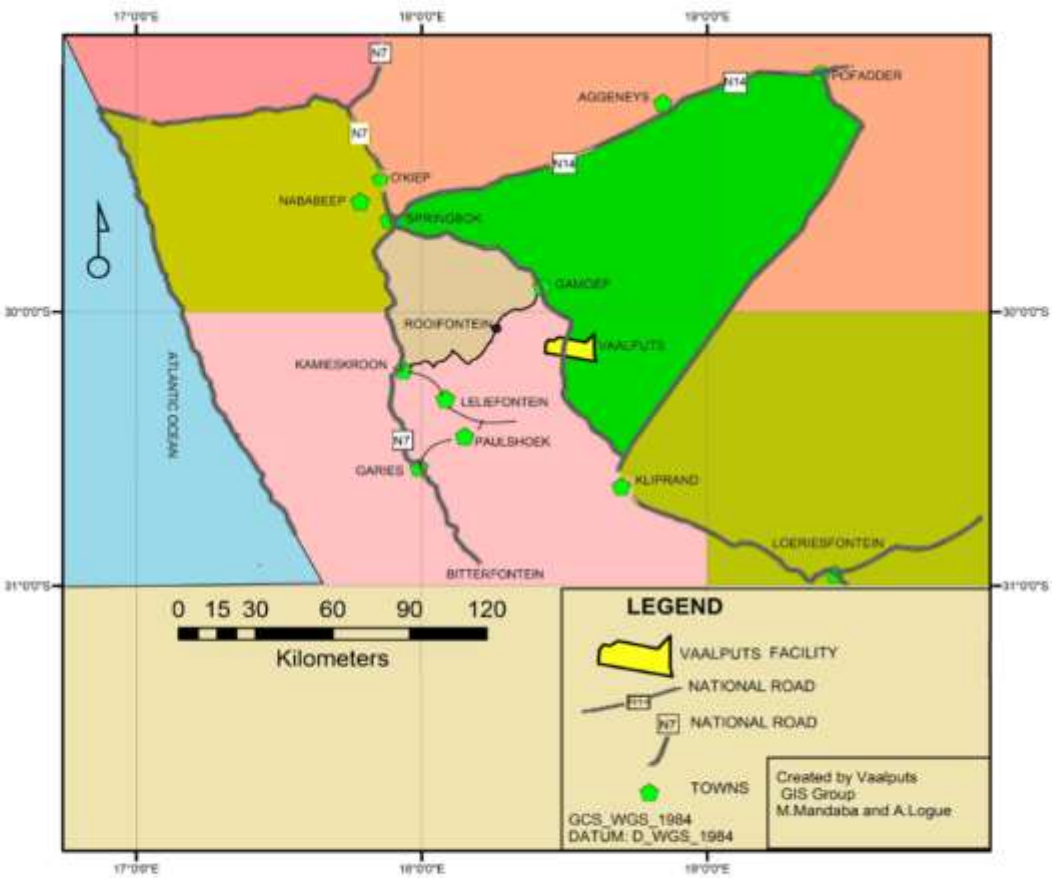

Figure 10: Vaalputs in relation to neighbouring towns and settlements

The currently authorised disposal area is situated inside a securely fenced area on the Vaalputs site as indicated in **Figure 11**. The dimensions of this securely fenced area are 900m x 1100m.

Within the securely fenced area is the currently authorised disposal area with dimensions of 700m x 500m.

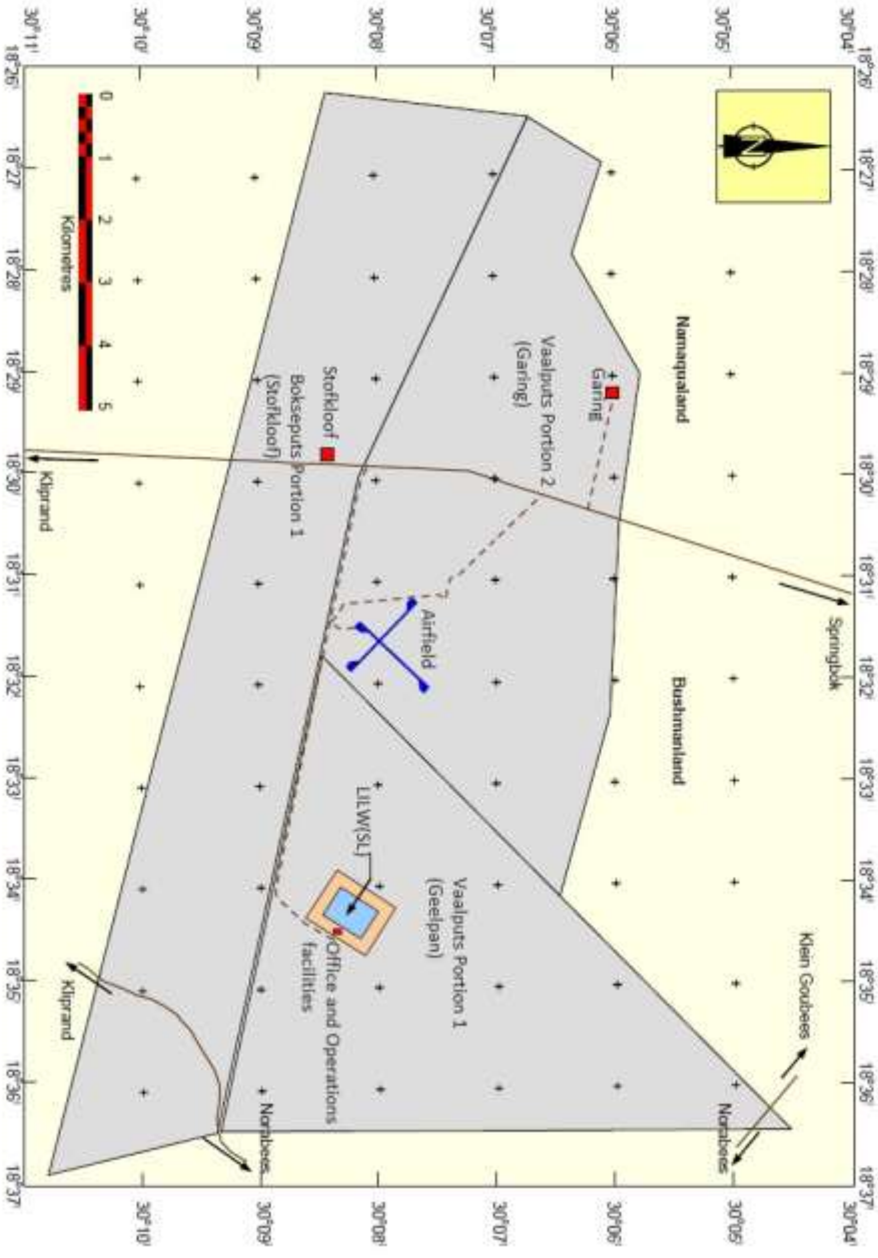

Figure 11: Site boundaries of the Vaalputs National Radioactive Waste Disposal Facility

The disposal area is surrounded by a 200 meters exclusion zone on all sides.

Included in the exclusion zone is a building which has an administrative area and an operational area.

- The administrative area of said building contains offices, storage facilities, an instrument room, etc.
- The operational area contains a radioactive waste transport vehicle reception area, a transfer area, shielded temporary storage area, a controlled radiological operations area, a decontamination area, a ventilation system for the building and a mechanical workshop.

6.2 Site Justification

In 1978 a programme was launched to select a suitable site for the disposal of radioactive waste in South Africa based on international site selection criteria. Three potential sites were selected: the central portion of the Richtersveld, the Kalahari, roughly north of Upington, and an area in Namaqualand/ Bushmanland. The following international site selection factors were, inter-alia, considered:

- Low population density;
- Sparse agricultural activities - the main agricultural activity around Vaalputs is sheep farming;
- Low potential for economic mineral exploitation;
- The disposal area in the Vaalputs Site is locally elevated above the surrounding area, reducing flooding potential;
- Low seismic activities in and around the Vaalputs area;
- Long-term geological and geomorphological stability; and
- Low rain fall and high evaporation rate.

The Vaalputs property straddles the transition between summer and winter rainfall areas in South Africa which results in semi-arid to arid climate in which evaporation far exceeds precipitation. Topography around the disposal site shows little altitudinal variation not exceeding 43 m within the eastern part of the site (maximum altitude 1033 m, minimum altitude 990 m).

This region is characterised by ~130 mm rainfall and ~2800 mm potential evaporation annually. Over 33 years of monitoring have shown the extreme minimum and maximum yearly rainfall to be 30 mm and 305 mm respectively and there is no distinct seasonal peak due. Rainfall occurs primarily as winter showers and autumn thunderstorms however individual storms can produce up to 100 mm of rainfall.

The ambient temperatures range from -5°C to 43°C and 33 years monitoring indicate an extreme minimum of -4.7°C and maximum of 41.5°C. The mean annual temperature is 16.7°C and shows a clear seasonal variation between summer and winter (mean maximum: February, 33°C; mean minimum: July, 2.7°C). Frost can be expected on average 20 days per year.

6.3 Natural hazards

The selection of the Vaalputs site was carried out in accordance with internationally accepted site selection criteria which also considered natural hazards that could impact on the waste disposal operations. In terms of natural hazards, the site characterisation process considered the following:

6.3.1 Seismicity

Studies showed that the probability of an earthquake occurring similar to that at Ceres (Richter magnitude 6,32) is very low. Even if an earthquake of this magnitude would occur it is not expected to cause any radiological risk because it will have little effect on the disposed waste or on the facility buildings.

6.3.2 Surface erosion

Geological studies pointed towards the long-term geomorphological stability of the region. Surface erosion from wind or water is not a feature of the site and is therefore not expected to uncover waste packages within the facility lifetime.

6.3.3 Flooding

The site lies near a triple-junction of three water sheds and contains no active surface drainage. The site is therefore unlikely to flood and there is no possibility of radioactivity contaminating surface water courses and entering man's food chain by this pathway. Also, the low rainfall combined with the high evaporation rate results in very little surface recharge of the underground water.

6.3.4 Groundwater recharge

The age of the underground water was determined by carbon dating and ranged from 2 000 to 13 000 years. Generally, no water less than 50 years old has been found below the top 4 m of soil and the water contained in the underlying clay layer formations forms an almost static regime. All these factors and the properties of the groundwater system indicate that water movement is very slow and the possibility of water transport of any radioactivity away from the disposal trenches is also very low.

6.3.5 Ponding

Studies have shown that prolonged storms could result in some ponding in certain areas of the site due to local contour variations. It will be many years before it may be necessary to excavate trenches in the affected areas. However, the situation will be monitored going forward and any necessary action, such as constructing a storm water drainage system to divert potential runoff, will be taken timeously.

6.4 Human Induced Risks

The release of radioactivity that may have been caused by a human induced event was considered. In this regard, an aircraft crash scenario was assumed and analysed as summarised in Section 6.4.1 below.

6.4.1 Aircraft Crash

The risk to the worker and member of the public associated with an aircraft crash into the Vaalputs trenches was determined. This scenario postulates that a fully fuelled large commercial jetliner crashes directly into the facility with enough momentum to damage and release all radioactive material from one hundred concrete waste packages on the top layer. The resulting fire that develops and is sustained briefly, releases all radioactive material (from one hundred waste packages) into the atmosphere. The analysis was done for the worst-case scenario using concrete waste packages containing the highest total activity.

The dose received by the worker was calculated to be 2.8×10^{-3} Sv (at 100 m radius). The total dose rate to a worker was calculated to be 1.37×10^{-8} Sv/a and the corresponding mortality risk was calculated to be 5.47×10^{-13} fatalities/a.

The dose received by a member of the public was calculated to be 4.0×10^{-05} Sv (at 1km). The total dose rate to the member of the public was calculated to be $1.96X10^{-10}$ mSv/a and the corresponding mortality risk was calculated to be 9.78×10^{-12} fatalities/a.

For this scenario, the maximum annual mortality risk limit for an individual worker is set at 5×10^{-6} fatalities per year per site while the average annual risk limit for workers is 1×10^{-5} fatalities per year per site. The mortality risk limit for members of the public is set at 5×10^{-5} fatalities per year for an individual and an average of 1×10^{-8} fatalities per year per site for a population. The dose limits are set at 20 mSv per year for workers and 1 mSv per year for members of the public.

For the worst-case scenario described above, the potential exposure risk in terms of mortalities as well as in terms of radiation exposure to workers and members of the public, were well within regulatory limits.

6.5 Demography (population density and distribution)

The population densities and distances between the Vaalputs site and neighbouring towns and settlements, with their respective localities are summarised in Table 5 below.

Table 5: Population densities and distances between the Vaalputs site and neighbouring towns.

Town	Distance (km)	Population (Census 2011)
Okiep	95	6 306
Springbok	110	12 792
Nababeep	100	5 373
Kamieskroon	60	894
Garies	73	2 106
Rooifontein	25	330

Town	Distance (km)	Population (Census 2011)
Kamassies	25	342
Nourivier	40	459
Tweerivier	55	252
Leliefontein	45	618
Paulshoek	35	414
Kliprand	55	204
Bitterfontein	105	987

The potential of future development in the Vaalputs area is very limited due to the following:

- The rural areas around Vaalputs are sparsely populated. The population density in a radius of 20 km around Vaalputs varies due to about 35% of the community being migratory. Many farmers have more than one farm and they migrate between these farms according to the summer/winter seasonal rainfall.
- Apart from the development at Vaalputs there is no knowledge of other growth areas in the region. Due to the aridity of the area and low agricultural potential, the permanent population in a 20km radius around Vaalputs is not expected to increase substantially.
- The major agricultural activity around Vaalputs is sheep farming with about 66% of the area supporting sheep. Vaalputs is situated in a transition area between convectional showers during summer and autumn in the interior and sparse winter rainfall along the west coast. During dry seasons farmers move their sheep to greener pastures if they are able to do so. Dry weather conditions have resulted in some farmers deserting their farming activities altogether. Due to the area remaining essentially semi-arid, it is not expected that the agricultural activity practised will change over time.
- There has been a decline in industrial activities that support sustainable growth and development in the area.
- No economic mineral deposits of any type were found in the vicinity of the Vaalputs site during the site investigation and characterisation processes. It is

therefore unlikely that any economic developments in terms of mining and other industrial activities will be undertaken in the area.

6.6 Potential radiological impact on the public and the environment

The closest towns to Vaalputs are as listed in Table 8 with a combined population of about 31077. The population densities are in accordance with the 2011 national census. The chosen location of Vaalputs with its small growth potential and lack of economically exploitable mineral deposits make it a very unlikely candidate for future socio-economic development.

6.7 Exposure pathways

Safety analysis and results of environmental monitoring have shown that there are no exposure pathways beyond the Vaalputs site boundaries that would result in exposure of the environment or members of the public to radiation dose or mortality risk in excess of regulatory limits.

The long-term impact of the waste disposal activities was assessed in terms of the radioactivity migrating towards the groundwater, which is then assumed to be extracted by a member of the public (neighbouring farmer) and consumed as drinking water. For this scenario as illustrated in Figure 12 below, the dose to the most exposed individual (i.e., the neighbouring farmer) as a result of drinking this water would be less than the dose constraint of 250 µSv/a for the groundwater pathway.

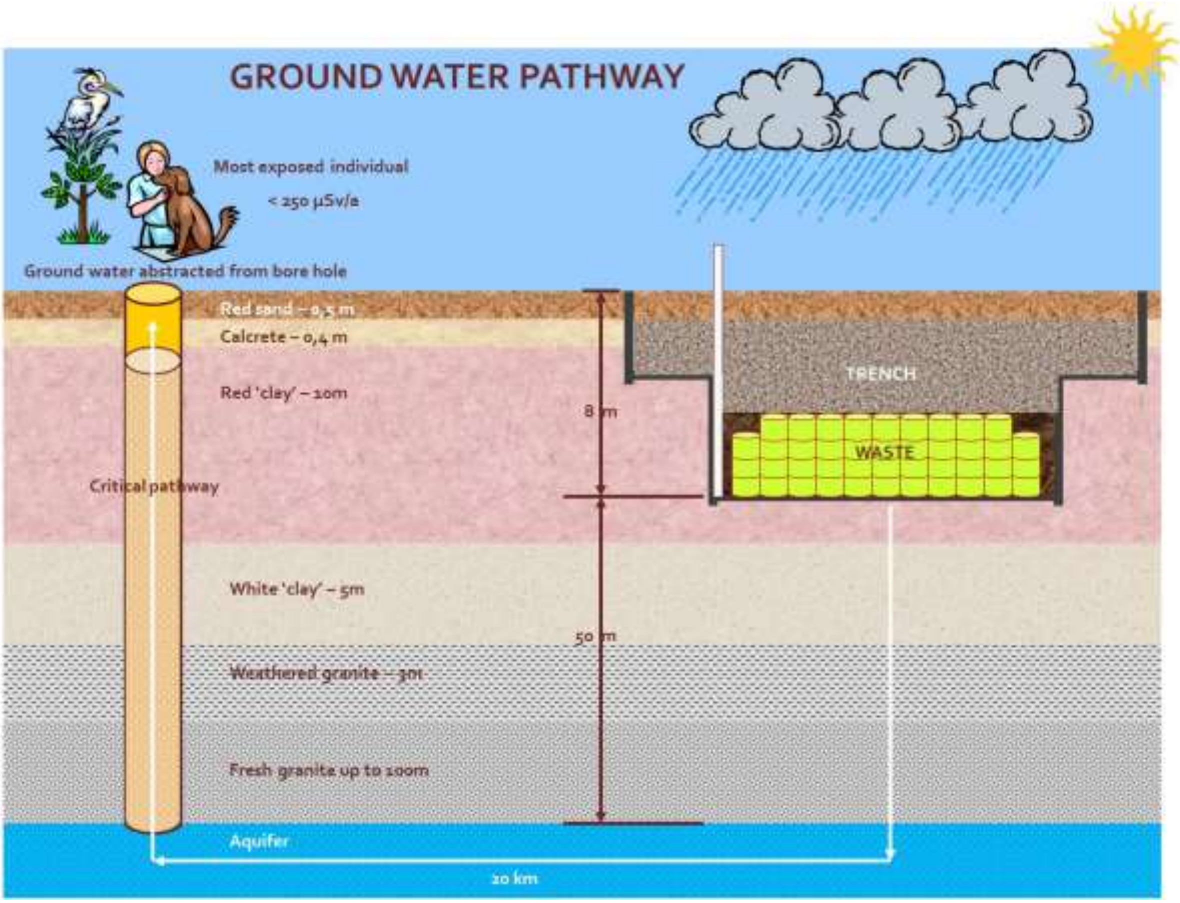

Figure 12: Graphical illustration of the groundwater pathway

7 SAFETY ASSESSMENT

7.1 Safety Analysis

A Hazard and Operability (HAZOP) study was conducted, whereby the following hazards were identified to be the worst-case scenarios and as such were assessed:

(a) Worker radiation exposure due to waste disposal activities.

(b) Worker radiation exposure when waste packages are off-loaded by crane at the trenches.

(c) Dropping of concrete waste package/s onto another concrete package/s during off-loading in the trenches due to failure of lifting equipment.

(d) Dropping of steel waste package/s onto another steel waste package/s during off-loading in the trenches due to failure of lifting equipment.

(e) Dropping of concrete waste package/s during off-loading in the waste treatment area due to failure of lifting equipment.

Vaalputs implements a radiation protection program to ensure that the workers are not being over exposed to radiation emanating from the waste packages. Compulsory statutory in-service inspections are performed on the lifting and rigging equipment to ensure that these are always maintained in a safe condition for operational use.

In addition to the hazards identified in the HAZOP, the annual dose and mortality risk to the worker and member of the public due to external threats to the facility such as an aircraft accident was also assessed as indicated in section 6.4.

An unmitigated release of radioactive nuclides from waste packages will not have consequences that exceed a dose of 20 mSv for a worker, or 1 mSv for a member of the public, thus the facility is classified as a hazard level zero nuclear facility.

7.2 Management system

Integrated Management System (IMS) - Vaalputs has an integrated management system comprising of nuclear and conventional safety, health, environment and quality management systems in order to show compliance with statutory and regulatory requirements governing the site.

The IMS for Vaalputs has been developed in accordance with the requirements of ISO 9001:2015, the EMS is in accordance with ISO 14001:2015 and the Occupational Health and Safety is in accordance with ISO 45001:2018. Vaalputs is currently certified to the quality management standard (ISO 9001: 2015). All operations and activities are therefore controlled in accordance with the Vaalputs quality management system. A legal register listing the applicable legal safety and environmental related requirements has been established and the environmental aspects are linked to these requirements.

Vaalputs as a nuclear facility implements the requirements and conditions of the Nuclear Installation License as authorised by the National Nuclear Regulator.

The Technical Officers and Radiation Protection Officers have independent authorities to stop-start at Vaalputs any activities where violation of the IMS requirements, Nuclear Installation License, Occupational Health and Safety Act, all relevant environmental legislation or Behavioural Based Safety occurs.

The QMS of nuclear facilities supplying waste to Vaalputs is audited on a regular basis to confirm compliance with the Vaalputs waste acceptance criteria. Non-Conformance Reports (NCRs) pertaining to deviations from the waste acceptance criteria are forwarded to waste generators to follow-up on or participate in corrective and close-out actions.

Responsibilities and authorities of Vaalputs personnel performing work affecting quality are documented within the procedures, works instructions, job profiles and descriptions that apply to the functions they perform.

Documented information is managed and maintained in accordance with the ISO 9001:2015 standard. The identity, location and inventory of the waste is appropriately recorded and maintained in view of the long time frames involved in the disposal of radioactive waste.

Design and development at Vaalputs include the design of new disposal trenches and development of new disposal concepts.

No components, plant items, equipment, etc. are manufactured at Vaalputs. Should these be required they are purchased from external providers according to an approved suppliers list.

External audits are performed on a regular basis. These include corporate audits in SHEQ, NNR audits of the nuclear installation license and other third-party audits, e.g., certification body.

The effectiveness of the IMS is continuously assessed and improved through the use of the IMS policy, IMS objectives, audit results, inspections, analysis of data, corrective and preventive action and management review meetings.

7.3 Safety Management Systems

This section outlines the operational programmes that are in place at Vaalputs to ensure compliance with the regulatory requirements on nuclear safety.

7.3.1 Operational support Programme

Radiation Protection Programme - Vaalputs has a radiation protection program in place to control the work environment to such an extent that the health risks associated with radiation are kept as low as reasonably achievable.

Medical surveillance Programme– All Vaalputs personnel undergo an extensive medical assessment prior to being employed. This is to ensure that they are fit to work as radiation workers. It is also the NNR requirement that periodic medical assessments be carried out at defined intervals. These intervals are defined within the medical surveillance programme for Vaalputs.

Personal and Equipment Protection - Various processes are in place to protect individuals from harmful effects of exposure to hazards; including processes for the proper care, inspection and maintenance of safety structures and components to prevent events of failure and consequential exposure of individuals to uncontrolled release of energy, physical hazards and release of hazardous substances accompanying such failures. These are addressed in the SHEQ system documents.

Radiation Safety - Radiological control is exercised in accordance with the policy, procedures and requirements for Vaalputs. These include radiological control programmes for monitoring personnel, facilities, equipment and the environment, according to the requirements in the applicable SHEQ documents.

The Radiation Protection Officer conducts environmental radiation and contamination surveys on a routine basis within and around operational and non-operational trenches. Confirmatory air sampling in and around trenches is done on an ad-hoc basis. Ambient radiation dose rates using dosimeters are measured in the general trench areas.

Environmental Management Plan (EMP) - An EMP defining the environmental aspects, assessing the related impacts, listing objectives, targets and action plans to mitigate the significant impacts has been developed for Vaalputs and is implemented.

Safety Assessments - The safety arguments and evidence in support of disposal operations undertaken by Vaalputs is documented in the Vaalputs Safety Assessment Report.

Radiological Survey Program - A dedicated operational radiological environmental surveillance program has been compiled and is implemented for the Vaalputs facility. The environmental samples are collected and analysed.

The RPO ensures that radiological hazards at Vaalputs are identified, measured, assessed and controlled in accordance with the radiation protection programme requirements.

Wastes (solid, gaseous and liquid) are monitored to ensure that discharges to the environment are controlled within the limits specified by regulators. Vaalputs monitors soil, vegetation, airborne contamination, ground water, ambient radiation, naturally occurring radioactivity in the environment, various weather-related parameters, etc., to obtain a comprehensive trail of environmental conditions. Monitoring results as per the requirements of permits and licenses are reported to the relevant regulatory authorities. Environmental sampling and monitoring are conducted as per applicable procedure.

Incident Investigation - Incidents are recorded, investigated, analysed, corrected and closed-out according to written procedures.

Meteorological Programme –Vaalputs has an automated weather station on site to monitor the appropriate weather parameters on a continuous basis.

Safety related structures, systems and components (SSCs) - Technical safety requirements and administrative controls all form part of items relied on for safety that function to prevent potential operational and design base accidents or mitigate their potential consequences to within safety criteria. SSCs identified in the safety assessment sections for the Vaalputs disposal facility include ventilation system, effluent systems, waste handling & lifting equipment and utility systems.

Due cognisance is given to optimise waste container performance and lifetime integrity by implementing rigorous quality control and engineering principals in the design, manufacturing and testing of radioactive waste containers. For example, waste container design takes into consideration international requirements for the transport of radioactive material in the public domain. Such waste containers would therefore have to withstand the applicable requirements, e.g., dropping and stacking tests. The NNR further requires that they approve all waste containers and packages intended to be used for transport and disposal of radioactive waste.

The waste container design and manufacture, waste nuclide measurement process, waste conditioning and waste container filling and handling processes implemented by waste generators shall be qualified in order to ensure that the processes meet all specifications and that the waste packages will perform as required in the disposal system.

The safety limitation on disposal trench design is specified in the engineering design of trenches. The Operating Technical Specification for disposal trench design includes the following amongst others:

- Actions and acceptance criteria – inspection and measurement of the relevant trench dimensions and compared to appropriate acceptance criteria,
- Quality check records in contractor's health and safety file in Vaalputs Records

The limiting conditions for operations – the limiting condition for the Vaalputs operations are documented in the Operating Technical Specification (OTS) in order to ensure the safe operation during normal and shut down conditions of the Vaalputs National Radioactive Waste Disposal Facility. The OTS prescribes the surveillance and maintenance required for ensuring compliance with the safety limits and limiting safety system settings, as well as the limitations on operations should a non-conformance be discovered.

The Vaalputs In-service Inspection and Maintenance process - is part of the inspection and preventive maintenance program consisting of planned periodic inspections, tests and examinations of systems, equipment and mechanical components whose failure or degradation could impact on the safety of the facility.

Emergency Plan – Vaalputs has an emergency plan approved by the Regulator. The plan describes in detail the procedure to follow in case of an emergency and roles and responsibilities of personnel and stakeholders are clearly outlined in this document.

7.3.2 Compliance with Safety Standards

The Nuclear industry in South Africa is governed by the Nuclear Energy Act (Act No.46 of 1999) (NEA), the National Nuclear Regulator Act (Act No. 47 of 1999) and the National Radioactive Waste Disposal Institute Act (Act No. 53 of 2008).

The governance and regulation of radioactive waste management is also subject to the provisions of the following additional acts:

- Hazardous Substances Act (Act No. 15 of 1973);
- Minerals and Petroleum Resources Development Act (Act No. 28 of 2002);
- Mine Health and Safety Act (Act No. 29 of 1996);
- National Water Act, 1998 (Act No. 36 of 1998);
- Water Services Act (Act No. 108 of 1997);
- Environment Conservation Act (Act No. 73 of 1989);
- Environment Conservation Amendment Act (Act No. 50 of 2003);
- National Environmental Management Act (Act No. 107 of 1998);
- National Environmental Management: Integrated Coastal Management Act (Act No. 24 of 2008); and
- The Dumping and Sea Control Act (Act No.73 of 1980).

7.3.3 NNR Regulations and Requirements

The following regulatory documents are applicable to Vaalputs:

- R388 (2008). Regulations on Safety Standards and Regulatory Practices.
- RD-0014. Emergency Preparedness and Response Requirements for Nuclear Installations.

- RD-0016. Requirements for Licensing Submissions Involving Computer Software and Evaluation Models for Safety Calculations.
- RD-0024. Requirements on Risk Assessment and Compliance with the Safety Criteria for Nuclear Installation.
- RD-0026. Decommissioning of Nuclear Facilities.
- RD-0034. Quality and Safety Management Requirements for Nuclear Installations.
- LD-1079. Requirements in Respect of Licence Change Request to the National Nuclear Regulator.
- RD-0038. Notification of Events at Facilities.

8 EMERGENCY PLANNING

The objective of emergency planning is to ensure that the Vaalputs National Radioactive Waste Disposal Facility is capable of implementing adequate measures to protect public health and safety in the event of a radiological emergency. The Emergency Plan is required by the regulator (NNR) as part of the conditions of the nuclear installation license.

The Emergency Plan and relevant procedures have been established, implemented and maintained to monitor and test, on a regular basis, the emergency preparedness and response.

8.1 Radiological emergency preparedness and response plan

This plan is concerned with the development and preparation of emergency plans to mitigate the consequences in the event of a radiological accident. Radiological emergency preparedness include the training of all persons who will be involved in implementing the emergency plans, the acquisition of resources and facilities and the testing of emergency plans and procedures by means of drills and exercises to ensure effective response in the event of a radiological emergency.

During a radiological emergency, specialist services as well as technical and scientific skills are utilised for radiological or chemical analyses, plume modelling for early predictions, media and public liaison, etc. Every member of the Vaalputs Waste

Disposal Facility is properly trained to perform specific roles and functions during an emergency situation. Periodic drills and exercises are carried out to test the effectiveness of the emergency planning and response.

8.2 Protective mechanisms and countermeasures

The emergency procedures for Vaalputs are in place to ensure adequate protective actions to protect the health and safety of workers, the public and the environment.

All facilities and equipment are maintained in a state of readiness to counter any emergency. Emergency facilities and equipment include the emergency control centre, communication equipment, smoke detectors, fire warning alarm system, alert and evacuation alarm system, fire station and firefighting equipment, water supply system, personal protective equipment and radiological monitoring apparatus. The emergency control organisation at Vaalputs includes a firefighting team that is trained on a regular basis.

8.3 Classification of nuclear emergencies

There are progressive stages of response to a nuclear emergency plan, depending on the seriousness of the potential consequences of an accident. These are;

Unusual Event - An abnormal occurrence that indicates an unplanned deviation from normal operations, the actual or potential consequences of which require notification of the Emergency Controller and activation of the appropriate components of the Emergency Plan.

Alert - A situation exists that could develop into a site or general emergency and therefore requires notification of all emergency personnel in order to obtain a state of readiness to respond.

Site Emergency - An emergency condition exists that poses a serious radiological hazard on site but poses no serious radiological hazard beyond the public exclusion boundary.

General Emergency - An emergency condition exists that poses, or potentially poses, a serious radiological hazard beyond the public exclusion boundary.

A nuclear emergency on the Vaalputs site will not extend beyond the site borders, i.e., it will not escalate beyond a Site Emergency as defined above.

8.4 Notification of an emergency

NNR - Emergency events shall be reported to the NNR as per NRWDI SHEQ-system requirements.

Public - Initiation of communication with local authorities and nearby residents will be done telephonically and is exclusively and procedurally via the Emergency Controller.

9 WASTE MANAGEMENT AND DECOMMISSIONING PLAN

Table 4 summarises the site management phases for Vaalputs assuming that the operational lifetime of Vaalputs is estimated to be sixty years after which the site will be closed. The institutional control period commences after repository closure and is assumed to be three hundred years for the Vaalputs near surface repository given the current operational constraints. The institutional control period would essentially comprise an active and a passive institutional control period.

The active institutional control period will commence after site closure and would last for up to 100 years (i.e., up to 2150). During this period there will still be controls on land use (site usage and occupancy). Having confirmed the passive safety of the site, the site would move into the passive institutional control period, which could last for up to 200 years past the active institutional control period, i.e., up to 2350, which is based on the current Koeberg lifetime.

9.1 Vaalputs closure

An assessment of the long-term safety of the site will be conducted at the end of the operational period to determine whether the remaining facilities and the environmental pathways should continue to be monitored after site closure, taking into account the total nuclide inventory as well as updated safety assumptions and conditions at the time. This safety assessment will form the basis according to which post-closure residual risks (engineering and environmental) will be managed in the institutional control period.

Other actions to be undertaken at site closure include:

- Final radiological survey of the site and buildings;
- Environmental monitoring and comparison of results with baseline measurements;
- Assembling and archiving records;
- Phases 1 and 2 decommissioning of buildings;
- Erecting adequate security fencing and/or intrusion barriers around the site perimeter and around the disposal area;
- Placing durable markers and monuments at strategically chosen locations to demarcate the repository and to acquaint possible intruders with the former use of the site for radioactive waste disposal;
- If required, construct storm water ditches to prevent rainwater from seeping towards the disposal trenches and thereby causing possible ponding conditions during heavy rainstorms; and
- Constructing a final cap over the disposal trenches, if required.

9.2 Decommissioning plan

Once waste disposal activities at Vaalputs have ceased the facility will be closed and decommissioned in a phased approach.

<u>Initial Decommissioning (Phases 1 and 2)</u>

During these decommissioning phases the waste reception area, maintenance workshop and utility buildings will be made passively safe to reduce post closure care and maintenance activities. The administration building including the laboratory area will be utilised to support residual work on the site such as environmental monitoring in the institutional control period and it is foreseen that these will be retained until the end of the active institutional control period.

Final Decommissioning (Phase 3)

Following the active institutional control period, it is assumed that there will no longer be a need for buildings that remained on the site. These facilities, being uncontrolled radiological areas, would contain no radioactivity. It is foreseen that these buildings would then be demolished and the rubble disposed on site, according to the best practise at the time.

9.3 Anticipated radiological conditions and control requirements during decommissioning

It is expected that the ventilation and liquid waste containment and solidification systems may have become contaminated on the internal surfaces during operation, but not to the extent that it would pose a radiological hazard in terms of external radiation exposure or contamination of the facilities housing the equipment during the operational period for Vaalputs.

Future dismantling and decontamination of these items would be done according to existing radiological control procedures, the Vaalputs nuclear installation license requirements and other regulatory control measures as required.

9.4 Provisions for the management and disposal of radioactive waste

Most demolished structures will be essentially non-radioactive and, after decommissioning, suitable for use as landfill material or backfill material for the borrow pits.

Relatively small volumes of low-level waste may possibly arise from dismantling the ventilation and waste solidification systems. If these cannot be decontaminated, they will be disposed of in the LLW trenches in line with the waste disposal practises and waste acceptance criteria applicable at the time.

The expected categories, classes and quantities of radioactive waste and other materials are presented in Table 6 below:

Table 6: Categories, classes and quantities of radioactive waste and other materials expected when decommissioning.

Waste description	Category	Class	Estimated quantities (m^3)
Concrete rubble and bricks from demolished buildings	Solid waste	Cleared waste	12 000
Scrap metal (pipes, door and window frames, corrugated roof sheeting, etc.)	Solid waste	Cleared waste	150
Scrap wood (doors, cupboards, etc)	Solid waste	Cleared waste	50
Other materials (lab equipment, plastic, vinyl tiles, PVC-pipes, non-hazardous chemicals, etc)	Solid waste	Cleared waste	10
Ventilation system	Solid waste	LLW	15
Liquid waste containment and solidification system	Solid waste	LLW	3

10 CONCLUSION

The disposal of Low-level radioactive waste is a proven technology that has been implemented for more than 60 years around the globe. International experience suggests that the scientific and technological basis for safe and secure implementation of LLW disposal is available. A large body of information is currently available on proven waste disposal technologies, offering a wide spectrum of disposal solutions.

The Vaalputs National Radioactive Waste Disposal Facility is duly authorised and regulated by the National Nuclear Regulator (NNR) and has been disposing of Low-level Waste in near-surface trenches for more than 33 years. During the operational period, more than 36 000 metal and concrete waste packages have been disposed of without any accidents. Over the last 9 years, the maximum individual dose of radiation workers was 1.34 mSv/a, which is 14.9 times lower than the regulatory limit of 20 mSv/a. Results of environmental monitoring have shown that there has been no radiological impact on the environment or members of the public due to the waste disposal operations at Vaalputs.

As NRWDI, we are deeply committed to deliver safe, sustainable and publicly acceptable solutions for the long term management and disposal of all radioactive waste classes. This means never compromising on safety or security, taking full account of our social and environmental responsibilities, always seeking value for money, and actively engaging with stakeholders in an open, transparent and respectful manner. Vaalputs will continue to communicate and share information with local communities, surrounding farmers, local authorities, government bodies and any other interested an affected parties on a quarterly basis with regard to nuclear and radiological safety as well as operational safety matters.

NRWDI remains absolutely committed to fulfilling the vast expectations of South Africans to dispose of radioactive waste in a manner that meets or exceeds all applicable regulatory standards and requirements for protecting the health, safety and security of humans and the environment, now and in the future.

11 LIST OF ABBREVIATIONS

ALARA	As Low As Reasonably Achievable
CEO	Chief Executive Officer
EPD	Electronic Personal Dosimeter
HR	Human Resources
HLW	High Level Waste
IAEA	International Atomic Energy Agency
ISO	International Standards Organisation
KCWP	Koeberg Concrete Waste Package
KNPS	Koeberg Nuclear Power Station
LLW	Low-level Waste
LSA	Low Specific Activity
MAC	Medium Active Concentrates
NCWP	Necsa Concrete Waste Package
Necsa	South African Nuclear Energy Corporation
NIL	Nuclear Installation Licence
NNR	National Nuclear Regulator
NRWDIA	National Radioactive Waste Disposal Institute Act
NRWDI	National Radioactive Waste Disposal Institute
RP	Radiation Protection
RPO	Radiation Protection Officer
RWMF	Radioactive Waste Management Fund
SABS	South African Bureau of Standards
SSC	Structures, Systems and Components
SCO	Surface Contaminated Object
SHEQ	Safety, Health, Environmentand Quality
TLD	Thermo Luminescent Dosimeter
WAC	Waste Acceptance Criteria